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# EFFECTS OF WAR ON THE ENVIRONMENT

The Proceedings of an International Conference on »EFFECTS OF WAR ON THE ENVIRONMENT« organized by the University of Zagreb, the Ministry of Civil Engineering and Environmental Protection, and the Ministry of Science of the Republic of Croatia,

Zagreb, Croatia, 15-17 April, 1993

HDKI / Kemija u industriji - Zagreb, 1994

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# THE PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON THE EFFECTS OF WAR ON THE ENVIRONMENT

Zagreb, 15-17 April, 1993

## *Editors Preface*

The first international conference covering the subject of the effects of the war and military activities on the Environment was held on April 15-17, 1993, in Zagreb, Croatia. During the same period of time the environment in Croatia was still a subject of permanent, aggressive and intentional devastation by conventional, and in some cases chemical and other warfare agents and weapons. The conference was organized by the University of Zagreb, in cooperation with the Ministry of Science and the Ministry of Civil Engineering and Environmental Protection, of the Republic of Croatia. Additional support to the conference was given by the United Nations Development Organization, Vienna, The Royal Society of Chemistry Toxicology Group, United Kingdom, and the Croatian Chemical Society, Zagreb. Approximately 140 scientists from different international and domestic organizations both industrial and academic attended the meeting. The Conference was opened by the Chairman of the Organizing committee and and of the first session Prof. Dr. S. Rendic, followed by the introductory words given by Prof. Dr. M. Sunjić, the Rector of the University of Zagreb. In this issue the papers covering following themes discussed during the Conference are presented:

– General approaches to the environmental protection in Croatia during the war with suggestions and proposals for future collaboration in the field of environmental management and remediation of the damaged environment are presented by representatives of recognized international organizations (UNIDO, Vienna, Institut für Europeische Umweltpolitik, Germany, Regional Environmental Center for Central and Eastern Europe, Hungary, Science Applications International Corporation, USA).

– Application of international legal norms and conventions to the protection of the environment in time of armed conflict from diverse aspects (uses of biological, chemical, and conventional warfare agents, effects on cultural heritage, energetic objects and economic situation due to blockade and bombardment of Croatian sea-ports).

– Environmental pollution due to destroyed, industrial, agricultural, and power plants, and consequences for the present and future economic development of Croatia is presented by recognized international scientists and based on a UNIDO mission in Croatia and the Technical Report thus prepared.

– War effects on the cultural and natural heritage is illustrated by the Nature Park Lonjsko Polje and by destruction and reconstruction of the Cathedral of Šibenik. The declaration made by the participants is focused to the need of protection of the cultural heritage in the present and future armed conflicts.

The aim and objective of this issue is to assist assessments of risks and hazards, their reduction, and protection of the environment in Croatia from consequences of intentional and nonintentional destructions during the war activities.

It is recommended that there is an urgent need for enforcement of legal protection of the environment, to monitor the pollution not only in Croatia but also in the countries which use the rivers as a source of potable water downstream as well as to develope positive and rapid management techniques to avoid further environmental damage.

The publication of this Special Issue the journal "Chemistry in Industry" was supported by United Nations Development Organization, UNIDO, Vienna, and by The Ministry of Science of the Republic of Croatia.

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# I. GENERAL ASPECTS AND COMMENTARIES

## Activities of United Nations Industrial Development Organization (UNIDO) in the Area of Chemical Industry

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Activities of UNIDO, Wien, in the field of development and technical support of developing countries are described. Some of the countries have gone trough traumatic experience of war with heavy war damages (Kuwait, Croatia). International organizations such as UNIDO, UNEP, could play an important role to provide assistance in tackling the ecological damage. UNIDO's primary mandate is to assist promotion in the formulation of development, scientific and technological programmes and plans. The assistance is vital especially in planing development of "cleaner" technologies that generate minimum or no waste.

In conclusion, Croatia needs the assistance similar to post-war Marshall plan. UNIDO with other organizations would give all the necessary advisory and technological assistance in rebuilding the country, especially in the industry sector.

On behalf of the newly elected Director General of UNIDO, Mr. Mauricio de Maria y Campos and on my own behalf, I want to welcome you all to this very important conference to discuss the effects of war on the environment. We are indeed very happy to support this international conference which will set the scene for action to be taken by your new born republic through local efforts and by bilateral and multilateral assistance. Countries such as Kuwait and Croatia, have gone through a traumatic experience of war with displacement of people from their own towns and cities and faced the consequences of a long term damage to the ecological system. Now your country is left to cope with the war damages to property, industry and above all to the cultural heritage which is very difficult to replace. However, Mr. Chairman history has shown that mankind is resilient and despite great sufferings they do survive linking themselves to cultural and religious ties. Today, Croatia is going through the same process as shown in this conference. Many delegates having links to Croatia, are here to give both moral and technical support to build the country from the ruins of war.

International organiza ions such as UNIDO, UNEP, could play an important role in providing the badly needed assistance to Croatia in tackling the ecological damage. UNIDO's primary mandate is to assist promotion and acceleration of industrial development in developing countries and specifically to assist in the formulation of development, scientific and technological programmes and plans for industrialization in the public, cooperative and private sectors. In this special attention is given by UNIDO to:

- human resource development
- development and transfer of technology
- industrial rehabilitation
- small and medium scale industries
- environment, energy and economics
- mobilization of financial resources for industrial development
- promotion of the cooperation between developing countries
- industrial safety, waste management
- cleaner technology
- use of renewable resources
- reduction/elimination of CFCs and other ozone depletion compounds.

Today, we all know that industries play a vital role in determining the standards of living of mankind but at the same time, they are directly or indirectly contribute to the pollution of soil, water, air, and to the ever growing consumption of non-renewable resources. It is obvious that this part of the world, the Mediterranean region depicts the differences that exist between North and South and they are of extreme contrasts. They are evident especially among the eighteen countries that embrace the common coastline of the Mediterranean Sea. They affect all spheres such as economy, religion, politics, level of industrialization, rate of population growth, literacy rates, infant mortality and so on. The population of the region, especially of the Mediterranean countries, will reach around four hundred million by the turn of the century.

Every year around a hundred million tourists pass through this region and all this will put enormous pressure on the Mediterranean countries, especially on the coastal areas and the fresh water resources in the south which are becoming very scarce.

The problems facing the region are clearly stated in the Bergen Ministerial Declaration of May 1990 of the United Nations Economic Commission for Europe. It specifies that destruction of the biosphere and its ecosystems, environmental degradation, population pressures, depletion of resources and extinction of species threaten the quality of human life as well as human health and many of the earth's biological systems.

Since the Bergen declaration, the Mediterranean has been changing fast with some countries moving from centralized economy to free market economy and above all, the world went through the Gulf war and today we are witnessing civil unrest threatening the Balkan states. In other words, this region is going through an unpredictable consequences on the life of the people and the environment.

UNIDO has been getting requests from countries in Eastern Europe and also from the Mediterranean countries to assist in privatizing their ineffective public enterprises, cleaning up of the environment and introducing cleaner technologies.

Exactly one year ago UNIDO actively participated in Athens Conference on Environment Protection and Recycling of Waste. Many recommendations were made and one of which was that UNIDO should promote in this region technologies that generate minimum or the waste. This is in accordance with UNIDO's concept of Ecologically Sustainable Industrial Development (ESID) which defines industrialization so as to

- maximize industrial output from a given level of resource ensuring appropriate use of human, renewable and non-renewable resources.
- make certain that industrial pollution does not exceed a critical load beyond which it adversely affects human beings and nature thus ensuring the quality of human life and proper management of natural assets.

In the Athens Conference I mentioned before, UNIDO reported on the sustainable management of industrial, domestic and agricultural waste. UNIDO is now more and more getting involved in waste minimization, waste recycling and proper disposal of waste. Energy conservation is a primary concern of UNIDO. In this we strive for low pollution in generating energy especially in coal and petroleum fuel utilization and in reducing energy consumption per unit production of industrial goods which are all of vital importance for ESID.

Another area UNIDO is giving importance is to air and water pollution control because they have consequences beyond national boundaries. The acid rain, ozone depletion, global warming, river pollution, eutrophication are all directly related to localized pollution generation having global consequence.

Finally industrial safety is vital for any plan to develop industries in developing countries. This cannot be emphasized more in chemical and allied industries where safety related to plant, workers' health and environment (SHE) aspects are given low priority in many countries. This is reflected in various accidents and ill health caused during handling, storage and transport and use of chemicals. In this UNIDO has developed Integrated International Safety Guidelines for Pesticide Formulation in Developing Countries. We are also conducting regular workshops on normal and preventive maintenance of petrochemical complexes. Recently we are giving assistance to Pakistan and Kuwait in dealing with eco-toxicological aspects related to chemical contamination. We are also providing assistance to Poland in clean coal technology and cleaner pesticide production.

In the chemical industries sub. sector our technical assistance programme covers the basic necessities of developing countries *viz.*

Health, Hygiene, Nutrition, Food security, Shelter, Clothing and Energy

At the end of 1992 UNIDO in all industrial sub. sectors had 715 operational projects and 413 pipeline projects.

In conclusion, Mr. Chairman, Croatia needs the assistance similar to the Marshall plan to Europe after the world war, to put the country on the road to recovery from war damages. UNIDO along with other organizations would give all the necessary advisory and technical assistance to put your sufferings behind and start rebuilding the country especially in the industry sector. I sincerely hope that this conference would put Croatia on the road to recovery from the ruins of the war. We are indeed very pleased to actively participate in this conference and along with the number of experts, UNIDO in collaboration with other organizations would be able to provide the necessary advice for controlling and rehabilitation of the chemical and allied industries damaged due to war. I wish you all a very successful deliberations and a pleasant stay in Croatia.


## SAŽETAK

### UNIDO djelatnosti na području kemijske industrije

*A. Tcheknavorian-Asenbauer*

Iznesen je prikaz djelatnosti Organizacije Ujedinjenih Nacija za Industrijski Razvoj, UNIDO, u Beču, na područjima razvoja i tehničke podrške industriji zemalja u razvoju. Posebice onih koje trenutačno prolaze kroz teška razdoblja kao što su posljedice ratnih aktivnosti (Kuvajt) ili su izložene ratnim razaranjima (Hrvatska). Naglašeno je da je jedna od glavnih zadaća međunarodnih organizacija kao što su UNIDO i UNEP da pruže Hrvatskoj nužnu pomoć za saniranje ekoloških šteta te da surađuju kod donošenja planova daljnjeg industrijskog razvoja i pripremanja novih znanstvenih, razvojnih i tehnoloških programa u privatnom i javnom sektoru. Ova suradnja je od posebnog interesa kod planiranja

razvoja "čistih" tehnologija na području Mediterana s obzirom na postojeće međunarodne deklaracije i konvencije. U zaključku je navedeno da je u ovom trenutku Hrvatskoj potrebna pomoć slična Marshallovom planu, donesenom nakon II. svj. rata te da je UNIDO spreman surađivati pri obnovi kemijske i srodnih industrija.

*United Nations Industrial Development Organization, Vienna, Austria*

*Prispjelo 15. travnja 1993.*
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# Environmental and Information Management

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In summary, the effective implementation of environmental management considerations requires knowledge, context, information and conviction. The required knowledge is obtained through training, experience and technology transfer. Context refers to the planning process that integrates environmental activities into other related endeavors including those related to public health, legal systems, and public awareness. Data or information requirements relate to the information necessary to understand environmental risks. Finally, conviction is necessary in order to make the trade off decisions required to prioritize environmental activities. This conviction represents commitment to environmental protection.

Environmental management techniques must be integrated into the planning process as Croatia establishes its institutions. The word 'integrated' is important since the opportunity exists for environmental considerations to be included in Croatia's master planning for economic development, public health facilities and capabilities, government ministries and legal systems, and the inclusion of public input into the entire process.

The Republic of Croatia is at a critical point; although top priority must be placed on securing its borders and providing for the immediate security and health of its people, the opportunity exists for Croatia to benefit from the experience of others and to develop an environmental management system to incorporate forward thinking into its building and re-building process.

## Introduction

The principles of Environmental Management are of great importance as Croatia emerges into independence from its past association with the Yugoslav Federation; of special relevance is the impact of war on the environment as conflict continues in and around the Croatian territory. The current situation in which Croatia is establishing the infrastructure and public institutions to carry out the mandate of public and environmental protection is the optimal time at which to evaluate and implement programs for the protection of the public health and of the environment. The following comments are intended to point out issues that may have a bearing on the development of Croatia's environmental programs and institutions.

## Technology trends: the US experience

In the USA, the last three decades have witnessed significant changes in the emphasis of environmental protection. During the 1970's, environmental protection concerns centered on issues of large scale air and water pollution characterized by gross water pollution of surface water bodies, and regional air pollution as exemplified by smog-choked cities such as Los Angeles. At the beginning of the 1970's, the principal technologies for environmental protection were biological, physical and chemical methods for treating water pollution, the physical removal of airborne particulates, and evaporative controls on automobile emissions. Toward the end of this decade, scrubbers were installed to control sulphur oxide emissions from power plants; automobile emission standards required the use of oxidation catalysts; and new detection technologies were being applied to detect toxic water pollutants at very low levels.

During the 1980's, concern shifted to toxics in the environment. This period is characterized by concern over the leakage of toxic chemicals into groundwater or exposure through air, water or land. More sophisticated detection and risk assessment techniques heightened public concern related to toxics exposures, especially fear of cancer. Toxic waste abatement strategies were based on engineering containment in landfills. By the end of this decade, most hazardous

waste streams required some form of treatment before disposal was allowed.

By the late 1980's and leading into the 1990's, environmental concerns again shifted to global environmental issues. Ozone depletion was identified as an issue when the ozone hole was discovered over the antarctic. Effort has been applied to the analysis of complex, global environmental systems to evaluate issues such as global climate change and habitat destruction. Attention has been redirected from pollution controls and remediation to prevention.

The US Environmental Protection Agency's Science Advisory Board has recommended a number of changes in emphasis as the US plans future environmental programs. First, the Board recommended that priorities for environmental programs be established on the basis of comparative risk. It suggested that environmental policies be linked to policies related to agriculture, energy, transportation and urban development. The Board emphasized the importance of pollution prevention as the cornerstone of abatement strategy.

## Environmental management

Environmental management comprises the broad range of environmental activities that may be relevant in establishing and maintaining an effective environmental protection program. Specific organizational elements of an environmental protection program may be focused on these specific areas. These include:

- Compliance activities to include formulation of laws or regulations; guidance for implementation of such requirements; and enforcement. Without some form of enforcement, compliance cannot be expected;
- Pollution abatement, including controls on releases to the air, water and soil;
- Waste reduction or minimization, including process modifications and recycling;
- Waste management including processing, handling, packaging, storage, transportation and disposal;
- Cleanup or environmental restoration of facilities, soils and waters;

and related fields such as worker safety, health and liability.

## Environmental information management

As environmental requirements become increasingly complex, information management techniques are becoming more necessary to organize, track and manage the full range of evolving requirements. In addition, environmental modeling, data base management, field data collection and analysis, and records management and document retention are needs supported by the increasingly available and cost effective small computer systems. Two principal drivers toward increased application of information technology are the rapid proliferation of environmental information and requirements, and the existence of inexpensive, widely available computer resources.

To organize and track environmental compliance requirements, it is possible to break down laws, regulations and industrial codes and standards into unit requirements which can be treated as elements in a data base. Although this can be a labor intensive process, several major benefits can be obtained:

- by condensing the data base to eliminate duplication and extraneous requirements, significant reductions in the amount of information to be managed can be achieved.
- contradictions between requirements can be identified and resolved
- linkages to operating policies and procedures can be used to verify compliance
- the full impact of changes in laws or regulations can be readily appreciated
- environmental audits can be supported through the generation of checklists from requirements through to the tracking of follow up actions.

## Environmental management in the context of war

With regard to the specific issue of the effects of war on the environment, several areas of relevant experience can be identified from ongoing programs in the USA. First, the US is currently implementing a significant level of military base closures and associated environmental cleanup to return government facilities and land to alternative civilian uses. Related to this is the cleanup of military land (e.g., gunnery ranges) which include significant quantities of unexploded ordinance and ordinance debris. Another relevant activity is the program in the US to demilitarize and destroy chemical munitions. The cleanup of hazardous and mixed radioactive/hazardous contamination from defense industrial laboratories is another area. Finally, epidemiological studies related to military uses of toxic chemicals (e.g., defoliants) have been conducted.


## SAŽETAK

### Gospodarenje okolišem i sustavi informacija

*C. F. Smith*

Sažeti prikaz razvoja gospodarenja okolišem i razvoja informacijskih sustava u različitim fazama razvoja gospodarstva S.A.D. Istaknuta je važnost primjene svih djelatnosti koje mogu doprinijeti zaštiti okoliša (modeliranje i osnivanje sustava informacija primjenom malih ali djelatnih računarskih sistema). Navedeni su primjeri programa koji se koriste za rješavanje specifičnih problema zaštite okoliša kod zatvaranja i ponovnog civilnog korištenja vojnih baza, vojno-industrijskih laboratorija i sličnih postrojenja, a razvijeni su za potrebe zaštite okoliša tijekom rata i nakon ratnih aktivnosti. Programi zaštite okoliša u

Hrvatskoj, naglašeno je, trebaju biti dijelom programa ukupnog ekonomskog razvoja, razvoja zdravstva i pravnog sistema.

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# Possibilities for East-West Cooperation in the Field of the Environment in Croatia

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1. Main Characteristics of the Environmental Situation in Croatia and Other Countries of Central and Eastern Europe
   - Economic policies of the last decades
   - Administrative and legal deficiencies
   - The lack of technology
   - The war in Croatia and other former Yugoslav republics
   - The lack of public awareness
2. Possibilities for East-West Cooperation
   - Areas of cooperation and assistance
   - The extent of cooperation and assistance
   - Assistance for self-sustainability (Hilfe zur Selbsthilfe)
   - Cooperation with the European Communities
   - Cooperation with international lending institutions
   - Multilateral Cooperation - The Environmental Action Program for Central and Eastern Europe
   - Bilateral Cooperation - The case of Germany
3. The Role of Non-Governmental Organisations (NGOs)
   - NGOs, public awareness and civil society
   - East-West NGO cooperation
   - The role of the Regional Environmental Center

In the first part the autor gives an overview of the Western point of view of the main characteristics of the environmental policies in Croatia and other Eastern European countries, taking into account the situation of the past but also the impact of the war on the territory of Croatia.

In the second part of the lecture, the author describes the possible areas and the possible extent of East-West cooperation and for Western assistance. The role of the international lending institutions like the World Bank or the European Bank for Reconstruction and Development will be analyzed. Furthermore the author will describe possibilities for multilateral cooperation in the framework of the Environmental Action Plan for Central and Eastern Europe and bilateral cooperation, using Germany as an example.

The third and last part of the lecture focuses on the role of non-governmental organisations and the Regional Environmental Center for Central and Eastern Europe.

## Introduction

For countries such as Croatia, international co-operation is crucial to improve the situation of the environment. Many of the urgent environmental problems can only be solved if there is sufficient western assistance in both finance and expertise. Western countries are willing to assist, but it is clear that the main part of the burden is on the side of CEE countries. Only if the CEE countries have a real wish to introduce changes in environmental policy, international cooperation can work.

This report will give a short overview about the possibilities for cooperation between Croatia and Western countries, starting with an overview about the main characteristics of environmental policies in Croatia, seen from a Western and general perspective. In the second part of the report, the author will describe possible areas of East-West Cooperation. Section 3 is dedicated to the role of Non-Governmental

organisations.[1] This report does not claim to be complete, it just gives some highlights on possible areas and ways of cooperation between East and West.

The author is aware of the fact, that Croatia is a country which still is in a quasi-war situation and that international aid programs, such as the PHARE program, are not yet available for Croatia. Nevertheless, the author counts on a peaceful solution of the conflicts in the region so that the environment can have the priority in Croatia that it deserves. This report does not deal with special support programs of international organisations, such as the UN, which will be presented in other lectures.

## Main characteristics of the environmental situation in Croatia and other countries in Central and Eastern Europe

### *Economy*

Although the situation of the environment in Croatia is better than in other heavily industrialized countries of Central and Eastern Europe, environmental problems have their roots primarily in the economic politics of the last decades. The environment never was (and still is not ) treated as a political priority. It was (and still is) not acknowledged that economic and environmental policies are conceptually related with one another. Although the former economic system was replaced by a market-oriented system, a total transition to a market economy has not yet been mastered in Croatia. Even more, the potential for the coupling of economic and ecological modernization has only partly been recognised. The course on which Croatia will follow today will have profound ramifications for environmental protection in the coming decades.

Due to the war and to structural problems, Croatia finds itself in a heavy economical crisis and as a result of this, there are almost no financial means to solve even the most urgent environmental problems.

### *Legislation*

In the former Yugoslavia, environmental legislation existed[2], but complete legislation was never put together in a working legislative framework. As in the field of economy, there did not exist a real concept for an effective and implementable environmental legislation.

Also the administrative and legal system of the country in the former time was far from being sufficient. There were >1000 laws and regulations to handle environmental problems sufficiently. Where legislation existed, the implementation and enforcement was deficient.

In particular in the field of water and air pollution, the Yugoslav legislation was inadequate. Fines, which were a part of the regulations, were so low that it was not a problem for the polluter to pay them.

Croatia was the first Yugoslav republic to introduce the environmental impact assessment in 1984. Nevertheless, only a few projects with a negative impact on the environment this mechanism could stop.

In the meantime there are efforts in Croatia, to elaborate a consistent legislation for the protection of the environment. The environmental framework law passed the parliament, and other specific laws are under preparation. However, the problem of implementation and enforcement of the laws is not yet solved.

The "Right to Know Legislation" is also not yet implemented in Croatia. Such legislation is particularly crucial because it allows the public to monitor governmental decision. The western experience has shown that the public, in particular NGOs, always have been the motor(engine) of environmental policy-development.

### *Administration*

Environmental administration in Croatia is still not effective enough to solve the urgent environmental problems. In the Ministry for Civil Engineering and Environmental Protection, only a minority of employees is working on environmental protection. In particular the different responsibilities between national level, regional level and local level are not yet elaborated. It also has to be mentioned that the economic situation in Croatia does not allow it to give an adequate payment to state employees, which hinders the hiring of more and qualified personnel.

### *Technology*

Although the technology which is used in Croatia is quite advanced, compared with the other former socialist countries of Central and Eastern Europe, it does not meet western standards. Where cleaning facilities for air or water exist, often they are out of order and spare parts are missing. There is a urgent need for the transfer of western technology to Croatia. Up to now, the lack of money made it impossible to solve this problem.

### *The war in Croatia*

The war on the territory of Croatia has enlarged the environmental problem of the country. The rich and beautiful natural heritage of the country was threatened[3]. For instance the national parks of Krka, Paklenica, Mljet and the Plitvice Lakes and many other areas were struck by military attacks. Attacks on chemical plants, such as the refinery at Sisak caused additional environmental pollution.

As a result of the war situation and the constant threat of a continuing war, great portions of the state budget are going to the military force, what leads to a disasterous economical situation. Furthermore, funds for environmental protection are marginal.

## Possibilities for East-West cooperation/Areas of cooperation and assistance

### *The economical framework of environmental protection*

A basic requirement for an economically-based environmental policy is the internalization of external

costs of environmental pollution. This takes place in the precautionary environmental policy of Western states, particularly in the legal stipulation of binding emission limits which force the producers of emissions to implement environmental protection measures. This principle, the Polluter-Pays-Principle, was not common in Croatia up to now. Environmental protection investments were financed by state budgets, yet enterprises took no interest in their realization because their economic co-efficients (prime costs, efficiency, productivity) declined.

Western countries can help Croatia to restructure the economic system, taking into account environmental matters. A precondition is that compatible environmental standards in Western countries and Croatia have to be established, in order to prevent the unrestricted trade of products and technologies. The medium-and long-term economic perspectives for potential investors should be made apparent through well-defined environmental standards. Only a high level of harmonization of environmental standards can assure that CEE states do not become a dumping ground for Western countries.

One possibility for this, taking also in account Croatia's membership in the EC, would be to set up environmental standards in Croatia according to EC standards. Of course the EC regulations cannot be adopted just as they are. Each directive has to be investigated in order to find out whether it is appropriate for the situation in Croatia. Also a time schedule for implementing the regulations has to be set up. This will need, of course, some time, because the number of EC regulations is quite high. For example after 1990 the EC adopted more than 150 directives in the environmental field.

*The extent of cooperation and assistance*

Due to the world economic crisis, there are limited resources in the West to assist CEE countries in solving their environmental problems. Western countries, such as Germany, are willing to assist countries like Croatia in their efforts to restructure the economy and the environment, in particular when such measures support the stability of the region. But western countries are not willing or able to pay the whole bill alone. In particular western aid focuses on two issues:

- Burden sharing
- Assistance for Self-Sustainability

*Burden sharing*

Western countries, such as Germany, are willing to assist CEE countries. But a condition for this is that CEE countries also pay their part, even if it is painful (such as the closing of an enterprise, which may cause unemployment). This is what is called, for instance in the framework of the Luzern Conference, the principle of Burden Sharing. Only if CEE countries such as Croatia allocate as much as possible of their own resources, if they prove the will to solve their environmental problems as far as possible with their own means, western countries will assist them.

*Assistance for self-sustainability*

Western aid for solving the economic and environmental crisis in CEE countries is limited. It is obvious that within the next few years the amount of available money from the West will decline. Therefore it is the intention of Western countries to enable countries like Croatia more and more to solve environmental problems on their own. The West is willing to give technical assistance. Germany for instance has bilateral environmental agreements with almost all CEE countries. A very important part of this agreement is the exchange of experts and assistance in the development of legislation and of effective administrations.

*Cooperation with the European Communities*

The EC has several environmental aid programs for CEE countries. Some of them, such as the PHARE program, are not yet available in Croatia, due to the war situation. Nevertheless, because hopefully the future will bring some changes, some components of the EC aid program should be presented here:

*PHARE*

The PHARE (originally Poland Hungary Assistance for the Reconstruction of the Economy) Program at the moment covers the following countries: Albania, Bulgaria, Czech and Slovak Republic, Estonia, Latvia, Lithuania, Poland, Romania and Slovenia. Among other projects, PHARE is supporting projects in the field of the environment. The total budget between 1989 and 1992 was 2.28 billion ECU. PHARE is the most important financial aid program for CEE countries. The intention of the PHARE Program is to assist CEE countries to create the necessary legislative, financial, administrative and environmental framework for a working market economy. In 1991 10% of the PHARE budget was used for environmental projects, a share of the total sum which should be enlarged in order to reach an effective environmental protection in CEE.

*Tempus program*

As a part of the PHARE program, the TEMPUS scheme which was adopted on May 7, 1990 by the Council of Ministers of the European Communities, is designed specifically to promote the development of the higher education system in countries of CEE, also where related to environment. Croatia is still not eligible for grants under the TEMPUS program. The TEMPUS program is mainly designed for cooperation of universities. It supports joint European projects, offers mobility grants for staff or students, and supports publications, participation in conferences etc.

Also the program Ouverture has to be mentioned which supports citizen partnerships between East and West.

*Lending institutions: The World Bank, The European Bank for Reconstruction and Development*

Another possibility for East-West Cooperation is the assistance of lending organisations such as the

World Bank in Washington or the European Bank for Reconstruction and Development and others. These organisations are banks what means, support usually comes in the forms of loans which have to be repaid. At the moment there are negotiations between the World Bank and the Croatian Government for a project related to the cleaning of the Rijeka Bay.

It has to be mentioned that up to now these lending insitutions very often supported projects with a negative impact on the environment. As examples: The European Investment Bank has lent over 500 Mill. $ in the region but has no published environmental procedures. In 1991 the World Bank approved over half of its loans to the region (2000 Mill $) without any pre-approval environmental impact assessment.

At least for the World Bank it seems that this policy is changing. However, responsible environmental ministries and NGOs should have an eye on the activities of these institutions in order to ensure that only environmentally-friendly projects are supported.

*The Luzern environmental ministers conference*

On April 28 to 30, 1993, environmental ministers and governmental representatives from the whole of Europe, the USA and some other countries will come together in Luzern, Switzerland, in order to discuss possibilities for closer cooperation in the field of the environment. This pan-European conference is the second conference of this type. The first one was held in June 1991 in Dobris, CSFR. The preparatory work for this conference consists of two elements: An Environmental Action Program for Central and Eastern Europe and the Strengthening of Tools and Mechanisms for pan-European cooperation.

The most important document, which will be discussed in Luzern is the Environmental Action Program. It aims to identify the mix of actions to combat the highest priority problems. The underlying concept of the EAP is one of partnership. The goal is first, to establish a consensus with and between countries in East and West on the priority problems, and second, to agree on a mix of policy, investment and institutional actions, with complementary commitments on the part of all countries and institutions involved. The EAP should be adopted in Luzern as the overall broad strategy for the integration of the environment into economic transformation of CEE countries and as the basis for East-West Cooperation.

Up to now, Croatia participated in the negotiations for Luzern. Recently a World Bank Delegation (The World Bank is responsible for cooperation with the EC to prepare the EAP) visited Croatia. The task of the Croatian side now is to identify priority areas for cooperation and to define the extent of commitments which will be made on the Croatian side.

*Bilateral cooperation - The case of Germany*

Germany has bilateral agreements for cooperation in the field of the environment with almost all CEE countries. At the moment there is no such agreement with Croatia but it is planned. In the framework of these agreements, it is not foreseen to give huge financial assistance to the partner countries. These agreements focus on assistance for self-sustainablility. They try to enable the CEE partners to solve the environmental problems mainly by themselves. Germany is offering assistance such as expert exchange, information, technical assistance but not more.

## The role of NGOs

*NGOs, public awareness and civil society*

In particular in a difficult economic situation, where people have to fight for their daily survival, NGOs play an important role as a promotor of environmental awareness. NGOs even can assist the state in implementing unpopular decisions[4] A precondition for this is that environmental information is freely available for everyone (Right to Know).

In Croatia there are around 20 active environmental organisations[5]. Many of them are working under difficult conditions because of the war. Others, such as Green Action Zagreb or the Green Alliance of Croatia are important actors in environmental policy-making.

*The role of the Regional Environmental Center for Central and Eastern Europe*

In order to support environmental NGOs in CEE countries in 1989 the Regional Environmental Center for Central and Eastern Europe (REC) was set up after an initiative of President George Bush. The REC is a non-governmental, not-for-profit and non-advocacy organisation, which mainly supports environmental NGOs through grants. It is sponsored by the US, EC, Canada, Japan, New Zealand, Hungary, Germany and others. The yearly annual budget is around 3 Mill ECU. Support is given to CEE countries, excluding the former Soviet Union. Due to the international embargo, no support is given to Serbia and Montenegro. The REC has so called Local Offices in four countries. In Croatia there is a Local Coordinator, working for the REC. In 1994 it is planned to open an office.

The REC can be seen as a unique example for East-West cooperation.

It offers three main services to the following constituencies: NGOs, Government, Local Government and Business:

*The grants program*

Project grants are given to environmental NGOs. From Croatia, Green Action Zagreb got a grant for producing a book about environmental consequences of the war and for an educational program. The Green Alliance of Croatia got a grant for a project on avoidance of plastic waste.

In the second half of 1993 the grants program will change. The so called Earmarked Grants Program offers grants on selected environmental problems. In the framework of the Local Grants Program, grants up to 3000 ECU per year and per organisation are offered. Local Grants are administered on the local level and applications can be sent in Croatian.[6]

*Information Clearinghouse Service*

In the framework of this service REC is answering all information requests, from all constituents. For example in January 1992 the REC financed the stay of two lawyers from Albania in Budapest for collecting information about environmental legislation in CEE countries.

*Task Forces*

At the moment the REC is running two so-called task forces: The Legislative Task Force and the Local Authorities Task Force. In the framework of these taskforces the REC tries to provide a forum for East-West but also East-East Information Exchange. Representatives from Croatia are frequently participating in the task force meetings.

*CEE governments and the REC*

Up to now the REC is sponsored mainly by Western Countries. Hungary is the only CEE country to support the REC. In the long run it is intended to get more funding from other CEE countries such as Croatia. The reason is that the principle of burden sharing also should be introduced in the REC. The REC is willing to support NGOs and to assist governments, but the donor countries such as the EC, also like to see that CEE governments give their part to the REC budget. Such participation in financing the REC activities could be, for example, assistance in running a REC Local Office in Croatia.

*Conclusions*

This report only gave a short overview about possibilities for future cooperation without demanding to be complete.

Some of the above mentioned cooperation has already started, further cooperation depends on stability in Croatia, with respect to the war and also democratization.

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1. Parts of this report are based on a paper "Environmental Action Plan for Central and Eastern Europa", by Helmut Schreiber and Ulrich Weissenburger, published in 1992 by the Deutsches Institut für Wirtschaftsforschung. The author participated in the preparation of this paper.
2. Although Yugoslavia was one of the first countries of the world which put in 1974 the protection of the environment in the constitution (article 85), this never had a serious impact on the environmental legislation.
3. For further information see: The War-devastation of the natural heritage of Croatia, in Ekološki Glasnik, Godište II, Broj 5–6, 1991/92.
4. For further information about this topic see also: P. Hardi, A. Juras, M. Toth-Nagy (ed.), New Horizons? Possibilities for Cooperation between NGOs and Governments in Central and Eastern Europe, Budapest 1993 (available at the Regional Environmental Center).
5. Before the war, the number of active environmental NGOs in Croatia was much higher, but due to the recent events their number declined.
   About NGOs in Croatia see also: A. Juras (ed.), NGO Directory for Central and Eastern Europe, Bonn 1992; V. Terselic, Civil Society and the Environment in Yugoslavia, in: D. Fisher, C. Davis, A. Juras, V. Pavlović (ed.), Civil Society and the Environment in Central and Eastern Europe, Budapest 1992 (both books available at the Regional Environmental Center).
6. For further information please contact the Regional Environmental Center (1, Miklos Ter, Budapest 1035, Hungary or the Local Coordinator for Croatia: Lidija Pavić, Avenija V. Bubnja 23/IV, 41020 Zagreb, Croatia).

**SAŽETAK**

**Mogućnosti suradnje Istok-Zapad i zaštita okoliša - Hrvatska nakon rata - Uloga službenih i nevladinih organizacija**

*A. Juras*

1. Glavne značajke koje uvjetuju stanje okoliša u središnjoj i istočnoj Europi su:
   - Gospodarstvena politika posljednjih dekada
   - Manjkavosti u upravnom i pravnom sustavu
   - Nedostatak javne svijesti

   Izneseni su pogledi zapadnih zemalja na glavne značajke odnosa prema okolišu u Hrvatskoj i drugim istočno-europskim zemljama, uzevši u razmatranje i utjecaj rata u Hrvatskoj.
2. Mogućnosti suradnje istok-zapad
   - Suradnja i pomoć
   - Podrška vlastitim programima razvoja
   - Suradnja sa europskim zajednicama
   - Suradnja sa međunarodnim bankarskim ustanovama
   - Multilateralna suradnja - Akcioni program zaštite okoliša za središnju i istočnu Europu
   - Bilateralna suradnja - primjer Njemačke

   Dan je pregled mogućnosti za suradnju sa zemljama Zapadne Europe.
3. Uloga nevladinih organizacija (NGO)
   - NGO udruge, javna svijest i građansko društvo
   - NGO suradnja istok- zapad
   - Uloga Područnog centra za okoliš (Regional Environmental Center)

   Istaknuta je uloga NGO udruga i Područnog centra za okoliš, Budimpešta.

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# II. LEGAL NORMS AND PROTECTION OF THE ENVIRONMENT DURING ARMED CONFLICT

## Humanitarian International Law and the Protection of Environment in Time of Armed Conflict

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As the environment includes the entire and all results of the history of humankind, many of the traditional rules regulating warfare could be considered as protecting the environment.

Yet the most direct rules on the protection of the environment are to be found in the 1977 Additional Protocol to the Geneva Conventions of 12 August 1949.

As the war against the Republic of Croatia commenced within a federal State, and very soon it acquired all the properties of an international armed conflict (as well as the war against Bosnia and Hercegovina), the author analyses the relevant provisions of both 1977 Geneva Protocols and their implementation and violations in the savage war of destruction of the nature and all the civilisation achievements of the history of the Republic of Croatia.

1. The title of my contribution to this Conference was formulated some time ago, when there was still some hope that Dr. Joseph Goldblat would submit a general paper on the »Protection of the Environment in Time of Armed Conflict«. However, I have always had some reservations in respect of the use of the term »humanitarian« in dealing with the laws of war. Namely, it is almost impossible to destinguish strictly humanitarian international rules from the other laws of war – all of them representing some limitations in waging armed conflicts. The content of the 1977 Additional Protocols to the 1949 Geneva Conventions is a proof of the unity of international law of armed conflicts. However, the use of the term »humanitarian« is particularly inappropriate in respect of the rules on the protection of the natural environment. Namely, their purpose in not only to protect the humankind, but all the ecosystems and all the necessary conditions for the survival of the entire nature. And its survival – at least for the time given to the Planet Earth by the natural and/or supernatural laws of the Universe – is endangered only by human beings. In times of peace man endangers the natural balance of the environment mostly by negligence; in times of war he does it deliberately in order to harm his enemy.

2. Altrough nations do not hesitate to engage in armed conflicts, they are nowadays somehow shy in developing laws of war. According to some sources, since the creation of the United Nations, 20 million people have been killed in armed conflicts and the international community only sporadically engages in the progressive development of international law of war. This general situation has also been reflected in respect of the rules on the protection of the environment. Contrary to innumerable rules on environmental protection in times of peace, there are but few rules directly, expressly addressing the protection of the environment in times of war. That is why it has often been asked whether at least some principles of environmental law are applicable also in times of war. The answer is positive: the principle that a State must not cause damage to the environment beyond the limits of its national territorial jurisdiction is often mentioned as a confirmation thereof.

Yet, in addition to the application of environmental rules, some general principles of the law of war can be applied to the protection of the environment. Namely, the purpose of international humanitarian law since its inception has been to set limits on the right of belligerents to cause suffering and injury to people and to wreak destruction on objects, including objects belonging to the natural environment. A succinct expression of these goals is to be found already in the Declaration of St. Petersburg of 1868, which states that »the only legitimate object which States should endeavour to accomplish during war is to weaken the military forces of the enemy«. The Hague Regulations respecting the Laws and Customs of War on Land of 1899 and 1907 contain a principle which provides the basis for later limitations of the use of

certain kinds of weapons and means of warfare. Namely, Article 22 of the Regulations reads:

»The right of belligerents to adopt means of injuring the enemy is not unlimited.«

However, the following articles of the Hague Regulations specifically deal with the protection of some objects. Article 23 (g) forbids »to destroy or seize the enemy's property, unless such destruction or seizure be imperatively demanded by the necessities of war«. Another provison of the 1907 Regulations forbids the attack or bombardment, by whatever means, of towns, villages, dwellings, or buildings which are undefended«. Moreover, generally, »in sieges and bombardments all necessary steps must be taken to spare, as far as possible, buildings dedicated to the religion, art, science, or charitable purposes, historic monuments, hospitals, and places where the sick and wounded are collected, provided they are not being used at the same time for military purposes« (Art 27).

3. In the Geneva Conventions the most relevant provisions in respect of the protection of the environment are to be found in the Convention relative to the Protection of Civilian Persons in Time of War. Under Article 33 any destruction by the occupying power of real or personal property is prohibited, except where such destruction is rendered absolutely necessary by military operations. Extensive destruction and appropriation of property, not justified by military necessity and carried out unlawfully and wantonly is considered a grave breach of the Convention (Article 147).

The destruction of the cultural heritage of mankind in the course of World War II caused the adoption of the 1954 Convention for the Protection of Cultural property in the Event of Armed Conflict.

4. The new realities of the wars waged after the establishment of the United Nations incited the elaboration of the 1977 Additional Protocols to the Geneva Conventions. The purpose of these new instruments was to improve the protection of civilians, combatants and prisoners of war as well as the protection of civilian objects. These goals are to be achieved also by the prohibition of the use of some methods and means of warfare.

Both Protocols contain rules on the protection of civilian objects, such as cultural objects and places of warship, objects indispensable to the survival of the civilian population and the protection of works and installations containing dangerous forces. This last provision is extremely important as dams and dikes where destroyed in previous wars. Unfortunately, non-international armed conflicts have been regulated by less detailed rules than the international ones. Moreover, only in respect of international conflicts a general provision on the protection of the natural environment has been adopted. Article 55 of Protocol I reads:

»1. Care shall be taken in warfare to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods or means of warfare which are intended or may be expected to cause such damage to the natural environment and thereby to prejudice to the healths or survival of population.

2. Attacks against the natural environment by way of reprisals are prohibited.«

5. As already mentioned, the 1977 revision of international law of armed conflicts has provided rules concerning limitations of the use of some methods and means of warfare. The first two paragraphs of Article 35 of Protocol I reaffirm two traditional principles: the limited rights of the parties to the conflict to choose methods and means of warfare and the prohibition »to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering«.

However, in the context of this paper the most important provision is contained in paragraph 3 of Article 35:

»It is prohibited to employ methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment.«

The satisfaction in seeing this provision is blurred by the vague standards used in it – widespread, long-term, severe – which have to be fulfilled cumulatively – and by the restrictive interpretation given to each of these terms.

Although »environment« has been mentioned for the first time in this context, the principle contained in the quoted provision of Article 35 can be considered as the codification of the environmental aspect of the restrictions already agreed upon in respect of the arms of mass destruction. Namely, from the 1925 Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gasses and of Bacteriological Methods of War to the 1993 Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction, several international instruments have been concluded concerning the restrictions and/or prohibitions of testing, production, stockpiling and use of bacteriological, chemical and nuclear weapons.

Taking into account the behaviour of belligerents in the last decades, rather important are the provisions of 1980 Convention of Prohibition or Restriction on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects. The Protocols to this Convention regulate and restrict the use of mines and incendiary weapons.

Contrary to Article 35 of Protocol I and all the other disarmament provisions which a side effect of protecting the environment, the goal of the 1977 Convention on the Prohibition of Military or any Other Hostile Use of Environmental Modification Techniques is to prohibit any techniques for changing-through the deliberate manipulation of natural processes – the dynamics, composition or structure of the

Earth, including its biota, lithosphere, hydrosphere and atmosphere, or outer space. Such techniques include tides, tsunamis, earthquakes, etc. They are forbidden as far as they have widespread, long-lasting or severe effects.

Although sketchy, this overview of treaty rules applicable to the protection of the environment in times of armed conflict demonstrates that scarcity and vagueness are not their main weakness. Some of these rules deserve to be considered customary international law and there are scholars who claim that some of them have even acquired the status of *ius cogens*.

Although the preventive role of humanitarian law is its most important aspect, enforcement remains a great problem also in this part of the international law. A threat of sanctions could only contribute to their preventive effect. That is why, according to the proposals of the International Law Commission, acts of States or individuals causing serious damage to the natural environment should be considered as international crimes. However, it is a long way to the adoption and implementation of these proposals. For the time being there is a rule in Article 91 of the First Protocol to the Geneva Conventions which reads:

> »A Party to the conflict which violates the provisions of the Conventions or of this Protocol shall, if the case demands, be liable to pay compensation. It shall be responsible for all acts committed by persons forming part of its armed forces«.

Unfortunatelly, the Protocol itself does not provide for a judicial system of dispute settlement, but only for the establishment of an international fact-finding Commission. Therefore, the implementation of Article 91 depends upon the free choice of an effective procedure for dispute settlement by the parties to the conflict or on the enforcement by the United Nations bodies. It is deplorable that the United Nations have not yet proved to be effective either in preventing environmental damage in armed conflicts or in restoring the damage caused to it.

6. Dealing with all the aspects of the protection and preservation of the environment, the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, could not avoid mentioning the environmental risks in armed conflicts. Paragraph 24 of the Rio Declaration and paragraph 39.6 (a) of Agenda 21 require that States »respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.«

After the Gulf War, the General Assembly of the United Nations was asked by Jordan to put on its agenda an item entitled »Protection of the environment in time of armed conflict«. Resuming the results of several expert meetings, a report of the International Committee of the Red Cross and the discussions held in its Sixth Committee, on 25 November 1992 the General Assembly adopted resolution 43/37, in which it urges States to take measures to ensure compliance with the existing international law applicable to the protection of the environment in times of armed conflict. It also appeals to States to consider becoming parties to the relevant international conventions, but it does not suggest adoption of new rules in the field.

7. Instead of any conclusion at the end of these brief remarks, I would like to indicate some relevant facts concerning the aggression against Croatia which should be taken into account while discussing the topic I have dealt with:

*One* – The destruction of parts of the environment of the Republic of Croatia was carried out in the span of two years. In terms of international law, these were times of peace and war. At its very beginning the armed conflict had a non-international character and after the proclamation of the independence of the Republic of Croatia it was transformed into an international conflict.

*Two* – Violations of international law on the Croatian territory were committed not only after its independence, but also in the first part of 1991, when Croatia was still a State within the Yugoslav Federation.

*Three* – Many a component of the environment of Croatia has been damaged in this war: the flora and fauna, the human settlements, national parks, dams, etc. Yet, besides the environment within the borders of Croatia, the environment of other States as well as the global commons have also been endangered: and/or already polluted: waters of international rivers (Sava, Danube), the Adriatic Sea, the air space.

*Four* – Croatia and other States in the region have not yet witnessed all the possible environmental threats: the destruction of the Krško nuclear power plant and the acquisition of nuclear weapons from the former Soviet Union are the favourite dreams of the paranoic earthly lords in our neighbourhood who consider themselves as already consecrated mighty Gods of War, who can defy the entire world with no punishment whatsoever.

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SAŽETAK

**Humanitarno međunarodno pravo i zaštita okoliša u oružanom sukobu**

*B. Vukas*

Kako okoliš obuhvaća ne samo cijelu prirodu, već i objekte izgrađene u tijeku ljudske povijesti, mnoga tradicionalna pravila o ratovanju ujedno štite i okoliš. Ta su pravila sadržana u Pravilniku o zakonima i običajima rata na kopnu iz 1899. i 1907. i u Konvenciji za zaštitu kulturnih dobara u slučaju oružanog sukoba iz 1954.

Ipak, najneposrednije se na zaštitu okoliša odnose pravila iz Dopunskog protokola uz Ženevske konvencije od 12. kolovoza 1949. o zaštiti žrtava međunarodnih oružanih sukoba (Protokol I). Članak 55. Protokola odnosi se na zaštitu prirodnog okoliša, a članak 56. na zaštitu građevina i instalacija koje sadrže opasne sile. Međutim, Protokol II uz Ženevske konvencije, koji se odnosi na zaštitu žrtava međunarodnih oružanih sukoba, sadrži izričitu odredbu jedino o zaštiti građevina i instalacija koje sadrže opasne sile (čl. 15).

Kako je rat protiv Republike Hrvatske započeo unutar jedne federacije, ali je vrlo brzo poprimio sve značajke međunarodnog oružanog sukoba, pisac analizira primjenjive odredbe oba Ženevska protokola iz 1977. i njihovu primjenu i kršenja u okrutnom i divljačkom ratu uništavanja prirode i svih civilizacijskih tekovina povijesti Republike Hrvatske.

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# Public International Law of the Use of Biological and Chemical Weapons

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This paper deals with the international law of the use of biological and chemical weapons in war. A brief outline of the sources of public international is given with emphasis on the law of treaties (including their interpretation). Consideration is then given as to the status of war in international law; no analysis is made however of any distinction between intra-state war (civil war) and inter-state war. The Geneva Protocol 1925 is taken as the starting point for this exercise and the Chemical Weapons Convention (signed in 1993) is discussed by way of contemporary comment. Although The Geneva Protocol 1925, The Biological Weapons Convention 1972 and The Chemical Weapons Convention are the key international instruments relating to biological and chemical weapons, other treaties are referenced where they have particular significance to the impact of war (including use of biological and chemical weapons) on the environment. Examples of any pertinent reservations (made by States when obliging themselves under treaties) are given.

## Introduction

Sources of (public) international law include treaties, international customs, the general principles of law recognised by civilised nations and judicial decisions (case law). This paper will deal primarily with treaties as a source of public international law concerning the use of biological and chemical weapons.

The Vienna Convention on the Law of Treaties 1969 (»the Vienna Convention«), which entered into force 27 January 1980, covers all international instruments in the nature of treaties (including declarations, charters, treaties, conventions, protocols, pacts, concordats and covenants). Articles 31 and 32 of the Vienna Convention govern treaty interpretation.

Under Article 31 treaties »shall be interpreted in good faith in accordance with the ordinary meaning given to the terms of the treaty«. Terms must be interpreted »in their context in the light of (the treaty's) object and purpose«.

Under Article 32 recourse may be had to supplementary means of interpretation including the preparatory work of the treaty (travaux préparatoires) and the circumstances of its conclusion e.g. when the interpretation according to Article 31 leaves the meaning ambiguous or obscure or leads to results which are manifestly absurd or unreasonable.

Articles 31 and 32 therefore emphasise a textual approach to interpretation.

Under Article 4 of the Vienna Convention it applies only to treaties which are concluded by States after the entry into force of the Vienna Convention with regard to such States.

**The legal status of war**

The General Treaty for the Renunciation of War 1928 (»The Pact of Paris/Kellog – Briand Pact«) is still binding upon over 60 states. Under Article I, the parties condemned recourse to war for the solution of international controversies and renounced war as an instrument of national policy in their relations between the parties to the treaty. They further agreed (Article II) that the settlement or solution of all disputes or conflicts of whatever nature or of whatever origin which may arise among the parties should only be solved by pacific means. Although the parties to the treaty renounced the right of war as a legal instrument, the treaty did not abolish the institution of war. The effect of the treaty is that resort to war remains lawful for certain specific reasons e.g. as a measure of collective action for the enforcement of international obligations by virtue of existing instruments such as the United Nations Charter.

Although the treaty has never been terminated, it should now be viewed in the light of Article 2 (4) of the United Nations Charter 1945 which states that »All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any State, or in any other manner inconsistent with the purposes of the United Nations«; under Article 1 of the Charter one of these purposes is »suppression of acts of aggression«.

Article 2 (4) is not absolute however, e.g. Article 51 permits self-defence.

Article 2 (4) refers to the threat or use of force and not the threat or use of war. Therefore, Article 2 (4) applies whether or not there has been a formal declaration of war of whether or not the parties have denied that a technical state of war exists between them.

Under Article 5 (2) of the Charter, a war of aggression is a crime against international peace. What constitutes aggression is a question for the Security Council of the United Nations to determine in accordance with Article 39 of the Charter.

In conclusion, neither the Kellog-Briand Pact nor the United nations Charter contains an absolute prohibition on the use of force.

**Protocol for the prohibition of the use in war of asphyxiating, poisonous or other gases, and of bacteriological methods of warfare 1925 (»The Geneva protocol«)**

The Geneva Protocol entered into force February 8, 1928, although it was not ratified by the United States until 1975. The parties to the Geneva Protocol accepted a prohibition of the use in war of asphyxiating, poisonous or other gases and of all analogous liquids, materials or devices. The parties further extended this prohibition to the use of bacteriological methods of warfare. The text is silent as to the 'beneficiaries' of the prohibition ie. humans/other animals/plants. At the Geneva Disarmament Conference of 1932, the Committee on Chemical and Bacteriological Weapons favoured a broad rather than a narrow interpretation (of 'bacteriological') so as to include viruses; also the committee regarded humans, animals and plants as targets for the bacteriological warfare and also recognised »indirect« methods of affecting target organisms, e.g. polluting the atmosphere, water and foodstuffs.

Some of the parties to the Geneva Protocol entered reservations e.g. that they would cease to be bound by the Geneva Protocol in regard to any enemy states whose armed forces or allies did not observe the provisions of the Geneva Protocol.

*Yugoslavia*

– signature 17 June 1925

– ratification 12 April 1929 (reservation: »The said Protocol shall cease to be binding on the Government of Serbs, Croats and Slovens in regard to all enemy States whose armed forces or whose allies do not respect the restrictions which are object of this Protocol«.)

**Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction 1972 (»The biological weapons convention«)**

This instrument was signed April 10, 1972 and entered into force March 26, 1975. The text has a preamble and 15 Articles.

Under Article 1, the parties undertook never, in any circumstances, to develop, produce, stockpile or otherwise acquire or retain:

(1) Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;

(2) Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

Nowhere in the Biological Weapons Convention is there any prohibition as to use of bacteriological (biological) or toxin weapons. How a party may use

that which it could not lawfully acquire is problematical; possibly through a surrogate state?

Under Article III, the parties undertook »not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in article I' of the Convention«.

Some parties to the Biological Weapons Convention made reservations and declarations e.g. – The People's Republic of China stated »China once was one of the victims of biological (bacteriological) weapons«. In the reservations and declarations, there is no equivalent to the reservation to the Geneva Protocol as regards use of chemical agents with respect to any enemy state whose armed forces or allies do not observe provisions of the Geneva Protocol. This is because the Geneva Protocol embodies a prohibition of the use in war whereas the Biological Weapons Convention (primarily) embodies a prohibition on the development, production and stockpiling.

*Footnote*: The Biological Weapons Convention does not define »Bacteriological (Biological) and Toxin Weapons«. A United Nation General Assembly Resolution adopted on 16 December 1969 defined biological agents of warfare as »living organisms, whatever their nature, or infective material derived from them – which are intended to cause disease or death in man, animals or plants, and which depend for their effects on their ability to multiply in the person, animal or plant attacked«. The Final Declaration of the Second Review Conference for the Biological Weapons Convention held in 1986 reaffirmed that the Biological Weapons Convention applied to both natural and artificially created microbial or other biological agents; thus genetically engineered microbes are covered by the Biological Weapons Convention.

*Yugoslavia:*

- signature 10 April 1972
- ratification 25 October 1973

**Convention on the prohibition of military or any other hostile use of environmental modification techniques 1977 (»The environmental convention«)**

The preamble to the Environmental Convention refers to »new means of warfare« and »scientific and technical advances may open new possibilities with respect to modification of the environment«. Under Article 1.1, the parties undertook »not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party«.

Part of the negotiating record for the Environmental Convention interprets some of the Article 1.1 terms as follows:

- »widespread« – encompassing an area on the scale of several hundred square kilometres
- »longlasting« – lasting for a period of months or approximately a season (Query: are all »seasons« of the same duration and what of a period »overlapping« more that one season?)
- »severe« – involving serious or significant disruption or harm to human life, natural and economic resources or other assets

Article II: As used in Article I, the term »environmental modification techniques« refers to any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere or of outer space.

The Consultative Committee of Experts gave examples of phenomena that could be caused by the use of environmental modification techniques including »an upset in the ecological balance of a region«.

The substantial use of biological and chemical weapons (taking a broad definition so as to affect man, animals and plants whether directly or indirectly) would be covered by Articles I and II of the Environmental Convention.

The examples of diseases set out below give an idea of the possible impact of weaponised micro-organisms on the environment.

| *Disease* | *Pathogen* | *Host* |
|---|---|---|
| Rinderpest | Virus | Cattle/Sheep |
| Anthrax | Bacterium | Cattle/Sheep |
| Lumpy Jaw | Fungus | Cattle/Horses |
| Yellow Dwarf | Virus | Potato |
| Leaf Blight | Bacterium | Rice |
| Rust | Fungus | Cereal |

**Protocol additional to the Geneva Conventions of 12 august 1949, and relating to the protection of victims of international armed conflicts (»Protocol I«)**

Protocol I entered into force 7 December 1978. In Part III (Methods and Means of Warfare, Combatant and Prisoner-of-War Status) Article 35 states:

1. »In any armed conflict the right of the parties to the conflict to choose methods or means of warfare is not unlimited.

2. It is prohibited to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering.

3. It is prohibited to employ methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment«.

Under Article 36, in the development or adoption of a new weapon, means or method of warfare, a party is under an obligation to determine whether its employment would be prohibited by this Protocol I or any other rule of international law applicable to the party.

In Part IV (Civilian Population), under Article 54 starvation of civilians as a method of warfare is prohibited. It is also prohibited to attack, destroy, remove or render useless objects indispensable to the

survival of the civilian population such as foodstuffs, agricultural areas for the production of foodstaffs, crops, livestock, drinking water installations and supplies and irrigation works for the specific purpose of denying them to the civilian population – whatever the motive. The prohibitions shall not apply, however, to such of the objects as are used by an adverse party as sustenance solely for the members of its armed forces or in direct support of military action (provided that in no event shall actions be taken against these objects which may expected to leave a civilian population with such inadequate food or water as to cause its starvation or force its movement). The use of biological or chemical weapons against e.g. livestock, crops or drinking water would be caught by Article 54.

Under Article 55, care shall be taken in warfare to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods of warfare intended (or may be expected) to cause such damage to the natural environment and thereby to prejudice the health or survival of the population. Attacks against the natural environment by way of reprisals are prohibited.

*Yugoslavia:*

– signature 12 December 1977

– ratification 11 June 1979 (Reservation: relates to occupation/capitulation).

**Convention on the prohibition of the development, production, stockpiling and use of chemical weapons and on their destruction. (»Chemical weapons convention«)**

The Chemical Weapons Convention was signed on behalf of 130 states in Paris in January 1993 and enters into force 180 days after the date of the deposit of the 65th instrument of ratification, but in no case earlier than two years after it opened for signature. Therefore, the earliest it can come into force is January 1995.

Under Article I, the parties undertake (inter alia) never, under any circumstances, to use chemical weapons.

Article II deals with the definitions and criteria for chemical weapons e.g. chemical weapons are defined in Article II (1) as follows: »Chemical Weapons« means the following, together or separately

(a) Toxic Chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;

(b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;

(c) Any aquipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b)).

Toxic Chemical has the meaning set out in Article II. (2) »Toxic Chemical« means:

Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to human or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere.

Under Article VIII, the parties established the Organisation for the Prohibition of Chemical Weapons to achieve the object and purpose of the Chemical Weapons Convention (»the Organisation«).

Under Article X, assistance can be given to the parties to the Chemical Weapons Convention by way of protection against chemical weapons including detection equipment, alarm systems, protective equipment, de-contamination equipment, de-contaminants, medical antidotes and treatments and advice on any or these measures.

Under Article X (7), each party to the Chemical Weapons Convention undertakes to provide assistance through the Organisation e.g. to contribute to the voluntary fund for assistance.

Under Article X (8), each state party to the Chemical Weapons Convention has the right to request and (subject to certain procedures) to receive assistance and protection against the use or threat of use of chemical weapons IF IT CONSIDERS that (a) chemical weapons have been used against it (b) riot control agents have been used against it as a method of warfare (c) it is treatened by actions or activities of any State where auch actions or activities are prohibited for the States which are parties to the Chemical Weapons Convention under Article I (see above).

Under Article XIII, nothing in the Chemical Weapons Convention is to be interpreted as in any way limiting or detracting from the obligations assumed by any state under the Geneva Protocol 1925 or the Biological Weapons Convention 1972.

Under Article XXII, the Articles of the Chemical Weapons Convention are not to be subject to any reservations. The Annexes of the Chemical Weapons Convention are only subject to reservations compatible with the object and purpose of the Chemical Weapons Convention. Therefore, unlike the Geneva Protocol 1925 in which some countries reserve the »right of retaliation«, the Articles of the Chemical Weapons Convention are not subject to such reservation.*

Toxicity to plants is not included in the Chemical Weapons Convention's Articles but the preamble expressly recognises the prohibition in international law of the use of herbicides as a method of warfare – »the prohibition, embodied in the pertinent agreements and relevant principles of international law, of the use of herbicides as a method of warfare«; the preamble does not identify any instrument as authority.

* The Annexes to the Chemical Weapons Convention cover a number of matters (e.g. toxic chemicals which have been identified for the application of verification measures are listed in Schedules contained in the Annex on Chemicals).

The Chemical Weapons Convention was open for signature in Paris 13 to 15 January 1993.

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*Both are strongly recommended with reference to the Chemical Weapons Convention.

**SAŽETAK**

**Međunarodno pravo i korištenje biološkog i kemijskog oružja**

*B. Jackson*

U prikazu primjene međunarodnog prava prema korištenju biološkog i kemijskog oružja i statusu rata, kao polazišne točke su uzete odredbe Ženevskog protokola iz 1925. i Konvencija o kemijskom naoružanju iz 1993. godine. Spomenute konvencije, uz Konvenciju o biološkom oružju iz 1972. temeljni su instrumenti kod primjene i kršenja međunarodnog parava tijekom ratnih djelovanja.

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# Effects of Conventional Warfare on the Man-Made Environment

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The effects of conventional weapons on man and biota are amplified through intended and unintended strikes on infrastructures of modern civilized societies (such as chemical and petrochemical facilities, nuclear facilities, hydrological and other facilities, large settlements etc.) due to released forces like toxic, inflammable, explosive and radioactive materials and other risk factors.

Possibilities of the lethal or harmful impact on man and biota are reviewed and extent and duration of effects and consequences on human life and health, as well as on social standards and natural environment are predicted and compared to those related to peaceful industrial accidents with different pushing mechanisms.

Some new lessons of environmental impact of warfare from the Persian Gulf War are learnt.

The complex matrix of interrelationships of environment, development and peace involves as a constitutive part also the interrelations between armaments (including research, development, testing, stockpiling, production, use and destruction) and arms control and environment. This paper is part of a systematic study devoted to the interrelationships of armaments and the environment.

Any kind of armament exerts a very negative influence on the socioeconomic structures as well as on the environment[1], endangers human beings and the whole of mankind, continuously diminishes the living

standards, affects human health, causes deaths in numerous wars and armed conflicts, and poses the threat of a global nuclear holocaust which could eradicate human civilization if these crisis phenomena escalate.

Besides their direct and indirect effects on man and human society and its structures, all kinds of arms also directly and indirectly damage the natural base for human life – the environment – in the whole course of the armament process.

Armament, even if not desired and noxious and only part of the contemporary scientific and technological process, must be considered as a cycle of research, development testing, production and use (and of course also destruction or demilitarization), which is actually open-ended and not repeated but reproduced on each higher level.

It should be stressed that all the mentioned steps, i.e. research, development, testing, production, stockpiling and use (even for the training and education of troops in peacetime) and also destruction of weapons (as an usual measure modernizing weapons or in the course of arms control and real disarmament process) pose risks to the environment. They have an actual potential to cause environmental damage and have in fact led to manifold damages even in peacetime, not to speak about the extensive, long-term or irreversible destruction of biota and of the physical environment as a result of wartime use of all kinds of modern weapons.

The individual steps of the whole armament process have different impacts on the environment. These impacts also vary according to the specific kind of armament. For example, the environmental effects of research, development, production and stockpiling of conventional weapons is not very profound compared to that of mass destruction weapons, but the destruction following their possible use in a wide and deep theatre of operations (e.g. in Central Europe) can be close to that of the use of mass destruction weapons, whereas all armament steps connected with the latter actually damage the environment even in peacetime in a very serious manner.

Studies have described the impact of nuclear war on the global environment as well as the impact of intentional environmental modification for hostile purposes (10). Much less is known about the environmental effects of chemical, bacteriological (biological) and toxin weapons.

The environmental impact of conventional (and incendiary) weapons is currently underestimated since it is considered only in terms of direct effects on man and biota.

This paper reviews the qualitative and quantitative rise of conventional forces and weapons, and of changed strategies resulting in a simultaneous coverage of the total area of an extended battlefield with pernicious strikes affecting man and biota. The paper analyses the irreversible changes in the balance of the natural environment caused by civilized industrial society with its large and dense settlements, energy and industrial installations, intensive agriculture, communication and traffic networks, etc., all of which are very vulnerable in wartime.

As for the environmental impact of conventional and incediary weapons, the paper emphasizes the amplification of their direct (primary) effects on man and biota by indirect (secondary) effects, especially of:

– extensive and long-lasting contamination by disseminated radionuclides due to released radioactive inventory from destroyed nuclear energy installations, reprocessing plants and radioactive wastes;

– frequent and more or less short-lived contamination by toxic fumes of chemicals released from destroyed chemical facilities;

– burnings of ignited chemicals, petrochemicals and other inflammable materials;

– blast waves from exploded fumes of gases from petrochemical facilities;

– flood waves from destroyed or damaged hydrological installations, and other effects caused by the destruction or water supply networks, water purification, sewerage, food supply, medical care and other communal services of a very sensitive and thus also extremely vulnerable civilized society.

## The rise of conventional forces and environmental impact of conventional armaments

Although this is the era of nuclear and space technologies, conventional weapons represent the most important and most widely spread kind of weaponry. Conventional armaments absorb the main part of military expenditure which now reaches nearly one thousand billion US Dollars worldwide. Conventional weapons are also an important item of international trade. The negative influence on the socioeconomic standards of the whole human society is well known. However, the direct and indirect negative impact of them on the environment requires further study.

Research and development of new conventional weapons and weapons systems, the starting point of the conventional armament process, precedes the production and use of conventional weapons its various direct and indirect environmental impacts.

In general, they are two principal directions in the development of conventional weapons with regard to their environmental effects.

The first of them is connected with weapons which possess high collateral effects, i.e. enhanced adverse effects on man and biota[2]:

– Bigger calibres (and explosive charges), or more efficient explosives (the so called high-explosives, HE) in artillery weapons, with a resulting increased effect against armoured vehicles and hardened stationary objects that leads to growing collateral effects.

– On the other hand, reduced calibres of small fire-arms (down to 5.56 mm or less) combined with higher muzzle velocities and muzzle energy increase wounding effects and lead to more devastating ex-

plosion wounds in human and animal tissues, resulting in an increased share of fatal casualties in man and biota.

– Increased fire velocity (up to 1000 rounds per minute) of automatic arms increases the probability of multiple injuries with reduced chances for survival for humans, and with similar effects on biota.

– Similar effects are produced by the development of other sophisticated anti-personnel arms like fragmentation and pellet ammunitions.

– The higher share of recoilless arms and multiple launchers with a better coverage also results in greater collateral effects.

– Mechanization leads to a higher consumption of explosives not only by mortars and other artillery arms, but also, for example, by an increased use of land mines. Explosive war remnants which need to be cleared make the solution of post-war environmental problems more difficult.

– Increased explosive charges (up to 1 tonne or more) in bombs designed to demolishing reinforced objects from the air can cause severe damage to the environment.

– Cluster and container air bombs with various fillings pose a great danger to the environment because of their effective area coverage and their highly efficient use of explosives and materials to be disseminated.

– The growing proportion of fire and incendiary charges which produce large fire zones or are designed to ignite inflammable materials has adverse effects on the natural and man-made environment. These charges can be used to set alight large forests and settlements. In such a case, the combined effects of high temperatures in the fire zone, lack of oxygen, and clouds of toxic gases and other combustion products, including particular pollutants, result in fatal consequences for urban populations.

– The development of a new ammunitions technology known as FAE (Fuel-Air-Explosive) operates with charges which compared to classic solid or dense explosives like TNT are relatively small. These charges, however, generate a greater overpressure in front of the explosion shock waves (followed by a zone of underpressure) and therefore are effective at larger distances, especially against soft targets.

All these trends in arms technology increase the direct effects on the natural and man-made environments.

The second direction in the development of conventional weapons is generally connected with decreasing colateral effects.

This direction is typified by the development of highprecision weapons which usually are equipped with terminal guidance so as to hit the target at the first round. It can be expected that this direction of development can lead to a lowering of direct environmental impacts. But it appears less innocent if one takes into account purposeful attacs against structures of the man-made environment of modern industrial society that cause secondary effects through »released dangerous forces«.

There is no doubt that today both these directions are combined in such a way as to develop more efficient conventional weapons. In this manner research and development ensure that production, limited peacetime and mass wartime use of weaponry achieve the greatest possible anti-personnel and environmental effect. But research and development also iavolve testing and therefore on numerous test-sites all over the world also cause direct adverse effects on the environment by explosions, fires and mechanical damage.

The production and the stockpiling of conventional weapons is directly connected with a substantial consumption of natural resources. The arms industry consumes very rare materials (especially metals), energy and human work, and usually needs large areas for production, storage and testing, including various safety zones[3]. For example, the complex for tank production in Detroit requires an area of about 2 $km^2$. Ammunitions factories require still more land. The ammunitions plant in Joliet (near Chicago) needs an area of no less than 115 $km^2$. The production, storage and handling of explosives and incendiaries pose great risks to employees and neighbouring communities alike.

The most serious step in whole course of conventional armament is of course the use of these weapons.

Even the peacetime use has a very significant impact on the environment. For example, 13 developed states use 0.3–3 % of their territories for the activities of armed forces (mainly in connection with conventional warfare). The total area used by the military is more than 14 million ha (The USA alone accounts for 10 million ha)[3].

The manoeuvres of one armoured division need (according to US norms) an area of 23 500 ha. It could be expected that due to increasing precision of new weapons systems the need for large testing grounds would decrease; but quite the opposite is true: since ranges also increase, there have been efforts to enlarge military reservations. Similarly, ocean zones reserved for naval training operations and other maritime activities have been steadily increasing, with the resulting adverse effects on fishing and transport.

Military bases and other military installations on foreign territories also occupy large areas. The USA alone has over 1 500 military bases and other military installations on the territory of 32 states on all continents. Most of these facilities are located in densely populated regions. The areas of such bases are usually lost for useful agricultural and other economic activities, and the soil is continuosly degraded by the military activities such as the use of explosives and heavy combat vehicles. A recent inspection of areas of the Soviet troops which were temporarily stationed on Czechoslovak soil after the military intervention in 1968 has also revealed that the troops do not behave according the strict environmental standards valid in Czechoslovakia. They have contamined soil and underground waters with oil and other harmful products.

The demand for land has been growing particularly in Third World countries which strengthen their military forces with additional heavy armaments. In developed countries the mobility requirements of defence missile systems increases the need for land for military purposes.

The wartime use of conventional weapons is the most devastating element in the course of conventional armament. Many still remember use of conventional arms in WW II when about 3.5 Mt explosives were consumed.

The Second World War showed some of the effects of a massive use of explosive and incendiary bombs. These effects are comparable to those of nuclear explosions. A number of air raids on Germany and one on Japan resulted in casualties on a previously unknown scale. The fires caused by roughly equal proportions of high explosives and incendiary materials were accompanied by gale force winds directed towards the centre of the conflagration. In the raid on Hamburg (17–18 July 1943) approx. 1 000 tonnes each of high explosive and incendiary bombs were dropped. The extension of the fire storm area has been estimated to lie between 10 and 22 $km^2$. The death toll reached some 40 000; 16 000 apartment buildings caught fire. Similar fire storms occured at Darmstadt and Kassel, and an extremely devastating one at Dresden (13–14 February 1945). The largest one occurred at Tokyo (9 March 1945) where some 1 600 tonnes of incendiary bombs caused fires which killed more than 80 000 people and completely destroyed about 40 $km^2$ of the city[1].

The nearly total destruction of large Soviet cities, like Kiev, Minsk, Stalingrad, Odessa and Sevastopol which was the result of combined land/air/sea operations is a known fact. A similar fate was suffered by thousands of towns and innumerable villages in the USSR, Poland and other countries with intensive operations during WW-II. Nobody can easily forget Rotterdam, Coventry and also Leningrad, where over 600 000 people died as a result of bombing and long-term blockades. Warsaw was systematically destroyed not only in land/air operations, but finally as a result of police-revenge in the framework of Hitler's East policy.

But even this picture of destruction would be much more severe in possible future wars which would be waged »only« with conventional weapons. One need only think of developments in military technology, quantitative and qualitative rise of conventional forces/arms, changes in strategies, and scientific and technological progress which has lead to profound changes in human society and its environment. It also brought with it a higher dependence on energy and other resources and thus also a higher vulnerability than ever before, with a possible dramatic impact on the natural and social environment.

One of such »future« wars has meanwhile become reality. The War in the Persian Gulf, even if not directed against the Iraqi people, was characterized by an extensive destruction of military installations, war economy structures, transport and other social infrastructures with a hitherto unknown massive use of conventional air-to-surface weapons of all kinds (including sea- launched cruise missiles).

In addition to technological changes there have also been quantitative changes in the armed forces. For example, a division possesses a 25 times higher fire capacity now than in the 1940s. The above mentioned consumption of explosives in WW II can be compared with the use of 6 Mt in the Second Indochina War. The saturation of contemporary armies with major arms is illustrated by the fact that in the last Arab-Israeli War one tank was destroyed every 6 minutes. But the amounts of explosives consumed to destroy the militarily relevant targets mainly in the densely populated regions of Bagdad and Bassra and close to the Iraq- Kuwait borders exceeded everything known until then. Sustained bombing and the following relatively short land operation of the Allied Forces destroyed nearly 95 per cent of over 4 000 tanks of Saddam Hussein.

The new development of weapons and saturation of troops with them combined with the present offensive and defensive strategies, such as forward defence and the even more aggressive strike-in- depth strategies (like the current NATO strategy of Air-Land- Battle) lead to a further extension of the overall size of the battlefield and of theatre of operations, and to concomitant negative effects on very large zones of the continental and subcontinental environment, including both the natural and the man-made environment. As the consequences of the Gulf War clearly show, these effects can be produced by both intended and unintended attacks against the natural and the human-made environment.

The strategic, operational and tactical demands on weaponry are reflected in the development of arms with an extended range (artillery up to 30 km), heavily armed fighter-planes equipped with many air-to-ground weapons, and of dual-purpose tactical (short-range, battlefield) missiles up to 500 km.

All these weapons, as well as the above mentioned modernized conventional weapons, if used in extended battlefields, simultaneously and on a massive scale, would produce effects incomparable with those of all previous major wars.

## The changed environment of developed industrial societies and the amplifaction of the effects of conventional weapons through interactions with the man-made environment[2]

Before analyzing the impact of the wartime use of conventional arms on the environment, it should be noted that the environment and its balance have been drastically changed by human society.

Intensive agriculture, human settlements, industry, transport, etc., have irreversibly changed the natural environment.

The effects of conventional weapons on the environment are direct (primary) or indirect (secondary).

The direct (primary) effects of contemporary conventional weapons are tremendous. They encompass damage to the landscape, destruction of water reservoirs, degradation of soil fertility, extensive damage of the whole flora caused by explosives and especially incendiaries, mechanical effects of combat and other support actions like military traffic and field constructions, direct effects on the entire fauna caused by ammunitions, explosives and incendiaries. Indirect damage to the fauna is caused by the destruction of food sources and cover, and generally by damaging the habitats.

Modern development in conventional warfare and changes in the environment of modern industrialized societies have made it relevant to study, first of all, the impact of conventional weapons on the man-made elements of the environment and thus the indirect (secondary) effects of such destructions on the rest of the environment, i.e. on the natural one.

The dependence of life on electricity, gas, heating, water, transport and communal services makes this increasingly crucial part of human society very vulnerable.

Potentially dangerous technologies, like the production and handling of chemicals, nuclear facilities, etc., are subject to safety arrangements and regulations for environmental protection, which place them among the safest in terms of long-term environmental impact under peacetime conditions. But large ecological accidents have already shown that even these »safe« technologies are not safe enough. The potential lack of safety can be activated by elemental action, or, in wartime, through damage inflicted by conventional weapons. In this manner the effects of conventional weapons on man and environment may be enhanced or amplified.

This means that in conventional wars, the primary destruction of human-made environment will cause more serious secondary effects in the natural environment than conventional weapons themselves if used directly against the natural environment. This amplification effect of the use of conventional weapons is a new phenomenon.

Man-made environmental elements might become tempting targets for conventional attacks not because of the environmental effects to be expected, but, more probably, because they constitute elements of the microstructures of the adversary's defence potential.

Attacks on energy resources will do more harm to modern societies depending on energy supplies than ever before. Secondary – collateral – effects of such attacks will heavily depend on the kind of technology which is hit. They will range from minor collateral effects in the case of precise strikes on thermal power stations, to more serious ones, such as flood waves caused by bursting dams or combined blast/fire/toxic cloud effects following the ignition of gas/liquid fuel storage tanks, to the most serious effects that attacks on civilian nuclear facilities, such as nuclear power plants, reprocessing plants for nuclear fuel and stores of radioactive waste, would have.

In the latter cases, vast areas of the environment will be contaminated for a relatively long time by the released radioactive material.

Attacks on civilian nuclear power facilities are among the most dangerous cases of indirect environmental damage caused in armed conflicts. The recent trends towards building ever larger power plants, arising from the economy of scale, make each of these power plants a highly attractive military target. Such plants will, no doubt, be strongly defended. The greatly improved capacity of modern missiles in terms of their explosive charge (nuclear/conventional), range and precision of terminal quidance, however, ensure a high probability of damage.

Any nuclear power reactor accumulates a vast amount of radioactivity in its core. Long-lived nuclei are continuously produced by the decay of short-lived nuclides. As a result, the proportion of fission products with a long half-life is much greater in a reactor than in a nuclear fission bomb. Consequently the overall radioactive decay in a reactor takes a considerable time and depends on other factors than in the fallout of nuclear weapons. For example, in the case of an exploded reactor (light- water reactor with installed output of 1 GW after several years of operation), the initial total activity is about 100 times lower than after the explosion of a 1 Mt bomb, but becomes equal after about four days. After that, the reactor activity exceeds that in the bomb and the difference becomes increasingly larger.

Thus radiation doses emanating from a reactor could remain at unacceptably high levels for a much longer time than those from a nuclear bomb which initially produced the same amount of radioaactivity.

It is evident that the proportion of radioactive inventory of the reactor released following an attack will heavily depend on the mechanics of the damage. Calculations have been made of the number of casualties and the extent of damage that might result from different kinds of accidents. One result of such studies is shown in Table 1, which lists the consequences of what is described as an »extremely serious« accident which may follow a deliberate military attack on a reactor.

Table 1 – *Consequences of an extremely serious reactor accident*[5,6]

| Consequence | Extent | |
|---|---|---|
| Immediate fatalities | 3,300 persons | |
| Early illness | 45,000 persons | |
| Thyroid nodules | 240,000 persons | spread over 30 years |
| Latent cancer fatalities | 45,000 persons | |
| Genetic defects | 30,000 persons | |
| Contaminated area | 8,000 $km^2$ | |

The extent of the contaminated area is very serious if one considers that it becomes completely uninhabitable, but the area affected by released radionuclides could be much larger still. Radiation could became a significant cause of deaths and of environmental contamination in a world increasingly popu-

lated with nuclear reactors and other nuclear installations. These constitute a real threat even if not a single nuclear bomb is used and the war is waged only with conventional means.

A similar risk is posed by conventional attacks on chemical plants and storage sites of harmful and inflammable chemicals. Such attacks can turn the theatre of operation in a conventional war in regions with a highly developed chemical and petrochemical industry into a battlefield almost resembling an area of chemical weapons use.

The chemical industry normally does not create long-term environmental contamination, though emissions emanate occasionally in accidents which can be very serious depending on the amount and toxicity of the released chemicals[7].

The number of chemical plants and storage sites of various harmful chemicals by far exceeds that of nuclear installations. Therefore, they more frequently pose a risk to the environment. On the other hand, chemical contamination is (with the exception of very stable, extremely toxic compounds with a low volatility, such as 2,3,7,8-tetrachlorodibenzo-p-dioxin, TCDD) not as persistent as radiological contamination, due to spontaneous natural decontamination processes (evaporation, dissolution in water, chemical breakdown through hydrolysis and chemical reactions with substances in soil including microbiological disproportionation, physical processes like sorption, washing off, etc.), undergone by the vast majority of chemicals[8].

The chemical contamination of the environment proceeds from various types of sources downwind in the lower layers of atmosphere and on the earth's surface.

According to the experience with past peacetime accidents and by means of theoretical calculation it can be estimated that the explosive-type destruction of a storage tank containing, for example, chlorine, can kill people and biota living at a downwind distance of tens of kilometers[8].

Besides the direct effects which conventional strikes on human settlements produce – particularly if they are directed against large urban areas and involve the use of high explosives and incendiaries – , such as killing and injuring people and destroying microstructures like communal organizations, medical care facilities, food resources, urban and suburban transport, water, gas and electricity supply, and communication means, there will also be secondary effects. These include fires, damaged water supply and sewerage systems including water purification stations, and the combined effects of deaths and injuries due to insufficient food and medical care as well as possible epidemics which will amplify the direct effects of the conventional strikes.

**The environmental impact of a possible conventional war in Europe[2]**

The overall effects of conventional war and the degree of amplification of primary effects of conventional weapons through the interactions with man-made environmental elements like nuclear installations, chemical plants, fuel storage and transport systems, hydrological installations like dams etc. obviously depend on the concrete character of the theatre of operations and on the intensity of warfare. These are determined by the nature of the conflict, the quantity of forces and arms used and, of course, by the duration of military operations.

Many of these factors cannot be predicted, but the character of the theatre of operation is always clear.

For example, Central Europe is a subregion, quite unique in the whole world, where all negative factors concerning the interrelations of conventional forces and the environment come into play: it is a highly populated area with a high degree of industrialization, and there is a high concentration of forces equipped with the most up-to-date weapons.

In this subregion, the greatest part of the air and land forces of NATO and WTO have been stationed together with the main mass of conventional arms. This subregion is most densely populated; there is a great number of towns and cities, there are many large and medium-sized chemical plants and also a vast number of nuclear installations (see Table 2).

One can perhaps hardly imagine what direct effects simultaneous conventional strikes on the whole territory of Central Europe would have. It can, however, be argued that the indirect (secondary) effects on the environment produced by the destruction of man-made components of the environment will undoubtedly be much more serious due to chemical and radiological contamination from destroyed chemical plants, storage sites and nuclear installations. These contaminations might extend over almost the whole territory and so make this subregion totally uninhabitable.

Thus a conventional conflict in Europe would have consequences similar to those of an extensive use of weapons of mass destruction, i.e. of nuclear and chemical weapons.

But such a conflict seems to be somewhat unlikely nowadays. The profound changes in international relations which followed the Soviet policy of new thinking and which facilitated fundamental political changes in Central and East Europe in 1989 and 1990 (including the unification of Germany) have been reflected in both Vienna CFE and CSBM documents signed together with the Paris Charter in November 1990. But in addition, it is also the dissolution of the military organization of the WTO that has made Europe a safer place than ever before. This is true in spite of a still existing concentration of arms and armed forces and of economic asymmetries and social, environmental, national and ethnic problems which could in some cases easy transcend state borders.

Table 2 – *Nuclear energy facilities in Central Europe and adjacent countries*[9]*

| Country | Reactors operating | GWe | Reactors in construction | GWe |
|---|---|---|---|---|
| Belgium | 7 | 5.50 | | |
| Bulgaria | 5 | 2.59 | 2 | 1.91 |
| Czechoslovakia | 8 | 3.26 | 8 | 5.12 |
| Finland | 4 | 2.31 | | |
| France | 55 | 52.59 | 9 | 12.25 |
| Germany | 30 | 24.82 | 8 | 3.32 |
| Hungary | 4 | 1.65 | | |
| Italy | 2 | 1.12 | | |
| Netherlands | 2 | 0.51 | | |
| Rumania | | | 5 | 3.13 |
| Spain | 10 | 7.54 | | |
| Sweden | 12 | 9.82 | | |
| Switzerland | 5 | 2.95 | | |
| United Kingdom | 39 | 11.24 | 1 | 1.19 |
| USSR** | 46 | 34.23 | 26 | 21.18 |
| Yugoslavia | 1 | 0.63 | | |
| Europe total** | 230 | 160.76 | 57 | 48.10 |
| World total | 426 | 318.27 | 96 | 78.91 |

* Status in 1990
** Including the Asian part of the USSR

From altogether 345 European reactors (operating, in construction and planned) 35 % are in the USSR, 13 % in the rest of Eastern Europe, 18 % in France, 8 % in FRG and 26 % in other countries (European here means on the territory from Atlantic to the Urals.)

**The Persion Gulf War and its impact on the environment**

The approximately four weeks long biggest one-sided air war of all times followed by the biggest land battle known in war history have led to very serious immediate losses and further consequences in the civilian population, as well as to the severe damage of environment in the Persian Gulf region as a tax for expelling Saddam Hussein's forces from occupied Kuwait.

The Gulf War itself has added quite new phenomena to the history of environmental consequences of warfare, both intended and unintended, as well as to the development of environmental warfare as such.

One of the main means of destruction of infrastructures, both in Kuwait by Iraqi forces and in Iraq by the Allies, were high explosives, which in Kuwait were used for the systematic demolition of country's material base and in Iraq in immense quantities for destruction by unbroken air raids. The bombing methode used in Iraq differed substantially from the »War of cities« practised in the previous War in the Gulf, where both Iran and Iraq used hundreds of non-accurate battlefield missiles against densely populated areas, while the Allies aimed to hit only militarily important targets and used high-precision weapons, in many cases with terminal guidance. Nevertheless, the quantity of the weapons and the very broad selection criteria of targets with some war relevance, which involve much more than only purely military targets, have led to the destruction of nearly the whole infrastructure with direct collateral effects and indirect secondary effects on the population and the environment.

Allied forces flew more than 1000 sorties in the first 14 hours of combat alone (in the Rolling Thunder campaign in Vietnam, US pilots averaged 3050 sorties per week in September 1965). The Allies dropped some 2232 tons of high explosive within the first 24 hours (much more than the daily tonnage of the intense Linebacker II campaign in Vietnam in December 1972)[10].

The direct casualties among the Iraqi people are still uncounted (and they will probably remain unknown most due to post-war turmoils and migrations), but some estimates range from tens to hundreds of thousands.

Severe and long-term environmental consequences of the destruction of chemical plants and nuclear installations as well as losses of cultural heritage must be expected. Desroyed and damaged infrastructures, fuel, water and food supplies, traffic and energy facilities, medical and communal services, some of which had already been affected by the pre-war economic blockade, have already led to a very serious health situation (outbreaks of infectious diseases such as cholera). This situation is potentiated by the present political turmoils in the South and the North of Iraq.

But the War in the Persian Gulf also brought new modes of environmental warfare. Apart from oil pollution in the Gulf as an unintended consequence of damaged oil tanks, oil was also directly used for the intentional contamination of Gulf waters by Iraqi forces. Saddam Hussein ordered to pump about 1,5 million barrels of crude oil from the Kuwait's oil loading terminal into the sea. There are three gigantic oil carpets in the Gulf which affect at least 400 km of beaches, endanger water-suply-stations in Kuwait and Saudi Arabia, and severely injury sea and sea-shore flora and fauna.

There were altogether 590 fires consuming 3 million barrels of crude oil each day. 6 percent of burned oil created smoke particles, among the products of burning were carbon, carbon dioxide, sulphur oxides and nitrogen oxides. The smoke screen already changed the local climate after the Persian Gulf War. Normal March temperatures are about 26 centigrades in the shade, in the 1991 it was only 10. The screen extended over a diameter of 1000 km within which the changes in climate could observed[11].

The polluted gases and particles directly affected the health of population, causing mainly respiratory difficulties.

It was expected, that within »the year after, about 0,5 g of soot per $m^2$ would precipitate over Arabia,

Ethiopia, Somalia, Sudan, parts of Egypt and Turkey. Other states, like Iran, Iraq, Pakistan, India and the South of the CIS face a similar danger.

It is difficult to predict the overall consequences of these fires, nowdays already successfully extinguished, to the global environmental changes, as well as the duration of regional environmental damages.

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**SAŽETAK**

**Utjecaj oružanog sukoba konvencionalnim oružjem na okoliš**

*J. Matoušek*

Navođenjem dostupnih podataka prikazano je djelovanje konvencionalnog oružja na okoliš tijekom ratnih djelovanja. Diskutirane su posljedice kao što su oštećenja infrastrukture, nekontrolirano oslobađanje toksičnih, zapaljivih, eksplozivnih i radioaktivnih tvari, te drugi činioci rizika. Uz pregled mogućih letalnih i drugih štetnih djelovanja po čovjeka i okoliš, razmatrane su i posljedice na društveni standard uz poredbeni prikaz različitih nesreća uzevši u obzir i iskustva stečena tijekom rata u Perzijskom zaljevu.



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# The Shiping and the War in Croatia


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In 1991 an armed attack on Croatia was launched by the »Yugoslav People's Army« and Serbian irregulars. These attacks have come on all fronts and the enemy made use of tanks, artillery, warplanes and warships. The author explaines how the sea warfare especially the non notified and non declared belligerend blockade raised against Croatian ports radically and finally changed the number of merchant ships under the Croatian flag. To evade the seizure and capture, most Croatian ships were flagged out from the Croatian register and registered in other countries and territories.

In the second part of this paper the author states that special »environmental damage« is caused by unexploded shells and mines. Two Croatian islands – Vis and Lastovo – former naval bases, when left by warships of the »Yugoslav People's Army« are covered by minefields laid by the enemy without record of their location. They are the threat to civilians and future tourists for decades to come.


The long discussion about the war in Croatia reminds me of a throught of the Greek philosopher Epiktet (about 130 years A.C.) who said that people were not embarrased by facts but by opinions about facts. Here are some facts: after the armed attack on Croatia launched in 1991 by the »Yugoslav People's Army« and Serbian irregulars and resulting in massive killings and mutilation, the devastation of towns and

villages, and the displacement of thousands of people with the aim of changing the national structure. The Croatian Government has still no control over one third of its territory. Opinions about these facts differ. One school of thought holds that one third of Croatia is occupied, the other more optimistic thinks that two thirds of Croatia are liberated.

Can we say that the war in Croatia has ended? Since the »Yugoslav Navy« has withdrawn from Croatian waters, and has left their bases on Vis and Lastovo and has gone to Boka Kotorska the hostilities at sea have ceased. But important ports such as Zadar and Šibenik are daily on general alert because they are shelled from the hinterland by Serbian paramilitary forces. The international insurance Law, always strongly connected with evidence and reality, provides an answer to this question. War insurance rates, both for ships and the cargo have soared considerably. The insurance premium for one call at a port between Zadar and Dubrovnik is for an Italian merchant ship 100,000.000 Italian Lira.

In any case in 1991 the blockade of seven most important Croatian ports (Pula, Rijeka, Zadar, Šibenik, Split, Ploče and Dubrovnik) as well as the bombing of some of the ports and cities by the Yugoslav Navy seriously affected the economic situation in Croatia, a Republic to which more than 80 % of the East Adriatic coast belongs. Gruž-Dubrovnik's merchant port was completely destroyed, Gaženica-Zadar's merchant port was heavily damaged. Also the complete international transport of goods through Croatian ports was brought to an end. In 1991 over 2000 yachts and pleasure boats and a merchant ship under the Maltese flag were shelled and sunk in Croatian internal waters.

The outbreak of hostilities directly affected the shipping in Croatia. At the beginning of 1991 Croatian shipowners started to transfer their ships to foreign registers to preempt possible confiscation of ships. By now, around 143 Croatian-owned ships are flying the flag of St. Vincent and Grenadines and further 45 ships the Maltese flag. According to data available at the Ministry of Maritime Affairs, Traffic and Communication of the Republic of Croatia (7 April 1993) these 188 ships have a Total Gross tonnage of 2,565.446 – Average Gross tonnage 13.645,99 and the average age of ships 15 years.

How many ships are left under the Croatian flag? According to the same source of information the number of ships flying the Croatian flag is 908 but their Total Gross Tonnage is only 199.660,59, average Gross Tonnage 219,809 but the average age of these ships is 43 years!

There are also 10 ships owned by foreign shipowners whose operator (barcboat charterer) is a civil legal entity with a seat in Croatia. The total gross tonnage of these foreign owned ship flying the Croatian flag is 38.859,85, their average tonnage of 3.859,85 and the average age of 14 years.

Notwithstanding of the benefits which Croatian shipowners enjoyed when registering their ships in the open registry countries avoiding to be seized and captured as prize, this system creates, for a longer period, great disadvantages. The ship registered abroad lacks the legal protection of the »home« country and the home, capital generating country, usually looses control over repatriation and reinvestment of shipowner's profits. Traditionally, an active shipping policy comprises mainly, if not exclusively the promotion of national shipping and is a prerogative of important maritime powers. The former Yugoslav federal government's unfavorable shipping policy must be changed by the Croatian Parliament by promoting the national shipping by measures of protectionist policy granting direct or indirect subsidies to national shipowners. Croatian shipyards must get new orders and get better credit conditions and financial support to build up a modern Croatian merchant fleet.

At the time of declaring independence in 1991 the Croatian Parliament adopted the federal Maritime and Inland Navigation Law as Croatian Law[1]. Competence in maritime matters has been transferred to the Ministry for Maritime Affairs, Traffic and Communication. Under the auspices of this Ministry the draft of the new Croatian code has been prepared and we hope that in a few months a new Law will be promulgated. The new Law amends the provisions on ship's registration and brings some fundamental changes in the Croatian shipping policy.

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Many of the rules governing armed conflict that are designed to protect civilian lives, health, and property also have the collateral effect of protecting the environment. Hundreds of thousands of unexploded bombs and shells fired recklessly by the heavy armed aggressor at civil targets will be a permanent threat for agricultural workers, children, strollers, domestic and wild animals. These unexploded devices, as the experience of the World War II has proved, will lie as triggers for decades to come and will unexpectedly cause accidents and environmental damage.

I want to show on two examples how the »Yugoslav People's Army« did such mischief with intent. Retreating from their naval basis on Vis and Lastovo (the two beautiful islands which foreigners were not allowed to visit for years) the army laid thousands of land mines below and above the ground in fields, vineyards and forests.

Until recently, land mines did not belong to the category of prohibited weapons, but under customary international law, it was prohibited to lay mines and explosive charges in places and buildings that serve only for peaceful purposes. The use of mines had to be limited to military objectives, an uncontrolled use was not permissible.

In 1979 the United Nations General Assembly decided to convene a conference on the prohibition or restriction of use certain conventional weapons, including land mines. After meeting in Geneva the Conference on October 10, 1980 adopted the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be excessively injurious or to have indiscriminate Effects[2]

and Protocols[3] thereto. The Protocol on Prohibitions or Restrictions on the Use of Mine, Booby-Traps or other Devices (Protocol II) in Art. 3 imposes general restrictions on the use of mines, and prohibits directing them against the civilian population or individual civilians and bans indiscriminate mine use. All feasible precautions, taking into account humanitarian and military considerations must be taken to protect civilians. Art. 7 imposes an obligation on parties to a conflict to record the location of all pre-planned minefields laid by them, and to endeavour to record the location of all other minefields which they have laid. Immediately after cessation of active hostilities the parties are to take all appropriate measures to protect civilians from the effects of mines and minefields, including possible provision of location records to the adverse party. This Convention came into force on December 2, 1983 and was ratified by former Yugoslavia in 1983[4].

These are the facts. I leave to the audience to draw conclusions.

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## SAŽETAK

### Pomorstvo i rat u Hrvatskoj

*V. Filipović*

»Jugoslavenska narodna armija« i srpske paravojne postrojbe izvršile su 1991. oružani napad na Hrvatsku. Napad je izvršen na svim frontama i neprijatelj se služio svim vojnim sredstvima: tenkovima, topništvom, ratnim zrakoplovima i ratnim brodovima.

Autor opisuje kako su ratno stanje, a posebno neobjavljena i nedeklarirana ratna blokada svih hrvatskih luka utjecali na broj brodova pod hrvatskom zastavom. Da izbjegnu uzapćenje i zapljenu, većina hrvatskih brodova se ispisala iz hrvatskih registara i upisala u strane države i područja.

U drugom dijelu rada autor opisuje specifičnu štetu počinjenu okolišu prouzročenu neeksplodiranim granatama i minama. Dva hrvatska otoka – Vis i Lastovo – bivše vojne baze, nakon što ih je napustila »Jugoslavenska narodna armija«, ostali su prekriveni minskim poljima kojima neprijatelj nije obilježio lokacije. Ona predstavljaju prijetnju svim civilima, kako lokalnom pučanstvu, tako i budućim turistima, u desetljećima koja dolaze.

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# Application of International Rules on the Protection of Cultural Properties in the War in Croatia

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A short historical review of rules of war and legal protection of particular religious sites. International accords and it's consequences from antiquity to modern times, with special emphasis on Hague convention of 1899 and 1907 (II &IV), Athens charter and Washington treaty (Roerich treaty).

Development of related international legal system after the II world war. Establishment of UNESCO, grater concern for the protection of cultural properties and environment. »Hague convention for the protection of cultural property in the case of armed conflict«. Special attention is given to the articles of convention dealing with internal and international qualifications of conflict, applying it to situation in Croatia. Survey of destructions of cultural properties in Croatia. Several findings of the ECMM teams. Analysis of tactics used during the conflicts. Significance of destruction of cultural and religious monuments in the policy of ethnic cleansing.

Possibilities of sanctions for crimes against cultural property are examined, emphasizing shortcomings of international legal system and specific position of cultural property protection in war.

## Introduction

Dire experience of war in Croatia, personal confrontation ( I have been working with European Community Monitoring Mission /ECMM/ from the very first moment of their arrival in Croatia, July 1991. as Liaison Officer and have done over hundred missions all over the Croatia's front lines.) with the appalling destructions suffered by all segments of life in our country, specially those afflicted to culture and artistic heritage in, as up to now, unseen dimensions. Relatively mild reaction of the world's public opinion. The fact that official as well as cultural and intellectual establishments throughout the civilized world have shown little interest. Urged me to put on the paper this small study of the International law concerning culture and artistic heritage, it's development, possible applications in our situation specifically of those parts dealing with the possible legal sanctions against perpetrators.

## Historic Compendium

Even the prehistoric communities, as much as they where primitive, where established on certain indisputable rules of behavior, (taboo) which have been protected by the most severe sanctions possible. Primarily they where certain religious doctrines protecting, among the others, distinct persons, (priests, shamans, etc), some places or artefacts needed for their religious rites. Taboos where absolute for all the members of the community, but all the other foreign individuals and groups, where as well expected to submit to the same rules with uniform severeness.

Development of the humankind. Emergence of the first states, and with it, interstate relations, have made the need for the protection of some most distinguished sanctuaries essential. One of the earliest known examples is that of the Delphic Amphictyony (after 1100 BC) which provides protection of the Delphic sanctuary. Not only because of its religious but political and diplomatic significance in the Greece of that time. Sanctions for the offender of these and the other regulations of the Amphictyonic assembly where extremely serious – immediate declaration of war from all other member states, what have actually happened in several occasions. Although it was not constituted as contemporary international concord we may take it as a first, known and historically documented, treaty covering the subjects of conduct in armed conflict. Providing special protection of distinct areas and objects[1]. Similar example is that of cessation of all wars during the Olympic celebrations.

There have been many cases throughout European history of more or less adequate codification of war laws and customs. Principally we talk about codification of knighthood mores and comparable written or unwritten codes of behavior which in certain historic conditions, had great influence. Specially it was a case during Medieval period, when these codes of honor have been at least generally (verbally) honored. It is important to emphasize that this rules have not been made as international treaties, or contracts, or any other kind of international laws, they where codes of honor and as such they where binding only morally and ethically, not legally or politically.

**Hague Convection of War Laws and Mores on Land – 1899. I 1907. (II i IV)**

More organized attempts on codification laws of war on international level in recent history have been made in the second half of 19-th century. Most important moment in that sense was signing the »Hague convention about war laws and mores on land« (II) 1989 and similar one (IV) from 1907.

Intention of both of these conventions have been primarily aimed to »... *be used as general rule of behavior of sides in conflict in their relations and their's relations with the population.*«[2]. In this case of international, legal, political, war, etc, repercussions, we are specially interested in the impacts of two particular articles, 27. and 56. which are dealing with the protection »... *edifices used for religious, artistic, humanitarian aims, historic monuments* ...«[3], establishing with it the foundations for the special treatment of culture heritage (in all it's aspects) in warlike situations. These two articles have determined the obligations of aggressor and defender. Article 27 clearly and undisputably forbids any intentional and unprovoked destruction by the attacker of aforementioned objects. Defender is obliged to mark these objects clearly, and forbidden to use them in any military sense. Article 56 is concerned with the treatment of culture property on the occupied territories. It is linked with articles 46 and 47 of the same Convention which are forbidding confiscation and plundering of private property. Since culture property is given the status, whomever the tenant might be, of the private property. Of the great importance is the second part of the article 56 which provides judicial prosecution for »... *the confiscation, destruction or intentional damaging of similar institutions, historic monuments, artistic and scientific works* ...«[4] introducing with it the elements of sanctions for such deeds, in the protection of culture heritage.

Similar propositions can be found in several other international treaties dealing with warlike situations such as »Convention (IX) about bombardment by the naval forces in the time of war«[5] in article 5, and in the »Rules of aerial warfare«[6] in articles 25 and 26 which are elaborating special rules of historic monuments protection.

**Athens Charter and Washington Treaty**

Next step in the structuring of international protective system for culture heritage was »Athens charter« 1933 brought as final document of architect's international gathering. It does not have any legal significance. It is dealing primarily with peacetime protection of historic cities heritage, but it has definite role in it's time on building up the awareness for the urgency of monuments protection.

»Washington treaty« (1935) is known also as Roerich's[7] treaty. This is regional concord[8] which is partially elaborating premises given in the articles 27 and 56 of the Hague convention (IV). It oblige the governments of the undersigned countries to prepare the legislation which would provide protection of historic heritage, proclaiming it neutral, and stipulating from the parties in conflict to observe them as such. Concurrently it defines the emblem to mark the monuments. Importance of this document is emerging from the fact that this is the first international treaty dealing exclusively and entirely with protection of the culture heritage in the war situation.

**Hague Convention for the Protection of Culture Property in Case of Armed Conflict**

As a consequence of hideous destructions of the world's culture heritage occurred during the II World war, establishment of the tighter international legislation system was essential. Need have emerged for the special international laws which will codify more accurately protection of the culture heritage, as well in the war, as in peacetime conditions. Founding of UN, and later on of UNESCO have made a framework for it. Most important step on this path is bringing of »The Convention for the protection of culture property in case of the armed conflict«[9] in Hague 1954. This international treaty is concentration and systematization of previous documents, customs and aspirations for the humanization and lessening of unredeemable losses for whole humankind. Basic assumption[10] of the Hague convention is that any culture property regardless of place or time of origin is the expressions of one nation and culture and as such is entirely part of the mosaic of the world's culture heritage. Hence, it should be given appropriate international protection. Importance of the Hague convention is not confined only to the war situations. It defines[11] concept of culture property (unmovable and movable). It's articles are providing *protection*[12], safeguarding[13], and before everything honoring[14] of culture properties during peacetime. This postulates pledge of the countries, parties of the treaty, to constant care, well-being and maintenance of culture properties on their territory in peacetime, their inventorying, and listing of the most valuable objects in International register. Obliging them to report about the condition of the object every four years to the General Director of UNESCO. And what is of utmost importance *honoring* the monument in sense that objects and their's vicinity are not used for any military purpose. This is elementary presumption on which this whole international contract is built.

Immunity[15], which has been given to culture properties, by Hague convention, is related to objects and transports under special protection which have been appropriately marked, is not absolute. It is limited[16] precisely with that stipulation[17], which might be revoked only with previous notice to the opposing side[18]. If the preventive measures have not been taken by the state to which these properties belong during the peacetime, it will not exempt the opposite side of culpability, and it can not be excuse for vandalism and wanton destruction of the monuments[19]. Special emphasis in the Hague convention is placed on the responsibility of the state, party of the treaty, to inform

systematically it's military force and population with these obligations. SFRY have done it with »Instructions for the Yugoslav armed forces regarding the implementation of the international war law«[20] of 13 January, 1972.

To interpret properly regulations of Hague convention, concerning different phases of the war in Croatia – first internal conflict, and later on, in second phase, with international recognition of the Croatian statehood – international conflict – is important to define moment of undisputable Croatia's sovereignty. For the first phase and occupation of approx. 30% of it's territory – of special consequence are those regulations dealing with conduct of occupying forces toward, the culture properties on the occupied territories, and the opposite side in internal conflict[21]. Special consideration should be given to the »Protocol« of Convention dealing with protection of portable culture properties, forbidding any export of these properties out of the occupied territories[22] and» commits occupying forces to return them at the end of hostilities to legal authorities of once occupied territory«[23].

Hague convention clearly defines positions of the antagonistic sides in the internal conflict and binds[24] them to respect minimum of the regulations, even, if they themselves, where not a signatory of the convention. In this case Yugoslavia is party, not only of this, but to many other international contracts which are dealing exclusively or partially with the issue of culture property protection. Possibility of different interpretations of Croatia's legal position throughout the conflict, and fact that the opposite side does not recognize Croatia's independence will not diminish their obligation of respecting international conventions. Specially since Croatian parliament have declared to recognize all international treaties relevant to Croatia, signed by Yugoslavia.

Hague Convention provides sanctions for disregard of it's provisions by dispositioning that all the countries, parties of the treaty[25], include them in it's penal law. Among the others, there are obligations of removing and recompensing the damage inflicted by it's own military units.

Equally important is regulation which definitely formulates shape of the sign, it's use etc[26].

## World's Culture and Natural Heritage Protection Convention[27]

General awareness and international concern for the world's culture and natural heritage, severely endangered by development in last decades, have resulted with »Convention for protection of world's culture and natural heritage« 1972 in Paris. It is basic document for international system of cooperation and help[28] in that field. As a result of which have been established »International committee for world heritage«[29], »World heritage List«[30], »Register of endangered world heritage«[31], »World's fund for the protection of culture and natural heritage« as a tools for permanent and systematic protection of the world's most valuable monuments[32].

Although this document is primarily intended for peacetime situations, clause about endangered world heritage provides as one of the reasons for enlisting in this category, even those objects already on the World's monument list, if their existence is in immediate and confirmed danger of emergence of warfare[33]. Under condition that the state to which belongs endangered property files request. Same goes for the natural properties. This have been done in both cases on the war afflicted areas of Croatia.[34] Although precise financial needs could not be given since destructions are not over yet. For the occupied areas, for example, Plitvice lakes[35], such reports can not be made because it is impossible to survey situation there.

## Yugoslavia's Unilateral Declaration about Protection of Culture Property in Case of Armed Conflict[36]

From the perspective of war in Croatia, and even more so of war in Bosnia and Herzegovina, absolute disregard of any humanitarian or international norms by the ex-Yugoslav army and it's joined paramilitary units became daily fact. Their undoubtedly deliberate and systematic destruction of Croatian culture heritage have been proofed by unbiased parties in many cases. In that light we should pay particular attention to the »Unilateral declaration of Yugoslavia about protection of culture property in the case of armed conflict« declared almost simultaneously with the Hague convention and addressed to the General director of UNESCO, and through him to all member states. Although this declaration does not have the same legal significance as Hague convention, because it is primarily statement of political intentions and attitudes, it isn't unimportant. Commitments and dispositions with which Yugoslavia have pledged itself in this declaration even before ratification of the Hague convention mainly correspond with it's postulations. Stressing with it Yugoslav resolve, »adherence« and »commitment«, and of course determination of its army to comply completely to all pledged obligations emerging from the declaration. Their real commitment to these obligations we can witness during the conflicts in Croatia and Bosnia and Herzegovina.

## Destructions of Culture Properties in Croatia

Even at the very beginning, when first sporadic skirmishes have occurred in Croatia, spring and summer 1991 we could have recognized first signs of very specific attitude toward culture heritage and adherence to international war law. Intensification of fighting after open involvement of YPA units in the conflict have shown distinctive tactical pattern of besieging the cities. First target is usually church tower, or some other object determining culture and historic identity of this particular place. Tactics they have used have been based on positioning of artillery on the

prearranged positions surrounding the town and starting the surprise bombardments of the civilian objects. Destruction of military unimportant buildings, but psychologically and identificationaly of utmost importance for the local population is done with obvious intention of intimidation and terrorizing, aiming to provoke panic and fleeing of inhabitants. Such tactical implementation of political strategy of ethnic cleansing on certain, by Serbian government previously determined territories of their interest, has as a result that we can state with conviction; in relation with time and territories engulfed in the fighting, number of destroyed culture and historic objects in Croatia and Bosnia and Herzegovina, surpass any other in our history.

Very early in the conflict first unequivocal evidences have been provided that it is not accident or misbehavior of some minor zealot officer and his unit. In many cases ECMM teams have established that destructions of religious or culture objects have been afflicted with weaponry of great precision and destruction power which exclude any possibility of error and undoubtedly point to the fact that, for example[37], Franciscan monastery and Pejačević palace (City Museum) in Našice, or Inter-University Center in Dubrovnik, and many other objects have been targeted with very precise anti- tank wire-guided missiles known as »Majutka«[38]. On example of the Dubrovnik Franciscan monastery, one of the most precious architectural and culture monuments, with priceless library, which have been visibly marked with red cross sign, we can recognize in the arched pattern of the over twenty mortar shell hits in the monastery's cloister obvious intention of destroying the library since several hits[39] have been in it's very vicinity, which unfortunately was not in that moment evacuated from that spot[40].

It have been with certainty established that the Serbian units have used 15-th century Gothic church in Voćin (Slavonija) as ammunition storehouse, and that it was intentionally blown up when they where retreating from this region. Informations about this kind of conduct, although insufficiently checked, but probable, are coming from the occupied territories. Wherefrom we actually don't have any trustworthy facts on the condition of the monuments.

Not to get lost in the, unfortunately, almost endless list[41] of examples I shell enclose only summary numbers of damaged or destroyed monuments conclusive with February 1993 in two Tables (see below) provided by Institute for protection of cultural Monuments (destruction has not stopped, so no list I could offer would be definite).

In this tragic list we have to include destruction of museum objects and collections[42]. Altogether 46 museums, galleries and collections have been damaged; including 10 in A category[43]; 16 in B category; 13 in C category. For some informations have been gathered during the fights in particular areas, after occupation we have very few informations about the fates of museum collection. In certain moment, before liberation of Dubrovnik region 18 museums have been under occupation. Fortunately collections

Table 1* – *The types of monuments affected (Data collected by February 17.1993)*

| Type of monuments | Category** | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | A | B | C | N | |
| **Individual cultural monuments** | | | | | | |
| Palaces and mansions | 0 | 43 | 34 | 108 | 64 | 249 |
| Fortresses | 0 | 9 | 5 | 1 | 1 | 16 |
| Sacred buildings (I) (churches) | 0 | 30 | 55 | 108 | 275 | 468 |
| Sacred buildings (II) (monasteries) | 0 | 19 | 11 | 2 | 10 | 42 |
| Monuments in public places | 0 | 3 | 2 | 0 | 6 | 11 |
| Mausoleums, tombs and cemeteries | 0 | 1 | 4 | 3 | 3 | 11 |
| Commercial buildings | 0 | 0 | 2 | 1 | 1 | 4 |
| TOTAL | 0 | 105 | 113 | 223 | 360 | 801 |
| **Old cities and palaces** | | | | | | |
| Historic and memorial sites | 0 | 0 | 1 | 0 | 0 | 1 |
| Old cities | 2 | 9 | 16 | 6 | 15 | 48 |
| Historic villages | 0 | 1 | 5 | 0 | 268 | 274 |
| Complexes of historic buildings | 0 | 16 | 1 | 0 | 0 | 17 |
| Archaeological sites and monuments | 0 | 4 | 3 | 0 | 3 | 10 |
| TOTAL | 2 | 30 | 26 | 6 | 286 | 350 |

* In tables are included all monuments regardless of their religious or ethnic origin.

**0 – entered in world Heritage List; A – national and world importance; B – regional importance; C - local importance; N – non categorized items.

of Cavtat museums were saved thanks to the local population. Although occupying forces have done several very rigorous searches trying to find hidden works of art and historic documents. Ethnographic museum in Ćilipi was completely destroyed, fortunately it's exhibits have been saved.

To this we have to add unknown number of private collections and works of art which have been looted on occupied territories. Some of this, according to unconfirmed informations, have already emerged on black art-markets of Belgrade and Slovenija.

Two incidents have occurred which are flagrant violations of the Hague convention. First happened immediately after the fall of Vukovar. Serbian legal authorities (Ministry of culture headed by it's minister), although they have stated officially in innumerous occasions that they have nothing to do with the »civil war« on Croatian territory, have led »salvage« operation of the endangered works of art from destroyed Vukovar. They have removed them mainly to Novi Sad[44] and Belgrade. Croatian authorities have insisted through UNESCO in several occasions on the list of the »saved« works of art. As a reply, Serbian

Table 2 – *Statistical data based on the degree of damage (Data collected by February 17.1993)*

| Degree of damage | Category** | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | A | B | C | N | |
| **Individual treasures** | | | | | | |
| Minor surface damage | 0 | 44 | 26 | 70 | 72 | 208 |
| Minor damage on non-support structure | 0 | 1 | 1 | 2 | 9 | 13 |
| Minor damage on support structure | 0 | 42 | 42 | 40 | 61 | 185 |
| Heavy damage on support structure | 0 | 0 | 0 | 3 | 4 | 7 |
| Partially collapsed buildings | 0 | 8 | 10 | 44 | 38 | 100 |
| Wholly collapsed buildings | 0 | 10 | 17 | 31 | 36 | 94 |
| No information available | 0 | 4 | 17 | 33 | 140 | 194 |
| TOTAL | 0 | 105 | 113 | 223 | 360 | 801 |
| **Historic entities** | | | | | | |
| Place destroyed | 0 | 0 | 1 | 0 | 45 | 46 |
| Place burnt down | 0 | 0 | 1 | 0 | 36 | 37 |
| Place partly destroyed | 1 | 5 | 11 | 3 | 69 | 89 |
| Place damaged | 1 | 5 | 8 | 3 | 131 | 148 |
| Minor damage on historic entities | 0 | 12 | 0 | 0 | 0 | 12 |
| Minor structural damage on historic entities | 0 | 3 | 0 | 0 | 0 | 3 |
| No information available | 0 | 5 | 5 | 0 | 5 | 15 |
| TOTAL | 0 | 30 | 26 | 6 | 286 | 350 |

* In tables are included all monuments regardless of their religious or ethnic origin.

**0 – entered in world Heritage List; A – national and world importance; B – regional importance; C - local importance; N – non categorized items.

authorities have stated that the list have not been made, and that anyway there where no inventories of the City museum, Bauer collection and Franciscan monastery. UNESCO have accepted this statement, although all collections where properly inventoried, microfilmed; moreover UNESCO itself had those inventory lists at that moment. Simultaneously to these events I have received private information that those lists have been made in the state »Institute for the protection of culture heritage« in Novi Sad[45] immediately after removal of museum objects there during December 1991 Serbian government has quoted during this action Article 18 subparagraph 2 of the Hague convention, actually acknowledging with it that they are occupying force, what they deny. To make it more bizarre larger parts of »saved« collections have emerged later in Yugoslav culture center in Paris on the exhibition about Serbian »Liberation« of Vukovar. Only after several interventions of Croatian authorities this mockery was closed by French government.

Second case; exhibition of icons and paintings from Dalmatia opened in Belgrad's National museum »Icons of Dalmatinska krajina«[46]. All exhibits where removed from museums and churches on occupied territory. This time all pretenses and justification with laws or international conventions where dropped[47].

## Sanctions ? – Possibilities

As it was stated before, main characteristic of the war against Croatia, and unfortunately even more so against Bosnia and Herzegovina, is absolute, systematic disregard of norms, rules, laws internal or international law. It is rather reasonable to expect that this situation will demand international legal action during, and especially after the war if we want to keep the any resemblance of the international legal system so painstakingly built after the tragic experiences of the II World War.

Culture heritage position, in the greater scope of dreadful atrocities committed on these territories, is very specific. Although historic, artistic and culture losses are priceless, and irreplaceable, not only for Croatia, but for the whole world community, it would be naive to believe that destructions of monuments would be somewhere on the top of agenda, legally or in a future reconstruction (except few of the utmost importance). Development of political and war circumstances in last two years will certainly have repercussions in legal treatment of war crimes and destructions of culture heritage. (Recent events have shown that international community is moving slowly in direction of legal response to all atrocities committed on the territories engulfed in war, but it is better not to expect too much from it.)

One of the most important moments in this affair is surely determining exact moment of Croatia's full independence. That moment isn't unequivocally defined and accepted by international legal community[48]. Since there are several legal theories in circulation, and discussions are still on this issue, we can state that two dates are considered, 25 June, 1991 or latest three months later when Independence declaration of Croatian Parliament have become definitely effective. In this context it is of great importance, because in the case of internal conflict completely different set of procedures is invoked

As I have stated previously »Hague convention for protection of culture property in case of armed conflict« is dealing in Article 19, also with internal conflicts. It sets level of convention's application, but it does not provides sanctions for violations. Similar situation is with »Geneva convention additional protocol«[49] (Protocol II) which in article 16 »... forbids any hostile acts against historic monuments, works of art, or temples which are national culture or spiritual heritage...« even here no sanctions against violator are provided for, although regulations of this article can be incorporated in article 3 of Geneva convention[50]. Hence, what is left to do in these conditions, is to refer to article 151 of SFR Yugoslavia penal code, and to

call up world public opinion through public media to condemn these acts. In this case of Serbia and it's para-political and para-military allies all around ex-Yugoslavia. Efficiency of this indirect, uncodyfied sanctioning can be well discused on the examples of Croatia and Bosnia and Herzegovina. I believe that it should be topic of some future thorough study.

From the moment of undisputed internationally recognized sovereignty and independence of Croatia another segment of international legal system which provides more opportunities, based on both Hague and Geneva conventions is invoked.

Qualification of the war in Croatia as international conflict enact »I Additional protocol to Geneva convention« (Protocol I)[51] which is dealing with protection of culture obj :cts and religious temples in several articles. Primarily in article 53 which forbids »performing any hostile act against historic monuments, works of art, or temples which are considered culture or spiritual heritage of people«[52], »Using such objects as support to military actions;«[53] and »to use such objects as targets of reprisals;«[54]. Article 85, subparagraph 4/d can be affiliated to previously mentioned article, and stipulate that deliberate violations of it's regulations will be considered major transgression of Protocol and Convention. Subparagraph 5 of the same article regulates that »grave violations of this instruments will be considered as war crimes.« Of great importance for any future legal treatment of this, as well as any other war crimes committed in Croatia or Bosnia and Herzegovina, are articles from 86 up to 91 which are regulating responsibilities of the sides in conflict, members of its military forces, and reciprocal legal help in penal matters of states parties of the Convention, their cooperation in matters of extradition[55], an commitment that »in cases of grave violations of Convention or this protocol .... will act, collectively or individually, in coordination with United Nations and in accordance with the United Nations Charter.«[56].

Since in case of international armed conflict whole Hague Convention, and not only Article 19, is invoked. With respect to sanctions key Article is No 28 which require taking measures which will grant that »... persons regardless of their citizenship, who have committed or ordered to be committed violation of this Convention will be pursued and submitted penal or disciplinary sanctions.« This article is related in this case to whole complex of Croatia's succession of Yugoslavia's international contracts with other states, specially those concerning extradition and commitments taken by the states subscribers of Hague, Geneva conventions and additional protocols.

Undoubtedly, the war in Croatia and Bosnia and Herzegovina have been and is, among all other consequences on domestic and international plans, one of the most serious exams for international legal system after II World War. Experiences of the last two years have shown beyond any doubt that even the highest possible international protection – »World heritage list« – obviously can not guarantee minimal protection of these objects. It clearly shows many flows in international legal system and that measures which should have been taken on international level where insufficient, and inappropriate, if taken at all. Not even UNESCO's reaction was appropriate to situation, for example during this conflict high commissioner for culture property has not been appointed at all, and that should have been done according to article 2, subparagraph C »Regulations for realization of the Convention for protection of culture property in case of armed conflict«. In several cases they have sent expert teams to monitor and to get acquainted with the situation.

Out of this we can conclude that it will be necessary to review functioning of international system for culture property protection, and to improve it. This is where I see important role of Croatian experts – to help to avoid such catastrophic deficiencies and mistakes which have already occurred.

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4. Ibid art. 56
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11. Ibid art. 1
12. Ibid art. 2
13. Ibid art. 3
14. Ibid art. 3, subpara. 1
15. Ibid art. 9
16. Ibid art. 11
17. Ibid art. 4, subpara. 1
18. Ibid art. 11
19. Ibid art. 4, subpara. 5
20. Articles 80 to 86 are referring to protection of culture property, marking etc.
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22. Protocol subpara. 1
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24. Ibid art. 19
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28. Ibid art. 7
29. Ibid art. 8
30. Ibid art. 11, subpara. 2
31. Ibid art. 11, subpara. 4
32. Ibid art. 15
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34. Plitvice, Dubrovnik
35. According to unofficial report of ECMM team situation on Plitvice lakes isn't bad, although objects are severely damaged, natural beauties aren't damaged or mined.
36. Proclaimed on 20.11.1954, Official Gazette SFRY, International Contracts, No. 1/1955. Deposited with UNESCO January 12 1955.
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52. Ibid art. 53, subpara. a
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## SAŽETAK

### Primjena međunarodnih pravila zaštite kulturnih dobara u ratu u Hrvatskoj

*M. Gašparović*

Kratki povijesni pregled ratnih pravila i pravna zaštita određenih vjerskih svetišta. Međunarodni sporazumi i njihov značaj od antike do modernih vremena. Posebna pažnja obraćena je Haškim konvencijama iz 1899. i 1907. (II & IV), Atenskoj povelji, Washingtonskom ugovoru (Roerichov ugovor) itd.

Razvitak relevantnog međunarodnog pravnog sistema poslije II svjetskog rata. Osnivanje UNESCO-a, povećavanje brige za zaštitu kulturnih dobara i okoliša u slučajevima oružanih sukoba. »Konvencija o zaštiti kulturnih dobara u slučaju oružanog sukoba« Haag 1948. Posebna pažnja obraćena je čkancima konvencije koji se bave kvalifikacijama unutarnjeg i međunarodnog sukoba i njihovom primjenom na razvitak situacije u Hrvatskoj. Pregled razaranja kulturnih dobara u Hrvatskoj. Nekoliko iznašašća timova Evropske promatračke misije. Analiza taktike korištene tokom borbi. Značaj razaranja kulturnih i vjerskih spomenika u politici etničkog čišćenja.

Razmatraju se mogućnosti sankcija za zločine učinjene protiv kulturnih dobara s posebnim naglaskom na nedostatke međunarodnog pravnog sustava u svjetlu posebnosti pozicije kulturnih dobara u ratu.


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# Destruction of Cultural Heritage in the War against Croatia: Adequacy of International Rules on Protection of Cultural Property

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The extent of destruction of the Croatian cultural heritage in the war against Croatia imposes the question of adequacy of international law rules aimed at protection of cultural property in armed conflicts. The paper represents an attempt to answer this question.

## Introduction

In the war against Croatia the Croatian cultural heritage has suffered enormous damage. According to the available information, systematically collected by the Institute for Protection of Cultural Monuments of the Republic of Croatia, since the beginning of the war 322 historic places, 801 individual historic buildings (more than 500 of which are sacred buildings), 42 museums buildings, 9 archive buildings and stores and 209 libraries have been attacked and destroyed or damaged[1].

Faced with the extent of deliberate destruction of the Croatian cultural heritage one must ask oneself whether it is senseless to speak about international rules devoted to the protection of cultural property in event of an armed conflict. Namely, it is obvious that the actual aggressor against Croatia considers not only the rules on protection of cultural property in armed conflicts but the entire law of war as no more than a collection of platitudes, which has no force and effect.

Being aware that the topic of cultural property protection in armed conflict, having regard to the extent of intentional devastation in Croatia may seem too academic, nevertheless I shall try to briefly examine the basic international rules devoted to the protection of cultural property in time of an armed conflict.

## Basic international agreements

The basic international agreement in the field is, beyond doubt, the 1954 Convention on the Protection of Cultural Property in the Event of Armed Conflict[2].

The Convention applies to all categories of armed conflicts, international and non-international, as well as to all cases of partial or total occupation. It is important to mention the scope of application of the Convention since the war against the Republic of Croatia began within a federal State and later after the Declaration of Independence of the Republic of Croatia in 1991 acquired the properties of an international armed conflict. Thus, all periods of the armed conflict in Croatia, including the partial occupation of its territory, are covered by the Convention.

As far as the cultural property falling within its scope is concerned, the Convention provides a detailed definition of cultural objects protected by its provision. Article 1 covers three classes of objects. The first relates to the movable or immovable property of great importance to the cultural heritage of every people and includes *e.g.* monuments of architecture, art or history, whether religious or secular; archaeological sites, works of art, manuscript, books and other objects of artistic, historical or archaeological interest as well as scientific collections and important collections of books and archives. The second category refers to buildings whose main and effective purpose is to preserve or exhibit the movable cultural property (*e.g.* museums, large libraries, depositories of archives). The third category refers to centres containing a large amount of cultural property, known as »centres containing monuments«.

The Convention distinguishes two levels of protection, *general protection*, which is accorded to all objects falling under the Convention's definition of cultural property and *special protection*, which is provided for a limited number of objects of the highest value. The requirements for establishing a special protection status are so stringent and the procedures so onerous that only the Vatican and a few special refuges to shelter movable cultural property in remote parts of Austria, the Netherlands and Germany have been put under special protection[3].

As far as the cultural property under general protection is concerned, the Convention imposes an obligation on State parties to prepare in time of peace for safeguarding of such property against the foreseeable effects of armed conflict. It is forbidden not only to use protected property and its immediate surroundings for military purposes but for any purpose which is likely to expose it to destruction or damage. Any act of hostility against such property is prohibited. Thus, the Convention obliges the State which has the cultural

property under its control not to abuse the protected status of such property by using it in support of the military effort. If the protected objects were used for military purposes, this would obviously constitute a violation of the Convention's provision, but it would *not* justify attacks or other acts of hostility against such objects. Such a right exists only in exceptional situations where military necessity imperatively requires such an exception. Since military necessity represents a reason which may justify attacks and damage or even destruction of cultural property otherwise protected by Convention, let me comment briefly on this legal concept not precisely defined in the Convention.

Military necessity is a legal concept which must not be confused with military convenience or strategic interest. It may be invoked only when exceptional circumstances and urgency to react exist. Resorting to military necessity is permissible only if a reasonable connection can be established between the attack and the necessities of war. In addition, the proportionality between the damage and anticipated military advantage is required.

Subject to all mentioned restrictions, the military necessity cannot be misused as a disguise for a military convenience or a strategic interest. Nevertheless, the military necessity exception is considered one of the most serious deficiencies of the Convention. It is argued that the application of military necessity exception depends too much on the personal evaluation of the field commander and under the fluid circumstances in the battlefield even a *bona fide* field commander could easily translate military convenience into military necessity. Consequently, concession to military necessity provided in the Convention could lead to situations in which cultural heritage of all mankind is put, as one commentator rightly explains, »at mercy of parochial interest of certain belligerent«[4].

It is precisely in this connection that the next international document relevant to our topic represents an important development for the protection of cultural property. Namely, the 1977 Protocol Additional to the Geneva Conventions of August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)[5] contains no military necessity derogation. Under the Protocol attacks against an object which constitutes the cultural or spiritual heritage of peoples are permitted only if such object is made into a military objective. The concept of »military objective« is precisely defined in the Protocol and means an object which makes »an effective contribution to military action« for the adversary and whose neutralization, capture or destruction offers a definitive military advantage (Article 52, para. 2). Thus, as long as the object concerned is not made into a military objective by those in control – and that is not allowed – no attack is permitted. Compared with often elusive concept of military necessity, the concept of military objective introduced by the 1977 Protocol I is based on more objective criteria and leaves less room for arbitrary judgements of field commanders.

The Second Additional Protocol to the 1949 Geneva Conventions, also adopted in 1977, which applies in the event of an armed conflict not of an international character[6], does not contain detailed rules on protection of cultural property. It only prohibits any act of hostility against cultural property and abuse of its protected status, stating that its provision are without prejudice to the provisions of the 1954 Hague Convention (Article 16).

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Although all the mentioned international agreements relate to immovable and movable cultural property, their provisions primarily concern the protection of immovable property. It should not be forgotten, however, that in addition to devastation of the immovable cultural property, the movable cultural monuments especially church inventories and museum articles on the occupied Croatian territory have also been desroyed or plundered. Suffice it to mention the examples of the Vukovar Museum and Franciscan Monastery, the Bauer Collection, the Drniš Museum, Meštrović sculptures.

Apart from the 1954 Convention which generally prohibits the requisition of movable cultural property in occupied or other foreign territory, the relevant provisions in this respect could be found in the 1954 Hague Protocol for the Protection of Cultural Property in the Event of Armed Conflict[7]. The Protocol reaffirms the obligation of occupying powers to prevent the exportation of cultural property from occupied territory and prohibits its retention as war reparation after the close of hostilities. Every Contracting Party has the obligation to take into custody any such property illegally imported into its territory until the conclusion of hostilities, at which time it is to be returned to the authorities of the previously occupied territory.

The treaty which could be of importance for the future destiny of the movable cultural property plundered from the occupied Croatian territory is the 1970 Convention on the means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property[8]. Illicit movement means import, export and transfer of ownership of cultural property contrary to legal prohibition of the State of origin. In addition to all possible situations of illicit movement in time of peace, the provisions of the Convention also apply to illicit movement of cultural objects arising directly or indirectly from the occupation of a country of origin.

The basic purpose of the Convention is to inhibit the illicit international trade in curtural objects. To achieve this, the State Parties to the Convention undertook to prevent the importation of illicitly exported objects and to facilitate their return to the state of origin.

In conclusion it should be said that former Yugoslavia was bound by all the mentioned international agreements devoted to the protection of cultural property. The brief analysis of their provisions clearly shows that it is hardly any rule to be found in the existing instruments which has not been violated by the Serbo-Montenegrin aggresor. It is not surprising if we

have in mind the purpose of the international conventions, on the one hand, and the aims of the aggression against Croatia, on the other hand. The provisions on the protection of cultural property are formulated to preserve the cultural property from the collateral effects of war. In the war against Croatia, however, the Croatian cultural heritage was, and still is, a direct target, since one of the basic aims of the aggression against Croatia is to conquer its territory and to destroy every evidence of Croatian culture and civilisation there. With such an aim the law of war and international rules devoted to the protection of cultural property in time of armed conflict – even more perfect than the present ones – cannot play any role.

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**SAŽETAK**

**Uništavanje kulturne baštine u ratu protiv Hrvatske: Adekvatnost međunarodnopravnih pravila o zaštiti kulturnih dobara**

*M. Seršić*

U ratu protiv Hrvatske hrvatska kulturna baština pretrpjela je goleme štete. Opseg te štete nameće pitanje adekvatnosti međunarodnih pravila posvećenih zaštiti kulturnih dobara u oružanim sukobima. U odgovoru na to pitanje razmatraju se odredbe Konvencije o zaštiti kulturnih dobara u slučaju oružanog sukoba iz 1954. te relevantne odredbe Protokola iz 1977. uz Ženevske konvencije o zaštiti žrtava rata iz 1949. Uz nepokretna kulturna dobra, brojni pokretni kulturni spomenici, posebno inventar crkava i muzeja, uništeni su ili opljačkani. U ocjeni adekvatnosti međunarodnopravne zaštite pokretnih kulturnih spomenika razmatraju se odredbe Protokola o zaštiti kulturnih dobara u slučaju oružanog sukoba iz 1954. te Pariške konvencije o sredstvima zabrane i sprečavanja nezakonitog uvoza, izvoza i prijenosa vlasništva kulturnih dobara iz 1970.



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# Protection of Dams in Armed Conflicts: The Peruča Case


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After having been mined by Serb forces – who had for months, repeatedly threatened to destroy it and cause environmental disaster – the Peruča dam, situated in the community of Sinj, in the Republic of Croatia, was blown up on January 28, 1993.

The author analyses the relevant rules of international law applicable to this particular case. These include provisions of the Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I) prohibiting damage to the natural environment, even if this effect is incidental, protecting works and installations containing dangerous forces and prohibiting to make any of them the object of reprisals (Articles 35, 55 and 56) as well as provisions (Articles 14 and 15) of the Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II).

In addition, attention is being paid to the environmental aspects of such hostile activities taking into account the fact that effects on the environment may be produced either accidentally (inadvertend or collateral environmental effect) or deliberately – where the effect must have been intended or at least foreseeable.

In conclusion it is stated that the military disruption of the environment in warfare is extremely difficult to limit or control by means of legal instruments only. Yet, in the case of the

Peruča dam not even the military presence and control of the dam by the United Nations Protection Force (UNPROFOR) was important enough a factor to prevent the destruction of the dam by armed forces which do not abide by any of the rules of modern warfare.

I.

1. The Peruča dam encompasses a hydro-electric power plant (41,6 MW) and an accumulation lake of 20 square kilometers surface (volume of stored water 541–570 million $m^3$)[1], built in a karst area on the river Cetina. The dam was completed in 1960 and is situated in the community of Sinj, in Croatia, some 30 km north of the city of Split.

The accumulation dam itself is 65,0 meters high, on elevation 60,0 meters off the ground thus falling among the so-called high dams. The maximal reservoir water level is on elevation 360 to 361,5 m a.s.l., while the spillway crest peak elevation is 363 m a.s.l. The accumulation is intended for use by the hydro-electric plants of Peruča and Zakučac (540 MW), and other power stations downstream from the dam to generate power for much of the adjoining region[2].

Therefore, when speaking about Peruča, the power plant itself is to be distinguished from the accumulation, the latter being of vital importance for the region as its water is used on the whole lower reaches of the river Cetina. The management of the water thus seems to be much more important than the production of electricity at the Peruča plant itself.

2. On September 17, 1991, Peruča was taken by the Yugoslav People's Army and only a few days later General Ratko Mladić of the Yugoslav People's Army declared that his forces had mined the dam and threatened to destroy it[3]. The Yugoslav Army occupied the area until June 1992[4], when Serb authorities from Knin took over the area deploying their »special police forces«. According to UNPROFOR sources »Serb military forces had, prior to their withdrawal earlier in the year, laid explosive charges at various points in and around the dam, and the urgent cooperation of the authorities in Belgrade and Knin has been sought to deal with this danger«[5]. It is obvious that in this very case the Knin authorities could not have acted without experts' help and advice from Belgrade, whether it goes for the very professional laying of the explosive charges, or the activating itself (see also *infra* note 12). The fact that UNPROFOR has repeatedly sought help from both the authorities in Belgrade and Knin is but another evidence of their connection and the interplay of their actions.

Ever since the army came into possession of the installation the dam was in a disturbing condition as the occupying force had closed the flood gates thus considerably increasing the water level in the dam. Consequently, there was increased pressure on the structure of this vital and vulnerable installation as well as considerable fear of possible damage. This also prevented an adequate flow of water for power stations downstream from the dam. Having regard to the vital nature of the Peruča dam and to the environmental disaster that would result from its destruction, the Croatian authorities have ever since their first contacts with UNPROFOR in March 1992 informed them of the very dangerous situation at Peruča and have repeatedly demanded UNPROFOR protection of the site. Following the agreement of the Serb authorities to withdraw their forces from the Peruča High Dam, UNPROFOR brought in international experts in dam technology to inspect the installation. They produced a disturbing report about its condition[6].

UNPROFOR took over the control and management of the Peruča Dam on 14 September 1992[7]. Emergency measures were at once taken to lower the level of water and reduce the pressure on the structure thus minimizing the danger of its self-destruction. This provided, for the first time in many months, an adequate flow of water for power stations downstream from the dam[8]. After the Government of the Federal Republic of Yugoslavia (Serbia and Montenegro) finally informed UNPROFOR that it was unable to assist in the task of demining the facility, demining experts from different countries were brought to inspect and render safe the Peruča Dam[9]. They did not, however, succeed in removing the explosive charges from the dam and its immediate vicinity.

On 27 January 1993[10] the Croatian Army regained control of the Peruča Dam following an action by its military and police forces in the Zadar hinterland.

After expelling UNPROFOR staff from the dam, Serb forces have, on 28 January 1993 at 10,48 a.m., from afar activated the previously laid explosive charges and severely damaged the installation. A possible catastrophe for the adjoining region was avoided only because the water level at the very moment of the explosion was under the maximum. Therefore, the dam was not completely demolished and thus did not provoke the feared massive and destructive flooding[11].

According to different unofficial sources, about 30,000 kg of explosive were used. Having in mind its positioning, it is definitely held that it was laid by experts on dam technology[12].

3. According to experts[13], the demolition of the dam could have provoked a water wave which could possibly have flooded the whole downstream area, from the dam to the mouth of the Cetina river into the Adriatic Sea. On its 76,5 km long way it would primarily have inundated the valley Hrvatačko polje and secondary the flat land of Sinjsko polje and a 50 km long canyon to the coast town of Omiš.

At the worst this could have caused the death of about 12,000 people, left some 60,000 persons homeless, without drinking water and electricity, and the farming land of Sinjsko polje without fertile land for decades[14]. Sinjsko polje is a valley 12 km long and at its widest point about 7 km large. The entire area is used for agriculture. In addition, some vital objects as the Sinj airport, the »Cetinka« factory and a pumping site near Trilje are situated in the flat land. The floods would have seriously disturbed the drinking water sup-

plies for the region (especially for the towns of Omiš and Makarska and the islands Brač, Hvar and Šolta by destroying pumping sites on the river Cetina or by contaminating them. In addition, the river Jadro which is supplying drinking water to the cities of Split, Solin and Trogir would have been contaminated. All this damage would have had long lasting effects.

Had the water wave been as strong as intended it would also have flooded and destroyed most of the town of Sinj and the settlements in its vicinity. It would have damaged or destroyed the accumulation dam of Prančevići, the Dale and Zakučac power systems as well as numerous bridges and settlements up to the town of Omiš[15].

Important ecological damage would have been both immediate and delayed. Some of the effects would have been felt only after the water had withdrawn, as a mud coat might have destroyed the crops, livestock and would have rendered farming land useless.

4. Fortunately enough, this intended and frightening goal was not materialized due mostly to the above mentioned fact that at the moment of the explosion, thanks to UNPROFOR, the water level of the Peruča Lake was under the maximal level, namely on 356,28 m a.s.l. According to Paul Back who inspected the site, it was only a miracle that the dam had not failed[16]. Had the water level been only four to five meters higher (see *supra*, section I) a real catastrophe could not have been avoided.

The real damage of the dam itself is still being assessed by consultant-engineers from Croatia and from abroad.

Yet, according to experts' views some of the resulting environmental damage can already be described[17].

– The first ecocide on the river Cetina was perpetrated by the destruction of the generators of the plant and the leaking of toxic lubricants from its bearings. Their chemical composition polluted and contaminated its waters and caused destruction of the flora and fauna of the watercourse. Still, most of its consequences will only be noticeable in the time to come.

In this respect the fact should be borne in mind that the Cetina is a karst river with numerous precipices along its bed in which it disappears underground. The water comes up again at springs, some of which are used for water supply of the coastal region. Therefore, any changes of water quality at such springs should be carefully followed in order to be able to prevent any undersirable consequences.

– The Peruča Lake stored a water volume of over 540 million $m^3$, which protected lower reaches of the river Cetina from sudden and unexpected autumn-spring flooding.

– In the artificial lake and adjacent to it, a particular eco-system along with new micro climate conditions has gradually developed, especially in the area between the Dinara massif and the Sinjsko polje flat land. Living organisms have adapted to the situation and have been living at the established rhythm. As an important outflow of water from the lake is indispensable after the destruction of the dam and is being conducted relatively rapidly because of the necessary reparations, the fish stock in the lake is endangered and an important amount of fish will be »captured« in the natural shallow waters. As parts of the area are under Serb occupation no concrete help can be envisaged at the moment. Therefore, once the dam is repaired the water of the new accumulation lake will be poor with fish. Additional stocking with fish and several year's time will be necessary to get back to the original conditions.

– The rotting of organisms in mud and dirt will contaminate part of the water entering the Peruča Lake and this contamination will slowly get transported to the lower reaches of the river Cetina causing unwanted pollution.

– According to seismologic previsions, due to the fact that the mass of water of the Peruča Lake produced tectonic stability in the area, an increased risk of earthquakes is to be expected in the near future – *i.e.*, the next few years in which the lake will stay without water[18].

Consequently, it might be stated that it will take years until the now damaged ecological balance of the region is reestablished.

II.

5. In the light of today's existing environmental awareness and the concern over ecological consequences of armed conflicts, the destruction of the Peruča Dam by Serb forces is chosen as a staggering example of ways of waging war without any regard to the existing legal restraints. Both rules of armed conflict protecting civilian population and those protecting the natural environment have been violated by this attack. It is well known that the destruction of dams in a geographic situation as the one of Peruča is the most straightforward means of producing destructive floods[19]. An intended ecocide, however, has been avoided only because of circumstances out of control of the attackers.

6. The most direct rules of contemporary international law to be applied in cases of attack on dams, are to be found in Article 56 of the Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)[20] and in Article 15 of the Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II)[21]. These articles provide protection to the civilian population by imposing restraints on attacks against certain installations, including dams, containing dangerous forces which, if released as a result of an attack, could cause severe losses among the civilian population. These limitations primarily seek to protect the victims of war. But they also have an environmental character and quality because they seek to prevent ecological damage from the release of a dangerous force[22]. Thus, damages to the environment are prohibited under certain circumstances because they affect the civilian population[23].

Article 56 (*Protection of works and installations containing dangerous forces*) of Protocol I, falls among

provisions which are additional to the rules concerning humanitarian protection of individuals contained in the Geneva Convention Relative to the Protection of Civilian Persons in Time of War of August 12, 1949 and in other international agreements binding upon the parties, »as well as to other rules of international law relating to the protection of civilians and civilian objects ...against the effects of hostilities« (Article 49 (*Definition of attacks and scope of application*), paragraph 4, Protocol I).

The corresponding provisions of Protocol II (Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of Non-International Armed Conflicts), especially Article 14 (*Protection of objects indispensable to the survival of the civilian population*)[24] and Article 15 (*Protection of works and installations containing dangerous forces*) also prohibit attacks against dams. Even if »Protocol II does not set out to protect civilian objects generally«[25] it provides for special protection of objects indispensable to the survival of the civilian population (Article 14) and of works and installations containing dangerous forces because of the serious consequences that may follow if they are destroyed (Article 15). Unlike Article 56 of Protocol I, Article 15 does not provide for any exceptions from the general principle it sets, which makes that the rule is stated even more categorically.

7. In time of armed conflict adversaries have always tried to strike at one another also by releasing natural or artificial forces. In ancient times and in the nearer past there had been examples of such practice which resulted in serious consequences and led to heavy losses among the civilian population[26].

In order to safeguard the civilian population from such a disaster, and because no direct rules of international law existed to prohibit such attacks, the International Committee of the Red Cross (ICRC) – prompted by the reactions of public opinion against such forms of warfare – decided to deal with the matter. Thus, when presenting its Draft Rules for the Limitation of the Dangers incurred by the Civilian Population in Time of War in 1956, it had already introduced an article on the protection of installations containing dangerous forces. Following the failure of this initiative, the ICRC developed new proposals and finally presented an article on the matter to the Diplomatic Conference on the Reaffirmation and Development of International Humanitarian Law Applicable in Armed Conflicts (Geneva, 1974 to 1977). Two protocols additional to the Geneva Conventions of 1949, representing the results of the Conference, both contain articles containing a prohibition on attacks or destruction of dams, dykes and nuclear generating stations[27].

8. According to Article 56 of Protocol I and Article 15 of Protocol II works or installations containing dangerous forces, such as dams, shall not be made the object of attack, even where these objects are military objectives, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian population. They are protected against attacks, which means, according to Article 49 (*Definition of attacks and scope of application*) of Protocol I acts of violence against the adversary. This protection also applies to a party's own territory under the control of the adverse Party.

This special protection may only cease in cases that an installation is used for other than its normal function and in regular, significant and direct support of military operations and if such attack is the only feasible way to terminate such support. If the dam is not used for any other purpose, it must not be attacked under any circumstances.

If, however, any attack is directed against a dam which, according to Article 56, paragraph 2, of Protocol I has ceased to enjoy special protection, all other rules of international law including the general rules of Article 51 (*Protection of the civilian population*) and the precautions provided for in Article 57 (*Precautions in attack*) of Protocol I, protecting the civilian population, must be respected. Even if they constitute military objectives they must not be made the object of attack if such attack may cause the release of forces contained therein, and consequent severe losses among the civilian population. In such a case belligerents must take all practical precautions to prevent dangerous forces from being released. The principle of proportionality between losses inflicted and military advantage gained from the attack on the dam is particularly to be respected, even in cases where such an objective has lost special protection[28].

In cases when some of these works have a combined function serving partly for irrigation, drinking water installations and supplies (Article 54, paragraph 2)[29] and partly to generate electricity an attack on them is subject to the additional conditions imposed by paragraph 3 of Article 54 (*Protection of objects indispensable to the survival of the civilian population*) of Protocol I.

Even if Protocol I does not contain a general provision on reprisals, it has gone pretty far toward the complete prohibition of reprisals. Thus, there is also an express prohibition of reprisals against dams (Article 56, paragraph 4). This prohibition, supplementing the previous provisions of Article 56, was included by the Diplomatic Conference with a large majority, as part of its general idea of prohibiting all reprisals in this field (general protection against the effects of hostilities)[30].

Finally, it should be underlined that launching an attack against works or installations containing dangerous forces under the condition that such attack is committed willfully, in the knowledge that it will cause excessive loss of life, injury to civilians or damage to civilian objects (as defined in Article 57 (*Precautions in attack*) of Protocol I, paragraph 2(a)(iii)) is considered a grave breach of the Protocol (Article 85 (*Repression of breaches of this Protocol*), paragraph 3(c)). It has to be emphasized that grave breaches of the Convention and of the Protocols are regarded as war crimes (paragraph 5).

9. It should be stated that provisions of both Protocols Additional to the Geneva Conventions for the Protection of War Victims undoubtfully set the attack on the Peruča Dam as a violation of existing international law. It is evident that the Peruča Dam should not have been made the object of attack and that the practice of using floods as the means of impeding the adversary's advance is outlawed.

The special protection a dam enjoys can only cease in strictly prescribed circumstances, yet even in that case the civilian population continues to enjoy the protection as already described (*supra*, section 8). In the case of Peruča, however, it was obvious that it was a purely civilian installation, used only for its normal function, with no military objectives located at it or in its vicinity.

In addition, this attack was prohibited also because it was well known that it was an object of vital importance for drinking water installations and supplies for most of the adjoining region, encompassing the towns of Omiš, Makarska and the islands of Brač, Hvar and Šolta. Moreover, an attack on it could also have destroyed or rendered useless agricultural areas for the production of foodstuffs, crops and livestock (Article 54, paragraph 2 of Protocol I and Article 14 of Protocol II), in particular in Sinjsko polje. According to the ICRC Commentary »... the verbs »atack«, »destroy«, »remove« and »render useless« are used in order to cover all possibilities including pollution, by chemical or other agents, of water reservoirs, or destruction of crops by defoliants ...«[31]. As regards the objects which are especially protected »the Conference mentioned agricultural areas for the production of foodstuffs, drinking water installations and supplies, and crops, which should be interpreted in the widest sense, in order to cover the infinite variety of needs of populations in all geographical areas. Furthermore, the words »such as« show that the list of protected objects is merely illustrative«.[32]

The attacker of a dam is always under an obligation to respect the rules protecting the civilian population and the precautions in attack, both prescribed by the Protocols (see *supra*, section 8). In particular it must not undertake attacks with effects which are incompatible with the principle of proportionality. In every attack it must carefully weigh up the humanitarian and military interests at stake. This was obviously not the case in the attack on the Peruča Dam.

Futhermore, the Serb forces were, with the help of the Yugoslav Army preparing themselves for this attack for a long time. On several occasions they declared that they had laid explosive charges in and around the dam and threatened to activate it in order to exert pressure on the Croatian Government and to intimidate the population. Even though attacks against the civilian population by way of reprisals are prohibited under Protocol I in general (Article 51 (*Protection of the civilian population*), paragraph 6), as well as in the specific case of attacks on dams (see *supra*, section 8), Serb forces openly threatened to destroy the dam as reprisals in case the Croatian side, even with the help of UNPROFOR, tried to take over the control of the Maslenica bridge, as foreseen in the Vance plan[33]. After the attack they openly admitted that their attack against the Peruča Dam had been taken in reprisal against the Croatian offensive in the »pink zones«, started on 22 January 1993, *i.e.*, with the intent to force the Croatian Army to change its conduct. This proves that they acted consciously and with intent, with their mind on the act and its consequences and in violation of the relevant provisions of the Protocol, in particular with Article 85, paragraph 3(c)[34] which expressly prohibits such attacks.

In order to be regarded as a grave breach of the Protocols, *i.e.*, a war crime, the attack against a dam in addition to other conditions has to result in *causing death or serious injury to body or health*. »The effect must be such that, even if it does not cause death, it will affect people in a longlasting or crucial manner, either as regards their physical integrity or their physical and mental health«[35]. When the commission of the act in question begun but was suspended or failed to have effect as a result of circumstances outside the control of the persons who had begun committing or committed the act – it can be regarded as an attempt. Humanitarian law does not specify whether the attempt of a grave breach is also punishable. According to the ICRC Commentary, under the different treaties reffering to grave breaches, the attempt to commit a grave breach or a similar crime is not always subject either to universal jurisdiction or to penal suppression. However, the attempt may and will often be subject to penal or disciplinary sanctions under national legislation[36]. The International Law Commission's Draft Code of Crimes against the Peace and Security of Mankind makes attempt a punishable act. Article 3, paragraph 3 of the Draft Code deals with the responsibility and punishment of any individual who commits an act constituting an attempt and gives a definition of attempt. It states that any individual who commits an act consituting an attempt to commit a crime»... is responsible therefor and is liable to punishment. Attempt means any commencement of execution of a crime that failed or was halted only because of circumstances independent of the perpetrator's intention«[37].

In the case of Peruča the mining has not produced all the intended, expected and possible effects as a result of circumstances outside the control of the attackers. Namely, between the laying of explosive charges and their activating the water level of the accumulation lake was lowered by UNPROFOR forces who had, in the meantime, taken over the control of the installation. In our view this does not exculpate the attackers of punishment in accordance with international law.

10. In addition to being prohibited under the International Law of Armed Conflict, attacks on dams have to be considered having in mind their possible environmental impacts. Therefore, the specific limitations on environmentally disruptive activities during armed conflict have to be analyzed. In other words, rules of existing international law should be deter-

mined which relate to the protection of the environment and which can be applied in this very case.

The already analyzed provisions of Protocol I contain also some very important environmental considerations. They limit the means of destruction in armed conflicts by requiring combatants to consider the environmental impact of their actions; they also impose on the parties to control their methods of warfare to a grater extent than ever before in order not to cause environmental damage, *i.e.*, to refrain from attacks on the environment as a means of waging war[38]. In this sense Protocol I stresses the means and methods by which war can be waged, reflecting at the same time the desire of the world community to avoid environmentally devastating methods of warfare[39]. Thus it marks a significant step forward in the protection of the environment.

11. Article 35 (*Basic rules*), paragraph 3 and Article 55 (*Protection of the natural environment*) are considered as the broadest of all the environmental provisions of Protocol I. Therefore, they apply also in the case of Peruča insofar as they place new limits on the means by which war is waged. Article 35, paragraph 3 makes unlawful methods or means of warfare which are intended, or may be expected, to cause widespread, longterm and severe damage to the environment. According to Article 55 an attack is clearly unlawful only when it causes damage to the environment and thereby prejudices the health or survival of the population. In addition, the effect must have been intended or at least foreseeable. A mere collateral environmental effect of an attack does not make the attack unlawful[40]. The repeated declarations by Serb forces that they would destroy the dam containded threats to the civilian population from which it was obvious that they were not only aware of the effects such an attack would produce, but even that such effects were intended.

12. Eventually, it can clearly be stated that in the case of the attack on the Peruča Dam even the most damaging environmental effects would not have been merely incidental. Moreover, it was obvious from the Serb own statements that the attack was supposed to lead to direct human losses but also to enormous damage to the environment. Consequently, the least that may be stated is that ecological considerations have not played a dominant role in the attackers conduct. Therefore, let us conclude by using a remark made in another context and more than a decade ago: this case is only another obvious example (or proof) that military disruption of the environment is exceedingly difficult to limit or control by means of legal instruments[41]. This should, however, not be interpreted as a sign of frustration (or even resignation!) by an international lawyer, whose country is at war, in regard of the need for further codification of international law in this field.

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19. A. H. Westing, Weapons of Mass Destruction and the Environment, SIPRI, London, 1977, p. 54
20. The text of Article 56 is as follows:

»1. Works or installations containing dangerous forces, namely dams, dykes and nuclear electrical generating stations, shall not be made the object of attack, even where these objects are military objectives, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian population. Other military objectives located at or in the vicinity of these works or installations shall not be made the object of attack if such attack may cause the release of dangerous forces from the works or installations and consequent severe losses among the civilian population.

2. The special protection against attack provided by paragraph 1 shall cease:

(a) for a dam or a dyke only if it is used for other than its normal function and in regular, significant and direct support of military operations and if such attack is the only feassible way to terminate such support;

(b) for a nuclear electrical generating station only if it provides electric power in regular, significant and direct support of military operations and if such attack is the only feasible way to terminate such support;

(c) for other military objectives located at or in the vicinity of these works or installations only if they are used in regular, significant and direct support of military operations and if such attack is the only feassible way to terminate such support.

3. In all cases, the civilian population and individual civilians shall remain entitled to all the protection accorded them by international law, including the protection of the precautionary measures provided for in Article 57. If the protection ceases and any works, installations or military objectives mentioned in paragraph 1 is attack-

ed, all practical precautions shall be taken to avoid the release of the dangerous forces.

4. It is prohibited to make any of the works, installations or military objectives mentioned in paragraph 1 the object or reprisals.

5. The Parties to the conflict shall endeavour to avoid locating any military objectives in the vicinity of the works or installations mentioned in paragraph 1. Nevertheless, installations erected for the sole purpose of defending the protected works or installations from attack are permissible and shall not themselves be made the object of attack, provided that they are not used in hostilities except for defensive actions necessary to respond to attacks against the protected works or installations and that their armament is limited to weapons capable only of repelling hostile action against the protected works or installations.

6. The High Contracting Parties and the Parties to the conflict are urged to conclude further agreements among themselves to provide additional protection for objects containing dangerous forces.

7. In order to facilitate the identification of the objects protected by this Article, the Parties to the conflict may mark them with a special sign consisting of a group of three bright orange circles placed on the same axis, as specified in Article 16 of Annex 1 to this Protocol. The absence of such marking in no way relieves any Party to the conflict of its obligations under this Article«.

21. Article 15 reads:

»Works or installations containing dangerous forces, namely dams, dykes and nuclear electrical generating stations, shall not be made the object of attack, even where these objects are military objectives, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian population.«

22. B. K. Schafer, »The Relationship Between the International Laws of Armed Conflict and Environmental Protection: The Need to Reevaluate What Types of Conduct are Permissible During Hostilities«, California Western International Law Journal, Vol. 19, No. 2, 1988–1989, p. 310.

23. M. Bothe, »War and Environment«, Encyclopedia of Public International Law, R. Bernhardt, ed., Instalment 4, 1982, p. 291

24. Article 14 states as follows:

«Starvation of civilians as a method of combat is prohibited. It is therefore prohibited to attack, destroy, remove or render useless, for that purpose, objects indispensable to the survival of the civilian population, such as foodstuffs, crops, livestock, drinking water installations and supplies and irrigation works.»

25. C. Pilloud, J. de Preux, Y. Sandoz and others, Commentary on the Additional Protocols of 8 June 1977 to the Geneva Conventions of 12 August 1949, (Y. Sandoz, Ch. Swinarski, B. Zimmermann. eds.), International Committee of the Red Cross, Geneva, M. Nijhoff, 1987, p. 1456, para. 4794 and p. 1462, para. 4817.

26. Commentary on the Additional Protocols..., op. cit., p. 666–667, paras. 2142–2144; Weapons of Mass Destruction and the Environment, op. cit., pp. 54–55.

27. Commentary on the Aditional Protocols..., p. 667–668, para. 2145.

28. According to some authors, this provision represents the first codification ever of the customary rule of proportionality. Cf. G.H. Aldrich, »Progressive Development of the Laws of War: A Reply to Criticisms of the 1977 Geneva Protocol I«, Virginia Journal of International Law, Vol. 26, No. 3, p. 699; Commentary on the Additional Protocols..., op. cit., p. 683, paras. 2204–2205.

29. Article 54, paragraph 2, states: »It is prohibited to attack, destroy, remove or render useless objects indispensable to the survival of the civilian population, such as foodstuffs, agricultural areas for the production of foodstuffs, crops, livestock, drinking water installations and supplies and irrigation works, for the specific purpose of denying them for their sustenance value to the civilian population or to the adverse Party, whatever the motive, whether in order to starve out civilians, to cause them to move away, or for any other motive«.

30. Commentary on the Additional Protocols..., op. cit., p. 673, para. 2171.

31. Ibid., p. 655, para. 2101.

32. Ibid., paras. 2102–2103.

33. Cf. UN doc. S/23280, Annex III; Security Council Res. 762 (1992) of 30 June 1992.

34. Cf. Commentary on the Additional Protocols..., op. cit., p. 994, para. 3474.

35. Ibid.

36. Ibid., p. 980, paras. 3414–3416.

37. Article 3, para. 3 of the Draft, Report of the International Law Commission on the work of its forty-third session, General Assembly, Supplement No. 10(A/46/10), p. 239.

38. Schafer, op. cit., 288–289.

39. Ibid., p. 311.

40. Botha, op. cit., p. 292.

41. A. H. Westing, Warfare in a Fragile World, Military Impact on the Human Environment, SIPRI, London, 1980, p. 191.


## SAŽETAK

### Zaštita brana u oružanom sukobu: Slučaj Peruča

*N. Vajić*

Nakon što su srpske snage minirale branu Peruča i mjesecima prijetile da će je uništiti i izazvati ekološku katastrofu eksploziv je aktiviran i brana uništena 28. siječnja 1993.

Autorica analizira pravila pozitivnog međunarodnog prava koja su izravno primjenjiva na taj slučaj. To su odredbe Dopunskog protokola uz Ženevske konvencije od 12. kolovoza 1949. o zaštiti žrtava međunarodnih oružanih sukoba (Protokol I) i Dopunskog protokola uz Ženevske konvencije od 12. kolovoza 1949. o zaštiti žrtava nemeđunarodnih oružanih sukoba (Protokol II), oba iz 1977. Te odredbe zabranjuju nanošenje štete prirodnom okolišu, čak i kada se radi o nenamjernim učincima, zaštićuju građevine i instalacije koje sadrže opasne sile i zabranjuju da takvi objekti budu predmet represalija, a sadržane su naročito u čl. 35, 55. i 56. Protokola I i u čl. 14. i 15. Protokola II.

Posebna je pažnja posvećena opisu nastale štete i navođenju mogućih posljedica rušenja brane Peruča na čovjekov okoliš.

Očuvanje čovjekova okoliša u vrijeme rata je izuzetno težak zadatak, a posebno je teško putem isključivo pravnih instrumenata ograničiti ili kontrolirati vojno djelovanje koje šteti okolišu. U slučaju brane na Peruči čak ni prisutnost Zaštitnih snaga Ujedinjenih naroda (UNPROFOR) nije predstavljala dovoljno značajan faktor koji bi spriječio rušenje brane od strane neprijatelja koji se ne pridržava ni temeljnih pravila suvremenih oružanih sukoba.


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*Prispjelo 15. travnja 1993.*
*Prihvaćeno 1. studenog 1993.*

# III. AGRICULTURE, INDUSTRIAL AND POWER PLANTS DURING THE WAR IN CROATIA

## The Assesment of Hazards and Risks to the Environment caused by War Damage to Industrial Installations in Croatia

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The devastation caused to the environment in Croatia as a result of the war is considerable. Many of the incidences, for example, the fire at the Sisak oil refinery; if it had occured in Western European countries would have been number 1 headline news for days.

This contribution to this International Conference outlines but a few of the ravages caused to the environment and are based on a UNIDO mission to Croatia for just 2 weeks in January 1993. During this mission, 18 severely damaged towns, 50 installations were visited, over 100 scientists and officials interviewed and the consultant travelled a distance of ca. 4000 km by road and 1200 km by air.

Many hazards were identified, the worse common one being massive contamination of soil from polychlorinated biphenyls (PCBs), which will lead to contamination of waters. A large scale monitoring programmme using both specific and generic techniques (Microtox test) to enable risk assessment to be undertaken are a vital requirement.

The potential adverse effects to the water environment (surface, ground and marine) are prodigious and where transnational rivers are involved there are grounds for grave public health risks resulting from water abstracted from such rivers (river Danube) for potable water requirements in downstream countries.

This mission enabled a detailed review of only a small proportion of the damage, other damage, in particular that in Bosnia needs to be assessed with great urgency, when personal security permits. However, the long term risks to people in all countries to the East of Croatia must be assessed with urgency and further immissions must cease immediately.

This conference will provide the necessary information to enable the Government of the Republic of Croatia to make the right decisions, thereby avoiding costly mistakes.

### Introduction

Initially the destruction of chemical installations caused atmospheric contamination, this has now dispersed. Today, we need to consider the massive and continuing adverse effects to both the aquatic (ground, surface and marine) and soil environments. Disposal of spoilt commodities, chemicals, food and excreta has led to major hazards, which, if not monitored adequately, the risks assessed and remedial action taken quickly and effectively can only lead to persistent problems which, in turn, may effect future generations' health.

It must be remembered that noxious chemicals emitted to air and water do not recognize national boundaries, and such emissions can cause adverse effects, not only to the immediate location of that emission, but also to countries in the direction of the prevailing winds, *i.e.* to the East, and in major rivers. It should be remembered that the 2 major rivers – Drava and Sava flow from West to East to join the river Danube and hence pollutants emitted in Croatia have the potential to contaminate river derived potable water resources abstracted in Serbia, Romania, Bulgaria, Moldavia, and the Ukraine. In addition, consideration will need to be given to the fragile ecology of the Danube delta which supports many aquatic and avian species, and to the fishing industry of the Black sea, which in turn can contaminate the Mediterranean sea.

The interior regions of Croatia are largely limestone karst, and once contaminated may take decades to recover, or require extremely costly remedial treatment. Rivers in the interior of Croatia flow either on the surface or subterraneously to the Adriatic sea, which because of the highly indented coastline and is-

lands, could very easily induce high localized areas of contamination.

## The initial investigation

The author, accompanied by Dr. Josip Čiček from the Ministry of Civil Engeneering and Environmental Protection, with a driver, inspected chemical and other infrastructures, including power plants and sewage treatment works in January 1993. They visited destroyed installations to the East, viz: in the towns of Osijek, Vinkovci, Dakovo, Našice, Slavonski Brod, and the totally destroyed towns of Pakrac and Lipik; in the interior, they inspected Sisak, Delnice, Karlovac, Ogulin, Otočac and Gospić; and on the coast: Zadar, Šibenik, Split and Dubrovnik.

In all 18 towns and ca. 50 installations were inspected and over 80 officials from communes and industry were interviewed in these towns, plus a further 20–30 academics and others in Zagreb within a period of 14 days.

A detailed report[1] was prepared and submitted to UNIDO for onward submission to the Government of the Republic of Croatia; some of these findings are given below.

### Recommendations

#### Towns/installations

Short (Table 1), medium (Table 2), and long term (Table 3) recommendations on a town by town basis are shown.

In all cases the vital importance of monitoring is stressed, so that these hazards identified during the january 1993 mission can be subjected to the necessary risk assessment.

Table 1 – *Short term recommendations (timescale <1 year. Some projects* to be attempted and reported at Zagreb conference).*

| Location/ Installation/ Industry | Chemical/ hazard | Proposed Action | Visit Ref. No. |
|---|---|---|---|
| **Osijek** | | | |
| Saponia | Sodium hydroxide | *Dissolve, use for ion exchange regeneration at power plants. | 1.1 |
| | Detergent residues | Re-use or via cement kiln - great care necessary re phosphate levels. | |
| | Pesticides | *Cement kilns. | |
| Thermo electric power plant | Heavy fuel oils | Treat microbially | 1.2 |
| | PCBs | Monitor initially | |
| Slavonka leather factory | Chromium salts, dyestuffs, biocides | Analysis and trade effluent treatment | 1.8 |
| **Vinkovci** | | | |
| Wheat silo | Wheat | Seek advice from FAO | 2.1 |
| | Heavy fuel oil | Seal pipe | |
| INA oil refinery | Spent engine oil | Burn in thermo-electric power plant | 2.4 |
| Cibalia leather factory | Chromium salts, dyestuffs etc. | *Prevent discharge to R. Bosut. Rebuild effluent treatment plant | 2.5 |
| | Contaminated water in cellar | Analyze and seek expert advice | |
| **Pakrac** | | | |
| Wood factory | Wood dust | *Instal dust extractor. | 5.1 |
| | Fungicides | Investigate alternatives and improve techniques. Monitor river (Microtox). | |
| Sewage treatment works | – | Provide/reconstruct | |
| **Lipik** | | | |
| Glass works | Chimney | *Demolish or repair | 6.1 |
| **Slavonski Brod** | | | |
| Duro Daković | PCBs from transformers, heat transfer systems and hydraulic oils | Chemical analysis and assess magnitude of problem. | 7.1 |
| | Lead paint | Soil analysis initially | |
| | Trade effluent | Consider mobile peroxidative plant | |
| Hladnjača | | | |
| Vino-voće Bijeliš (cold store) | Ammonia | *Refrigeration enginner to prevent further ammonia losses and to assess damage. | 7.3 |
| **Sisak** | | | |
| Power plant and transformer stations | Heavy fuel oil and PCBs. | Analysis and microbial treatment/ incineration. Examination of fish from R. Lonja for PCBs and genetic abnormalities. | 8.1 |
| Thermo-electric power plant | Ion-exchange chemicals | Obtain specifications and means of discharge of spent chemicals. | 8.2 |
| **Delnice** | | | |
| Hydroelectric scheme lakes | – | Protection of resources by detailed catchment study including wood industry pesticides and tree bark residues | 9 |

| Location/ Installation/ Industry | Chemical/ hazard | Proposed Action | Visit Ref. No. |
|---|---|---|---|
| Transformers | PCBs | Analysis of soil on hillside | 9.1 |
| **Karlovac** | | | |
| Milk factory (February 1993 - Reported as destroyed totally) | – | Improvement to cleaning. *Ammonia - advice from refrigeration engineer. | 10.3 |
| **Ogulin** | | | |
| Munitions dump | Cadmium Mercury Thallium | Further analytical surveys, including sub-surface soil samples, groundwater etc, for metals and Microtox testing for other toxins. Consider treatment of ground with sulfur or sulfides to immobilise cadmium/mercury. | 11.1 |
| **Lešće** | | | |
| Hydroelectric power station | – | Investigate, identify, and prevent causes of contamination. | 11 |
| **Otočac** | | | |
| Cosmochemia | Organic solvents | *Remove from underground tanks and inspect tanks for damage. | 12 |
| **Gospić** | | | |
| Sewage treatment | – | Very urgent need for repair ca. 4 MDEM | 13.1 |
| **R. Lipa** | | | |
| Excavator in river | PCBs | Remove or at least recover PCB hydraulic fluids | 13.4 |
| Trees | Unknown | *Survey to be undertaken by local school children | |
| Battery factory | Manganese, zinc | Metal analysis and organics by Microtox testing required in soil samples. | 13.6 |
| Vehicle repair depot | Spent engine oil | Oil analyses, toxin by Microtox required. | 13.7 |
| Refuse collection and disposal | – | Replacement garbage collection vehicles and better control of landfill site. | 13.10 |
| **Zadar** | | | |
| Drinking water supplies | – | Need for detailed chemical (and bacteriological) analyses plus frequent assessment by Microtox. | 14 |
| **Šibenik** | | | |
| Transformer | PCBs | Analysis required | 15.3 |
| **Dubrovnik** | | | |
| Former chlor-alkali works (Malanica bay) | Mercury alkyl mercury | Analysis of sea water, fish and mussels in particular. | 18 |
| Marine Biological Institute | Aquarium - fish | *Examination of fish for genetic change, generally malformation, sores, and in particular for signs of hermafroditism. | 18.1 |
| Drinking water supplies | – | Improvement to laboratory. More testing, eg. by Microtox. | 18.2/ 18.17 |
| Sewage treatment (Mali Ston Bay) | – | Reconnection to sea outfalls and repair to pumping station | 18.4/ 18.6 |
| Refuse disposal | – | Thorough survey of alternatives. Develop management plan. | 18.3 |
| Graphite (copper) factories | Carbon monoxide PAHs | Analysis. Incinerate toxic waste at cement works at Split. | 18.11 |
| Limestone | – | Provide dust extraction equipment. | 18.7 |
| Wine cellar | – | *Blank off undamaged wooden vats and fill with water. *Remove and re-use unbroken glass bottles | 18.12 |
| **General** | | | |
| Refuse | Building debris, broken glass, household garbage, industrial waste. | Develop overall management plan. Recycle wherever possible. | |
| Broken glass | – | Provide recycling plants at, eg. Kutina, Split | |
| Microtox | – | Very urgent provision (US$ 40 000) for University of Zagreb. | |
| Chlorination of drinking and bathing waters. | – | Use of *in situ* electrogeneration of chlorine for hotels, municipalities, etc. | |

Table 2 – *Medium Term Priorities, 1-2 years*

| Location/ Installation/ Industry | Chemical/ hazard | Proposed Action | Visit Ref. No. |
|---|---|---|---|
| **Vinkovci** | | | |
| Wheat silo | Dust extraction | replace | 2.1 |
| Pesticide storage area | Pesticides | Monitor soil for residues (Microtox) | 2.6 |
| **Đakovo** | | | |
| Pesticide storage area | Pesticides | Monitor soil around replacement store for residues (Microtox) | 3.1 |
| **Lipik** | | | |
| Glass works | – | Consider float glass plant | 6.1 |
| **Slavonski Brod** | | | |
| Oriolik-Oriofleke | Furniture chemicals | Analyze for phosphates, chromate, bromide and tin. Urethane residues. | 7.2 |
| **Sisak** | | | |
| INA oil refinery | Burnt oil and oil residues | Treat soil microbiologically. Improve monitoring, eg. by Microtox, also at Rijeka, Zagreb (Ivanić-Grad), etc. | 8.3 |
| **Delnice** | | | |
| Munition dump | Cadmium Mercury Thallium, etc | Detailed chemical analyses for metals and for organic pollutants by Microtox. | 9.2 |
| **Karlovac** | | | |
| Municipal rubbish dump | – | New site required, compaction, and improvements to management. | 10.2 |
| **Ogulin (Plaški)** | | | |
| Sulfur cellulose factory | – | Survey required | 11 |
| **Šibenik** | | | |
| Aluminium smelter | – | Great care to be exercised in restoration, especially transformers. | 15.1 |
| Vegetable oil and wine/alcohol factory | Genotoxins produced by combustion. | Fish monitoring for genetic damage. | 15.6/ 15.7 |
| Potable water resources | – | Need to undertake detailed catchment surveys. | 15.10/ 15.11 |
| **Metković (Neretva Delta)** | | | |
| Agrochemical usage | – | Expert needed to assess requirements for modern pesticides, fertilizers, etc. | 17 |
| **Dubrovnik** | | | |
| Drinking water supplies | – | Survey of catchment required, eg. Bileća, Trebinje, etc (Bosnia). | 18.2 |
| Incinerator | – | Remove mines from Lokrum. Complete and commision incinerator. | 18.3 |
| Chicken/egg farm | – | Treat decomposing animal tissue and prevent spread of pathological organisms. | 18.5 |
| | Phosphate | Analysis required | |
| Graphite factory | Copper PAHs Carbon monoxide | Analyses required. Installation of fume extraction equipment. This factory should be relocated away from Dubrovnik. | 18.10 |
| Vineyard | – | Expert assessment required. | 18.12 |

Table 3 – *Long Term Recommendations (time scale >2 years).*

| Location/ Installation/ Industry | Chemical/ Hazard | Proposed Action | Visit ref. No. |
|---|---|---|---|
| **Osijek** | | | |
| Hospital | Radioactive gold | Recover from R. Drava or R. Danube | 1 |
| Drava Safety measure products | Not known | Survey required. | 1.4 |
| IPK | ditto | ditto | 1.5 |
| LIO | ditto | ditto | 1.7 |
| **Đakovo** | | | |
| Meteor | Detergents, etc | Apply BPEO, BATNEEC, to reduce discharges. Install trade effluent treatment plant. | 3.2 |
| **Sisak** | | | |
| Thermo-electric power plant | Ion-exchange resins. | Recover if possible | 8.2 |

| Location/ Installation/ Industry | Chemical/ Hazard | Proposed Action | Visit ref. No. |
|---|---|---|---|
| **Karlovac** | | | |
| Milk factory | – | Refurbishment of laboratory and air filters on chimney. | 10.3 |
| INA oil distribution | Diesel oil residues | Soil monitoring by Microtox testing. Survey of trees by school children. | 10.4 |
| **Ogulin** | | | |
| Winter hotel facilities | – | Provision of sewage treatment and improvements to all aspects of water disposal. | 11 |
| **Otočac** | | | |
| Sewage works | – | Necessity to provide full facilities | 12 |
| **Split** | | | |
| Sewage works | – | Necessary to provide at least primary treatment. | 16 |
| Former chlor-alkali works | Mercury, alkyl mercury compounds. | Analysis | 6 |
| **Dubrovnik (Gruž)** | | | |
| Coal fuel power station | – | Renew dust extraction equipment. | 18.8 |

By example, further details are given on 2 of these sites:

### *i) Saponia at Osijek*

*Manufacturers of detergents, soap, cosmetics, including lipsticks, toothpaste, shampoos, etc.*

The factory is totally destroyed and has been burnt out. There is an estimated 1000+ tonnes of residues to be removed. This is matter of urgency as each time it rains (snows) residues are eluted from the site across a field (which is mined – position of mines unknown) and then to the river Drava which is 25 km from the river Danube. The geology of the land is black clay and hence there should be little penetration, monitoring of the river Drava is of urgency.

A full list of chemicals is being submitted, but residues of the following were noted: Genapol (Hoechst Germany); optical whitening agents (Ciba-Geigy, Basle); phosphates, including tripolyphosphates; sodium sulfate; some pesticides, including Diuron and those used for treating potatoes; Command EL from FMC Philadelphia; xylene; 1-butanol; EDTA; zeolite; etc.

There is a significant quantity (250+ tonnes) sodium hydroxide (some now as a solid rock, some pellets, flake and solution).

All of the above is contaminated with broken glass, plastics (PVC + polythene) and asbestos, both grey and green asbestos from roofs, together with fragments of exploded grenades and other munitions.

The sodium hydroxide should be dissolved in water to form as near as possible a 50 % solution, filtered, and used for regeneration of ion exchange columns for boiler water treatment at thermoelectric power stations.

The sodium sulfate and, in particular, the sodium phosphate are of similar concern, but it may be possible to incinerate these in the cement kiln at Našice. Monitoring is essential, especially for the phosphate as this could interfere with the cement setting characteristics, even so, it should be possible to destroy these basic inorganic residues by addition to cement kilns at a rate not exceeding 1 % of total feed, but obviously dependent on the current phosphate content of the cement. Alternatively, it maybe possible to reuse these salts at either Saponia's other factory (time did not permit a visit), or at another cosmetics factory, eg. »Meteor« at Dakovo, but because of the relatively high sophistication of Meteor's plant, this would require a great deal of supervision.

The organic compounds, including the pesticides, are suitable for destruction in the cement kilns at Našice.

In order to prevent further environmental damage, it is recommended that remedial work starts quikly, with the view of reporting progress at the Zagreb conference in April 1993.

### *ii) Wheat Silo, Vinkovci*

The 10 000 tonnes of wheat in the damaged silo presents a major problem. If it is allowed to remain wet, mould will commence with the almost certain formation of aflatoxin. This, in combination with the development of rodents, will also certainly lead to a major public health problem. In addition, the silo is needed for the 1993 harvest.

The best solution would be to utilize this wheat for human or animal feed, but because of the degree of contamination, previous attempts have failed. An agricultural expert from FAO might be able to advise on a solution to salvage at least part of it.

Hence, if destruction is the only pragmatic solution, transportation to the cement works at Našice and modification of the cement kiln would involve major costs.

A second alternative would be deep ploughing into the surrounding agricultural land, but as the ground is clay, this would incur very heavy machinery and much expenditure of fuel.

The third proposal would be to digest it anaerobically. The sugar cane factory at Osijek, in all probability, produces large quantities of highly polluting effluent. The waste from the sugar factory, enhanced

with domestic sewage sludge, would be ideal for anaerobic digestion. Such a plant would also digest the wheat. This type of anaerobic digester plant would also provide a valuable source of methane gas and the resulting sludge would be of value as a fertilizer. It is proposed that this suggestion be examined by an anaerobic digestion expert.

**Of immediate importance is the *need* to treat the surface of the wheat with a fungicide, to prevent the formation of aflatoxins, and with rodenticides**

### Refuse disposal

The disposal of general domestic and industrial refuse is a matter of great concern.

General building debris from war damaged buildings, etc. mixed with glass, household garbage and industrial waste is being dumped by the roadside on the approaches to many towns, and indeed in the countryside generally.

The situation is aggravated by landfills at a number of towns being either now in Bosnian/Serbian territories or UN protected zones making access difficult or impossible.

Whilst it is fully appreciated that there is a vital need to reconstruct dwellings (and industry) with all speed, there is no need to incur even greater environmental problems for the future.

Additionally, a number of landfill sites are badly position, eg. too near important water resources, overfilled with no facilities for compaction, or simply inadequately managed.

There is a very urgent need for the Croatian Ministry of Environment to develop a nationwide master plan for both the handling of rubbish produced on a daily basis and to tackle the rubbish already accumulated.

Initially, it will be important to segregate refuse into at least the following categories.

i) Brick and cement based buildings materials. Special care will be necessary for disposal of asbestos, type usually unknown; this will be ofparticular concern for asbestos already dumped at roadsides, etc. There are uses for such debris, eg. in road making, core for foundations of new buildings, etc.

ii) Glass. The general disposal of glass in lay-by's on the Adriatic highway for example, coupled with dumping of tonage quantities in small (and very accessible) bays on the coast, if not abated immediately, will surely detract significantly from the return of much needed tourism. Croatia currently has only one glass recycling plant near Zagreb which is wholly inadequate for its current needs. In view of the large wine producing areas along the coast, and on the islands Korčula, Hvar, etc and in the north, Slavonia and the mineral water factory at Lipik, there is a requirement for glass recycling works. Suitable locations would be Našice or Slavonski Brod in the north and, Split on the coast. These should be considered as urgent joint venture enterprises.

Whilst it is foreseen that such enterprises would be much utilized for the next 2–3 years during reconstruction, throughput would then decrease for Croatian requirements. However, these, or similarly located enterprises would be geographically well placed to recycle glass from Bosnian where broken glass will be no less a problem.

iii) Domestic garbage. There is a need to recycle as much as possible, eg. food cans, plastic and paper food packaging etc. Expert from western countries should be invited to assist.

However, of paramount and immediate importance is good management of landfill sites, with adequate compaction. This should form an integral part of an environmental master plan. Obviously, it is of vital importance that landfill sites should be located sufficient distances from water resources, drinking, irrigation, fish farming, bathing etc. Whilst provision of such sanitary landfills is feasible in the clay type soil in the north-east area, eg. Slavonia; far greater care will be necessary in the interior, eg. in the Lika, where the geological structure is largely limestone karst which, if polluted, will prove costly and difficult to decontaminate.

In such areas and the coast, there may be noalternative to incinerate. If incineration is the only alternative, such facilities should be adjacent to thermoelectric power stations so as to utilize the waste heat effectively.

iv) Industrial Waste. Considerable care and an integrated plan are vital for the disposal of industrial waste. It is proposed that legislation based on that currently being deployed in the United Kingdom (and other western European countries), eg. Intergrated Pollution Control (IPC), Best Practical Means (BPM), Best Practical Environmental Option (BPEO), and Best Available Techniques Not Entailing Excessive Cost (BATNEEC).

Croatia, prior to the conflict suffered from a deficit of sewage treatment, a matter which needs consideration in its own right.

Factories which have lost their trade effluent treatment plants must not be permitted to recommence production, even on a limited scale, if their only means of disposal of hazardous wastes is to adjacent rivers.

Again, consideration of suitable incineration, whilst the last choice may be the only pragmatic alternative, but wherever possible consideration should be given to biological treatment or, on a limited scale, peroxidative treatments.

### Water resources

i) It is vital that Croatia inland water resources are protected from future abuse, from both chemicals or untreated sewage, the continual bombardment to both industry and to sewage treatment facilities increasingly

causes a potential public health hazard to countries to the East.

ii) Similarly, discharges of hazardous chemicals and polluting substances must be controlled prior to immission to the environment. This is particularly important for aqueous discharges to the tributaries of the River Danube so as not to impair the quality of drinking water supplies to other countries.

iii) In addition, greater care is vital, especially with refuse disposal (eg. at Dubrovnik) and untreated sewage to the Adriatic Sea.

**Polychlorinated biphenyls (PCBs)**

The spillage of PCBs from transformers and/or their condensers at the many towns damaged during the war is a major problem.

It is believed that one of the PCBs in question is Askarel (grade unknown) and is manufactured in Slovenija and perhaps Germany.

In many towns, eg. Dubrovnik 50+ transformers were destroyed, which has led to major hazards to both soil and waters.

In the north-east areas, in the basin of the rivers Drava and Sava, contamination of soil is likely to remain localized because of its clay-like nature; However, in the interior Lipa region and on the coast where the ground is limestone, contamination is likely to have severe consequences as the PCBs will transport to groundwater; surface and marine waters. In turn this will lead to contaminated potable drinking water resources, river and marine fish.

PCBs are known to bioaccumulate in fish with bioconcentration factors for Aroclors of 250 000 upwards. PCBs bioconcentrate in the food chain, as they are fat soluble, and are stored in lipid tissues of animals. They resist metabolic change. They have high toxicity to fish:

$LC_{50}$ (20 d) rainbow trout 21 $\mu g\ L^{-1}$

$LC_{50}$ (30 d) bluegill sunfish 150 $\mu g\ L^{-1}$

(for Aroclor 1260)

Its (Aroclor 1240) anaerobic removal from lake sediments is slow, maximum dechlorination rates for Hudson River and Silver lake organisms were: 0.04 and 0.21 $\mu g$–atoms of Cl removal per g of sediment $wk^{-1}$ respectively.

There is limited evidence for carcinogenicity to humans, and sufficient evidence for carcinogenicity to animals, IARC classification group 2A.

A retrospective cohort study in the U. S. provided some evidence for an association between occupational PCB exposure and mortality from malignant melanoma. There was an increased incidence of brain cancer among workers who had more than twice the estimated cumulative PCB dose than the comparison group.

Hence, it is unequivocal that massive spillage to soil and/or water of several tonnes in some towns can only lead to unacceptable hazards.

In order to undertake a much needed risk assessment, both soil and water analyses are required with urgency.

The Federal Environmental Agency in Vienna has offered to undertake a limited number of analyses and this offer should be accepted without delay with the view that results from such analyses can be discussed at the Brijuni conference in April.

It is recommended that the GC analyses for both soil and water should be undertaken at the locations indicated in Table 4. However, it may be possible to make an initial assessment for gross contamination by means of a Beilstein test.

*General remarks*

i) One grade of Askarel which, until 1977, was manufactured by the Standard Chlorine Co. Inc., Governor Lea Road, Delaware City, DE 19706, USA, was a 50:50 mixture of 1,2,4-trichlorobenzene and polychlorinated biphenyls. A risk analysis pertaining to this mixture was reported by Boykin in 1986[2].

ii) When burnt PCBs can be converted to polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzodioxins (PCDDs), thus leading to extremely toxic soots[3,4].

iii) The use of PCBs have been recommended for discontinuation in the former Soviet Union[5]. This review outlines details of the toxicity and ecotoxicity of PCBs.

*Treatment*

The treatment of PCB contaminated soils is both costly and involved. There are a number of case histories in the USA where decontamination from 1000 mg $kg^{-1}$ have been reduced to <10 mg $kg^{-1}$. The process consists of mixing potassium hydroxide, polyethylene glycols and other co-solvents and catalysts with the soil in a heated slurry process which dechlorinates the PCBs to non-toxic end-products. Plans for a mobile unit were proposed[6].

Mills et al.[7] proposed an incineration scheme for treating 266 000 L of PCB contaminated wastes. However, extensive rock coring monitoring well installation and pump testing, coupled with intensive groundwater quality monitoring, has allowed the delinioration of the DNAPL plume within the red rack. It is anticipated that similar large scale investigations will be necessary within Croatia, as microstrategraphy of the sites are a critical requirement.

It is also possible to treat PCB containing waters with U.V. light and hydrogen peroxide.

The long term consequences of such major PCB contamination of waters cannot be over-emphasized for both Croatia and countries to the East.

Table 4 – *Recommended Sites PCB Analyses*

| Town | Location | Soil | Water |
|---|---|---|---|
| Osijek | Near to destroyed thermoelectric plant | Yes | R. Drava |
| Pakrac | Near destroyed transformers | Yes | R. Pakra |
| Slavonski Brod | Duro Daković Holding Near destroyed transformers | Yes | R. Sava |
| Sisak | Near destroyed transformers | Yes | R. Sava |
| Delnice | On hillside by transformer | Yes | – |
| Gospić | Near destroyed transformers | Yes | R. Lika |
| Šibenik | | | Sea in harbor |
| Dubrovnik | Near destroyed transformers | Yes | Adjacent semi-saline water |
| | | | Drinking water supplies |
| Karlobag | | | Drinking water |
| Zadar | | | Drinking water |

NOTE: If river/sea water samples indicate concentrations >0.5 mg L-1 then fish tissues should also be analyzed.

**Training**

1. Microtox. This can be self-taught from a video[8].
2. Analitical chemical techniques such as GC, HPLC, GC-MS, Atomic Absorption, etc.
3. Newer techniques in water bacteriology.
4. Chemical information retrieval, validation and interpretation.
5. Hazard assessment of chemicals[4].
6. Risk assessment of chemicals[3].
7. Risk management of chemicals[2].
8. Safe disposal of chemicals.
9. Landfil management.
10. Safe transportation of chemicals, including hazardous and toxic waste.
11. Handling and disposal of asbestos.
12. Upland and lowland water catchment surveys.
13. Marine biological institutes at Split and Dubrovnik (and possibly Zagreb and Rovinj) training for examination of fish for genetic damage, eg. chromosomal aberrations, sister chromatid exchange, P450 cytochrome activities, etc.[8].
14. General training in factory worker exposure of the British COSHH Regulations and emission standards.

**Joint ventures**

1. *Glass recycling works*

Largely to produce bottles for wine, mineral water, milk, fruit juices, etc. Suggested locations Našice or Slavonski Brod and Split.

2. *Electrogeneration*

Electrogeneration of chlorine from sodium chloride solution at all municipal waterworks, hotels, food processing factories, etc. The use of ozone and chlorine dioxide should also be investigated.

3. *Paper making*

Using clean technologies at Slavonski Brod and Šibenik or Omiš, or inland on the rivers Krka or Cetina.

4. *Lipik glass factory*

Whilst this continues to manufacture specialist items, eg, car, bus, boat, windows, and curved tempered glasses; its sheet glass plant is completely destroyed. A feasibility study is required to consider if a float glass plant in this area is viable. Much needed window glass is being imported currently. Obviously, there is a need for window glass for the next 1–3 years in Croatia during reconstruction and possibly a further 2 years for Bosnia. There are also prospects for double glazing, especially for units utilizing PVC (or other plastics) frames, as it appears that wood frames were the material of choice.

5. *Tourism – Hotels, leisure centres, etc.*

There are many opportunities for hotel/leisure centres, particularly along the coast. The prospects are good, particularly for modern design all-in facilities, including advanced technology swimming centres. It should be remembered that whilst the costal scenery is magnificient, beaches are largely shingle or stones, with almost no sand. The sophisticated modern traveller would appreciate swimming pools to the sea. Additionally, in some areas the sea or shore may be polluted or at least contaminated with refuse or building debris, broken glass, etc.

Hence, large leisure centres, discretely built within the trees, the centres should be self-contained, with their own sewage treatment plants, and water purification facilities (using *in situ* electrogeneration of chlorine). Indeed, it might be feasible to convert the whole small islands. All year round complexes within 70 km of airports (Dubrovnik, Split, Zadar (when reopened), Rijeka, Pula, etc), are especially suitable. Similar complexes could be considered in the hills north of Slavonski Brod, near Lipik, with refurbishment of the spa facilities etc, at Dakovo, etc.

6. *Slavonski Brod*

Oriolik Oriofleke furniture factory. This was totally destroyed, but some limited production has commenced at a second site.

Because of the influx of refugees, the requirement for furniture, such as chairs etc, for hotels, houses, flats, to rehouse refugees from both Croatia and Bosnia, and the requirement for seats for buses, trains, etc. A joint venture with this company has enormous potential.

7. *Osijek*

Saponia detergents/cosmetics factory. It is understood that joint ventures for reconstruction of the eastern factory and modernization of the factory in the town would be welcomed.

8. *Otočac*

Cosmochemia factory – household and allied products. They would welcome a joint venture partner to recover their former flourishing market. However, prior to refurbishment, consideration would be needed as to whether Otočac is the best location. BPEO and BATNEEC would need to be applied to generate a »zero waste« philosophy.

9. *Gospić*

Wood industry. Joint venture partner is sought to double at least existing wood industry. The wood industry at other locations should also be considered for enhancement.

10. *Dubrovnik*

Graphite copper electrode/bush factories. These factories provide essential accessories for electric motors and many other industries. Whilst the factory in the town centre is partially in operation (largely sintered cooper), and the second (largely graphite) totally destroyed. These are essential industries for Croatia and require to be located away from such a tourist town to either Split or, say Kutina.

11. *Dubrovnik*

Wine cellar and vineyard. It was estimated 4 MDEM would be required to rebuild the cellars. However, it should be noted that the wooden vats are largely undamaged. A further 2 MDEM would be required for the vineyards. An initial assessment by a qualified expert is required.

12. *Šibenik*

Aluminium smelter. An investment of at least 1 MDEM would be required.

### Monitoring

The question of monitoring can not be overstressed. This will need to be specific, especially for metals, PCBs, etc; but in the majority of cases generic monitoring such as that obtainable by the Microtox test, ie, that based on the effect to the luciferase activity of *Photobacterium phosphoreum* is an essential and immediate requirement[8].

### A multidisciplinary approach

Croatian scientists also need to receive training in multi-discipline, multi-process techniques so that they can advice on cross-utilization of products wasted at one plant for use at a second, as a raw material. This is of particular importance so that materials badly damaged and having little or indeed a negative value at one location could be either used usefully at a second location or destroyed by the consideration of the construction of a facility currently lacking at that installation. Such a facility could be used to destroy damaged material from the second location, eg. the wheat from the damaged silo at Vinkovci could be anaerobically digested at the IPK sugar factory at Osijek, which would mean that provision of an anaerobic digester at IPK would have an enhanced immediate benefit.

## Conclusions

The effects of war on the natural environment are considerable. Many of the damage to the environment as detailed in this report will undoubtedly lead to polution of soil and water. The effects resulting from the many and, in some cases, massive spillages of PCBs are very serious.

The consequences of damage to chemical installations and to sewage treatment facilities are predicted to be acute, chronic, and severe. These will (or already are) causing adverse public health effects likely to develop from potable waters abstracted from the River Danube from Serbia, through to the Black Sea. In turn this is likely to affect fish and all aquatic and avian species reliant on this great river. If unabated, similar adverse effect will result in the Adriatic Sea.

The spillage, and in particular, loss of sewage treatment facillities in towns such as Gospić in the interior could lead to contamination of underground waters essential for potable waters at the coast, islands, etc.

The indiscriminate dumping of refuse enhanced by building debris, broken glass, etc, is not a solution, but the making of an even greater problem for the future. This is but one of the many aspects that the Croatian Ministry of the Environment needs to address with urgency.

The next stages should include:

i) Further visits and assessments as indicated above;

ii) Monitoring of the hazards identified;

iii) Risk assessments; and

iv) Remedial action.

Simultaneosly with i – iv above, serious consideration is advised for joint venture projects.

A similar mission to Bosnia must be considered as an urgent priority as soon as security permits.

Only by means of a sustainable environment can a stable economy be achieved.

It must be stressed that if discharges to soil or water or contamination to soil remains unabated, then the effects to public health, both short and long term, are potentially significant for Croatians and in its neighbouring countries to the East. There are now many references in the literature[9] to such adverse effects, especially so in the countries in the Former Soviet Union where in many areas mortality rate is exceeding birth rate and increasing incidences of congenital mal-

formations are placing an ever increasing load on an already over burdened infrastructure.

These problems are not just local problems but must be reviewed as global problems and can only be atacked successfully by a concerted effort on a global scale.

These, and other environmental problems can only be tackled by agreement being reached between ALL the nations on earth. The only planet currently we are able to inhabit – nature's tolerance (to the abuse observed in Croatia and assumed to be even worse in Bosnia) is finite – we have nowhere else to go and no more time to waste.

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**SAŽETAK**

**Procjena hazarda i rizika po okoliš u Hrvatskoj kao posljedica ratnih razaranja**

*M. L. Richardson*

Pregledno su prikazana oštećenja industrijskih instalacija u Hrvatskoj kao posljedice agresije. Mjesta i oštećene instalacije su poimence navedene sa procjenama rizika i prioritetima sanacije. Prikaz se temelji na misiji pokrenutoj od strane UNIDO-a, Beč za utvrđivanje stanja oštećenosti industrije i okoliša ratnim razaranjima. Uz ostale vidove zagađenja naglašena je možebitna kontaminacija zamljišta i vodotokova spojevima tipa poliklorirani bifenili (PCB), te potreba hitnog djelovanja radi procjene rizika za stanovništvo istočne Hrvatske i susjednih zemalja.



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# Contamination of the Air with Mineral Fibres Following the Explosive Destruction of Buildings and Fire


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Mineral fibres of, for example, gypsum, glass and asbestos are ubiquitous contaminants of the environment. Asbestos is generally present at levels below 1 fibre/L in air though 10 fibres/L may be found in cities, levels which do not appear to be high enough to present a hazard to health. The fibres result largely from the use of fibrous materials as thermal and acoustic insulation in nearly all buildings as well as their use as friction materials. Occupational air levels historically were often very high, though in the Western world this is not true today. As a result the clinical effect was a high incidence of fibrosis and also cancer in exposed workers, mostly among those in the industries concerned with the winning or processing of asbestos fibre. Levels high enough to produce disease have also occurred para- occupationally in the families of asbestos workers. The effect of fire and explosion in a building is to disrupt its structure and vastly increase the level of airborne fibre for a considerable distance (kilometres) around it. Air levels of fibre can remain high for months. The earliest occupational experiences are likely to be repeated. From the fibres the greatest danger is from exposure to blue and brown asbestos since it is known that even a single high exposure can be responsible for the development of a tumour decades later.

## Introduction

Mineral fibres are ubiquitous contaminants of the environment although air levels have increased about 10-fold since the start of the industrial revolution. A hundred and fifty years ago there was little production of and few uses for mineral fibres. Exposure, therefore, was only to the background level of mineral particles derived from natural comminution of rocks or sand and the air lofting of dried clay or alluvial deposits. Fibres came from natural sources such as the erosion of asbestos and asbestiform rocks. Chrysotile, for example, has been found in cores from the Greenland ice-cap dated to 1750[1] and in a study of the fibre content of Antartic ice nearly $10^6$ f/l were found in 10,000 year old ice. In comparison just over $10^7$ f/l were found in snow falling in Japan in 1984[2]. The industrial exploitation of asbestos began about one hundred years ago following the discovery of large deposits in Canada and South Africa. Man-made mineral fibres (MMMF) have been around for rather longer, about 150 years, with the first mineral wool produced from slag and intended for insulation[3]. The uses for these fibrous minerals expanded dramatically, and their exploitation continued even after the health hazards associated with their use became known. It is important to underline, though, that »normal ambient levels«, although readily measurable, do not apparently constitute a health hazard[4] and that potential risks from such exposure are small[5] when compared with, for example, sports activities[6]. A particular impulse in the exploitation of asbestos came with the first world war. Asbestos fireproofing of warships was said to be a dramatic success, although, ironically, both sides used the same amphibole from South America in the famous navel battle of Jutland.

There are a number of common fibres both natural minerals and man-made materials. Asbestos is well known but this is a collective, trivial, name given to a group of highly fibrous minerals belonging to two distinct cristallographic groups (Table 1). These minerals are readily separed into long, thin, strong fibres and are used for their insulating properties, or in a composite, where they add strength, as in cement, or increased friction, as in brake shoes. Chrysotile, or white asbestos has accounted for over 90 % of the world trade in asbestos minerals. It is a serpentine mineral while the others are all amphibole minerals. Amphibole asbestos has greater acid and water resistance than chrysotile and has been used where these properties make it more suitable. However, it is often commercial reasons which decide the type of asbestos to be used. Users and fabricators would often be unaware of the defferences between the types of asbestos and so different minerals could have been used for a single application.

MMMF is a self-explanatory term but a large variety of types are produced with diverse chemical compositions, properties and uses[7]. Sometimes referred to as »asbestos substitutes« the majority of uses for the man made fibres are relatively novel and ones for which the natural fibres are unsuitable. For example refractory ceramic fibres are resistant to considerably higher temperatures than are any of the natural fibres (Table 2). The development of synthetic fibrous insulation materials has been given a great impetus in recent years by the need for more thermally efficient buildings and industrial processes.

Table 2—*Man-made mineral fibres (MMMF)*

| Type* | Uses |
|---|---|
| Continuous filament glass | Reinforcement of composites, textiles, electrical insulation |
| Glass wool<br>Rock wool<br>Slag wool | Thermal and acoustic insulation |
| Refractory:<br>ceramic<br>others (e.g. SiC) | High temperature (furnace) insulation |
| Glass microfibre | High performance insulation especially aircraft. |

* The glasses and rock and slag wools are generally molten in the range 1000-1500 °C. Ceramic materials melt over range 1700-2600 °C but start to disproportionate below 1000 °C

The high levels of environmental asbestos and other fibres found today reflect the heavy usage of fibrous materials in buildings, for insulation and as reinforcement in composites, and as insulation for boilers and pipework in ships and factories and elsewhere. Other fibres found in the environment besides the various asbestos minerals include calcium sulphate, MMMF, silica fibres, usually of plant origin and a number of

Table 1 – *Characteristics of some fibrous minerals*

| Mineral | Class | Theoretical Formula | Colour | Thermal* Stability (°C) | Density ($d.cm^{-3}$) |
|---|---|---|---|---|---|
| Chrysotile | Serpentine | $Mg_3(Si_2O_5)(OH)$ | White to pale green | 450–700 | 2.55 |
| Crocidolite | Amphibole | $Na_2Fe(II)_3Fe(III)_2(Si_8O_{22})(OH)_2$ | blue | 400–600 | 3.3–3.5 |
| Amosite | Amphibole | $(Fe,Mg)_7(Si_8O_{22})(OH)_2$ | Light grey to pale brown | 600–800 | 3.4–3.5 |
| Anthophyllite | Amphibole | $(Mg,Fe(II)_7(Si_8O_{22})(OH)_2$ | White to grey or pale brown | 600–850 | 2.9–3.5 |
| Tremolite | Amphibole | $Ca_2Mg_5(Si_8O_{22})(OH)_2$ | White to grey | 950–1040 | 2.9–3.1 |
| Acinolite | Amphibole | $Ca_2(Mg,Fe(II))_5(Si_8O_{22})(OH)_2$ | pale to dark grey | 620–960 | 3.0–3.2 |

* Temperature range over which dehydroxylation or dehydrogenation (condensation) with consequent breakdown of the crystal lattice and loss of strength occurs.

other types of fibres of unknown origin. Most of the fibres derive from man's activities. The commonest fibre in indoor air is usually Gipsum (calcium sulphate) shed from plaster and other building materials, which is, with the evidence of centuries, harmless. In addition, asbestos fibres are commonly found in water, usually originating from asbestos-cement pipes or asbestos-containing aquifers. Concentrations are typically less than one million fibres per litre but a billion fibres per litre are occasionally found[8].

## Discussion

### *Asbestos use*

The construction of any domestic or public building usually includes mineral fibres as thermal and acoustic insulation or fire proofing. Asbestos is found as thermal lagging of pipes and boilers or sprayed or trowelled onto walls, roofs or structural members as fire protection. In addition it is used in a number of structural elements: as reinforcing for cement products for cladding and roofing such as asbestos cement slates, troughed or corrugated sheeting, soffit boards or fire proofing. Asbestos cement flue pipes, rainwater pipes and gutters are used extensively and even large water mains may be made of this material. Some building materials which are apparently non- fibrous may contain fibres, for example vermiculite can contain tremolite, an amphibole asbestos, as an impurity. Man-made mineral fibres (MMMF) such as rock and glass wools are commonly, used as loft and cavity wall insulation or may be compressed for use in partitions or for use as pipe insulation. Compressed to a higher density they are used in wall and ceiling tiles. Various MMMF are used as reinforcing agents in solid plastics, for example vinyl flooring, where they replace asbestos which is found in older materials, also both types of fibres are found in cement and as the base in bitumen felts. Glass reinforced plastic is used for cold-water storage tanks, as roofing and has other more specialised uses.

### *The aftermath of fire and explosion*

Although asbestos is often used for its non-combustible and fire- protective properties, in sheet form it does not merit any fire resistance and it cracks in building fires. The fabric of the sheet is even more likely to break apart if the material is worn or if it is impregnated with resin. Glass and other mineral wools while themselves noncombustible can be rendered combustible by resin and oil binders. External asbestos cement sheet becomes weathered with time through the loss of cement from exposed surfaces and it is known that interference with such material can cause high levels of air-borne contamination[9,10]. Explosive destruction will obviously produce very high ambient fibre levels and expose more fibre which means that care must be taken in subsequent demolition works.

Fire or explosion in a building will expose and release the fibre materials used in it. Fire, particularly, will liberate fibres used as re-inforcement in plastic and bitumen composites, and to a lesser extent that in asbestos cement sheeting. There are isolated reports of clean-up following fire[11] but no other readily available information. Explosion will reveal and disperse fibres from any site in a building. As a result not only will airborne concentrations of respirable dust increase over a wide area but there may be localised high concentrations in and near to damaged buildings. The greatest and most dangerous exposure of fibres probably results from explosion rather than fire. This is because asbestos is not thermally stable at high temperatures. Chrysotile starts to breakdown at 450 °C and the amphiboles at 400–600 °C (and although the asbestos may still appear to be fibrous the fibres will be readily comminuted to a dust which does not have the same pathogenicity as the original fibre. Mineral wools are much more resistant to high temperatures, this, for many is their *raison d'être*, but at the temperatures that would be found in the heart of a fire they may melt or otherwise be chemically and physically altered. Ceramic fibres at temperatures above 850 °C may undergo conversion to cristobalite and mullite which, like asbestos, makes them friable[12,13,14].

People perticularly at risk from exposure to fibres will be those seeking refuge during hostilities and later those involved in clearance operations to whom the risk of falling masonry may seem a greater threat than the soft fibre released by the destruction. High ambient levels of fibres will exist near any destruction for a considerable period of time[15]. Indoors levels could be raised for months[10]. Unfortunately, if the asbestos release contains significant amounts of amphibole, such raised levels could pose a health hazard. As will be detailed below, a single acute exposure to amphibole asbestos can be responsible for tumours appearing from 20 to 50 years later[16]. Once liberated into the atmosphere the aerodynamic properties of asbestos ensure that respirable fibres can travel considerable distances. The only cleaning mechanism for the air is washout by rain or snow. The ambient level, remote from any source of asbestos fibre, is generally below 1000 f/m$^3$ and often below 100 f/m$^3$ in rural areas but may be up to ten times greater in urban areas. Occupational levels can be an order of magnitude greater again. These levels will be vastly exceeded following an asbestos release. A more visible but probably less serious danger than that of inhalation arises from the contamination of water and food supplies[17,18].

### *The pathogenicity of asbestos and mineral fibres*

The discovery of the adverse health effects of asbestos was a slow process. Auribault (1906) gave an example of what happened when a French textile mill introduced asbestos to its spinning and weaving machinery without any modification of ventilation[19]. Over a five year period fifty workers died but, at the time, this level of mortality caused little impression. High death rates, usually due to tuberculosis, were common. However, the question was raised – did the clouds of dust expedite the tuberculosis deaths? It took

a long time, in the history of the industry, before the specific health effects of asbestos were noted. After the early observations, which were more concerned with tuberculosis, the first report of fibrosis due to asbestos is probably that of Cooke (1924)[20]. The first real studies into the health effects of fibres of insulation wool were not undertaken until the 1930s and even then the concern was with tuberculosis.

Today we know that mineral fibres cause pathogenicity and the effects are best seen in populations of exposed persons[21,22]. The effects of such exposures can include the excessive deposition of collagen (fibrosis) at various thoracic sites, tumours of the pleura or peritoneum (mesothelioma) and lung cancer. Attempts have been made to link asbestos exposure to tumours at other sites but these are problematic and poorly justified.

For fibres to exert a toxic effect on the body they must gain entrance to it and the only reasonable routes are by ingestion or inhalation. Health effects have been clearly associated with inhalation and this is by far the most important route of exposure to humans. The importance of ingestion is unclear and there is a general consensus that this route is of far less importance than inhalation. Only a fraction of airborne fibres are of a size to be respirable and, therefore, of biological importance. Large fibres, above 3 $\mu$m diameter, are not respirable, and the smallest fibres, below 0.01 $\mu$m diameter, are not retained in the lungs[23]. The concentration of mineral fibres at ambient levels found in most of the Western world are not considered harmful though sufficient to ensure that we inhale at least one fibre with every breath we take. Most of these fibres are not particularly durable *in vivo* and do not remain in the lungs. Chrysotile and MMMF are less durable than amphiboles[24] which are very durable. Over a lifetime we accumulate some $10^6$ fibres/g lung dry weight which are mostly amphiboles.

The health concerns about asbestos have a good basis but the facts are less dramatic than many would have us believe. Persons not engaged in occupations involving handling, processing or removing asbestos or MMMF are rarely exposed to levels of the fibre which are enough to produce any demonstrable clinical effect or give cause for concern. However the para-occupational exposure experienced in some families of asbestos workers has resulted in the development of pleural mesothelioma[25]. This has also been observed in people who lived or worked close to an asbestos plant in Pennsylvania[26]. Measurements made by Nicholson at al[27] in the homes of miners and nonminers in a chrysotile mining community in Newfoundland showed that fibre concentrations were several orders of magnitude higher in the former than in the latter. It is the observation that disease can result from such incidental exposure that is so worrying when considering the aftermath of fire or explosion. However, the epidemiological evidence, in summary, is that mesothelioma and possibly lung cancer can occur from domestic exposure or working near crocidolite mines or factories but this has not been observed for chrysolite or amosite[28].

In general it seems that a greater exposure is necessary for the development of fibrosis than for neoplasms. Fortunately, these »fibrotic« conditions are not a threat to the general public, frank fibrosis of the lungs or pleura normally only occurs after heavy occupational exposure. Asbestos miners and those who prepared and fabricated asbestos containing materials and who were exposed to enormous quantities of airborne dust have long been known to suffer the lung disease asbestosis, similar to the silicosis suffered by miners, sandblasters and others. This type of occupational disease is characterised by the deposition of »scar tissue« consisting of fibres of the protein collagen in the lungs. Exposure to fibrous dust can also cause scaring, or fibrosis, of the pleural lining of the chest or covering of the lungs, which does not happen following exposure to silica. Lower exposures of asbestos, and possibly other fibres, than are required to produce pulmonary fibrosis can result in the formation of so called pleural plaques. These are areas of fibrous tissue on either the pleural surface of the lungs (visceral pleura) or on the body wall lining (parietal pleura). These fibrous areas can become calcified but do not seem to cause any illiness and do not progress into any more damaging condition. Pleural plaques are endemic in parts of Europe and in people apparently not-occupationally exposed to mineral fibres. It is believed that the plaques could arise from the presence in the environment of fibrous clays.

The most serious pathogenicity associated with exposure to fibres is the development of cancer, either lung cancer or mesothelioma[29]. The risk of an individual developing lung cancer increases in a way linearly related to cumulative exposure. This is in contrast to the dose relationship for the development of mesothelioma which is proportional to fibre concentration and exponentially related to time since first exposure[30]. Because smoking is so common one factor that must be mentioned is that the risks of lung cancer from smoking and asbestos exposure are multiplicative. This and the interaction between fibres and other carcigens has been the subject of a symposium[31].

The disappearance of fibre from the body can take place by several routes: mechanical clearance of the larger fibres that have not penetrated deep into the lungs by the mucociliary escalator, engulfment by macrophages followed by translocation out of the lungs, or dissolution. Studies in guinea pigs of the short-term pulmonary clearance of MMMF have shown a two step clearance, the first with a half-life of 12 h is attributed to the fast clearance in the ciliated airways and the second with a half-life of 380 h to clearance of fibres from the pulmonary compartment[32]. It is the long-term clearance that is of the greatest relevance to dissolution studies. It has been shown that as the fibre dissolves it becomes thinner[33] and therefore more liable to breakage, also the surface area and consequently the rate of dissolution increases. This work suggests that the solubility of the fibre contributes most in the clearance of inhaled ceramic fibres from the lung.

Asbestos is not usually considered harmful by ingestion. Most inhaled asbestos is eliminated from the

body by the GI tract following clearance from the lungs up the mucociliary escalator. There is no information on how inhaled asbestos eliminated by this route might differ from ingested asbestos. Epidemiological studies in regions of high risk (over $10^5$ f/l) do not confirm a causal relationship between asbestos-contaminated drinking water and tumours of the gastrointestinal system or of other sites[17,34]. A major report from America of all the available literature pertaining to the potential risk of cancer associated with ingestion of asbestos[35] concluded that this risk »... should not be perceived as one of the most pressing potential public health hazards facing the nation.« However ingested asbestos is not without any effect. There are reports that short fibres are able to penetrate the wall of the intestine and can then be eliminated in the urine or accumulated in various organs and that elevated asbestos concentrations have been detected in colon cancers of asbestos workers[8]. Animal experiments in which rats were given 0.5 g/l chrysotile in their drinking water suggested that such chronic exposure resulted in a decreased ability of the intestine to absorb some non-metabolisable sugars[35].

Because of the proven pathogenicity of asbestos and some other mineral fibres, after occupational exposure to very high levels, there has been a public response in many countries which was sometimes near-hysterical and quite inappropriate to the risks generally posed by non-occupational exposure to the levels in ambient air. However, when ambient levels are vastly increased the exposure can be to the levels once known occupationally. Then the presence of durable mineral fibres in the environment is a hazard to future health and this should be heeded in the aftermath of the present hostilities.

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**SAŽETAK**

**Onečišćenje zraka mineralnim vlaknima kao posljedica eksplozivnih razaranja i požara**

*I. A. Hoskins and R. C. Brown*

Mineralna vlakna (gips, staklo, azbest) stalno su prisutni u zraku. Prisutnost azbesta je obično u nižim koncentracijama (1 vlakno/L zraka), dok u gradovima dosiže nivo od 10 vlakna/L što još uvijek nije dovoljno da bi predstavljalo opasnost po zdravlje. Porijeklo vlakana je iz materijala koji se koristi za toplinsku i zvučnu izolaciju. Značajnija izloženost mineralnim vlaknima može imati za posljedicu visoku učestalost fibroza i kancerogenih oboljenja. Zastupljenost vlakana u zraku može se znatno povećati požarima i eksplozivnim razaranjima u kilometarskim udaljenostima od mjesta eksplozije. Posebnu opasnost predstavlja izlaganje plavom i smeđem azbestu. Čak i jednokratno izlaganje ovom tipu azbesta može uvjetovati razvoj tumora desetljećima kasnije. Uz pregled primjene azbesta i posljedica eksplozija i požara navedena su i patogena djelovanja mineralnih vlakana.

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# Actions Intended to Reduce Radiation Risks in the Areas of Croatia Affected by the War

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Lot of devices with installed ionizing radiation sources have been used in the areas of Croatia affected by the war. They have been mainly applied in industry and medicine, but the most numerous radiation sources considered are radioactive lightning rods (protectors) and ionizing smoke detectors. In destruction caused by the war operations, a number of these devices was demaged or even destroyed, being turned into a special type of radioactive waste. Consequently, there have been developing circumstances leading to possible environmental pollution and imperilment of human health. Hence, the Croatian Radwaste Management Agency, as an authorized institution supported by some international organizations (IAEA, Conference of European Communities etc.) started the rescuing of radioactive waste deriving from damaged and/or destroyed radiation sources in the ares of Croatia affected by the war.

## Introduction

Since July, 1991 almost a half of Croatian territory has been affected by major war operations. Under heavy artillery attacks and air raids a large portions of Croatian regions of Slavonia, Banija, Lika and Dalmatia have suffered serious damages. It became eventually clear that in all areas affected by war a special attention should be played to damaged and/or destroyed ionizing radiation sources turned into radioactive waste. The sources have been installed mainly in medicine (used for diagnosis and therapy) and industry. But the most numerous sources are radioactive lightning rods (protectors) and ionizing smoke detectors. Consequently, damaged, destroyed or lost radiation sources are supposed to endanger the environment and human health not only in affected areas or even in entire Croatia itself but also – due to possible uncontrolled transboundary migration of these sources – in the other countries. Therefore, it has been given a high priority rate to the rescuing of radioactive waste that has been derived from damaged

or destroyed radiation sources in the areas of Croatia affected by the war. The project implementation started in September 1992, after the allowance for approach to damaged or destroyed sources had been issued by the Ministry of the Interior. The project is planned to be carried out until September 1993. The Ministry of Health, Ministry of Civil Engineering and Environmental Protection, Ministry of the Interior and Ministry of Defence are cooperating in the project. An expert consultancy has been given by the IAEA. Radioactive waste considered is being stored in interim storages in Zagreb.

It should be emphasized that rescuing of radiation sources turned into radiactive waste, figures as prerequisite of the country renewal. The approach of inhabitants of workers participating in restoration activities to most of buildings or facilities containing damaged or destroyed radiation sources will not be allowed before considered sources will be removed.

According to register on radiation sources in Croatia, there have been installed in the areas affected by war 6.800 ionizing smoke detectors, 105 radioactive lightning rods and 90 other sources, installed mainly in industry. The largest medicine institution affected by war is the hospital in Osijek, having installed a cobalt bomb (activity 90 TBq) and 16 needles Cs-137 reaching 55 GBq. The most frequent isotopes considered are Co-60 and Eu-152, encapsulated in radioactive lightning rods and ionizing smoke detectors, as well as Cs-137, being applied in industry.

In accordance with the above mentioned records, the mean (per source) activity of installed ionizing smoke detectors is ca. 100 kBq, of radioactive lightning rods cca 10 GBq and that of sources used in industry 370 MBq – 7.4 GBq. But it should be added that allowed activity of radioactive lightning rods in the OECD countries must not surpass 400 MBq if the source is Am-241, respectively, 40 MBq if the source is Ra-226. Without regard to these imitations, the use of radioactive lightning rods is not recommended in Italy, and is even forbidden in Sweden and Denmark[1].

The share of destroyed, damaged and lost sources in the considered areas *i.e.* the quantities and activities of radioactive waste derived from them is not yet precisely known.

Having in mind the present situation concerning come-back of refugees to their homes and restoration of Croatian economy, rescuing priorities in terms of objectives contained in the considered project, are given to the urban areas of Osijek and Vinkovci in Slavonia as well as to those of Zadar, Šibenik and Dubrovnik in Dalmatia.

## Methodology

Methods supposed to be used in the project implementation should consider types of radiation sources to be rescued, identification of damages on the radiation sources affected by war operations, defining of the project performance scenario and presentation of results. Therefore, these four topics are briefly discussed in the paper.

### *Types of radiation sources*

Since radioactive lightning rods and ionizing smoke detectors are the most numerous radiation source affected by the war, an information on operating types of both devices is given here.

### *Ionizing smoke detectors*

As it is presented, ionizing smoke detector is composed by two chambers containing low-active ionizing radiation sources: Ra-226 has been almost completely replaced by Am-241 (Figure 1). There are two Am-241 source types being applied: sources having lower activity (20–100 kBq) in households, and those with higher activities (up to 4 MBq) in industry.

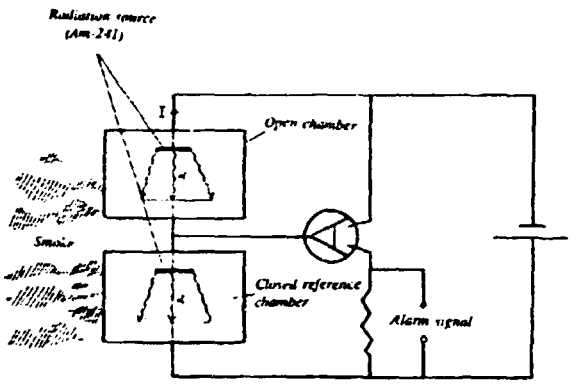


Fig. 1 – *Ionizing smoke detector*

After recommendations by the OECD/NEA, ionizing smoke detectors should be subjected to recovery and the normal radioactive waste disposal requirements at the end of their useful life[2]. If subjected to fire only very small amounts, if any, would become airborne. Ionizing smoke detectors are fairly safe even in case of accidents. It should be mentioned that the most likely pathway leading to exposure to radiation from the misuse or mutilation of ionizing smoke detectors would be that involving transfer of contamination from damaged sources to fingers and subsequent ingestion of the activity[2]. Circumstances leading to such accidents should be expected in the areas affected by the war, above all concerning the children playing around the places with damaged ionizing smoke detectors.

### *Radioactive lightning rods (protectors)*

Radioactive lightning rods bearing two types of ionizing sources have been applied most frequently: Co-60 and Eu-152,154. These sources are gammaemitters, being encapsulate in special holders (Figure 2). Their standard (mean) activity is 10 GBq, varying in

general between 7.4–14.8 GBq per source. Due to higher ionization capability Co-60 is more frequently applied, but it has shorter decay half-time than Eu-152,154. Based on air-ionization principle, maximal range of Co-60 gamma-emission is some 360 m and decay half-time 5.26 years. On the other hand, half-time of Eu-152,154 is 13 years, but due to its lower ionization capability, it should be installed a stronger source.

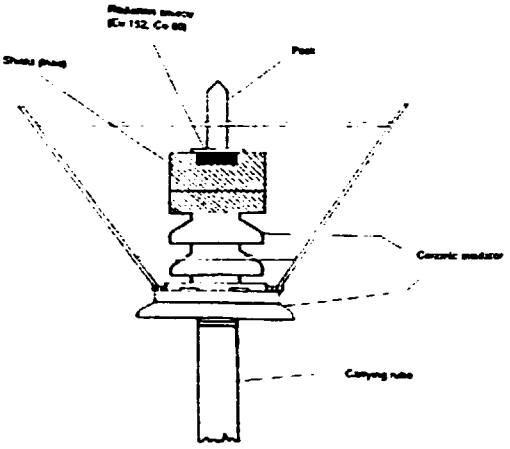

Fig. 2 – *Radioactive lightning rod (arrester)*

Due to estimate risk deriving from displaced damaged radioactive lightning rod, we have performed a rough calculation of dose rate for radioactive lightning rods with unshielded (open) dotted source characterized by isotropic radiation (Table 1). In calculation we have induced presumptions that displaced lightning rod is placed in the factory area and the worker is exposed to radiation 4 hours per day.

Table 1 – *Estimated exposures in ionizing radiation of radioactive lightning rod*

| Distance to radiation source (metres) | Dose rate (mSv/h) | Time needed for annual dose absorbtion (1 mSv) |
|---|---|---|
| 1 | 0.351 | 3 hours |
| 5 | 0.014 | 18 days |
| 10 | 0.0035 | 71 days |
| 15 | 0.0016 | 156 days |

*Damages identified an radiation sources*

As it has been already mentioned, the precise number of damaged, destroyed and lost radiation sources is not known so far but there is a well-arranged register on radiation sources in Croatia. The contact with most of radiation source owners in the areas affected by war has been re-established and identification of actual situation in the non-occupied areas of the country is going to be terminated soon. This introductory stage is being immediately followed by the field-inspection according to the above mentioned priorities.

According to available information, major damages and possible dangers concerning radiation contamination could be expected at facilities containing the industry applied sources like defectoscopes, gauge-metres etc., and both the ionizing smoke detectors and radioactive lightning rods which have been installed at numerous sites. The first rescuing action scheduled is to carry out an inspection of all affected sites by an expert team in order to assess radiation protection measures and, if needed, to remove the radiation source.

*Project performance scenario*

In order to ensure a complete and well-organized project implementation, based on realistic time-schedule and rational budgeting, the following operation stages should be considered:

(1) preparatory actions (including purchase of equipment and financial means needed to run the project);
(2) get reliable data on damages identified on radiation sources in the affected areas, according to the register on radiation sources users;
(3) provide for a strict access control for all damaged buildings and facilities containing radiation sources;
(4) measure the radiation and contamination levels, and foresee local actions referring to the management of damaged and/or destroyed radiation sources;
(5) organize rescuing of considered sources by the authorized expert team co-operating with representatives of source users;
(6) transport damaged and destroyed radiation sources by special vehicles equipped in accordance with the Law of Transportation of Dangerous Materials[3], and provide and adequate control;
(7) before storing, classify sources in order to separate those, foreseen to be re-used, apart of the unusable sources that will be considered as radioactive waste;
(8) provide adequately arranged necessary storing capacities for unusable *i.e.* damaged and destroyed radiation sources (undamaged radiation sources could be temporary stored at their original sites if it could be expected them operating in reasonably short term).

It should be noted that the public will be continually, completely and correctly informed on the project performance[4].

According to the available information, it seems to be even much more damaged or destroyed radiation sources in the neighbouring Republic of Bosnia and Herzegovina. It would be necessary to plan and integral and co-ordinated action of their saving as soon as the war in this country will be over.

*Presentation of results*

The operational stage leading to fulfilment of the project objectives, started in September 1992. It is reffering to inspection and immediate rescuing actions of damaged or destroyed radiation sources. The actions are being carried out by the experts coming from the ECOTEC, the authorized institution for handling radioactive materials. Each rescuing mission is supposed to be registered on Rescuing Action Report Form containing basic data on the ionizing radiation source (name of the owner, location, person in charge, radiation source and its activity and decay half-time, type of device bearing radiation source etc.), description of damages that have been caused by war, and performed radiation source rescuing measures. The report should present a status concerning possible environmental contamination and measured radiation doses on the site. It should be submitted by the operating expert team to the Ministry of Health holding the Register on Radiation Sources in Croatia and the Croatian Radwaste Management Agency as the project leading institution.

## Results

There have been performed nine rescuing missions until the end of 1992. All of them are referring to rescuing of displaced radioactive lightning rods and ionizing smoke detectors in the region of Eastern Slavonia as follows (given information is referring to: town – site – radiation source – date of beginning of rescuing action):

1. Slavonski Brod – compensator plant »Duro Daković« – radioactive lightning rod – 15/9/92;
2. Osijek/Nemetin – chemical industry »Saponia« – ionizing smoke detectors – 21/9/92;
3. Vinkovci – bakery – radioactive lightning rod – 30/9/92;
4. Vinkovci – grain elevator – radioactive lightning rod – 09/11/92;
5. Županja – dairy-plant – radioactive lightning rod – 09/11/92;
6. Osijek – »Mara« company – radioactive lightning rod – 10/12/92;
7. Vladisavci – »Mobilia« company – radioactive lightning rod – 15/12/92;
8. Čepin – oil plant – radioactive lightning rod – 15/12/92;
9. Slavonski Brod – grammar school – radioactive lightning rod – 15/12/92.

At all the mentioned sites, excluding the case 2, no contamination has been identified, and the measured radiation dose was within the background values. Damaged ionizing smoke detectors, scattered within destroyed buildings, were supposed to contaminate surrounding building material. Hence, after removal of damaged smoke detectors, this building material has been collected at sites where continual radiation control is possible to be carried out. According to the performance scenario, all the mentioned damaged radiation sources have been removed and transported to special interim storages for radioactive wastes.

## Discussion

Aiming to successful realization of the project, there are two topics needed to be discussed: operational problems arising from political and military situation in the parts of Croatia affected by war or occupied by Serbian rebels, and an international support to the project.

*Practical problems arising in the project implementation*

The main problem in carrying out the operational tasks is limited, aggravated or even impossible access to some areas where the objects containing radiation sources have been identified. There are mainly two groups of the access difficulties: physical and political. The first group of problems is relating above all to mine-removal around the objects or facilities of interest, and the second to the access to areas being not yet under control of Croatian Government, without regard for they are being controlled by the UN Protection Forces (UNPROFOR) or they have been neither liberated nor fully controlled by the UNPROFOR. Hence, the project has been planned to be carried out first in unoccupied areas where access to the buildings containing radiation sources is possible, and thereafter in the areas where the enemy is refusing to be replaced by the UNPROFOR. Although there is no access possible to these, still occupied zones, we have some information on situation concerning radiation sources safety in that regions: *e.g.* there is the alumina facility at Obrovac in nothern Dalmatia containing 18 radiation sources Cs-137 and one source Co-60 (their mean activity is 3.7 GBq per source). The facility storing area, being still under control of the enemy, has been meanwhile turned into the ammunition dump and – according to some rumours – blew up a couple of months ago. If it is true, disintegration of the radiation sources into dust particles occurred followed by their further airborne dispersion. In these circumstances, a serious contamination having possible impact to human health could be expected.

*International support to the project*

The stand-by arrangement in terms of consultancy and supervision of the project has been established with the IAEA. In accordance to this, an expert mission was carried out in August 1992[5]. The Croatian experience on management of radiation sources affected by war operations (and being consequently turned into radioactive waste) is supposed to be helpful to the IAEA; moreover, some of the IAEA actions in the field are being implemented for the first time just in the case of the war that has taken place in Croatia. According to this, the IAEA is going to develop procedures dealing with disasters, including war as well.

The procedures are expected to be issued as the special IAEA guidelines.

The IAEA has already purchased a part of the equipment needed for the project implementation, donating it to the project leading company – Croatian Radwaste Management Agency. The equipment is just being delivered and, consequently, some of project tasks have been run.

In addition, the Westinghouse Energy Systems International made recently a financial donation to the project. The project started in September 1992. However, the activities could soon be stopped if no additional financial support will be given to the project. In order to enable a proper project implementation, the project has been also presented to the European Community. It has been completely accepted by the Community expert, having in this way an occasion to be partly financed from the EC sources. But due to some formal reasons, financing of the project by the EC has not yet been achieved.

Some additional institutions have also payed an attention to the project realization (*e.g.* Central European Initiative, the governments of Germany, Switzerland and Hungary, the Regional Environmental Center for Central and Eastern Europe, the ENEA from Italy etc.). Some contacts were established with certain institutions from the USA and Canada as well as with corresponding offices of the United Nations Organization.

**Conclusion**

The urgent and complete implementation of the project concerning rescuing of radioactive waste materials derived from damaged or destroyed radiation sources in the areas of Croatia affected by war could prevent major radiation contamination in Croatia itself but also – through uncontrolled transboundary migration – in the other countries. The project is based on professional approach, safety regulations and rational budgeting. As a specific action it represents a new experience for international institutions in the field, anticipating the performance of a similar action in the neighbouring country of Bosnia and Herzegovina after the war will be over.

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**SAŽETAK**

**Aktivnosti za smanjenje rizika od radioaktivnog zračenja u ratom zahvaćenim područjima Hrvatske**

*D. Subašić, A. Saler, M. Gunarić* i M. Novaković***

U ratom zahvaćenim područjima Hrvatske bio je u upotrebi niz uređaja s izvorima radioaktivnog zračenja. Ovi izvori primjenjivani su u industriji i medicini, no najzastupljeniji su ionizirajući javljači dima i radioaktivni gr[illegible]obrani. Uništavanjem ili oštećivanjem objekata u/na kojima su bili postavljeni radioaktivni izvori nastupila je stvarna opasnost oštećenja zaštitne obloge radioaktivnih izvora, a time i stvoreni uvjeti za radioaktivnu kontaminaciju okoliša i ugrožavanje zdravlja ljudi. Zbog ovakvih okolnosti APO-Agencija za posebni otpad je u suradnji s Ministarstvom zdravlja RH, kao i ostalim nadležnim upravnim tijelima, a uz potporu relevantnih međunarodnih institucija (Međunarodna agencija za atomsku energiju, Konferencija europske zajednice), pokrenula akciju sustavnog zbrinjavanja radioaktivnih izvora u područjima naše zemlje zahvaćenim ratnim razaranjima.



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# Chemical Oxidation of Polychlorinated Biphenyls in Water with Ultraviolet Light and Hydrogen Peroxyde

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The treatment of polychlorinated biphenyls (PCBs) in water has traditionally been accomplished by a variety of techniques including adsorption onto granular activated carbon (GAC). The use of GAC for treatment of PCB-contaminated waters has two distinct disadvantages. First, because the adsorption process is based on concentration equilibrium, long residence times are required for treatment to low part-per-trillion levels. Large and expensive carbon beds are needed. Second, the presence of fine solids such as turbidity which have adsorbed PCB can flow through the carbon beds and subsequently re-contaminate the effluent streams. In addition, subsequent treatment or disposal of PCB-contaminated GAC may add to economic and/or liability cost.

The chemical oxidation process using ultraviolet (UV) light and hydrogen peroxide ($H_2O_2$) destroys PCBs to low part-per-trillion levels. Neither air-phase nor solid-phase waste by-products are generated from the water treatment, and the only chemical additive, hydrogen peroxide, is consumed in the treatment process. The end result is water treated on-site to well below the required discharge levels without the liabilities and concerns associated with treatment process which transfer the contaminants to a solid phase.

## Introduction

Polychlorinated biphenyls (PCBs) have more recently been discovered in a variety of waters, including groundwater, wastewater and stormwater. The treatment of these PCBs contaminated waters can be accomplished by a variety of methods. The most frequently used method is adsorption onto granular activated carbon (GAC).

In the liquid phase carbon process, organic-contaminated water is percolated through beds of granular activated carbon. The organics are adsorbed onto the carbon granules. The process theoretically is capable of reducing many organic concentrations to non-detectable levels.

One difficulty with carbon adsorption is that the organics, while they are effectively removed from the water phase, are transferred to the carbon,and disposal of the carbon then remains as a problem. Ultimately, the carbon is most often reactivated in a fired furnace, where the organics are oxidized. For PCBs high afterburner temperatures and retention times are required. Alternatively the carbon is disposed of in a hazardous waste landfill.

The problem of disposal of carbon containing some non-volatile organics such as PCBs can be much more complex than found with volatile organics. Sometimes carbon can not be completely reactivated or safely disposed of in a hazardous waste landfill.

In light of these issues, the decision as to the type of treatment to be employed involves many factors. The factors to be considered in the evaluation of approved technologies for treatment of PCBs contaminated water, in addition to the criteria of capital cost and efficiency required, include:

- Effect of air quality permit review time on treatment schedule.
- Monitoring costs for water stream during system operation.
- Cost and liability for treatment and/or disposal of activated carbon.
- Reliability and operability of air emission control equipment.
- Plant operator time required for operation of equipment and interface with regulatory agencies.
- Overall water and air treatment costs on a per gallon basis.

The above factors make it desirable to consider destruction technologies for the treatment of groundwater contaminated with PCBs. PCB wastewaters can be treated by various EPA approved methods that employ destruction as opposed to media transfer. These methods include thermal and chemical treatment. Of these methods only chemical oxidation offers the means of ultimate destruction of the organics without residual sludges, ash or air discharge.

## Chemical oxidation

Ultraviolet light in conjunction with hydrogen peroxide promotes the chemical oxidation of organic contaminants in water. Many organic contaminants absorb UV light and may undergo a change in their chemical structure or simply become more reactive to chemical oxidants. More importantly, UV light, at less than 400 nm wavelength, reacts with hydrogen

peroxide molecules to form hydroxyl radicals. These very powerful chemical oxidants then react with the organic contaminants in the water. If carried to completion, the end products of hydrocarbon oxidation with UV/peroxide are carbon dioxide and water. Halogens are similarly converted to their corresponding halides.

Hydroxyl radicals have been measured and recorded at work on earth in surface water and in the atmosphere. The radical is assumed responsible for the natural oxidation of many environmental contaminants. Advanced chemical oxidation processes simply facilitate the formation of hydroxyl radicals and target the oxidation process.

Like most other chemical oxidations, the UV/peroxide process is dependent upon a number of reaction conditions which can affect both performance and cost. The more important variables include type and concentration of organic contaminant and UV and hydrogen peroxide dosages.

## Case studies

Two case studies are presented to demonstrate the performance of chemical oxidation using UV light and hydrogen peroxide. The first study summarizes the results of a laboratory bench-scale treatment of groundwater containing PCBs. The second study demonstrates the on-site treatment of PCB contaminated stormwater.

### *Case I*

Peroxidation systems, Inc. (PSI) was contracted to perform a treatability study on contaminated groundwater from a Superfund Site using the **perox-pure™** Process. The groundwater reportedly contained 320 $\mu$g/l of PCBs. The treatment objective specified by the client was the destruction of PCBs to 1 $\mu$g/l.

A bench-scale **perox-pure™** tretability study was performed on the groundwater during February of 1991 at the PSI Testing Laboratory in Tucson, Arizona. These tests were designed to provide a range of data from which full-scale treatment criteria and costs could be projected.

Characterization of the groundwater sample was performed by PSI to determine parameters of importance for **perox-pure™** treatment. The groundwater as-received contained iron and suspended solids which were removed via gravity filtration prior to performing bench-scale testing. The characterization results for the raw and filtered groundwater are shown in Table 1. An analysis of the raw groundwater revealed the presence of 80 $\mu$g/l of total PCBs. Due to the first order nature of the oxidation rate and our previous experience it was judged that the data from this water would allow us to project treatment from 320 $\mu$g/l.

Table 1 – *Sample Characterizations of the Case I Groundwater*

| | Raw | Filtered |
|---|---|---|
| Visual Color: | Orange | Clear |
| Visual Appearance: | Cloudy | Colorless |
| pH: | 6.5 | 6.5 |
| Iron (mg/l): | 12.5 | 2.5-1.8 |
| Chloride (mg/l): | 14,250 | 14,250 |
| Total Organic Carbon (mg/l): | 7 | 7 |
| Total Dissolved Solids (mg/l): | 12,100 | 13,100 |
| Est. Suspended Solids (mg/l): | <20 | <0.2 |
| Alkalinity (mg/l): | 150 | 110 |
| Turbidity (FTU): | 85 | <5 |

The bench-scale **perox-pure™** test unit was charged by placing an aliquot of the water into a recycle reservoir. A pump was started which circulated the solution through the UV oxidation chamber and back into the reservoir providing continual mixing in the closed system. Sulfuric acid was added to the groundwater at this time to adjust the pH for certain tests.

The UV lamp was illuminated to start a test, and $H_2O_2$ was added as required to maintain a constant concentration in solution. The solution temperature was controlled through use of an in-line cooling coil. After the appropriate oxidation times, samples of the treated water were collected in 1-liter amber glass bottles. An untreated sample was also collected in the same way.

PCB destruction to less than 5 $\mu$g/l was demonstrated in this study (5 $\mu$g/l was the analytical detection limit). Oxidation rate data was extrapolated for full-scale projection. The criteria used to project full-scale treatment conditions for the **perox-pure™** Process are summarized in Table 3. These criteria were specified by the client.

Table 2 – *Criteria for Full-Scale Treatment of the Case I Groundwater*

| | |
|---|---|
| Flow Rate (gpm) | 350 |
| Influent PCBs ($\mu$g/l) | 320 |
| Effluent PCBs ($\mu$g/l) | 1 |

Full-scale **perox-pure™** Process conditions for the contaminated groundwater are projected and the full-scale oxidation time was calculated from the treatment criteria in Table 2 using the full- scale rate data from the results of the bench test. The oxidation time was then used along with the flow rate from Table 2 to determine the appropriate **perox-pure™** model and power demand.

The projected costs for **perox-pure™** treatment of the groundwater are shown in Table 3. The energy rate was assumed to be $0.06/kWh. The repair/maintenance costs are estimated at 8 % of the capital investement per year.

Table 3 – *Case I Treatment Cost*

| | $/1.000 Gallons |
|---|---|
| UV Energy @ $0.06/kWh | 1.03 |
| Hydrogen Peroxide (delivered) | 0.26 |
| Repair/Maintenance | 0.20 |
| TOTAL | $ 1.49 |

*Case II*

An on-site treatability study was conducted in August of 1991 by PSI on contaminated water at a schemical facility in the mid-west. The objectives of this on-site study were to confirm the feasibility of treating PCBs in water with the **perox-pure**™ Process and to determine the best **perox-pure**™ operating conditions in order to provide full-scale equipment design and cost projections.

The client's current system was designed to treat rain water percolate contaminated with PCBs using a dual carbon adsorption system. Rainwater percolate is captured by the recovery system which consists of an elaborate arrangement of aqueducts and lift stations. The water in the primary lift station is pumped to a holding pond. Water from the pond is pumped to a secondary lift station, which in turn is pumped through the dual carbon adsorption system.

Once the water had been treated it is held in a discharge sump pending analysis for PCB concentration. If the concentration is below the discharge limits, the water can be discharged to the local sewer system. If the water is not acceptable, it is returned to the holding pond and recycled through the treatment system until the concentration is acceptable.

PSI provided the **perox-pure**™ Demonstration Trailer for the on-site study. The trailer contained all necessary components for a photochemical oxidation treatment system, and was positioned near the PCB stormwater treatment plant. A schematic diagram of the **perox-pure**™ tretment system provided for this study is shown in Figure 1.

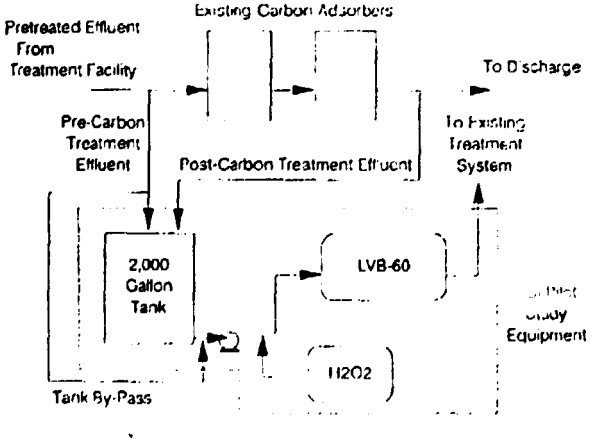


Fig. 1 – *SchematicDiagram of perox-pure™ System*

Two phases of testing were conducted; **perox-pure**™ treatment of the raw water, and treatment of the effluent from the existing carbon adsorption system. The use of flexible hoses and quick disconnect fittings allowed for rapid exchange from one mode of operation to the other.

Rapid destruction of the PCBs was achieved with the **perox- pure**™ Process in both the raw water and the carbon effluent. In each case, destruction of the PCBs to below the 0.064 μg/l treatment objective was achieved and in fact PCB levels as low as 0.002 μg/l were achieved.

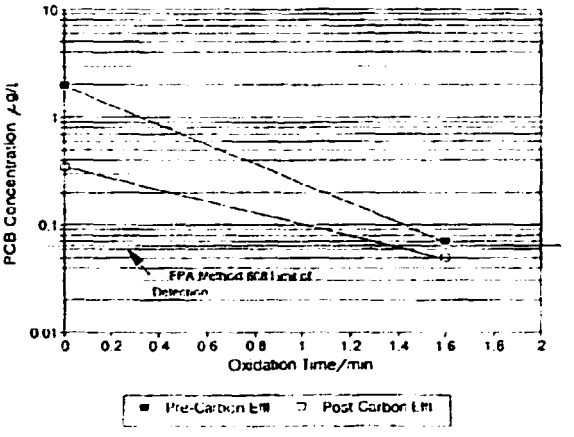


Fig. 2 – *PCB Destruction in Raw Water and Carbon Effluent with Identical Treatment Conditions*

Figure 2 compares the rate of PCB destruction for the raw water and the carbon effluent. Both of these tests were performed at a similar flow rate and hydrogen peroxide dosage. As shown, the level of treatment after 1.6 minutes was similar even though the PCB concentration in the raw water was approximately 6 times greater than that of the carbon effluent. The rate of PCB destruction in the raw water was approximately 1.6 times faster than in the carbon effluent. It was suspected that PCBs from the carbon were attached to colloidal solids and carbon fines and were more difficult to oxidize in this state.

Based upon these results, **perox-pure**™ treatment of the raw water is favored over treatment of the carbon effluent. This mode of operation will also eliminate the costs and liabilities associated with carbon adsorption.

The criteria used to project full-scale treatment conditions for the **perox-pure**™ Process are summarized in Table 4. The flow rate and effluent treatment objectives were specified by the client. The influent PCB concentration was taken to be the average detected during the on-site testing.

Table 4 – *Criteria for Full-Scale Treatment of the Case II Water*

| | |
|---|---|
| Flow Rate (gpm) | 150 |
| Influent PCBs (μg/l) | 2.8 |
| Effluent Objectives (μg/l) | 0.064 |

Table 5 – *Case II Treatment Cost*

| | $/1.000 Gallons |
|---|---|
| UV Energy @ $0.06/kWh | 1.40 |
| Hydrogen Peroxide (delivered) | 0.34 |
| Repair/Maintenance | 0.32 |
| TOTAL | $ 2.06 |

Full-scale **perox-pure™** Process conditions for treatment of the raw water was calculated from the treatment criteria in Table 4 using the full-scale rate data from the best on-site test with raw water. The full-scale oxidation time was used along with the flow rate from Table 4 to determine the appropriate **perox-pure™** model and power demand.

The projected costs for **perox-pure™** treatment of the raw water are shown below. The energy rate was assumed to be $0.06/kWh. The repair/maintenance costs are estimated at 8 % of the capital investment per year.

**Conclusion**

The chemical oxidation process using ultraviolet (UV) light and hydrogen peroxide ($H_2O_2$) destroys PCBs to low part-per-trillion levels. Neither air-phase nor solid-phase waste by-products were generated from the water treatment, and the only chemical additive, hydrogen peroxide, was consumed in the treatment process. The end result is water which was treated on-site to well below the required discharge levels without the liabilities and concerns associated with treatment processes which transfer the contaminants to a solid phase.


SAŽETAK

**Kemijska oksidacija polikloriranih bifenila u vodi ultravioletnim zračenjem i vodikovim peroksidom**

*H. E. Winkler, K. J. Kent i P. Burrows**

Uklanjanje polikloriranih bifenila (PCB-a) u uzorcima vode prikazano je primjenom metode adsorpcije na aktivnom ugljenu i UV-svjetlom u kombinaciji sa vodikovim peroksidom. Uz uvjete provodenja reakcija, razmatrani su troškovi s obzirom na vrstu i koncentraciju zagadivala u vodi. Naglašeno je da oksidacijom PCB- a sa UV svjetlom uz vodikov peroksid ne nastaju kruti ili plinoviti nuzprodukti reakcije. Jedini kemijski aditiv je vodikov peroksid koji se tijekom reakcije utroši.


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# Rodents as a War Risk

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Rodents are important pests destroying food and transmitting diseases. War results, not only in the loss of human an animal life but also in the destruction of buildings and other structures. In urban areas damage to sewers can be cause rodents to spread to areas where they are not usually found. Rodent food supplies may actual increase in war zones. Unlike disaster situations in peacetime, relief organisations may not be able to reach a worn torn area for weeks, months or longer.

The combination of disturbance, increased food supply and a extended timelag can lead to a increase in the rodent population, increased rat – human contact and hence an increase in the risk of disease transmission. These disease outbreaks can reach epidemic proportions. A programme for large scale rodent control is suggested but in war situations such programmes can be difficult to implement and may have low priorities.

**Introduction**

In peacetime rodents can be serious pests affecting food production and causing food losses at both the pre and post harvest stage. The health risk results from the fact that rodents act as reservoirs and vectors for a variety of diseases affecting human beings. The pest status of rodents is greater in countries where lack of resources and limited pest studies has resulted in inadequate information being available to evaluate problems and plan for effective rodent control.

*Crop losses*

Examples of the estimated economic crop losses in field and store for various countries are given in Table 1 and Table 2. They reveal the serious nature of the problem which can affect both food supplies and export earnings, with losses commonly of 5 % to 10 % in the field and 3 % to 5 % in stores.

Table 1 – *Estimated field losses of food crops due to damage by rodents.*

| Field crop | Area | Estimated damage (%) |
|---|---|---|
| Sugar cane | Jamaica | 5 |
| | Hawaii | 4–10 |
| | Barbados | 6 |
| Rice | Philippines | 10 |
| | yearly average | 10 |
| | National survey | 2–18 |
| | Indonesia (Java) | 40 |
| | India | 6–9 |
| | Bangladesh | 6 |
| | Pakistan | 3–8 |
| Wheat | Pakistan | 2–9 |
| | Bangladesh | 12 |
| Coconuts | Tokelau Islands | 30–40 |
| | Ivory Coast | 10–15 |
| | Tarawa | 23 |
| | Tahiti | 27–47 |
| | Fiji | 5–13 |
| | Jamaica | 5–36 |
| | Philippines | 57 |
| Cocoa | Solomon Is. | 1–9 |
| | Indonesia (Sumatra) | 1–15 |
| Macadamia nuts | Hawaii | 16 |
| Carob | Cyprus | 3 |

Table 2 – *Some estimates of the damage caused by rodents to stored foodstuffs*

| Country | Commodity | Extent of damage (%) |
|---|---|---|
| Bangladesh | Rice/grains | 2–5 |
| Brazil | Rice/maize | 4–8 |
| India | Various/grains | 1–15 |
| Mexico | Rice/maize | 5–10 |
| Nepal | Grain | 3–5 |
| Philippines | Rice/maize | 1–5 |
| Sierra Leone | Groundnuts/grain | 2–5 |
| Thailand | Maize/Rice | 5 |
| Tunisia | Grain | 6–8 |
| Zambia | Grain | 10 |

*Diseases*

Rodents act as vectors for more than two hundred pathogenic organisms affecting both humans and livestock. Some of the principal diseases are listed in Table 3.

Table 3 – *Some diseases transmitted to rats and mice to Man*

| Disease | Organism |
|---|---|
| Rabies | virus |
| Lassa fever | virus |
| Rat bite fever | bacterium |
| Salmonellosis | bacterium |
| Leptospirosis | bacterium |
| Plague | bacterium |
| Murine typhus | Rickettsia |
| Leishmaniasis | Protozoan |

Three of the most important vectors of these diseases are *Rattus rattus*, *Rattus norvegicus* and *Mus domesticus* as these are very widely distributed species with long histories as commensals with humans. However, some other rodent species are rapidly developing their commensal habits. Notable among these are *Bandicota bengalensis*, common in parts of India and surrounding countries; *Rattus exulans* in the far East and *Mastomys (Praomys) natalensis* found over much of Africa south of the Sahara.

Perhaps the most infamous example of a disease in which rats play a major role is Plaque where the causal organism, *Yersinia pseudotuberculosis*, is transmitted to Man mainly by the bite of the rat flea, *Xenopsylla cheops*. Fortunately most of Europe is probably plague-free, although recorded up to the early 1900's. Human and animal plague has been reported from countries in Africa, South and North America, Asia and the Far East in recent years. A significant observation is the reappearance of human plague after years of quiescence, eg Lobya in 1976/77 and again in 1984.

Many other serious diseases do not require the presence of vector between Man and rat. Lassa fever, so far restricted mainly to West and Central Africa, is caused by a virus usually transmitted in the bodily secretions of the rodent, *Praomys natalensis*. In other parts of the world, other haemorrhagic fevers are carried by various species of rodents.

Two very important diseases transmitted by rodents are Salmonellosis, (food poisoning) and Leptospirosis, (Weil's Disease). Their importance arises from the fact that unlike many rodent bourn diseases they are not localised but have a worldwide distribution and can be transmitted to man by coming into contact with areas and substances contaminated body secretions.

In the case of Salmonella poisoning infection most commonly occurs as the result of contamination of foods and food preparation surfaces by infected faecal droppings and urine. The house mouse probably plays a greater role than rats in spreading the disease.

Rat borne leptospirosis is caused by a spirochaete that lives in the kidneys of rats and spread in the rat's urine. Human beings frequently contract the disease by coming into direct contact with an infected animal or tissues but infection can also occur by contact with water or soil contaminated with infected urine.

*Economic losses*

The financial costs to health services in treating such diseases has to be added to the value of the losses associated with food production to give a more complete picture of the total economic costs of rodent related problems.

In summary, the paecetime costs of rodents in terms of both economics and human suffering are considerable. In a disaster situation these costs have the potential for dramatic escalation.

*The effect of disaster on man and rodents*

A major disaster, whether it is war, earthquake, flood or volcanic eruption have similar effects.

People and livestock are killed or wounded

Buildings, including homes, shops, stores and factories are destroyed or damages.

Food supply may be disrupted at the preharvest stage by crops being abandoned or damaged or in post harvest situations by the destruction or damage to grain stores and food production facilities.

Public services such as communication, transport, water, sewage are impaired to varying degrees.

The social organisation and cohesion of communities may also be adversely affected.

Issues such as food, housing, reestablishment of communication systems and medical help for survivors will have higher immediate priorities than a rodent control programme.

How does a disaster situation affect rodents?

Depending on the type of disaster food supply may be increased – abandoned crops, food buried in wrecked stores, homes, etc and bodies of humans and livestock.

An example of how a war situation can actually increase the food supply of rodents comes from the current conflict in the former Yugoslavia. At Vinkovci, some 350 km. east of Zagreb, a silo holding some 10,000 tonnes of grain was damaged, including the destruction of its roof. As a result the grain became infected with mould, contaminated with asbestos and infested with rodents. Not only was the grain being eaten by rodents but it was also being contaminated with rodent faeces and urine. The whole of that grain supply has had to be condemned and creates a problem of how it should be destroyed.

In urban situations sewers are centres for rat populations; if sewer systems are damaged then breaks in the systems multiplies the number of rat access points. This physical disturbance coupled with probable social disruption to the rat community, can lead to rats spreading to areas where they are not usually found, especially where new refuges exist in the form of damaged buildings.

In the case of many »natural« disasters the extent of the disaster is localised and disaster relief action from outside the stricken area can soon be added to the efforts of organisations and individuals within the disaster area. The timescale for the occurrence of the disaster and the arrival of aid is usually a matter of hours or days. A potentially important difference between »natural« disasters and war is the likelihood of an increase in the delay in the arrival of effective relief and clean up operations. Hostilities may well prevent significant outside aid coming in and severely hamper local relief activities for weeks or months.

Thus war can greatly magnify the problems of a natural disaster situation where not only is there can there be an abundant food supply and plenty of refuge areas (ruined buildings, etc) but also a time lag that allows rodents to breed unchecked. Such circumstances are ideal for the rat population to expand rapidly, increasing the chances of rat – human contact and the spread of rodent vectored diseases.

The wars in Vietnam were classic examples of circumstances which led to human epidemics of plague. Considerable alarm arose when plague was discovered in several species of commensal rats living in and around the major ports and airfields. The prospect of plague being transported to other parts of the world led to strict rat and rat-flea measures being applied to cargo storage areas and containers used in shipping materials. Fortunately the procedures proved effective in preventing the spread of plague from Vietnam by these transport routes.

Reports from Croatia suggest that at least part of this scenario has become a reality. Reports indicate an increase in rat populations in both town and country areas and a outbreak of Leptospirosis in Vinkovci.

*Rodent control measures in disaster areas and war zones*

Priority must be given to the restoration of communication and transport systems. Without these effective coordinated rodent control measures cannot be carried out.

Where water supplies and sewage systems have been destroyed medical authorities will be seeking their restoration as a matter of urgency. The principal threats, depending on the part of the world where the disaster situation is located, probably being cholera, epidemic typhus and dysentery. Rodents are not usually directly involved in the transmission of these disease but safe water supplies and repaired sewage systems would reduce possible contamination of water by rodent bourn diseases and help to contain the dispersal of rats.

If there is an obvious rodent problem a specialised rodent control unit should set up to organise and coordinate actions. An experienced team leader is essential

to direct and supervise activities of the unit and to liaise with other relief organisations and, where appropriate, military authorities.

The rodent control programme will follow three principal stages:

i) Survey and Planning Phase

Systematic survey and mapping of the area to detect infestation and disease locations and to record the conditions supporting the problems those sites. A programme strategy can then be planned

ii) Attack Phase

Poisoning of rodent infestation and restoration of sanitation and destruction of rodent food supplies and refuges.

iii) Maintenance Phase

Measures to ensure lasting effects on the reductions achieved

*i) Surveys*

A survey of the nature an extent of the problem is essential to provide a basis for planning operations. Information from the survey should be transferred to a large scale map showing the location of sewage system and possible major rat food and refuge areas, eg known grain or food stores. etc.. When the incidence of rodent infestation and rodent bourn diseases are mapped in this fashion, certain disease and infestation foci are likely to be revealed. The total area involved can be subdivided and priority given to worst affected areas.

Sewer and surface infestation should be treated at the same time where ever possible.

The overall strategy of a programme should be to achieve wide control

Where an rodent vectored diseases are known to occur it is essential to plan not only for the control of the rodent population but also their fleas and other ectoparasites to prevent possible disease transmission. This is necessary because when rodents are killed, their ectoparasites are left without hosts and they may use Man as a temporary host, thus increasing the risk of spreading disease. Even if an ectoparasitic disease is not confirmed in a rodent population or if only suspected in assisting in the transmission of a disease it is advisable to carry out ectoparasite control.

*ii) Programme implementation*

In order to achieve effective control, a programme must ensure the coordinated timing of various aspects of the operation such as laying rodenticide baits, removal or destruction of rodent food sources and harbourage sites and community health education.

Field staff should be organised into teams each team consisting of a field team leader and two to five operators. Each team should be assigned to cover specific areas for their operations but the organisation should be flexible enough to allow team movement to another area if this is necessary. Areas selected for team control treatment should lie as adjacent to one another as possible to reduce the risk of reinvasion from untreated areas.

Specific goals should be set, eg., the reduction of the incidence of infestation to certain level in a specified time period. However it is important to set goals that are realistic, taking into account manpower, resources and local circumstances. Setting specific goals allows the progress and effectiveness of the programme to be evaluated. It is essential that good record keeping is maintained of areas treated, follow-up surveys and treatments. Maps showing disease and infestation areas need to be continually up-dated. Record keeping can facilitated by the use of special data sheets for survey and control work.

Large scale rodent control programmes should use anticoagulant rodenticides wherever possible. There are a number reasons for this a major one being they are safer to use for both operator and non target species, especially man. The acute rodenticides such zinc phosphide and sodium monofluroacetate have a rapid mode of action and often no effective antidote. In contrast, with anticoagulants the slow mode of action, usually five to seven days, allows time for the antidote, vitamin K1, to be administered successfully in the case of accidental poisoning. However in disaster areas, especially war zones, availability of a rodenticide will often override concern about possible dangers due accidental ingestion. This will particularly be the case in epidemic-threatening situations.

Where ectoparasite control is necessary it is preferable to use organophosphorus and carbamate insecticidal compounds. These substances usually degrade into less toxic compounds in a matter days and thus pose much less hazard in the environment than the older, persistent organochloride insecticides.

The several days it takes for anticoagulants to work is advantageous if ectoparasite treatment is carried out at the same time as rodenticides are laid down. This is because it give time for the ectoparasites to be killed before the host dies thus reducing the risk of fleas and suchlike moving to a human, temporary host and transmitting a disease.

*ii) Maintenance phase*

A large amount of effort is required in achieving an effective degree of rodent control. The successes achieved can be wiped in a very short time if measures are not taken to sustain the improvement. Continued liaison between medical authorities, reconstruction planners and other relief agencies are important in monitoring the rodent pest situation. On the ground at a practical level, repeat surveys on a random sampling basis for signs of rodent reinfestation form an important monitoring procedure. Such surveys allow strategies and priorities to be adjusted.

Finally, rodent control in disaster situations is difficult; in war zones the problems are multiplied. Un-

like the situation with natural disasters it may be impossible for relief groups, including rodent control units, to reach the area and difficulties of transport, communication, and supply are magnified. Priorities of central and local government will be radically different in wartime compared to peacetime. In some circumstances the structure of government at all levels may breakdown so that no effective relief can be organised.

In reality is likely that only if rodent related problems reach catastrophic proportions will they receive the priority required to provide the resources for effective control of rodents in a war torn area.

SAŽETAK

**Glodavci kao rizici rata**

*G. H. G. Martin*

Prikazani su mogući rizici i utjecaji povećanja broja glodavaca tijekom ratnih stanja (prenošenje zaraznih bolesti, gubitci u poljoprivredi, troškovi zdravstvene zaštite, proizvodnja hrane).

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# War Risk Avoidance and Third World Livestock Development

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Third World livestock development schemes are usually based on the large-scale multiplication and distribution of perceived »improved« exotic breeds or their crossbreeds with indigenous breeds. The policy is coupled with intensive disease control. The major constraint to this programme in Africa is generally regarded to be ticks and tickborne disease(TBD) which are controlled by the unremitting use of intensive short interval acaricide treatments. This method ignores and destroys the benefits of TBD control by natural (or artificially induced) immunity and tick control by host immunity (resistance). It encourages the use of inappropirate cattle breeds and ignores the demonstrated potential of indigenous well-adapted breeds. It creates susceptible livestock populations which suffer disastrous epidemics when chemical supplies break down. Well documented examples are the 1,000,000 cattle dying from TBD in the Zimbabwe independence struggle, the disappearance of the Ugandan dairy herd during the years of instability in the regimes of Idi Amin and Milton Obote and peri-independence losses in Tanzania.

Livestock development in the Third World demands the use of programmes restricting the use of chemical tick control and making use of immunity to ticks and TBD in appropriate productive breeds to create a robust strategy capable of surviving periods of war or social unrest.

## Introduction

Warfare and social unrest bring with them not only direct human suffering and destruction of property but also the risk of long-term industrial and agricultural ruin. We have grown only too accustomed to the sight, on our television screens, of human suffering brought about by these activities in the Third World. The risk of starvation follows inevitably from the inability to cultivate and harvest crops in countries where large-scale storage facilities are absent (as they are often inappropriate) or inadequate. In any case, the subsistence farmer, who may represent the majority in many countries, is always dependent on a good crop to maintain his family from one harvest to the next. His form of agriculture is always risky because of climatic variation, irregularities in supplies of inputs such as his minimal fertilizer needs and strict dependence on correct organization of seasonal activities. Even shortterm disturbance in the natural rhythm because of war or insurrection may be as devastating to the chance of obtaining a reasonable harvest as complete disruption.

Livestock production, because of its inherent long time scale (in the tropics, for example, cattle take 2–5

years to reach marketable size) is an even more risky operation. In the Third World, despite the risk, livestock production remains essential, not only because it may be the cultural norm and there is a market to be satisfied, but because there are many environments where the only possible and efficient land use pattern is that of livestock production. The importance of draught oxen for ploughing and general cultivation in many cultures cannot be overestimated, together with their use for general traction purposes.

As with general agriculture, the climate can create severe constraints for the livestock producer, with most tropical and subtropical countries tending to have serious droughts on a more or less regular basis. The effect of droughts are much more damaging in the tropics than in temperate zones because of the much greater evaporative indices produced by high daytime temperatures and frequently light soils. Pressure on available pasture is ever increasing as livestock populations keep pace with the expanding human population. Frequently, these increased animal numbers are required to be grazed on less land because of alienation of land to National Parks and other uses. However, shortage of grazing is not the only constraint as devastating disease outbreaks have occurred in historically recent times. Of these, the great pan-African Rinderpest epidemics have had the greatest impact on domestic animals and wildlife with 90 % mortality occurring as the disease spread throughout Africa (1887–1898) from Ethiopia, where it had been introduced during the Italian campaign. Contagious bovine pleuropneumonia (CBPP) has also had serious effects since it was introduced from Holland in 1854. However, in modern times with effective vaccines to these viral and bacterial diseases (although not necessarily effective delivery systems), ticks and TBD are regarded in many countries as the major health impediment to the improvement of livestock industries.

## Ticks and tickborne diseases

There are approximately 650 known species of ixodid ticks found in most of the world's ecological zones, although the majority are restricted to tropical and subtropical regions where they present the greatest problems. Most species are rarely encountered but some 10 % have acquired livestock pest status both for their direct damaging effects and for the effect of the diseases they transmit.

Tick and TBD present their most acute problems in Africa where the abundant wildlife fauna developed an equally abundant tick and TBD fauna, some examples of which have created serious problems for many attempts to improve livestock productivity. These diseases have been known to the indigenous pastoralists for as far back as records are available; specific names for many of them exist in local languages although some were difficult to differentiate as they often are today (the Maasai use the same word for trypanosomiasis and East Coast fever – ECF). These peoples developed procedures to cope with them and minimize their impact.

The emergence of TBDs as significant livestock diseases in Africa occurred as an indirect effect of the devastating losses from Rinderpest[1]. Cattle numbers had been reduced to below the necessary numbers to support the transport needs of southern Africa (oxen were the mainstay of the transport system in these rapidly developing economies) and it was necessary to import stock from other countries. Around 1902, cattle from East Africa were imported into Southern Rhodesia and South Africa via Mozambique and with them came the disease ECF which spread rapidly and devastated the cattle population.

At more or less the same time settlers in East Africa were importing cattle from Europe with the aim of improving livestock productivity and also translocating indigenous breeds which were believed to have a high potential. These animals frequently contracted TBD and large numbers died.

In both southern and eastern Africa this mortality created crises – in southern Africa because of the dependence of the economy on ox transport[2] and in eastern Africa because of the belief that exotic animals were essential for the future development of the livestock industry. A solution had been developed in South Africa in 1895 and used successfully against ticks and TBD in Australia from 1896 onwards. This was to immerse infested animals in a dip- wash containing arsenious trioxide or »arsenic«. This treatment at weekly or twice-weekly intervals greatly reduced tick numbers and the incidence of TBD and was regarded as the only way in which exotic »improved« breeds could be maintained.

*Ticks.* It was early realized that specific tick species were responsible for specific TBD but their distributions were not fully known. In addition, it was not possible for the non- specialist to identify ticks correctly. For example, it was known that the Brown Ear Tick, *Rhipicephalus appendiculatus*, was the vector of ECF but it was not appreciated that there were many other brown ear tick species found in eco-climatic zones where the »true« Brown Ear Tick was not found. As a consequence all ticks came to be greatly feared and cattle dipping ordinances were widely introduced to cover all grades of cattle including the indigenous breeds and in areas where dangerous vectors were not present.

*Tickborne diseases.* All TBD are characterized by the possibility of the existence of enzootic stability. This represents a situation where young animals acquire a TBD infection early in life while still protected by age and maternal immunity. With this protection the symptoms are mild and recovery leads to lifelong immunity. If early infection is prevented by the absence of vectors or by artificial acaricidal tick control the early protection is lost and even indigenous breeds suffer serious losses.

*Cattle breeds and host resistance.* Just as cattle acquire immunity to TBD so they are able to acquire

immunity to ticks, which is usually referred to as resistance. In general, zebu breeds (*Bos indicus*) and their cross-breeds have a greater ability to develop worthwhile resistance than taurine (*B. taurus*) European breeds. In Australia these breeds were largely replaced by zebu and zebu crosses in tick-infested regions between 1970–1990 because of the costs and risks of maintaining tick susceptible breeds. In addition, it has become clear that the poor adaptability of taurine breeds to tropical conditions is a serious constraint. In Africa this realization is accepted in academic and research circles but it has been difficult to get the message across to many veterinary staff, farmers and, unfortunately, many NGOs concerned with development aid. If cattle are prevented from receiving a tick challenge they fail to develop any resistance and are at risk to enormous infestations leading to extreme morbidity or death if tick control breaks down.

**Effects of war and civil unrest**

One of the effects has been breakdowns in the supply of acaricide along with the other necessities of life. A first this may seem a trivial effect but it must be remembered that cattle, in many situations and cultures, are the essential economic basis to society. As we have seen, cattle held under intensive tick control are completely susceptible to a plethora of TBD and ticks themselves; all of which are separately life threatening and together represent a truly deadly cocktail. These breakdowns in control brought about by failures by individual farmers to keep up their weekly dipping schedules have individually serious effects. When the breakdown occurs on a regional or national scale then the results are devastating to the social and economic structure as well as to the farmer.

Apart from countless individual failures there have been a number of largerscale occurrences.

*Iringa, Tanzania.* Yeoman (1991)[3] describes how ECF and its vector were eradicated from an enzootic area of south western Tanzania in 1950–1957. The area was approximately half the size of Northern Ireland and had a cattle population of 160,000 which increased during the campaign to 250,000. The success of the programme arose from a number of factors which include the dedication and skill of those responsible, the enthusiastic support of the cattle owners, the situation of the area on a plateau salient mainly surrounded by areas ecologically inimical to the vector and the use of an acaricide which although unstable was being managed, by chance, in an effective manner. When I carried out a 3 year ecological study in the area in 1973–1976 one of the previously important tick species still had not become re-established.

In 1957 an overnight refusal to continue dipping their cattle was announced by the cattle owners. This refusal occurred against a background of developing protest and civil unrest that was to lead eventually to the granting of independence in 1963. Despite the initial enthusiasm of the cattle owners the continued imposition of the weekly dipping programme came to be resented as ticks were no longer being seen. Unfortunately, there was no qualitative vector and ECF monitoring which might have defused the situation by permitting a relaxation of the regulations.

The result of this breakdown in control was not immediately apparent but nevertheless, the vector tick commenced an inexorable invasion from the extreme south west of the control salient into a cattle population fully susceptible to ticks and TBD; all immunity had been lost because of the very success of the programme. During the 1960s this advance was accompanied by 90,000–100,000 cattle deaths from ECF and probably other TBD and it was necessary for the newly independent government to reintroduce stringent tick control regulations. Even more unfortunately, increased numbers of dips were built to minimize the trikking needed to reach the dips. The result was that dip emptying and replenishment schedules were lengthened and the acaricide in use was rapidly biodegraded and absolutely no benefit was being achieved from the new programme. This continued until 1974 when a UN/FAO project showed that the non-specific acaricide strength test being used should be changed to one specific for the active isomer of the acaricide in use. Of course, there had been an unexpected benefit from the use of the inefficient acaricide – enzootic stability became re-established and losses to TBD became negligible (this fact supported the belief of the local veterinary authorities that the programme *WAS* effective). Despite this inadvertent benefit it was obviously necessary to change the acaricide. When this was done a susceptible cattle population was built up over the next few years and ECF deaths occurred whenever dipping discipline was relaxed.

*Uganda 1972–1990.* A thriving dairy and beef industry developed in Uganda in the years following independence until the period of excessive instability and war instituted by Idi Amin Dada and Milton Obote and which continued for some time after their overthrow. During this time, supplies of acaricide became erratic and increasing TBD mortality wiped out the dairy herd which had been largely composed of the highly tick- and TBD- susceptible taurine Holstein/Friesian breeds and their crossbreads. This national dairy herd had consisted of some 100,000 animals and had supported efficient milk processing plants in a number of cities. These milk plants became dependent on imported EEC surplus milk powder/butter oil milk reconstitution operations. For many years, and against government wishes, sharities and NGOs have reimported large numbers of susceptible cattle with no attempt to plan for their survival by immunization before shipping; the result has been predictable with heavy losses to these TBD.

*Zimbabwe.* The best documented recent example occurred in Zimbabwe[2], where ECF was eradicated in the mid-1950s, but where compulsory short-interval cattle dipping continued to be strictly enforced. For 20

years this policy was considered to be extremely successful although no cost-benefit analysis was thought necessary. Between 1967–1973 the national herd increased from 4.1 million to 5.6 million head of cattle and the reported annual deaths from TBD only averaged 886. This situation would probably have continued but for the pre-independence war which started in late 1972. Thereafter, and until the end of hostility in early 1980, there was a progressive and accelerating decline in enforcement of tick control and lack of acaricide which was accompanied by disastrous epizooties in indigenous as well as exotic cattle breeds. These epizooties of babesiosis (*Babesia bigemina, B. bovis*), anaplasmosis (*Anaplasma marginale*), heartwater (*Cowdria ruminantium*) and Zimbabwean theileriosis (*Theileria parva bovis*) resulted in the deaths by 1979 of close to one million head of cattle in the herds of undipped cattle, particularly in the more productive high rainfall areas. Subsequently the numbers of deaths diminished and by 1981 it was considered that enzootic stability had become re-established.

Despite the decline in TBD mortality there was an immediate wish after the cessation of hostilities for intensive tick control to be re-established and for many years there was a vigorous debate. It seems that the outcome has been to accept the benefits of enzootic stability and reduce the amount of dipping. The decisive factor is likely to have been economic as the costs in foreign exchange to countries with chronic shortages of hard currency for acaricide purchases far out way the benefits. Recently the Zimbabwe Government was allocating ZS8 million in foreign exchange for acaricide purchase. In addition, studies on the economics of tick control in Zimbabwe, neighbouring Zambia and other African countries have shown that the benefits of tick control frequently do not cover the costs of the acaricide, let alone the management costs.

## Discussion

The three examples quoted above clearly illustrate the point that for nearly a hundred years tick control policies have been advocated that have created the continuing risk of disaster. A disaster that stems from the failure to accept the benefits of enzootic stability to TBD and of host resistance to ticks. The latter depends to a large extent on the selection of appropriate cattle breeds. These are usually not the popular European taurine breeds which also suffer from poor adaptability to tropical conditions and indigenous husbandry. The International Livestock Centre for Africa (ILCA) and animal production scientists from other countries and continents appreciate the true economic benefits to be gained from the correct use of indigenous cattle breeds. Indeed the Australian Government has made great efforts to obtain importations of representatives of successful African breeds to improve their gene pool. Despite this, local commercial farmers continue in many instances to rely on less economically productive stock requiring intensive tick control protection.

Protection against TBD can be gained by the re-establishment of enzootic stability. This can be achieved by carefully increasing dipping intervals with appropriate chemotherapy as was done at the Kenya National Boran Stud where the manager was determined that the stud for one of the world's truly outstanding tropical beef breeds was not to be at risk to catastrophic losses if ever tick control broke down. On a national scale, this can be achieved by immunization, which is now possible against all TBD, although the procedure is complicated against ECF and heartwater. Chemotherapy against these last two diseases is also not without problems so immunization would appear to be the best long-term option provided immunization is available at a realistic cost. This is certainly the case when economic analyses are sufficiently rigorous[4] and when judicious acaricide treatments are applied. These developments have been accompanied by dramatic decreases in acaricide costs in some countries which have blurred the clear economic argument. When it is considered that prices may rise again and the costs of the risk of breakdown are included it is clear that a robust solution, providing economic benefits and the stability needed to be unaffected by any difficulties in supplies, has to be the only sensible course for an individual or a nation to take.

This robust option may be called Integrated Tick Management[5]. It consists of the use of appropriate cattle breeds, the maintenance of enzootic stability and the use of acaricides only when economically justified. In this way the producer obtains a maximal sustainable benefit without the risk of disastrous losses.

The use of robust options should be considered for all agricultural activities in potentially unstable regions. This will not necessarily mean the adoption of low productivity systems; as seen above the robust option can be the most economic choice in the long run when the perceived wisdom from different environments is examined critically. The high input high output systems forced on producers in some parts of the world by the distortions in economic reality induced by government subsidies are environmentally unsound, fundamentally unsustainable and should not be exported as desirable programmes for the Third World[6].

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SAŽETAK

**Stočarstvo Trećeg Svijeta i rizici rata**

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Prikazane su mogućnosti razvoja stočarstva Trećeg Svijeta i mogućnosti smanjenja korištenja kemikalija za tretiranje bolesti stoke koje prenose krpelji. Kao primjer navedena je visoka smrtnost životinja od bolesti koje prenose krpelji, a kao posljedice ratnih stanja u afričkim zemljama (Zimbabwe, Uganda).

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# The Scientific Basis for the Control of Livestock Ticks Without Risk of Catastrophic Failure in Times of War or Social Unrest

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Modern livestock development in the tropics is often seen as requiring similar strategies to those used in Western Europe and North America where high inputs are demanded by ever more highly productive livestock. These animals are poorly adaptable to tropical environmental conditions and third world husbandry (where the necessary inputs are often lacking) and require intensive treatments against many ailments. These treatments in the case of tick and tickborne disease control prevent the development of natural immunity and discourage the use of better adapted indigenous breeds. Whenever the supplies of inputs break down there is the risk of catastrophic losses. This paper outlines the scientific basis for the modern low-input approach to control which provides a more robust, economic and secure future for livestock enterprises of all sizes.

## Introduction

The practice of modern agriculture is a continuing process of assessing and balancing risks.

Successful arable production requires informed judgement of future demands for a range of potential crop species; specific cultivars then need to be selected to fit soil type and expected climatic conditions (with all the risk entailed in long range weather forecasting).

Livestock production, because of its inherent long time scale (in the tropics, for example, cattle reach marketable size in 2–5 years) is an even more risky operation. In the Third World, despite the risk, livestock production remains essential, not only because it is the cultural norm and there is a market to be satisfied, but because there are many environments where the only possible and efficient land use pattern is that of livestock production. The importance of draught oxen for ploughing and general cultivation in many cultures cannot be overestimated, together with their use for general traction purposes.

The livestock producer has to decide on the species he will keep, the specific breed(s) within those species and the range of interventions he will need to use to maximize production and profit. Even here there is a difficult choice, as in the past increased production was perceived to lead to increased profit, pointed out that this is no longer the case.[1] The producer is faced with a mix of often irreconcilable fundamentals which cover economic pressures (supply/over-supply and demand), concern for the environment and animal welfare which all lead to a fundamental conclusion that inputs and outputs must be optimized to satisfy these needs and the needs of the market.

To optimize inputs is difficult in a world where it is a banal truism to state that the rate of technological discovery is increasing exponentially. This is particularly true for vector and disease control and other husbandry inputs where technical advisors often feel that because an intervention is possible, it should be made. As again was pointed out by Ellis[1], in economics there are always at least two choices – to do nothing

or to do something! Even this limited choice is not always easy.

An important aspect of this decision making is in the perception of various risks by the producer. If these perceptions are faulty, it is obvious that incorrect decisions will be made. The problems associated with ticks and tickborne diseases (TBD) of livestock which are the subject of this paper, provide a useful illustration of how risk assessment and perceptions can become confused over time.

## The problem

Ticks are important pests of livestock in most parts of the world. In Temperate zones their numbers tend to be relatively low and the diseases they transmit also relatively easily managed with efficient veterinary support. In the Tropics and Subtropics it is another story. Cattle can be infested with large numbers of ticks belonging to a wide variety of different genera and species. The diseases they transmit are also many and their severity may be extremely high towards susceptible cattle, particularly where close veterinary attention is lacking. Under natural conditions (with wildlife) or traditional Third World husbandry, ticks and TBD are stable and do not represent a desperately serious situation. This is because the cattle are immune to the TBD and to the ticks (resistant). In general, *Bos taurus* (European) taurine breeds do not have the ability to acquire a significant degree of resistance to ticks, whereas tropical indigenous breeds (usually *B. indicus* – *zebu*) can acquire a very worthwhile resistance. Both types of cattle acquire immunity to TBD, but the taurine breeds do so less readily and effectively in some instances than the zebu breeds.

## The historical background

Smith and Kilborne[2] made the seminal discoveries that a protozoan (*B. bigemina*) could be responsible for serious disease in mammals (Texas cattle fever) and that it was transmitted by an arthropod, in this case the tick *Boophilus annulatus*. This discovery set the scene for attempts to control ticks and in 1895 arsenic (arsenious trioxide) was used successfully in South African cattle dips for this purpose.

Events moved quickly with TBD creating disastrous epizootics in Australia in 1896 (when infected cattle carrying the vector, Boophilus microplus, were imported into the Nothern Territory) and in southern Africa in 1902 (when East Coast fever was first recognized, having been introduced in 1901 with cattle from East Africa and where the vector tick, *Rhipicephalus appendiculatus*, was already established in the country). In both instances the livestock industry was faced with mortalities of the order of 90 % and in South Africa, where draught oxen were the mainstay of the transport system, the national economy was jeopardized. The response was to build cattle dips and to attempt to halt the spread of the disease and the ticks by the use of the new acaricide, arsenic.

Meanwhile, in the southern states of the USA, continuing heavy losses in the cattle industry led to a tick eradication campaign, based on dipping the cattle, being launched in 1907. Seventy years later and after enormous expense the cattle tick had been pushed back to a buffer zone on the Mexican side of the USA border.

As a result of these separate situations, cattle dipping was seen, if not as the complete saviour, but at least, as the only means for the continuation of viable livestock industries. When European cattle breeds were imported elsewhere in the tropics, for reasons of settler nostalgia or their perceived advantages over the indigenous cattle, and faced high mortality from indigeneous ticks and TBD, it was natural to turn to dipping as the only cure for an intolerable situation.

Tick control, originally introduced as a response to crises, was soon to become a tradition and to be perceived as a good in itself. By extension, it came to be regarded in Africa as good for all cattle (not just those susceptible imported cattle that were at risk) and indigenous cattle owners in many countries became subject to government ordinances (partly introduced because influential settlers feared that undipped indigenous cattle grazing around their properties could reintroduce ticks) requiring them to dip their cattle or face heavy fines. Their cattle were not at risk to TBD because they were immune, nor were they usually suffering losses from the tick burden because the cattle were resistant. Nevertheless, for nearly 100 years, millions of potentially resistant cattle have been regularly dipped to the point that resistance to ticks has not been acquired and that immunity to TBD has been lost; with this loss, dipping has become essential even for these cattle. Tick control has moved from being the solution to a problem to being part of the problem.

The response to a risk, correctly identified and assessed initially, was to become, with the benefit of decades of research, far removed from a rational economic solution to a continuing problem and was to lead to numerous national and individual catastrophes. Civil unrest, wars and economic difficulties in the Third World leading to shortages of acaricides have all resulted in these catastrophic losses to TBD.

In addition, it has become apparent in the past decade that the intensive control of ticks is now prohibitively expensive. Neither the individual stock owner nor National Governments with chronic shortages of foreign exchange can afford current costs (*e.g.* $12 000 000–$15 000 000/year for Kenya).

## Current research situation

Recent research has provided a basis for the formulation of rational tick control strategies. The research includes studies on tick ecology, TBD epizootiology, economic analysis, animal production science and farming systems analysis.

*Ecological Studies.* These have been carried out first in Australia and subsequently in Africa and America to provide precise data on tick species distributions, seasonal dynamics of parasitic phases on livestock and the development and survival of free-living stages on the pasture. Data from some of these studies have been integrated with climatic data into computer models which have allowed the simulation estimations of the effectiveness of tick control using different strategies. By climate matching they have also allowed the determination of potential world-wide distributions of some particularly damaging tick species and the TBD they transmit. An example lies in the potential for spread in the southern states of the USA of the African species, *Amblyomma variegatum*, which transmits the dangerous livestock disease, heartwater. This tick has gained a foothold in some Caribbean islands and has been the subject of pilot eradication schemes and much project planning towards the aim of removing this new threat to American livestock.

In Africa these studies have shown that for much of the continent the vector (*R. appendiculatus*) of the most serious TBD, East Coast fever (ECF), is absent and that, in consequence, draconian measures of control are inappropriate. In addition, for much of the distribution of this tick where rainfall is strictly seasonal the adult tick is also only present at that time and control measures at other seasons are also inappropriate. Interestingly, these studies have shown that if global warming results in 2 °C–3 °C temperature increases in Central Africa, it is likely that this tick will be able to develop rapidly enough for 2 generations/year instead of only 1 generation/year. This would have serious implications for tick control (Dr. R.G. Pegram, personal communication).

Despite the significance of these new data, they have, so far, only been used enthusiastically by policy makers in Burundi and Zambia. In addition, Zimbabwe has recently officially adopted a strategic dipping policy and a United Nations Food and Agriculture Organization (FAO) Project has been able to influence some farmers to reduce dipping to only 6 occasions/year instead of the previously enforced 39.

*TBD Studies.* The landmark event in this field occurred over twenty years ago with the presentation of data supporting the concept of enzootic stability[3]. Enzootic stability describes a situation where young animals are born to immune dams and acquire their first infections while still protected by age immunity and maternal antibodies. This primary infection tends to be largely symptomless but nevertheless sets in train the immunological responses leading to lifelong immunity. This process is characteristic of all TBD. Unstable situations are those where young animals fail to become infected while protected and hence are susceptible and suffer greatly when the primary infection does occur. Previously uninfected mature animals are usually severely affected by TBD (mortalities close to 90 % are normal).

Young animals fail to become infected by particular TBD if the vectors are absent or are present in numbers too low to allow an adequate inoculation rate. This situation arises naturally at locations outside the distribution of the vector or which are only marginally suitable. It can also arise when tick numbers are artificially reduced by over-enthusiastic acaricide usage. This results in the creation of a herd which is permanently at risk.

The acaricide-induced loss of enzootic stability should be regarded as the wanton loss of a priceless natural resource. When it occurs on a national scale it can lead to catastrophic mortalities in national herds.

Crude attempts at immunization against TBD had been made from the early 1900s onwards and for the past 20–30 years the range of diseases covered and the effectiveness of the product has increased greatly. In Australia millions of doses have been produced of a trivalent vaccine against the 2 forms of babesiosis and anaplasmosis. A similar vaccine is being produced for use throughout Africa by a (FAO) project in Malawi.

An immunization process has also been developed by FAO against the most feared East and Central African cattle disease, East Coast fever. Successful trials have been conducted since 1976, but for a variety of reasons, not all of them rational, it is only recently that ECF immunization has been practised on a relatively wide-scale in Zambia, Uganda and Tanzania. The situation in Zambia is particularly acute, in that ECF is spreading across parts of the country that have not been previously affected and where in consequence the cattle are fully susceptible. The original dilemma for the livestock producer and the government is, therefore, being re-enacted once again. The immunization is expensive for the farmer if full cost recovery is demanded. In addition, a recent significant reduction in acaricide costs makes intensive tick control less of a financial burden. If the intensive tick control programme is selected, there is also the near certainty that tick control will need to be continued for the rest of time, or at least until a safer, cheaper immunization is available. There is also the risk that acaricide costs will increase either as a result of marketing policy or following the development of acaricide resistance by the ticks to the chemical in use; replacement acaricides are inevitably more expensive than earlier chemicals. Acaricide resistance can create desperate situations – in Australia, resistance has sometimes developed against all registered chemicals.

On balance, it is likely that the more stable policy of immunizing cattle and using acaricides at economic threshold intensities where costs are significantly less than benefits and monitoring to confirm that enzootic stability is quickly established should be preferred, but farmers may prefer the initial lower costs of acaricide treatment despite the knowledge that these costs will go on *ad infinitum* as will the risk of ECF for their susceptible cattle. Their herds will eventually also be at risk to all the other TBD to which they were originally immune.

Heartwater (cowdriosis) is another important and virulent disease of taurine cattle and sheep and goats, but which is much less significant for zebu cattle (even when first exposed as mature animals). An immuniza-

tion procedure does exist although it has similar drawbacks to that for ECF. There is no doubt that the use of zebu cattle would dramatically reduce the danger from this disease.

All TBD can be controlled and cured by chemotherapeutic drugs, but, often the period within which the drug can be used successfully may be rather short. Accurate early diagnosis and treatment is essential but these are usually lacking in the Third World.

*Animal production and genetic studies.* Observant cattle owners had longnoticed that certain of their cattle carried markedly fewer (or greater) numbers of ticks than the average for their herds. A long series of studies in Australia (1960–1990) confirmed these observations and revealed that the characteristic of tick resistance was acquired and had an immunological basis, that it was highly heritable and that zebu cattle breeds were able to acquire resistance to a greater extent than taurine breeds[4]. This ability of the zebu was also shared by their crosses with taurine cattle to a degree roughly proportional to the zebu fraction of their genetic constitution. Coupled with these studies there was a steady realization of the benefits to be gained from the greater adaptability of zebu cattle and their corss-breeds in tropical and sub-tropical environments. The result was that over a 20 year period the herd composition of tick-affected Australia changed from virtually 100 % taurine to virtually 100 % zebu (or cross-breeds) because of the economic benefit from reduced or non-existent tick control costs and improved productivity. Although this benefit was most obvious with the beef breeds there was a need for a tick resistant dairy breed and 2 new breeds (Australian Milking Zebu – Jersey x Sahiwal and the Australian Friesian Sahiwal) have been developed incorporating the Indian zebu breed, the Sahiwal. It is worth noting that the taurine Jersey breed, unlike other taurine breeds, possesses very nearly the same ability to acquire resistance to ticks as zebu breeds. This, coupled with its low maintenance metabolic requirements should make it a favoured breed for Third World dairy development programmes. This rarely happens because advisors are usually so obsessed with the productive potential under ideal conditions of the Friesian/Holstein type of animal, that their poor adaptability to tropical environments, extremely poor tick and TBD resistance and high maintenance metabolism is forgotten.

The risk, correctly perceived by the Australian livestock owner, of keeping taurine breeds in the tropics where ticks and TBD are an additional serious problem, is largely ignored elsewhere. This is particularly so in Africa where scientific, veterinary and public awareness of the benefits of tick resistance are very low. Indigenous African zebu and sanga (these breeds, which predominate in central and southern Africa, are assumed to have resulted from the intermingling of *B. indicus* and *B. taurus* breeds in the past when different streams of human migration with their livestock came together) cattle have a very strong ability to reduce infesting *Boophilus spp* to negligible numbers. Species of the other African tick genera, *Rhipicephalus, Hyalomma* and particularly *Amblyomma*, are not reduced to such low numbers by host resistance although there are still great benefits compared with taurine cattle. Nevertheless, these ticks are visible and are, therefore, perceived to be a problem even, as will be seen later, they are not causing sufficient direct damage under most circumstances to justify economically the intensive tick control measures that are being applied.

Despite these clear indications that African indigenous breeds have strong positive adaptive traits, they have tended to be disregarded in schemes to improve livestock productivity. This is partly because under traditional husbandry their productivity has been low in systems with many competing activities. African breeds are frequently smaller than the large European breeds and large size has come to be popularly associated with high productivity. In fact, the reverse is usually true and where African breeds have been compared with exotic beef breeds in terms of true productivity (*i.e.* an index per unit weight or per unit of grazing area) they can outperform the usually favoured taurine breeds. This is particularly true for the Tuli in high-performance environments and the Mashona in low- performance environments[5]; the latter breed even has a better butchering conformation than the Hereford.

Once again the risk of selecting a breed with inherently poorer performance indices and poorer adaptive traits is ignored by the so-called progressive commercial cattle owner who remains in favour of the traditional commercial breeds.

There is no doubt that for dairy production the indigenous African breeds do not compare well with taurine breeds. There is also no doubt that breeds like the Friesian have very poor adaptability and have no possibility of acquiring worthwhile resistance to ticks and hence require high inputs in terms of both nutritional supplements and acaridical treatments. This is not to say that improvements are not necessary or that they cannot be made. There are many African breeds that are regarded by the International Livestock Centre for Africa (ILCA) as having great potential for selection as eventual dual-purpose breeds (and this type of animal is most suited for the general small-scale farmer). The Kenana and Butana from the Sudan, the improved Boran (Kenya) which is already regarded as an outstanding world class beef breed, and the Barka and the Fogera from Ethiopia are examples of these breeds. Other robust options are to cross Jersey with the indigenous breeds or use Sahiwal cross-breeds; the Ayrshire x Sahiwal has proved very suitable for commercial dairy farms in the Kenya Coast Province.

*Economic analysis.* Studies attempting to quantify the benefits to be gained from tick control have been difficult to design and to analyze and many of the earlier publications were seriously flawed. Later studies have relied on 2 main scientific approaches. The first relies on the use of simulation/processtype models by which specific variables are investigated to determine

damage coefficients (loss in g of liveweight gain (LWG) or g/milk per tick) which are then related to tick burdens and control costs to give damage thresholds[6–8]. The alternative farming- systems approach has been advocated by Ellis[1] and Pegram and Chizyuka[9]. They believe that by replicating field conditions, as far as possible, a more accurate estimate of the economic impact of ticks within the overall productivity of the system can be obtained. Specific tick damage effects calculated from results obtained by these 2 approaches show significant differences, with the farming-systems approach demonstrating higher losses.

Trials quoted by the agrochemical industry frequently show dramatic differences between intensively treated and untreated cattle. These gross differences can arise by selection of cattle from known tick susceptible breeds and previously unexposed to ticks (and hence fully susceptible) for the trial. For example, Taylor and Plumb[10] demonstrated a difference of 48 kg in group mean weight gain of heavily tick-infested and tick-free cattle.

Analyses of costs and benefits based on specific data showed that in Australia using 1983 figures the economic damage threshold was 150 engorging ticks[8]. This number of ticks would have been regarded as disastrous by most farmers who would have been treating their animals long before such infestations were seen. Similarly, Pegram et al.[11] in Zambia using 1988 figures showed that the cost of control was ZK286.26 whereas the increase in value of production was only ZK175.48. Tatchell et al.[12] in a 16 month study on 60 cattle in Kenya showed absolutely no benefit from intensive tick control compared with no control. It should be borne in mind that the acaricide used in this study was an organophosphate (as were all the favoured acaricides in Kenya at that time) and these have some deleterious effect on zebu cattle which could have been balancing the effects of the ticks on the untreated cattle.

The most robust option would seem to be one where strategic tick control prevents serious economic damage while at the same time preserving enzootic stability. Computer modelling can provide an essential aid in devising such strategies as was demonstrated by Pegram et al.[11] who were able to reduce acaricide usage by 66 % while retaining a greater productive economic benefit than the full intensive programme. In addition to this strategic control, further use of appropriate breeds, preservation/re-establishment of enzootic stability, and improved nutrition can lead to a programme of integrated Tick Management[13] which should bring improvements in robustness and profitability.

## Additional constraints

Ticks are only too visible perceived constraints to production; there are more insidious constraints with much more serious effects. Studies by the International Centre for Insect Physiology and Ecology (ICIPE) in Kenya (Hassan and Punya, personal communication) have shown dramatically greater benefits from anthelminthic treatment of calves compared with intensive tick control. They also found that improved nutrition resulted in such great benefit that the study, using calves of local owners, had to be discontinued because the owners were so impressed that the supplements were being shared with all experimental groups! In addition, ICIPE workers have shown that when pasture conditions are good, cattle are more resistant to ticks (a result that fits well with results from Australia). The benefit of adequate nutrition is often neglected in Africa. Traditional husbandry practice usually results in grossly inadequate grazing periods for cattle. Ideally, ruminants require access to fodder 24h/day, but in Africa it is normal for cattle to be held overnight in fenced yards without food or water. In many systems the cattle will not be let out to graze until close to midday and may return to the yard as early as 1600h. Under these circumstances it is not surprising that time to maturity may be 5–7 years and that the animal appears stunted. What is surprising is that the farmer and the veterinary surgeon may regard ticks and TBD as the prime cause of poor productivity.

Notwithstanding the above constraints, the Commonwealth Agricultural Bureau Symposium Meeting on »Improving Agricultural Production in Africa« in Arusha, Tanzania in 1984 concluded that the true prime constraint was poor marketing facilities. If these could be improved, a dramatic utilization of improved husbandry practices by farmers would result in an equally dramatic increase in off-take. As things are, the cattle producer is usually at the mercy of the traders as he lacks any information on current pricing. Attempts at setting up transparent auction systems are easily frustrated by the political influence of the traders (who are often politicians themselves). Farmers will have little incentive to increase production while profits remain low, as the days of the dependent, economically illiterate smallholder are, in general, long past. The emergent progressive farmer is better regarded as a self-reliant and somewhat sophisticated entrepreneur, well capable of assessing costs and benefits if properly informed.

## Conclusions

Rational control of livestock ticks demands an accurate assessment of the risk associated with different policy options and an accurate assessment of the true benefits to be gained from these different policies. Risk assessment and cost benefit analysis needs continual up-dating, otherwise advances in scientific knowledge and understanding will be ignored to the detriment of the decision making process.

These processes have been well-illustrated by the manner in which livestock producers in different countries have reacted over the years to the problems they face with ticks and TBD. Initially there was an overwhelming threat from TBD to which cattle were absolutely susceptible. The only possible response was

to attempt to control the vector by the use of acaricide treatments.

Eventually, this chemical control of ticks came to be regarded as a good in itself and was extended to cattle that were not at risk. Thus having the result that TBD immunity and enzootic stability were both lost and tick control became a necessity for these cattle as well.

Meanwhile, improvements in cattle productivity were being sought, not by improving husbandry techniques in cattle breeds that had evolved within an environment but by the introduction of breeds that had been selected for high productivity within different economic and natural environments. In Australia, over the period from 1970–1990 this trend was reversed as economic reality (partly driven by the fear of acaricide resistance as well as costs) was accepted, but in southern Africa »progressive« commercial farmers are finding it difficult to accept the benefits they could obtain by changing to the once derided indigenous breeds. Elsewhere in Africa, aid agencies and charities continue to be misled by experts familiar with the breeds of their north temperate homelands and only too willing to ignore the risk of trying something new.

It has to be accepted that TBDs are only a risk if the cattle are susceptible and if that is the case then attempts should be made to reintroduce immunity and enzootic stability by immunization or judicious exposure of calves to ticks and TBD. Once this step has been taken (and it is not easy), it is possible to use minimal acaricide interventions to reduce tick damage to below economic thresholds.

Unfortunately, what van Emden[14] calls the »user mentality« of preferring to use chemical control when it is effective because chemicals are familiar, convenient and under the direct control of the user has prevented the use on a large scale of an Integrated Tick Management package[13]. At the moment too much attention is paid to the high input, high output production systems which are going out of favour in the over-developed world. Integrated Tick Management, would be environmentally preferable (direct pollution and residues in animal products), in that the use of chemicals is minimized, full use is made of renewable, biological natural resources in enzootic stability and in the genetic resource of the adaptive traits acquired over an evolutionary time scale by indigenous breeds.

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**SAŽETAK**

**Znanstvene osnove kontrole širenja krpelja stoke bez rizika katastrofičnih promašaja u vrijeme rata ili socijalnih nemira**

*R. J. Tatchell*

Uspoređen je način kontrole širenja krpelja stoke u tropskim i subtropskim zemljama u [illegible] na tehnologiju proizvodnje stoke u visoko razvijenim zemljama iz kojih ta stoka u najvećem dijelu potječe. U zemljama Trećeg Svijeta nedostatni tehnološki postupci često smanjuju imunitet stoke i umanjuju korištenje odgovarajućih vrsta stoke otpornih na bolesti, a sve se to odražava i na katastrofične posljedice u ratnim uvjetima.

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*Prispjelo 15. travnja 1993.*
*Prihvaćeno 1. studenog 1993.*

# IV. CULTURAL AND NATURAL HERITAGE

## The Effects of the War on the Nature Park Lonjsko Polje, Croatia

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From 1986–1988 systematic inventories were made in the Sava wetlands, Croatia, to support the Croatian Nature Protection Authority's efforts to secure protection for the area. In 1991, the Croatian Government designated 506,5 km² of the Sava alluvial wetlands a Nature Park. The short-term effects of the war on on this internationally important natural area are as follows:

- Direct disturbance through fighting.
- Suspension of conservation measures.
- Destruction of villages and expulsion of inhabitants.
- Attacks on industrial areas and serious environmental pollution.

The following pose the threat of lasting damage to the development and protection of the Park:

- De facto removal of protection status by occupation of part of the area.
- Fragmentation and division of area.
- Long regeneration periods for some ecosystems e.g. forest.
- Pollution of parts of the area through oil and other chemicals.
- Destruction of traditional agriculture.
- Development of tourism has stopped.
- Damage to the area's image on an international level.
- Obstruction to the area's development.
- Severe economic damage to the communities contained in the Park.

The Nature Park Lonjsko Polje and the surrounding wetland areas represent an ecological unit which must be secured. In respect of the area's importance for Europe as a whole, restoration and rehabilitation of the areas affected by the war should be supported with international funds.

### Introduction

In 1984, Professor Hartmut Ern (Botanic Gardens Berlin-Dalem) and Professor Gerhard Thielcke (Max-Planck-Institut, Ornithological Station, Radolfzell), impressed with the natural diversity of the Sava Wetlands, felt that an organization was needed to promote the preservation of important natural areas of this kind in Europe.

In 1986, the Nature Protection Authority of the Republic of Croatia proposed designation of the Nature Park Lonjsko Polje. In the following three years, I myself was given the opportunity to study the Sava wetlands on site. In 1987, the European Natural Heritage Fund was founded and has since then supported the protection of the Sava wetlands. In 1990, the Croatian Parliament passed a law for the creation of the Nature Park Lonjsko Polje.

In 1992, I accepted the invitation to lecture at the Congress »The Effects of War on the Environment« on my study area in the Sava wetlands in Croatia. I assumed at the time that it would be possible for me to assess the consequences of the war on site and that I could then compare more recent data with that gathered during 1986–1988. However, this has proved impossible – at the time of writing (April 1993), 38% of the study area is inaccessible, despite the presence of UNO troops.

For this reason, here I can offer only an overview of the consequences of the war. The results of the 3-year study (1986– 88) form its basis, as new studies have not yet been possible. Due to the significance of the Sava wetlands and the Nature Park Lonjsko Polje for conservation in Europe, I hope that the remarks will help to point to the threats to these and other natural landscapes in Croatia. The protection and the reinstatement of legal measures will require the support of the international community.

### Methodology

The avifauna of the study area of 1,766 km² between Ivanić Grad, Sisak, Dubica, Kutina, Novska

Okučani and Bos. Gradiška was recorded on 466 days from 1986–1987 (Fig 1). I examined the most important parts of the area every 14 days during the breeding season. I reached the large continuous unbroken inundation zones by car, and individual parts of the area were studied on foot or by bicycle. The forest areas were searched for territorial raptors and black stork (*Ciconia nigra*) with binoculars: distant birds were identified with a telescope. All observations were noted with details of site (grid square 2x2 km), behaviour, age, sex and biotope. In the case of sites on which birds were observed, water level and agricultural use were described in detail.

The composition of the landscape was evaluated using old maps to a scale of 1:50 000 and a LANDSAT picture from 1986 (Table 1). The size of the biotope and the observations were recorded on the basis of grid squares each of 4 km$^2$. The data were evaluated at the Computer Centre at the University of Constance, Germany, with the statistical analysis programme SAS. The description of environmental pollution was made on the basis of a report made by the Croatian Ecological Society[1].

## Importance of the Sava wetlands

The Sava wetlands are of enormous importance in terms of European conservation. The most significant feature is the inundation zone of 600 km$^2$ (Table 1). In Central Europe, only the floodplains of the Biebrza and the Narew in Northeastern Poland are larger. Two other very important characteristics of the Sava wetlands are:

1. *The autochthon forests, which are probably Europe's largest alluvial forests*

The forests are cultivated but their rich species potential has been preserved as the Croatian forestry authorities have traditionally used only native species[2]. White-tailed eagle (*Haliaeetus albicilla*), lesser-spotted eagle (*Aquila pomarina*) and black stork (*Ciconia nigra*) have Europe-wide significance[3,4]. Other species endangered on a European scale, such as the middle spotted woodpecker (*Dendrocopus medius*), grey-headed woodpecker (*Picus canus*) and the collared flycatcher (*Ficedula albicollis*) are present throughout the areas. The presence of otter (*Lutra lutra*) and the European pond terrapin (*Emys orbicularis*) show that the area is also of great importance for other groups of animals.

2. *The traditional use of the floodplain as wet pasture and meadows mowed once a year, unique in Europe*

Extensive agriculture is carried out with ancient domestic breeds[5]. The various breeds of »woolly pig« – the »sarena«, for example, which is related to the Mangulica pig – is particularly important[6]. The Posavina horses are also very well-adapted to conditions in the floodplain. The natural value of the Sava wetlands is closely linked to the traditional grazing regime. Almost all of the endangered bird species prefer the wet pastures as a feeding site. Rare water plants have adapted to the wet pastures[7]. In addition, traditional land use is reflected in the village architecture (oak farmhouses). A unique cultural landscape has been preserved on the Central Sava, a river valley unequalled in the rest of Europe[8].

The remaining areas represent 10% of the original floodplain of the Sava[9,10] (Fig 2). Their protection as an entity is prerequisite for the preservation of high diversity. The designation of the Nature Park Lonjsko Polje was an important initial step. The area is an Important Bird Area[11] and has been listed by BirdLife International as one of the 50 most important nature conservation projects in Europe.

## Results

### *Fighting*

I was unable to observe the effects of the fighting at first hand. The effects on fauna can, however, on the basis of numerous studies on hunting disturbance[12] be said to be grave. Hunters' shots cause disturbance in a radius of up to 500 m of the hunter. Along the whole of the front and due to low-flying aircraft and the shooting in and around the towns, no undisturbed resting places were available (compare Fig. 1,3). The area from Novska to Okučani was for a long time one of the principle areas of fighting in this war. There was intensive fighting on the motorway from Novska to Okučani and on the access road Okučani – Gradiška. Apparently, there was even tank fire in the virgin forest reserve Prasnik.

The destruction of this last remaining section of original Slavonian oak forest, 350 years old, would be a great loss. The area has been included in the UNESCO's »Man and the Biosphere« programme on the grounds of its unique natural and cultural value[13].

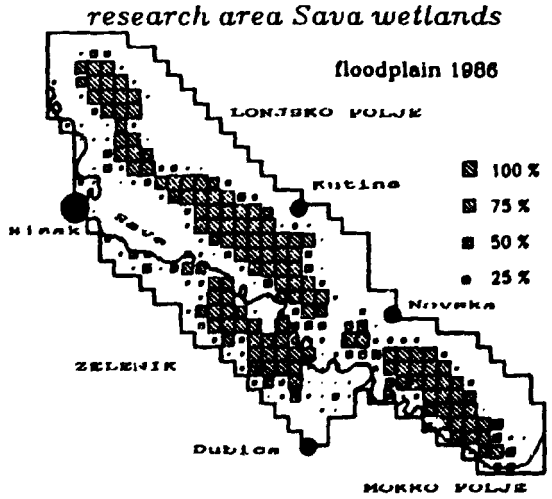


Fig. 1 – *Research area Sava wetlands with current inundation zones and the most important sections). Each grid square is 2 x 2 km in size.*

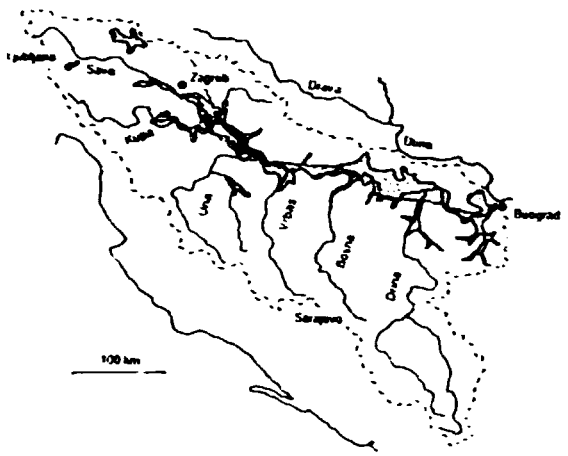


Fig. 2 – *Overview of the former inundation zone of the Sava (dotted) and the catchment area. The large intact inundation zones are shaded black. Almost all of them lie in the research area.*

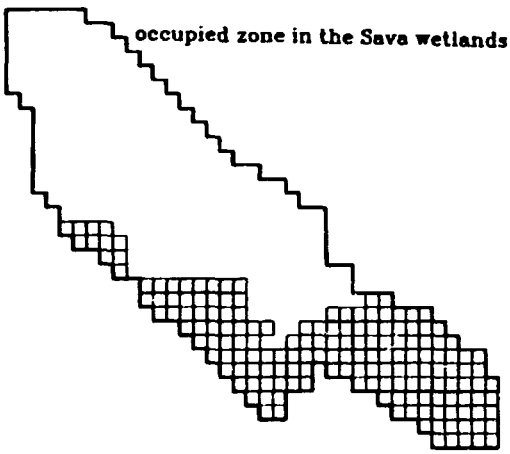


Fig. 3 – *Shows the occupied zones and the front which runs through the research area.*

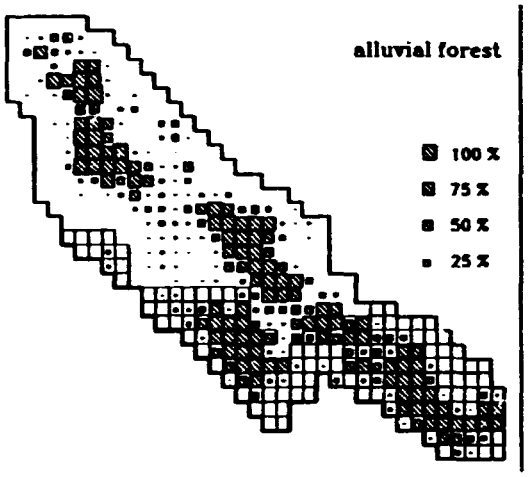


Fig. 4 – *Distribution of the autochton alluvial forest and lowland forest in the research area and in the occupied area.*

Table 1 – *Size (in km²) of the respective biotopes in the research area Sava wetlands and occupied zones.*

| | | Occupied | |
|---|---|---|---|
| | km² | km² | % |
| Research area | 1766 | 670 | 38 |
| Nature Park | 506 | 176 | 35 |
| Floodplain | 612 | 264 | 43 |
| Water bodies | 72 | 38 | 53 |
| oxbows | 8 | 5 | 63 |
| Sava | 28 | 18 | 64 |
| fish-ponds | 16 | 7 | 44 |
| Forest | 522 | 233 | 45 |
| Meadows | 121 | 72 | 43 |
| Pastures | 119 | 40 | 34 |
| Hedgerow landscape | 228 | 89 | 39 |
| Reparcelled land | 459 | 109 | 24 |
| Settlements | 100 | 33 | 33 |

Numerous reports and photographs point to the threats to wild animals by mines[1,14]. Also, it is well-known that on the Croatian side of the front, soldiers stationed on the front have regularly hunted in the forests (compare Fig 4). The same can be assumed for the other side of the front. Thus, a large area, possibly the whole of the Nature Park, has been damaged by uncontrolled shooting. The extent of the damage caused is not yet known.

### *Destruction of traditional agriculture*

The destruction of the villages destroyed by the front and the expulsion or murder of their inhabitants is not only a breach of human rights – it also means the destruction of traditional landscape in these parts of the study area (compare Table 1). As the remaining floodplain on the Sava can already be classified as a small remnant biotope, a further reduction in size would have to be regarded as critical. The effects would be particularly detrimental to the old breeds of pig and horse, in view of the loss of genetic information. Records of the remaining numbers in Lonjsko Polje were begun in 1993. Large wet pastures or river plains are important for the breeding success of the white stork[15].

The destruction of several villages in the occupied areas has had severe consequences for the surrounding countryside. Among these these are Staza and Visnica, on the Southern Bank of the Sava, and Kosutarica, Rajic and Varos in the Mokro Polje area. As the extensive, traditional agricultural regime is an essential aspect of the Sava wetlands' value, the destruction of the villages and the expulsion of the farmers is a great loss to conservation. The wet pastures near Bobovac on the part of the front south of the Sava cannot currently be used because of shooting. Only in the Lonjsko Polje area has the near-natural cultural landscape been spared destruction through war (com-

pare Fig. 5). However, due to the expulsion of farmers on the southern side of the Sava and the inaccessible wet pastures and meadows, some of the remaining cattle now graze in Lonjsko Polje.

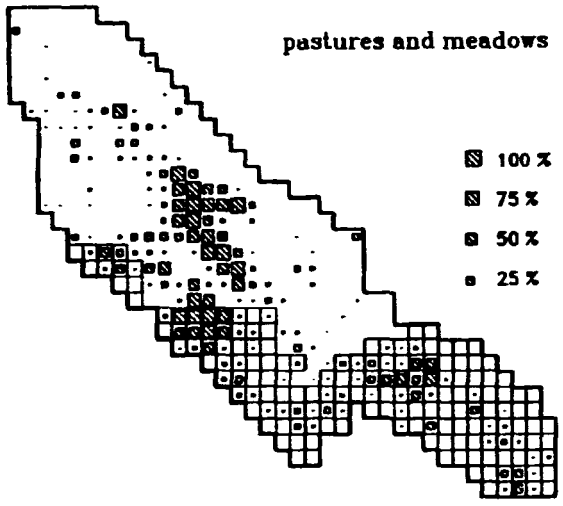


Fig. 5 – *Distribution of the wet pastures and meadowland in the research area and the occupied zone.*

### *Ecological importance of the occupied areas*

The Lonjsko Polje area was visited a number of times between 1992 and 1993 (Fig 1). In the Autumn 1991, when the front near Jasenovac pushed forward over the Sava, I had feared that this area, which is unique in cultural and historical terms, would be destroyed. However, here, the damage inflicted here has not been severe (several houses and the church in Lonja did sustain some damage). Fortunately, the villages along the northern bank of the Sava, with their wooden houses, escaped serious damage (and in some cases were left completely unscathed).

In this section, in order to point to the threats to the Sava wetlands ecosystem from the war, in this section, I will cover in detail the importance of the occupied areas. However, I am unable to comment on the current ecological situation. A presentation of its value must be made with population data from the years 1986–1988. The occupied area (Fig 3), which has not been monitored by the Croatian conservation authorities since the summer of 1991, contains an important part of the Sava wetlands ecosystem. About half of the important biotopes such as riparian forest (Fig 4), water bodies, wet pastures and meadows (Fig 5) are occupied (Table 1). This is also the case for the distribution areas of the endangered birds (Table 1).

The various parts of the alluvial plain have developed different characteristics depending on the water regime. The occupied Mokro Polje is, as the name indicates, a very damp river plain area, which is inundated for several months each year. The two wet pastures Poganovo Polje and Mokro Polje, located in the middle of the riparian forests, are especially valuable in ecological terms. On the other hand, the occupied parts on the southern side of the Sava are flooded only for a short time. The Zelenik forest is one of the largest areas of closed riparian forest. The areas on the Sunja are characterized by large meadow complexes.

While the non-occupied part of the Sava wetlands has been extended as a retention basin, the two inundation areas Mokro Polje and Zelenik are not dyked. They are linked to the Sava via the tributaries Sunja and Strug. Their significance for river plain conservation in Europe must therefore be assessed as particularly high[16].

A quantitative representation of the loss of area for individual species or through possible changes in the occupied areas is represented in Table 2. The loss of parts of their habitat (Table 1) could have serious consequences for several endangered species. A detailed analysis of the risks would require exact ecological data. The aim of this paper is to point to the significance of the currently occupied areas using several bird species as examples.

Table 2 – *Total number of grid squares (n) each 4 km² with observations of endangered European species of avifauna in the research area Sava wetlands. The figures on the right represent the number (n) and the percentage (%) of grid squares in the occupied zone.*

| | | Occupied | |
|---|---|---|---|
| | n | n | % |
| *Phalacrcorax carbo* | 59 | 20 | 34 |
| *Ixobrychos minutus* | 7 | 3 | 43 |
| *Egretta garzetta* | 50 | 21 | 42 |
| *Ardea purpurea* | 25 | 11 | 44 |
| *Ciconia nigra* | 150 | 75 | 47 |
| *Ciconia ciconia* | 117 | 44 | 38 |
| *Platalea leucorodia* | 36 | 13 | 36 |
| *Aythya nyroca* | 15 | 8 | 53 |
| *Haliaetus albicilla* | 99 | 48 | 48 |
| *Circaetus gallicus* | 14 | 10 | 71 |
| *Aquila pomarina* | 102 | 32 | 31 |
| *Crex crex* | 41 | 15 | 37 |
| *Chlidonias hybrida* | 25 | 12 | 48 |

*Case Study 1: White tailed eagle (Haliaeetus albicilla)*

The white-tailed eagle is threatened on a global scale[11]. The Sava wetlands, after the Nature Park Kopački Rit[17,18], are the second most important breeding area in Pannonia[4]. About half of the breeding and feeding area (Fig 6) lies within the occupied zone. Apart from the Lipovljani fish-ponds, most white-tailed eagle congregation sites lie in the part of the study area under occupation. The fish-pond group at Okučani, the wet pastures in Mokro Polje and on the Sunja are all important congregation sites.

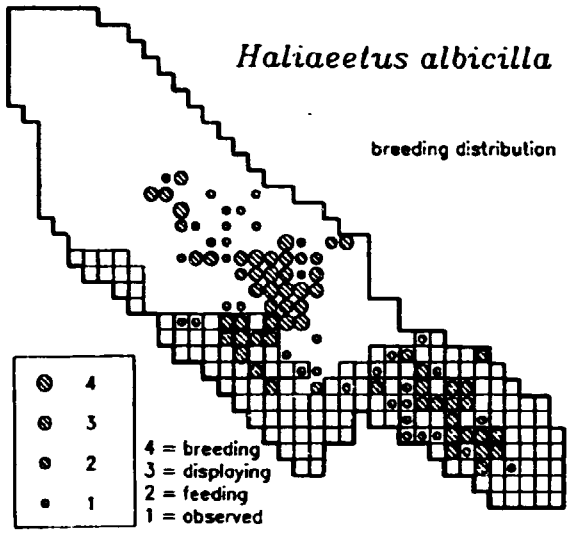


Fig. 6 – *Breeding distribution of the white-tailed eagle (Haliaeetus albicilla) in the research areas and in the occupied zone.*

Wing-markings were used to study the dispersion of young birds in the former Northern Yugoslavia[19]. As well as exchange between the individual areas, it was established that a large number of the young white-tailed eagles wandered into the population centre Kopački Rit. This area was the centre of the Pannonian white-tailed eagle population[17] (Fig 7), due to its undisturbed natural landscape and excellent protection in the core zone, the Special Ornithological Reserve. While about 43% of the Sava wetlands is occupied, all of Kopački Rit is occupied and parts are on the front itself[20]. Also, the study areas fulfil an important function as second congregation areas. During the study of 1986–88, young birds from throughout the area were found to have gathered here[19].

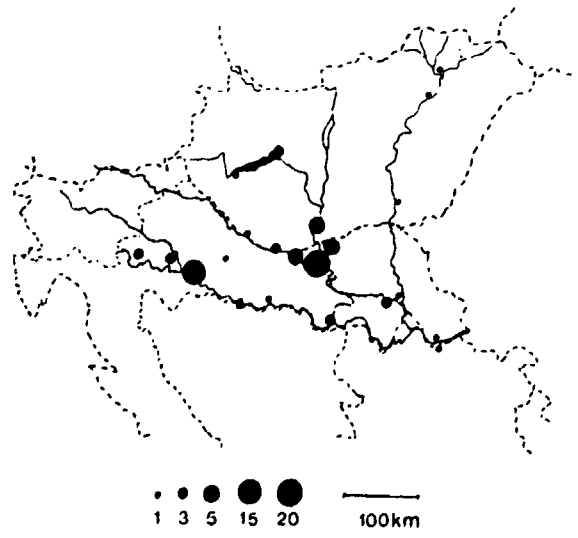


Fig. 7 – *Overview of the structure of the Pannonian white-tailed eagle population with the centres Kopački Rit and Sava wetlands (acc. to Grimmett & Jones[11], and Ham et. al.[26]).*

*Case Study 2: Spoonbill (Platalea leucorodia)*

The presence of the spoonbill in the river plain is one of the great characteristics of the Sava wetlands. Up to 10% of the European population breed in the area[3]. The only breeding site is the Ornithological Reserve Krapje Dol, which in 1991 lay directly on the front (Fig 8). Nothing is known of the breeding success in the year 1991, as the warden of the Biological Station was forced to evacuate the station. This was broken into and raided shortly afterwards.

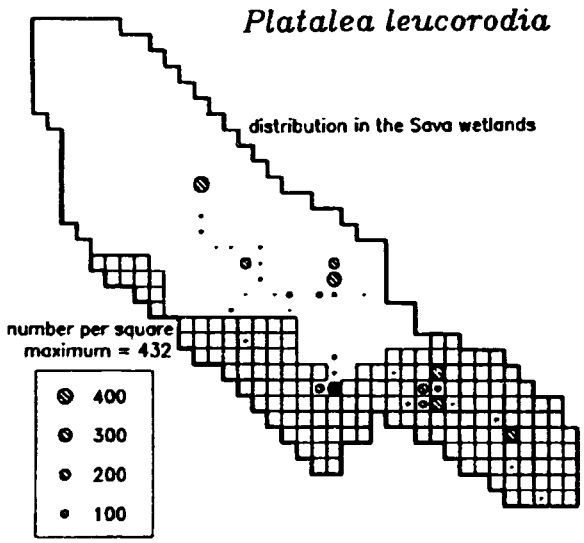


Fig. 8 – *Distribution of the spoonbill in the research areas and in the occupied zone. The colony Krapje Dol is shown as a black dot.*

The breeding colony was occupied again in 1992, but because of its vicinity to the front, work has not been resumed in the Biological Station. According to the observations made in 1986–1988, the most important feeding sites lie within the occupied zone (Fig 8).

The spoonbill's highly specialized feeding habits mean that only parts of the habitat can be used as feeding grounds.

It requires flat, muddy shallow water zones, where food is abundant. In the breeding season, favoured sites are the wet pastures as floodwater drains off, and, in spring and autumn, emptied fish-ponds.

Figure 9 shows the interaction of the various breeding sites in 1987 and 1988. The spoonbills searching for food concentrate on optimum sites in which the retreating water has left shallow pools in depressions. The protection of feeding sites in the occupied areas is essential for the preservation of the species. Without these feeding sites, bottleneck situations could arise in the course of the year, leading to adverse conditions for the raising of young birds or even abandonment of nests.

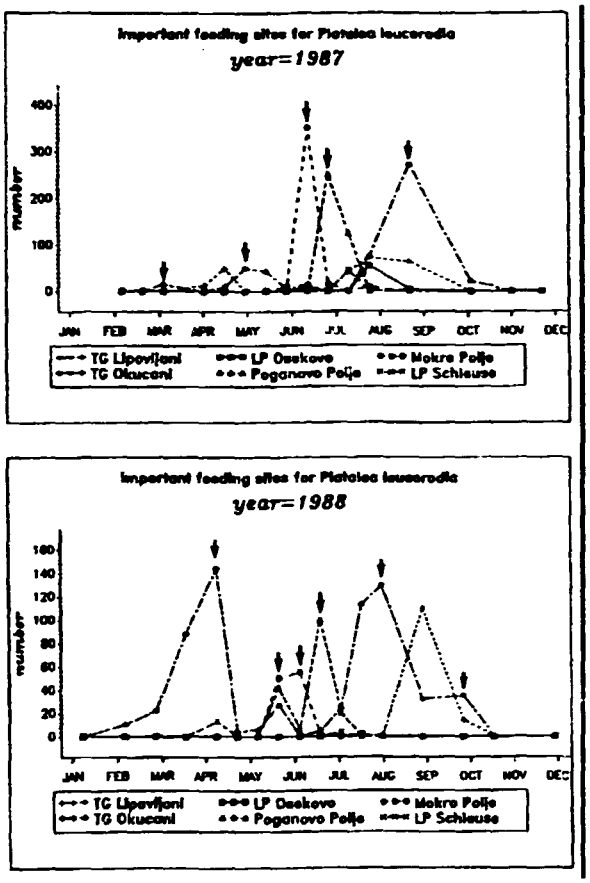


Fig. 9 – *Overview of the changing feeding sites of the spoonbill in the Sava wetlands according to population surveys made in 1987 and 1988. The feeding places in the occupied zones are marked with an arrow (fish ponds of Okučani, Poganovo polje, Mokro polje).*

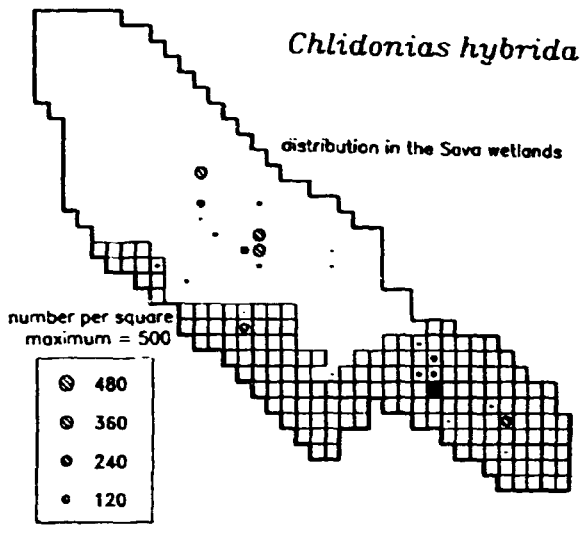


Fig. 10 – *Distribution of the whiskered tern (Clidonias hybrida) in the research areas and in the occupied zones. The only successful colony (shown in black) lies in a wet pasture in the occupied zone.*

*Case Study 3: Whiskered Tern (Chlidonias hybrida)*

The whiskered tern is a specially adapted to the floodplain. It breeds on floating aquatic plants in the shallow water zone. Breeding attempts in Lonjsko Polje failed as the floodwater drained off too quickly (Fig. 10). The only successful breeding site, with up to 250 breeding pairs, lies in the occupied part of the study area (Fig 10) in Mokro Polje. This wet pasture, Poganovo Polje, is remarkable for a large depression which retains water throughout the year. Changes in land use in this area would lead to the disappearance of the species in the Sava wetlands. The wet pasture in the Poganovo Polje supports the greatest diversity in the Sava Wetlands in terms of birds and water plants[21,8].

*Strategic destruction of industrial plant*

The destruction of industrial areas brings with it massive threats for man and the environment. In 1992, the refinery in Sisak was attacked 26 times and in 24 cases caught fire as a result. 133,221 tonnes of oil products were spilled into the surrounding area – most of which burned. 400 tonnes of oil spilled into the Sava alone. The effects of the oil on the river are not yet known. The sewage works were completely destroyed during the fighting, and today there is no treatment of waste water[22].

To date, the effects of this environmental catastrophe are unknown. To my knowledge, no water analyses have been made. As the Sava flooded in 1991, it is probable that pollutants from the industrial zone reached some of the flooded parts of the river plain in Mokro Polje and Zelenik, which are not separated from the Sava by dams[16]. The oxbows along the Sava also contain a very rich flora and fauna, which could be seriously affected by pollutants[7,21].

The vicinity of the industrial zone of Kutina poses an even greater threat. On 2 December 1991, and on New Year's Eve, the army attacked the fertilizer factory in Kutina, which lay several kilometres behind the front. It is the largest factory in the former Yugoslavia, with production of 1.6 million tonnes of fertilzer per year. Fortunately, the plant was not severely damaged. According to the Croatian Environment Ministry, an explosion in this factory would have been lethal up to 100 kilometres away from the factory. Also, the factory has a disposal site at the edge of Lonjsko Polje which contains about 1.7 million tonnes of phosphoric gypsum and phosphoric acid, contaminated with other toxic residues from processing. Fortunately, the attack on 12 December 1991 missed the plant. The destruction of this disposal site would have had very serious long-term effects on the Sava and Danube and would have wiped out large areas of Lonjsko Polje's flora and fauna.

***Destruction of Park Development***

Effective management of Nature and National Parks and the development of tourism in and around them depends in part on their infrastructure. In the Nature Park Lonjsko Polje, there is only the Biological Station Drenov Bok, which was forced to suspend operations in the summer of 1991. Despite the fighting, the warden from this village operated the water pipe to the spoonbill colony Krapje Dol.

Since 1991, there has been no eco-tourism to speak of in the area. At the beginning of May 1991, after the murders at Borovo Selo, a seminar in Lonjsko Polje was cancelled due to the withdrawal of all of the participants. Since 1985, television films in Germany and many reports in the international press have pointed to the importance of the area. Before this, groups of tourists from Belgium, Germany and Switzerland had visited the area. The war has destroyed long-standing efforts to support the protection measures with eco-tourism. The consequences in other Nature and National Parks in Croatia have been even worse. The war has deprived them of DM 25 million in entrance fees alone. Facilities such as the various services for catering and excursions yield ten times this amount. As well as this, there is the loss of income from the renting of accommodation and hunting guests. About DM 4 million was created through big game hunting in Kopački Rit. The Plitvice enterprise produced DM 35 million profit per year[23].

*Blocking international protection measures*

For the last four years, there have been intensive efforts to set up the Nature Park through international sponsorship. Inter alia, the ICBP made an application for funds to the European Community, which was backed by the Nature Protection Authority in Zagreb In 1993, the IUCN submitted an application for support at the EC Minister Conference in Lucerne. However, due to the current political situation, the project will not be receiving international funding, although this is urgently needed. The only exception is a programme being run by the Environment Ministers of the Federal Republic of Germany for Central and Eastern European countries, which financed the consultancy work of the European Natural Heritage Fund in 1993.

In other parks, the effects of war are worse. In Krka National Park, construction of an urgently needed sewage treatment plant within the framework of the EC's PHARE Programme was nearing completion. Should the occupation of Knin continue, further pollution of the Park with sewage must be expected.

*Problems with pollutants in the floodplain*

The extent of the threat to Man and wildlife from pollutants entering the ecosystem as a result of the war is not yet clear. As some water bodies were highly polluted before the war, an increase in pollutants could have serious consequences. For example, the Croatian Environmental Report of 1992[24] points to water quality values of III – IV for the Sava and its tributaries. The Drava reached Stage II – but in its lower course only. In the riparian forests on the Drava near Varaždin, soil samples revealed a lead content 20 times that of control floodplain soils (up to 1445 g Pb/kg)[25].

The white-tailed eagle is a good example of the threats posed by environmental poisons to the area's wildlife. This species is especially threatened as it feeds on fish, birds, tortoises and carrion and is thus at the top of the food chain in the floodplain ecosystem. Mikuska (1979)[17] reports on having discovered several dead birds on the Drava in the Kopački Rit area. 16.0 ppm mercury were measured in the feathers of one of the corpses. Further studies were carried out as part of the white-tailed eagle project, and these confirm the threats[26,27]. Also, examination of infertile eggs for DDE and PCB has shown that the parts of the floodplain on the larger rivers are highly polluted and already pose a threat for the white-tailed eagle population[28].

Increased pollution from war activities must be considered as particularly serious (comp. plenary lecture, Richardson, these proceedings)[29]. A build-up of PCBs in the population centres of the white-tailed eagle (Fig. 7) could poison the whole Pannonian population. The spoonbill and the black stork, whose gathering sites also lie in the floodplain[11,30,31] face similar threats.

*Long term consequences of war and occupation*

In order to evaluate the dangers to conservation from the war, secondary effects must also be considered. Inaccessibility due to the front has been one positive effect. In the winter of 1992–3, many water birds rested on the Sava near Lonja, as this area is a no-man's land (Crnko mdl.) – access is prohibited and there is no fighting. Parts of the forest are inaccessible due to mines. The lack of disturbance can be positive for species sensitive to disturbance. However, in general we must assume great degradation due to the tense economic situation in the occupied zones. In these areas, the food supply for the human population is limited, and this could lead to increased dependence on natural resources, e.g. hunting of wildlife. Some reports point to the clearing of large parts of the autochthon woodland. All of these reports must be confirmed in the occupied areas.

In March 1993, there were reports of rat plagues in the villages around Lonjsko Polje. The use of poisons to fight the problem could lead to the death of wild animals. Carrion feeders such as the white-tailed eagle are especially at risk.

The situation near Lonjsko Polje is particularly critical because the road and railway track on the southern edge of the inundation zone between Sisak, Dubica and Novska is blocked. The villages of Sunja and Greda can be reached only with the ferry via the Sava. Current economic and strategic considerations could lead to the construction of a new road around

the occupied zone. Thus, in addition to short and long-term damage inflicted by the war, the intact part of the Lonjsko Polje and the stork villages could be threatened with a road construction project.[32]

Reports indicate a similar situation in other areas. Apparently, in Spring 1993, the Serbs had planned construction of a road in the occupied Nature Park Kopački Rit. However, objections submitted to UNPROFOR by ecologists from Osijek[33] managed to prevent realization of the project.

***Summary***

An analysis of the damage to nature reserves by war must cover a wide range of influences. For Lonjsko Polje and the other nature reserves in Croatia, this is only possible in the form of a review, not however as final results. The reasons are as follows:

1. The inaccessibility of large areas in the currently occupied zones.

2. Lack of data on indicators and habitat quality.

3. Absence of exact measurements of pollutant build-up due to destroyed industrial plant, abandoned fighting equipment and vehicles.

Despite this, the damage caused by the war can be classified as serious, as scientific monitoring, income from tourism and grant programmes have been brought to a halt by war activities.

The war has also been directly responsible for the destruction – during fighting – of numerous villages which are an integral part of the cultural landscape. A great deal of the wildlife which should be protected in the Nature Park Lonjsko Polje is linked to the cultural landscape and is endangered by the destruction of traditional agriculture. A typical example of synantrophy is the white stork (*Ciconia ciconia*) whose breeding success is at its worldwide best in the Central Sava[3].

The Nature Park Lonjsko Polje is just one example of a threatened natural area in Croatia. In contrast to other areas such as the National Park Plitvice or Kopački Rit, only half of the area is occupied and one part, the Lonjsko Polje, sustained little damage during the war. However, the fact that the front could have extended 10 km over the Sava near Sisak, or that damage to the factory in Kutina could have caused more damage makes clear the extent of the threat faced by the Nature Park Lonjsko Polje.

In view of the destruction of many villages to the West of Sisak, the value of the intact parts of Lonjsko Polje as a unique cultural landscape in Croatia has increased. A book by Čačić & Salopek (1991)[34] describes the impressive architecture of the area.

Protection of the Sava Wetlands depends on the following:

1. Avoidance of all further war activities to prevent further or even greater damage.

2. Efforts on the part of the UNO peace troops to demilitarize the most important natural areas and nature reserves in the occupied areas.

3. Examination of these areas with regard to species potential and environmental quality.

4. Trust-creating measures through international organizations, in order to reinstate the former situation in which the various population groups lived together peacefully. Every farmer who lived here or still lives here is of great importance for the Nature Park.

5. Development of nature reserves with corresponding infrastructure; administration, tourism management, strict protection areas.

The Croatian wetlands are of great importance for conservation in Europe[2,11,25]. Their protection must be a priority, nationally and internationally. A peaceful solution to the current situation will require a high degree of international effort.

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## SAŽETAK

### Utjecaji rata na Park prirode Lonjsko Polje, Hrvatska

*M. Schneider-Jacoby*

Prikazani su mogući utjecaji ratnih djelovanja i okupacije dijela parka prirode Lonjsko Polje. Uslijed ratnih djelovanja i okupacije dijela teritorija park prirode je izgubio status zaštićenog područja, podijeljen je na područja koja su izvan kontrole, dijelovi područja zagađeni su kemikalijama i naftnim derivatima, napušteni su tradicionalni načini privređivanja poljoprivrednim djelatnostima uz znatne ekonomske štete, a regeneracija ekosistema trajati će kroz duži period. Zaključeno je da s obzirom na širi značaj područja prirodnog parka Lonjsko Polje za ovaj dio Europe, obnovu i zaštitu područja trebaju podržati i financirati međunarodne institucije.

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# Structural Analysis of Architectural Heritage - A Prerequisite for its Reconstruction

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By the use of FE Method, using the COSMOS-M system, we have analysed the damage done to the dome of the Cathedral of Šibenik, a masterpiece of the Croatian Quttrocento architecture. Before that, an elaborate analysis of the whole structure was done, using more conventional analysis methods. Fortunately, the shell injury to the dome structure is not a dangerous one, but there was an imense luck, because the projectile has missed the rib of the dome arch, which coud have than a devestating effect to the whole structural stability of the dome.

To approach the damages to hystorical monuments, scientific analysis methods should be used to asses the damage and approach the most suitable sanation methods.

## Introduction

Systematic destruction of the architectural heritage in the aggression against Croatia is an almost insuperable problem for our devastated country: an immense number of damaged monuments have made us realize that the greatest part of our cultural property is not even studied. Only the most important monuments have been scientifically elaborated, but these researches rarely do contain their structural analysis[1].

This presents a serious difficulty, since the trough comprehension of the structural behavior of ancient buildings is a preresquisite for their proper reconstruction.

## Methodology

The structural analysis of an excellent building – the Cathedral of Šibenik – served to the rationality and logic of masonry structures. Static analysis was carried out with the classical approach and with the COSMOS/M finite elements program.

## Results

One of the best achievements of the Mediterranean stone masonry tradition is undoubtedly the Cathedral of Šibenik, a masterpiece of the Croatian Reanaissance architecture. Built in 1431–1536[2,3], in the times of Turkish invasion in the Balkans, which threatened the small Mediterranean town as well[4], the Cathedral was damaged by the new Vandals in September 1991. Its greatest value is the harmony and the complex unity of its structure and form[5]. The most impressive part of the Cathedral are its vaults, erected with a peculiar tehnique, unique in its kind, which enabled very elegant and audacious structure. The barrel vaults with thin one- layer plates, shells, which also make the roof of the church, are constructed by mounting large thin stone slabs on relatively slender semicircular stone arches tightened with iron ties. It is clearly a prefabricated structure, based on the tradition of constructing wood[5]. This all design, which seems formally Renaissance, but is structurally Gothic, for its plain skeleton, its clear distinction and hierarchy of primary and secondary structural elements, was used even for the dome structure. The dome, generally a spatial structure par excellence, is made here as a system of planar arches, converging into one point, and the web, acting as a covering, consist of stone slabs, like that one of barrel vaults[6].

The main objective of our research was the structural analysis of the octagonal dome, damaged by a bomb-shell. The static analysis was carried out with the computer finite element modelling, using the COSMOS/M FE program. As we suspected, the damage, a circular hole in the upper part of the stone dome system has not much consequence on the carrying capacity of the dome, since that is one part of the dome where the stresses are low, and the deformations extremely small. This can be seen on the presented screens (Figs. 1–4). Fortunately, it is not a dangerous structural damage which could jeopardize the stabillity of the Cathedral, because only a secondary element was harmed. The projectile has missed the rib only by chance: there could have been a devastating effect to the dome stability, if the rib had been hit and damaged.

Consequently, due to the structural hierarchy of the elements of its vaults, the Cathedral of Šibenik resisted even the intentional attempt of demolition. This is a proof of the fascinating strength of its apparently fragile structure.

## Discussion

As the analysis has shown, the structure of the Cathedral of Šibenik is very elegant, audacious and

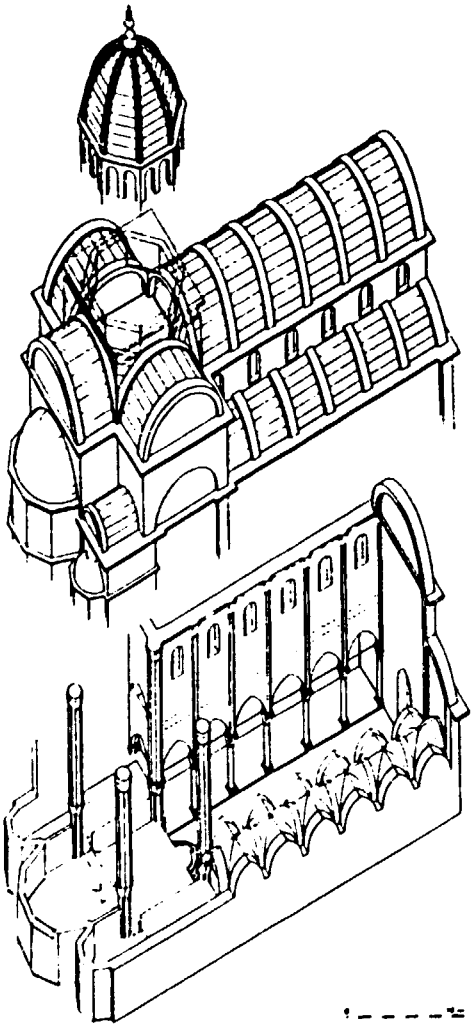

Fig. 1 – *The 3D entities*

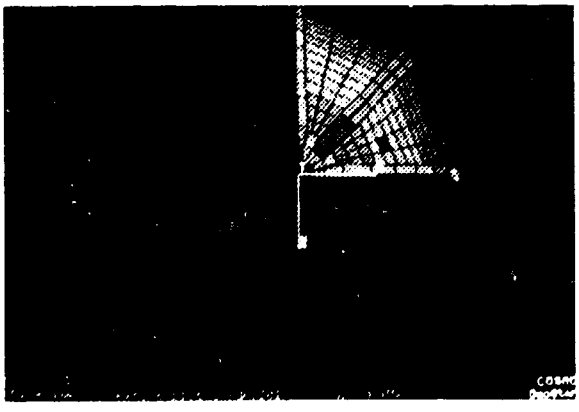

Fig. 2 – *The finite element (FE) mesh using 3D SOLID elements*

Fig. 3 – *The part of obtained results: deflections (d. lines)*

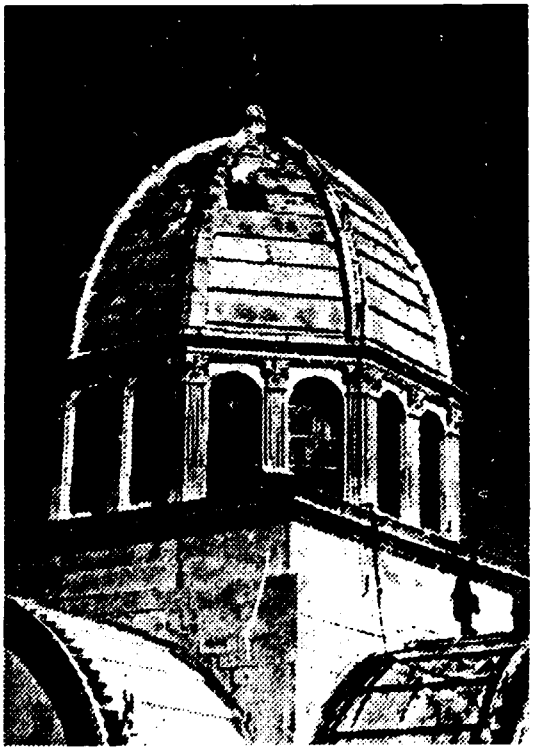

Fig. 4 – *Displacement of a substructure element*

purposeful. The structures of most ancient buildings are very complex, but also extremly logical and rational. This is a result of the very quintessence of the structure, which is influenced by strict laws of mechanics, so that every structural error is inevitably punished[7]. Only properly designed buildings could resist the time, and even withstand very strong earthquakes much better than modern structures[8]. Centuries-old continuity of constructing with traditional materials and techniques gave to ancient master- builders an opportunity to examine existing buildings as full- scale models[9]. Thus, they always considered buildings as indivisible unity, so that the idea about dichotomy between structural and decorative elements was completly strange to their mind. Therefore, their own works were also very sophisticated and purposeful, and often the apparently decorative details have a precisely determined

structural role[10]. That is the reason why the restoration of ancient buildings is such a delicate problem.

## Conclusions

Inappropriate methods of structural restoration have often caused incurable damage to the architectural monuments, because the introduction of individual elements in their delicate organisms can not only provoke the loss of their structural integrallity, but also change their structural characteristics. In this way the restored buildings get a different bearing system[11], which can be even less favorable than the original one.

Therefore, every intervention on the structures of an ancient building requires a comprehensive analysis of the structural characteristics and behavior.

## *ACKNOWLEDGEMENT*

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## SAŽETAK

**Analiza konstrukcija povijesnog nasljeđa – preduvjet njihovih konstrukcija**

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Koristeći se FE programskim paketom COSMOS/M analizirano je oštećenje kupole Katedrale u Šibeniku, umjetničko graditeljskom dostignuću hrvatske arhitekture. Prije ove analize provedene metodom konačnih solid elemenata, struktura katedrale bila je statički analizirana korištenjem konvencionalnih metoda grafostatike, tako da se imalo uvida u cjelokupnost strukturalnog djelovanja. Na sreću, oštećenje od eksplozije projektila nije strukturi kupole nanijelo veće strukturalno oštećenje, jer na sreću projektil nije pogodio rebro kupole, što bi imalo katastrofalnih posljedica i uzrokovalo njeno urušenje. U pristupu analizama oštećenih konstrukcija povijesnih objekata, potreban je suvremeni znanstveni pristup, kako bi se na najbolji način sanirala oštećenja objekata.

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*Prihvaćeno 1. studenog 1993.*

# Declaration: Destruction by War of the Cultural Heritage in Croatia and Bosnia-Herzegovina

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Declaration made by the participants in the session concerning the Destruction by War of the Cultural Heritage in Croatia and Bosnia-Herzegovina at the International Conference on the Effects of War on the Environment, Zagreb 17th April 1993

A. **Recognising** that information concerning the effect of war on the cultural heritage is insufficient as a basis for planning future action we:

1. ask the European Community Monitoring Mission to facilitate visits by international experts to areas inaccessible to the Croatian and Bosnian authorities and further
2. ask that a decision to enable this is taken at the highest possible level within the European Community

*in addition* given the feeling that the present information being provided by Croatian and Bosnian institutions is insufficient in extent and detail to allow a full and objective assessment of the cultural heritage to be made we

3. ask those institutions to carry out more fieldwork as a matter of urgency.

B. **Recognising** that international conventions concerning the protection of cultural monuments and cultural property have not been observed during the conflict in the former Yugoslavia we:

1. call upon the Croatian authorities to organise a conference in Croatia to discuss practical means for enforcing these conventions.
2. ask the United Nations to review, as a matter of urgency, the efficacy of the Hague Convention of 1954, the 1977 protocols to the 1949 Geneva Convention and the 1972 Paris Convention.

C. **Realising** that in order to prevent secondary damage to the environment and to the cultural heritage by neglect, planning needs to be begun at the earliest possible moment we:

1. call upon the relevant international, national, regional and local bodies to begin preparations for repair and reconstruction immediately and

**Realising** that this process is being hampered by lack of co-ordination and dissipated by duplication call upon

2. The Council of Europe as the European body most concerned with the protection of the environment and the cultural heritage to co-ordinate the efforts of the various international bodies interested in the preservation of the heritage.
3. the Croatian government to determine one body responsible for the co-ordination of the national response to war-damage and to ensure that similar co-ordination is achieved at the regional and local level and which involves local people and values their contribution.

and further *realising* that further loss through deterioration is a serious possibility and that there is a desperate need for shelter we

4. call upon the relevant international, national, regional and local bodies to provide immediate practical aid and advice to the owners of historic buildings, including the owners of traditional rural buildings, to enable repairs to begin in a non-destructive way.
5. ask the Croatian authorities to make a clear assessment from the detailed surveys called for above, of the material needs of the cultural heritage so that international aid can be directed to the main priority areas.

**SAŽETAK**

**Deklaracija: Razaranje kulturnog nasljeđa ratom u Hrvatskoj i Bosni i Hercegovini**

*J. Salle and J. Wade*

Deklaracija očituje stav sudionika konferencije koji su sudjelovali u radu sekcije sa temom zaštita kulturnog nasljeđa od razaranja tijekom rata u Hrvatskoj i Bosni i Hercegovini.

Zaključeno je da informacije o razaranjima spomeničkog nasljeđa i o nepoštivanjima međunarodnih konvencija tijekom rata nisu bile dostatne da bi poslužile kao osnova za šire angažiranje međunarodne zajednice. Upućen je i apel Ujedinjenim Narodima sa upozorenjem na nedjelotvornost međunarodnih konvencija koje imaju cilj zaštite kulturnog nasljeđa u slučaju ratnih djelovanja.

*European Council for the Village and Small Town*

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*Prihvaćeno 1. studenog 1993.*

# V. CASE STUDIES

## Principles of Risk Assessment

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Chemical risk assessment is a task which can only be undertaken with an adequate knowledge of the chemistry of the substances involved. Risk assessment is a multi-disciplinary subject with worldwide consequences.

It is vital to remember that risk assessment based decisions taken in one country can have far-reaching effects in other parts of the world. Hence those causing damage by war or the effects stemming from natural disasters or accidents not only have effects to the country in which these effects occur but in neighbouring countries or indeed globally.

The probability (*i.e.* the risk) that any given level (hence the requirement for a massive monitoring programme) of a chemical in the environment presents a hazard to the exposed population whether human, animal, fish or other species, can be extremely difficult to determine, but it is essential that rigorous scientific methods are used in any such assessment.

The ultimate aim of this International Conference, supported by both the Croatian Chemical Society and the Toxicology Group of the Royal Society of Chemistry is to minimize both controllable and unnecessary risks, to make responsible decisions and take pragmatic, feasible and beneficial courses of corrective action. Any gross mismanagement, even of everyday events such as refuse disposal which is already a major problem in the war strafened Croatia could lead to a regression in our way of life. That is, the way of life for us all.

Only by a thorough understanding of the procedures and terms used can experts advise governments and the international agencies on risk assessments and risk management techniques which must never mislead the public about the real trade-offs necessary between risks, costs, and benefits, and hence distort priorities.

The priorities arising from the war in Croatia (and Bosnia) are high but only by assessing the greatest risks can remedial work from world aid sources be applied pragmatically to preserve vital resources such as water on which we all depend.

### Introduction

A hazard assessment of some of the chemicals discharged to the environment during the war in Croatia have previously been outlined by the author earlier in this Conference.

In order to provide a meaningful risk assessment a massive monitoring programme is required as previously indicated. This can be by specific or generic, *e.g.* by the Microtox® test[1]. Only by means of an adequate risk assessment can remediation and reconstruction be achieved in a totally cost beneficial manner.

Hence, in order to achieve an adequate understanding of the principles involved in hazard and risk assessments some definitions are necessary.

*Hazard*

The set of inherent properties of a chemical, mixture of chemicals, or a process involving chemicals which, under production, usage, or disposal conditions, make it capable of causing adverse effects to organisms or the environment. In other words, and depending on the particular degree of exposures, it is a source of danger[2].

*Risk*

(i) Possibility that a harmful event (death, injury or loss) arising from exposure to a biological chemical, or physical agent, may occur under specific conditions; or,

(ii) Expected frequency of occurrence of a harmful event (death, injury, or loss) arising from exposure to biological, chemical, or physical agent under specific conditions. Hence, risk can be considered as Σ hazard x exposure[2]. It is vital that risk is not confused with hazard, as is often the case[3,4]. Perhaps, the most important consideration is that risk should always contain an element of quantification.

In non-technical terms, risk means that there is a probability of a generally unfavourable outcome.

*Risk assessment*

Risk assessment is the combination of 4 aspects:
Hazard identification;
Risk characterization;
Exposure assessment, *i.e.* measurement (monitoring); and,
Risk estimation.

It is the identification and quantification of the risk resulting from a specific use or occurrence (or disposal) or from destruction caused by war activities of a chemical taking into account possible harmful effects on individual people or society of using (or being exposed to) the chemical in the amount and manner proposed and all the possible routes of exposure.

Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

*Risk management*

Risk management also needs to be considered. This is the management, decision-making, and active hazard control process involving consideration of political, social, economic, and engineering factors with relevant risk assessment relating to a potential hazard so as to develop, analyze, and to compare regulatory options and to select the optimal regulatory response for safety from that hazard.

It is a combination of:

Risk evaluation;
Emission and exposure control, and,
Risk monitoring.

It is of paramount importance that process control is emphasized. Further details are available from WHO, Geneva[5].

Hence, in order to undertake risk assessments, it is necessary to assess both the hazard and the exposure.

*Hazard assessment*

Firstly, the hazard has to be identified and this is undertaken from a knowledge of the chemicals purchased, synthesized or formulated and sold at each factory.

The methodology for achieving this is described in the literature[6–14], and is preferable to the consideration of sophisticated chemical analysis, at least initially.

It is then necessary from a knowledge of these chemicals to assess their toxicology and ecotoxicology. This requires access to a large selection of books, journals, or online databanks and bases, CD-ROMs, etc[15], or from various dictionaries[16].

*Risk assessment, including monitoring*

Having gained acceptance that a substance is hazardous it is then necessary to make a risk assessment, this by definition (see above) requires a knowledge, albeit semi-quantitative data, as to the concentration of the chemical(s) in question. This can be achieved by chemical analysis varying from simple techniques such as ion-specific electrodes for simple cases, such as fluoride, through to sophisticated techniques, such as high-performance liquid chromatography (HPLC), GC-MS, or even HPLC-MS, or MS-MS[17].

An alternative and more pragmatic approach is to consider generic means of monitoring, one of the most robust, peer reviewed, rapid and portable methods is the Microtox® test[18–19]. The Microtox test has been assessed for its comparisons with fish[20–21] and for its value in assessing landfill leachates. It is based on the reduction of luciferase activity in marine bacteria *Photobacterium phosphoreum*.

## Conclusions

The hazards identified in the UNIDO consultant's report[22] and issue paper[23] to this International Conference, require to be assessed for their risks. Remedial action for restorative work can then be identified to prevent further damage to the environment within Croatia, the transnational rivers and the tributaries polluted by the ravages of the war, the Adriatic sea, etc.

This lecture will set the scene for the discussion, both on the consultant's report and on the preceding papers in particular the effects of mineral fibres, national and social disasters, emission of volatile organic compounds to the atmosphere, restoration of contaminated environmental media, etc.

In this way pragmatic proposals to remedy the ravaged environment will be debated by global experts.

A stable economy is achievable only from a sustainable environment.

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**SAŽETAK**

**Principi procjene rizika**

*M. L. Richardson*

Procjena rizika kemijskih tvari može se provesti samo uz odgovarajuće poznavanje kemijskih svojstava tvari koje su uključene u rizik. Procjena rizika je multidisciplinarno područje s međunarodnim posljedicama. Procjena vjerojatnosti da će određena koncentracija kemijske tvari štetno djelovati na okoliš može se provesti samo primjenom najsuvremenijih znanstvenih metoda za što je u uvjetima rata u Hrvatskoj neophodna pomoć međunarodne zajednice. Rješavanje čak i svakodnevnih problema koji su se pojavili tijekom rata u Hrvatskoj kao što su odlaganje otpada i problem kvalitete vode zahtjevaju uključenje međunarodnih agencija kako bi se izbjegle krive procjene rizika i kako bi se koristile tehnike procjene koje će omogućiti ispravno informiranje javnosti o rizicima, troškovima, dobicima i prioritetima.

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# Public Health and Ecological Aspects of War Destructions in the Republic of Croatia

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In this paper specific public health and ecological aspects and consequences of war destructions in the Republic of Croatia are identified on the basis of currently available data, since there are still ongoing war activities.

On the basis of available data on actual destructions and devastation of the environment and taking into consideration the uncontrolled discharge of different and highly toxic substances, possible short-term and long-term impacts on human life are described from the aspect on health ecology.

Actual suggestions based on these considerations are targeted to alleviation of consequences, to taking indispensable restoration measures and measures for permanent monitoring the toxic and hazardous substances in ecosystems (soil, water, air) and foodstuff chains, with the view to enable preventive public health and ecological actions in order to protect health of Croatia's population.

## Introduction

War is one of the greatest disasters to befall a nation or a land. Consequences and damages inflicted by wars are multiple and frequently felt for decades. Each war brings about suffering, fear, direct destruction and endangerment of human lives, physical disablement, long-term population and demographic changes accompanied with numerous public health and ecological consequences.

In addition to common features of all wars, the war in the Republic of Croatia shows some specific characteristics:

– destructions focused on civil targets and objects of differential industry and infrastructure, with the aim to cause maximal and long-term consequences through total destruction of economic and ecological resources;

– ethnic cleansing of particular regions (Slavonia, Kordun, Bania, Lika, Dalmatia);

– destruction of rural areas as population reservoirs and ethnic symbols (Slavonia, Dalmatia, Bania, Kordun, Lika);

– regiocide – devastation and depopulation of entire regions (*e.g.* the Lipik-Pakrac region, the Slunj region etc.);

– intentional infliction of ecological damages (destruction of water power plants and dams);

– using exceptionally valuable natural entities as hostages with the aim to achieve political and military objectives (the Plitvice Lakes National Park, the Kopački Rit Nature Park);

– brutality and destruction of natural and cultural heritage;

– brutality towards wild and domestic animals;

– destruction of numerous health facilities and institutions.

### *Purpose and objective of the study*

The objective of this study is to identify and systematize environmental damages and their scope known so far, taking into consideration all possible public health and ecological consequences of the damages inflicted by war destructions.

### *Methods of the study*

The methods used were analyses, deductions and syntheses and particularly collecting the written or direct information by taking an insight while touring the war affected areas of the Republic of Croatia, as well as data available through the UNIDO mission which visited Croatia in January 1993 at the invitation of the Ministry of Civil Engineering and Environmental Protection of the Republic of Croatia. On this occassion numerous information were systematized, supplemented, revised and checked.

## General information on the Republic of Croatia

According to the census data of 1991, the Republic of Croatia has 4,760,344 inhabitants (in 1971: 4,426,221, in 1981: 4,601,469). The average rate of population increase was 0.62 % in 1971, 0,39 % in 1981 and 0,35 % in 1991.

The area of Croatia covers 56,536 km$^2$. The area of the territorial sea is 3,100 km$^2$. The length of the littoral line with islands: 5,789 km. The number of islands: 1,185 (of which 66 inhabited).

By its shape Croatia belongs to the group of countries with indentations and stretched-out form. Distances between the farthest points of the state territory are almost twice the size of the diameter of the circle with the same surface area.

As a Central-European and an Adriatic state, Croatia has also a specific geographic position in Europe. It lies closely to densely inhabited and industrially developed parts of the Central Europe. It lies mainly in the Pannonian straits and Danube basin, it has the most indented seashore and the longest coastline on the Adriatic, while its very impressive and characteristic Dinaric mountainous complex has its narrowest and lowest points within the borders of Croatia. The features of the Croatian geographic position have an indubitably large impact on the economic development, and at the same time, they influence and change the quality of the environment in the state's territory.

The Croatian territory is separated by the high Alps from the most developed parts of Western Europe, and this also partially lowers the negative impact of transboundary pollution onto the state territory. Due to its relief openness, important impacts on the quality of environment in the continental part of Croatia arrive from the neighbouring Hungary and industrially developed Slovenia, as well as from industrial and power supply basins of Bosnia and Herzegovina. The littoral area, especially Istria and Northern Adriatic region, are more exposed to impacts of the developed Italian North.

Croatia has few significant rivers which in their entirety flow through its territory and on whose quality the impacts come exclusively within Croatian borders. Most of the riverflows which are in their hydrological and economic context more important are rivers from the neighbouring countries (Slovenia, Bosnia and Herzegovina and Hungary) with very low quality of water.

Croatian territory has no unified natural-geographical features; it can be divided into three large natural-geographical entities:

a) Pannonian and Peripannonian territory which takes up the northern area. The eastern part of it is used for agricultural and cattle production;

b) the montainous territory which is only a small part of larger Dinaric mountainous region. Being close to the sea, it acts as a climatic barrier to warm and moist air masses from the sea. Within this territory, there are two main regions: Gorski Kotar and Lika,

where valleys and fields interchange with high mountain rocks;

c) the Mediterranean region which consists of narrow littoral area and island shoreline. In the mainland coastline waterways are few and mainly force themselves through narrow canyons towards the sea. The climate in the region is characterized by dry, hot summers and mild, rainy winters with a lot of sunny, clear days. The Mediterranean territory can be separated into three regions: islands, mainland coast and inland, but it can also be divided in the Northern and Southern Croatian coast.

In Croatia there are 1,782,000 dwellings, with a total of 105,378,000 $m^2$ (data for 1990). Data for 1980 show that 54.9 % of dwellings have installations for water supply and 65.7 % are connected to the sewage system.

The number of urban population amounts to 54.3 % (data for 1990). The average number of inhabitants per $km^2$ is 84.2. The capital of Croatia Zagreb has about one million inhabitants.

*Natural systems and the state of environment*

Croatia's most important natural resources are fertile soil, forests, surface and underground waters, the Adriatic sea and numerous natural areas, protected for their specific features and values.

The most important energy sources include crude oil and natural gas. Estimated reserves amount to 2.3 billion tons of hydrocarbon in the Pannonic basin and low-lying coastal regions, covering the greatest percentage of Croatia's requirements in this field. With the exception of bauxite, no considerable reserves of metal ores have been registered. However, there are relatively abundant reserves of non-metal raw materials.

Waters:

Despite deficient surface water potentials in its karstic part, Croatia has favourable conditions for satisfactory and long-term water supplies for urban centers, settlements and industry. The estimated renewable annual quantities of water amount to about 10,000 cub. m. of water per capita. The quality of waters, however, is increasingly endangered by still insufficient waste, water treatment, the dumping of major parts of dangerous waste and inefficient control. The water quality conditions differ in various water regions and depend on a series of elements, primarily on the level of economic development and the type of industry located in that region.

Water area of the Sava river basin: On its course through Slovenia the river Sava passes through a series of settlements with developed industry, receiving their waste and sevage waters. The waste waters are mostly not purified before being emptied into the Sava river. Since the nuclear power plant in Krško (Republic of Slovenia) was put into operation, there has been an additional constant source of heat burdening of the river Sava, which has negative impact on the already poor quality of water. A further burdering of the river Sava on its course through Croatia is brought about by its effluents of Sutla, Krapina and expecially the polluted waters of the Vrbas and the Bosna river.

Water area of the Drava and the Danube river basins: From its source to the Austrian-Slovenian border the Drava river comes as water of a rather high category. This condition gets remarkably worse during its course through Slovenia. On its course through Croatia the Drava river is further directly poluted by waste waters of several Croatian, but also Hungarian towns. The Danube, that profiles the state border with Serbia, according to the data from 1975 till now, falls into the second category as regards water quality. This category level holds on its whole course through Croatia.

Water area of the Croatian littoral and the Istrian river basins: On the basis of monitoring data obtained it can be concluded that the water-courses are very clean in their upper parts, while they are moderately or considerably polluted in their lower parts, or at their mouth into the sea. This is a consequence of the inflow of unpurified or insufficiently purified waste and sewage waters from households and industry, of agricultural areas and cattle farms into waterstreams, lakes and storage lakes.

The water courses in the Dalmatian river basin are also clean in their upstream courses, and moderately or considerably polluted in their downstream parts, particularly at their mouths into the sea.

The water flow energy potentials amount to about 20,000 GWh per year, of which 6,100 GWh per year have been up to now. Less than 2 % of agricultural land has been included in hydromeliorative intervention projects.

Sea

The Adratic region ranks Croatia's most important development potential. In addition to traditional fishing and navigation, tourism and industry are developed. In summer months the number of inhabitants in the coastal area multiplies which is not without any effect on this system, ecologically so highly sensitive.

The quality of most volume of the sea water (over 95 %) is extremely well preserved. It is the only immediate aquatoria of major sea ports that are endangered. An exception to such good state of preservation is the Northern Adriatic whose average depth is up to 20 m. In this part of the Adriatic sea there is from time to time a phenomenon of creation of mucilaginous agglomerations. The investigations performed with the task to explain the mechanism of creation of those organic agglomerations, the so called »flowering of the sea«, have asserted that this is not due to seas pollution. The increased excretion of mucilages occurs in situations of ecological stress that is probably caused by sudden changes of hydrometeorological and oceanographic conditions in the Northern Adriatic.

Soil:

Fertile soil occupies 31,904.3 km$^2$, that is 56 % of total area of Croatia. The agricultural areas were diminishing in the period from 1975 to 1985 with average annual rate of 44 km$^2$. However, the yields of main farming crops in the last 25 years have been doubled, largely owing to the use of new selections of crop plants and to modern technology, as well as to the use of mineral fertilizers and biocides. Still, the quantities of chemicals, artificial fertilizers and plant protective agents consumed in Croatia are relatively small. The artificial fertilizer consumption per arable land units lays behind in comparison with the consumption rates in countries with a developed agricultural production. Some high pesticide concentrations have been ascertained only locally. After the exploration of the features of heavy metals in the forest soils, the first findings in the region of Gorski Kotar, the Una basin, the Dubrovnik region, the northern part of Velebit range, have shown medium to strongly prounounced anomaly coefficient.

Forests:

Forests and forested land cover 20,226 km$^2$ or 36 % of Croatia's total area. According to estimates, Croatia's forest land is annually reduced by about 1,000 ha, because of urban settlements growth, building of infrastructure and the excessive cutting of trees. In recent years, especially along the Adriatic coast, forest trees have been on the decrease. In the past twenty years or so almost 7 % of total land under forests has been destroyed by fire. War destruction has also had its effect on forest damages. As in the whole of Europe, the appearance of »forest slowly dying« is present in Croatia too. Almost 50 % of mountain forests are subject to die back due to effects of acid rains, mostly brought on by transboundary atmosheric pollution.

Air:

Measurements have shown that quantities of sulphur dioxide ($SO_2$) which get into soil by transboundary pollution are greater than those from local sources. It is estimated that transboundary pollution constitutes 60 % of air pollution. Due to the state of technology and energy production use, $SO_2$ load per product unit is about twice bigger than in the developed countries of Europe.

Beside the general pollutants in the air in the large urban and industrial centres, specific contaminations connected with different industrial activities have also to be emphasized. Some industrial branches have a detailed insight into their own pollution sources, but also some local administrative units have pollution cadastres for their regions. The use of unleaded petrol is still very low in Croatia, and the concentration of lead in petrol is 0.6 g/l. However, due to the fact that traffic is still not so dense, average annual concentrations in ambient air, even in the urban areas, are below 1 microg.am/cub.m.

Table 1 – *Population by sex and age (estimates 30 June 1988)*

| Age groups | Males | Females | Total |
|---|---|---|---|
| 0–4 | 156,146 | 147,803 | 303,949 |
| 5–9 | 169,479 | 160,406 | 329,885 |
| 10–19 | 326,774 | 312,181 | 638,955 |
| 20–39 | 345,094 | 336,028 | 681,122 |
| 40–59 | 592,111 | 613,778 | 1,205,889 |
| 60–79 | 287,040 | 419,501 | 686,541 |
| >80 | 30,525 | 65,908 | 96,433 |
| Total: | 2,265,774 | 2,415,107 | 4,680,881 |

Table 2 – *Birth rate and mortality rate in Croatia (period 1983-1988)*

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|
| Newborn per 1000 | 14.2 | 14.0 | 13.5 | 12.9 | 12.7 | 12.5 |
| Death per 1000 | 11.9 | 11.6 | 11.2 | 11.1 | 11.4 | 11.3 |
| Natural increase rate | 2.3 | 2.3 | 2.3 | 1.8 | 1.3 | 1.2 |
| Infant mortality per 1000 | 18.7 | 16.8 | 16.6 | 15.7 | 14.0 | 13.1 |
| Stillborn/100 newborn | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| Vital index: | | | | | | |
| newborn/100 deaths | 119.0 | 119.8 | 120.4 | 116.4 | 111.5 | 111.1 |
| Males/100 females | | | | | | |
| Newborn | 106.2 | 107.6 | 104.7 | 106.3 | 105.6 | 107.2 |
| Death | 110.3 | 109.4 | 107.4 | 106.1 | 104.9 | 107.2 |

Table 3 – *Population by employment*

| | 1971 | 1981 | 1991 |
|---|---|---|---|
| Industry | 354,500 | 489,000 | 567,300 |
| Electroenergy | 9,900 | 17,100 | 20,300 |
| Mining | 4,900 | 1,400 | 2,100 |
| Oil and gas | 10,300 | 6,600 | 7,400 |
| Agriculture (excluding private farming) | 51,800 | 41,800 | 53,800 |
| Forestry | 16,600 | 14,800 | 16,200 |
| Construction | 84,400 | 144,400 | 135,000 |
| Communications | 81,900 | 116,900 | 128,200 |
| Trade and catering (tourism) | 125,500 | 148,900 | 252,200 |
| Handicraft trades | 66,500 | 38,200 | 47,100 |
| Health and social services, education etc. | 149,100 | 223,400 | 268,400 |
| Administration and government | 37,000 | 57,000 | 64,400 |

Table 4 – *Area structure of Croatia (1981) in km²*

| | km² | % |
|---|---|---|
| Agricultural | 31,904.3 | 56.0 |
| Forests | 20,225.6 | 36.0 |
| Settlements | 3,316.2 | 5.9 |
| Communication | 250.5 | 0.4 |
| Water (ground) | 618.8 | 1.1 |
| Other | 222.8 | 0.6 |

Table 5 – *Settlements/number of inhabitants*

| | | | |
|---|---|---|---|
| 500,000 | – | 1,000,000 | 1 |
| 100,000 | – | 500,000 | 4 |
| 50,000 | – | 100,000 | 5 |
| 20,000 | – | 50,000 | 12 |
| 10,000 | – | 20,000 | 18 |
| 5,000 | – | 10,000 | 43 |
| 2,000 | – | 5,000 | 150 |
| <2,000 | | | 6,467 |
| Total: | | | 6,700 |

*Short macroeconomic overview*

A short macroeconomic quantitative overview describes the present economic status of Croatia. Croatia's GDP per capita in 1990 was 3,700 US$. In 1992 the GDP per capita was 2,100 US$, what passes GDP about 10 billion. In the last three years, Croatia's GDP has declined 2 to 3 times a year, due to the war. In 1990 52 % of GDP originated from mining and industry, while 11 % accounted for agriculture and forestry, and 37 % came from service industries. The rate of employment in the socially owned sector has fallen by about 25 % between 1990–1992. It has been compensated to the same degree by a booming private sector, which presently represents about 10 % of total employment rate (in 1989 it was about 1.3 %). There are estimetes of about 260,000 of the unemployed (January 1993) which accounts for 18 % of the total labour force. In addition, 750,000 registered retired persons and 500,000 – 800,000 (at various periods of time from 1990 till present) of displaced persons and refugees are an extraordinary economic burden to the total of 1,250,000 employees. The total refugee costs amount to 1.3 billion US$. Inflation rates rose sharply in 1992. Such a burden is beyond Croatia's resources. It has contributed significantly to the rapid decay of Croatia's economic power and performance. Average retail prices grew 15–29 % monthly. However, on the other side, monthly salary increases amounted to 7–23 %. The Croatian Dinar, introduced on a temporary basis at the end of 1991, has been losing its external value. In 1991, the average rate of exchange between Croatian dinars and the American dollar was HRD 40 to US$ 1. In 1992 it was HRD 280. By March 1993 the exchange rate was about HRD 1,480 to US$ 1 and by August it was 2,930 HRD. Governmental revenues in 1992 reached 1.5 billion US$. Foreign trade amounts to 4.6 billion US$, 40 % of which is with the EC. Croatia has established new bilateral trade arrangements with the EC and EFTA.

*Academic aspects*

In the area of science and education there has been a unique set of a features which can be named as the post-communistic academic syndrome. Those features seem to be common to amajority of Central and East-European countries. The post-communistic academic syndrome is composed of the following characteristics:

a) Scientific performance has been almost exclusively limited to academic science, with no or very limited nonacademic (developmental or technological) science. The only exceptions were applied sciences focused on military purposes and rarely to the consumer foods production development. Therefore, science in those societies played more a decorative than productive social role.

b) High degree of one way mobility of scientists towards western countries has produced the »brain drain« phenomenon.

c) Pseudoscientific performance which can be clearly identified through a low impact figures of research. This is due to the official hypocrisy of the totalitarian communistic regime which imposed the derogation of quality and promoted almost officially the quasi-quality surrogates.

d) Special mental anlage of the citizen with minimal private incentive, initiative and latent expectation that collective effort will be the way out of a crisis. Such attitudes are part of internal inertia of human mind. This phenomenon has reflected in the field of science as well. It is most transparent in humanistic social sciences, where ideology has deeply inhibited the very structure of activities which are claiming to be science.

e) Underdeveloped (retarded) branches of science. Due to the collective decision making mechanisms the critical forces were ignorant of the trends in science. Therefore, beside a lack of apllied research, whole fields such as molecular biology, brain research and maritime biology were thereby ignored.

Higher education system comprises four universities and 20 independent scientific institutes. Four university centres (Zagreb, Rijeka, Split, Osijek) include 61 faculties and colleges. Each year some 70,000–75,000 students enroll for their studies. The Ministry of Science and Technology is financing 1,705 scientific projects and nearly 11,800 scientists. There are about 5,000 Ph. D. equivalent holders and about 4,000 M. Sci. degree holders. Post-communist and the post-war period will require a special attention and special effords.

*War aspects*

The war in Croatia produced a tremendous human, social, economic and cultural load. The nature of aggressive activities discloses a unique brutality and be-

stiality. Preconvinced and selective destruction of the symbols of civilization like hospitals, churches (more than 400 were completely destroyed), schools, cemeteries and historical monuments has revealed a new, negative quality of aggressor's behaviour. Such barbarian brutality has continued in three wars in a row: against Slovenia, Croatia and Bosnia and Herzegovina.

A short summary of tragic war effects on Croatia includes seven thousand dead, fifteen thousand missing persons, twenty thousand disabled and about 200,000–300,000 displaced persons and refugees. More than 23 % of the territory of the Republic of Croatia is still occupied by the aggressors. 30 % of industrial facilities have been destroyed and are out of function. It is difficult to estimate direct and indirect due losses. 408 churches have been destroyed or demolished, 350 settlements were ground into rubble by the war machine. Roughly 15 % of the total housing stock of 1.8 million units have been destroyed or damaged. There are estimates of about 20–30 billion US$ loss and damage expenses in the last two years. GNP and income have been lowered several times within the last two years. The country has been additionally flooded by about 1 million refugees from the neighbouring Bosnia and Herzegovina, with a half of them still staying in Croatia.

*Destruction of public health institutions*

In the course of war public health institutions all over Croatia became a frequent target of attacks, which is one of specific features of this war, contrary to existing international legal regulations. The former Yugoslavia has been since 12 August 1949 a Signatory to four Geneva Conventions ratified on 21 April 1950 and effective since 21 October 1950. These conventions regulate the protection of civil and military health institutions. Heavy destructions were reported particularly of the following health institutions: medical centers and hospitals in Vukovar, Vinkovci, Pakrac, Karlovac, Sisak, Slavonski Brod, Nova Gradiška, Gospić, Zadar, Šibenik, Dubrovnik; the same applies to General Hospital in Osijek and health centers in Daruvar and Sinj. Health resorts in Daruvar and Pakrac were demolished, whereas numerous hospitals and medical centres in temporarily occupied areas (Glina, Petrinja, Topusko, Slunj etc.) became prey of the aggressors. All this causes via facti considerable difficulties due to the growing need for health care of a constantly increasing number of patients.

*Some immediate consequences of war activitie in Croatia*

Approximately one third of Croatia's territory is temporarily occupied, causing, among others, numerous problems in transport connections and preventing adequate supply of food, water and other goods and fuels, which has negative public health effects.

Almost a quarter of inhabitants was forced to leave their homes, thus becoming displaced persons and refugees. An additional burden and public health problem emerged with a great number of refugees from Bosnia and Herzegovina. So, there are instances of marked overpopulation with consequential overloading of existing infrastructure facilities and obvious lowering of hygienic-sanitary living conditions on one hand, and of entire areas of the country faced with depopulation carrying all accompanying negative effects of such tendencies with it, on the other. The overpopulated regions represent epidemiologically highly risky areas, since overpopulation normally favours the development and spreading of diverse epidemics. In order to lower and control the risk of epidemics outbursts, the public health system operates day and night and even beyond its capacities, spending far greater quantities and doses of various desinfectants and other means, which in the long term has an unfavourable impact on man and environment.

Due to destruction of families and death of a great number of mostly young people the reproduction of population is stagnating, thus aggravating the tendency of »white death« in Croatia reported already in the past, which means a greater number of deaths than births with long-term demographic effects.

Beside a great number of war victims one should not neglect the explosive increase in the number of the disabled with all negative public health, social, psychological and other consequences.

Inner tensions among the population, particularly between the residential population and refugees, are constantly rising due to evident adverse psychological effects caused by the drop of living standard and quality, which is manifested in the lack of food, medicines and fuels, combined with even more profound hopelessness and psychological dullness as a result of disastrous economic situation brought about partially by the necessity to provide for hundreds of thousands of refugees and displaced persons.

Apart from public health consequences, war destructions are the source of numerous ecologically negative effects on human environment. So they cause the discharge of a great number of toxic substances which directly and in the long term endanger the present and the future generations. For instance, in Oriovac, after heavy attacks with phosphorous bombs a section of ORIOLIK, a plant for furniture production, containing the storehouse for finished products and polyurethane raw materials, was burnt down in great fire. Other storehouses contained radioactive lightning-rods and fire-alarm systems made of radioactive substances. The fire destroyed the plastic cases, whereas radioactive substances spilled about the ashes and environment. Possible hazardous effects can be illustrated by the fact that within the radius of 2.5 km round the site of fire all trees died. A similar instance of phytotoxic consequences was reported after war destructions in Gospić.

After demolition of a great number of transformers containing considerable quantities of polychlorinated biphenyls as electrolytes these markedly toxic substan-

ces were released into the environment, whereas a portion of polychlorinated biphenyls which burnt down contributed to the rise of dioxine concentration in the atmosphere. It needs to be stressed that these substances can hardly be disintegrated and show carcinogenic character.

In war destructions storehouses with agrochemicals were destroyed, thus directly and indirectly endangering human health and environment. During war events numerous plants and fuel storehouses were demolished and burnt, causing the uncontrolled discharge of diverse hazardous and toxic substances which can have adverse effects on health of the population.

Due to destruction of waste water purification plants waste products are being released directly into recepients, inducing in the long term a series of hazardouse ecological consequences. Unfortunately, the state destroyed by war will, in the near future, hardly be able to provide funds for reconstruction of the existing and installation of new equipment.

*Some important health and ecological aspects of war destructions in the Republic of Croatia*

– aggravation of existing hygienic state of the environment;

– uncontrolled discharge of effluents from infrastructure facilities (water supply and sewage system, conditioning devices, purification plants, dust separators etc.);

– destruction of energy supply and infrastructure facilities accompanied with uncontrolled discharge of hazardous and toxic substances;

– destruction of combat means, aircrafts and ships, tanks and artillery, releasing highly toxic substances;

– intentional sinking of military equipment and combat means into the sea;

– great fires devastating material goods and discharging toxic substances;

– forest fires destroy the production of oxygen, releasing dioxin and furan, increasing erosion of ground, causing visual pollution and destruction of landscapes;

– contamination of drinking water, food, air and common appliances;

– destruction of resources for production and storage of food reserves;

– frequent appearance of epizootes and zoonoses;

– explosive propagation of rodents and pests;

– problematic hygienic disposition of waste due to lack of dumping grounds which are located in temporarily occupied territory;

– problematic disposition of medicines from humanitarian donations with shelf-life expired.

*Public health aspects of war destruction*

– destruction of settlements and housing units, aggravation of housing conditions and hygiene, discharge of toxic substances (asbestos etc.), accumulation of enormous quantities of waste material and glass;

– destruction of infrastructure facilities for water supply, drainage, solid waste disposal;

– troublesome maintenance of personal and public hygiene which directly endangers public health;

– lack of fuels, problems with heating of dwellings, infant nurseries, kindergartens and old people's homes, causing increased frequency of death of older and sick persons;

– continuing stay in shelters accompanied with all negative impacts on human physical and mental health;

– migration of population; depopulation of some areas and overpopulation of others, thus increasing the risk of infectious diseases and infestation of population with louses, fleas, bugs and scab;

– higher incidence of wounds, injuries and death with all age groups;

– lack of food accompanied with malnutrition deseases and deficient diet, intensifying the inclination of getting ill (due to insufficient nourishment, protective forces of individuals and population are weakened);

– collective and individual sense of fear with a series of psychotic and psychogenic reactions of the mass and individuals, and with the incidence of conventional mental derangements as well as of new mental diseases;

– aggravated conditions of treatment and transportation of injured and sick persons;

– overburdening of public health services due to the loss of facilities and death of employees (lack of personnel, equipment, medicines and capacities);

– destruction and incapacitation of a great number of health centers on all levels;

– remaining mines and explosive means;

– secondary war.

## Discussion

Presently it is impossible to quantify a great number of problems specified due to ongoing war destructions in some regions which inflict constantly new damages and forms of endangering human health. Moreover, it is difficult to evaluate ecological damages, because an intergated and unique information system for the Republic of Croatia is still missing.

Under war conditions and complicated transportation connections it is difficult to provide and carry out any integral monitoring.

On the other hand, the economy destroyed by war is not able to provide funds either for restoration of damages or for purchase of highly complex equipment to perform necessary monitoring.

Public health priorities, will, in addition, be focused on providing immediate medical protection to the sick, the disabled and the dying, whereas finances for restoration of ecological damages and solving the

public health problems will hardly be provided without support of specialized international organizations such as WHO, UNIDO, UNEP, UNDP, FAO etc.

Apart from all previously mentioned public health and ecological consequences, one can globally and in the long term expect the rise in the rate of evidence and prevalence of diseases connected with environmental health, and perhaps of certain new kinds of diseases.

## Conclusions

1. One of the essential kinds of support of international community to be rendered to Croatia for restoration and prevention of public health and ecological impacts of war in the Republic of Croatia would be the assistance in co-financing the establishment and activities of the National Environmental Protection Agency. The Republic of Croatia is the only European country without such an agency, which could be actively engaged in carrying out rational monitoring of the environment.

2. Within the framework of such an agency an Environmental Health Department is to be established, aiming at continuous implementation of programmes for restoration of war inflicted black points in the environment and at undertaking necessary measures for protection of human health.

3. In compliance with the Environmental Health Chart WHO Regional Office for Europe of 1989 it is necessary to encourage the development of a Health Environmental Information System which would provide the basis for further activities concerning these issues.

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SAŽETAK

**Javno zdravstveni i zdravstveno ekološki aspekti ratnih razaranja u Republici Hrvatskoj**

*J. Čiček i S. Racz*

U radu se daje prikaz specifičnih javno zdravstvenih i zdravstveno ekoloških aspekata i posljedica ratnih razaranja u Republici Hrvatskoj identificiranih na osnovi raspoloživih podataka, iako su ratna razaranja i aktivnosti i dalje u toku.

Na bazi raspoloživih podataka o aktualnim razaranjima i devastaciji okoliša posebice se naglašava i uzima u obzir nekontrolirana otpuštanja diferentnih i toksičnih tvari, te njihove kratkotrajne i dugoročne učinke na ljudske živote sa aspekta zdravstvene ekologije.

Daje se prijedloge na osnovi tih saznanja usmjerene na otklanjanje posljedica uzimajući u obzir otklanjanje opasnih i toksičnih tvari iz ekosistema (tlo, voda, zrak) te hranidbenih lanaca, sa gledišta preventivnih javno zdravstvenih i zdravstveno ekoloških aktivnosti u cilju zaštite zdravlja populacije Hrvatske.

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# War Damages in Water Management of the Republic of Croatia

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In addition to the problems due to incomplete construction, substantial war damages occured in 1991 and 1992 on water management works and systems in Croatia. Activities of Serbian paramilitary troups and of the former Yugoslav federal army resulted in damages and destruction, in particular of the water management works and structures for flood protection and for water supply to the settlements and industry. Total direct damage amounts to DEM 139,500,000; however, the indirect damages are considerably higher, resulting from decreased or discontinued functioning of a part of water management systems in Croatia, bearing in mind their economic and infrastructural importance.

There are no data on the status and functioning of water management works and systems on the territories of the sixteen temporarily occupied municipalities in Croatia. Reconstruction of damaged and destroyed water management works and structures is a precondition for both the economic reconstruction and development of Croatia, and for municipal and urban development of settlements.

## Introduction

In order to be able to realize and assess the extent of war damages on water management works and structures and systems, it is necessary to keep in mind the overall importance of water management in general. Water management activities have a great economic, infrastructural and social importance which determines the economic position of water management in the development of any country. There is an obvious technical-technological and socio-economic connection between water management activities and other economic and other development activities, such as:

– power production, industry, agriculture, transport, forestry, urban and municipal development, and the importance of water for sport and recreation.

In particular it is necessary to keep in mind the environmental importance of water management activities, and the importance of water in prevention and reduction of fire damages.

The overall importance and presence of water in practically all human activities, with simultaneous limitations by quantity, quality and location, prove the multipurpose importance of water management activities. Contrary to the experience and results achieved in developed countries, in our country the importance of water management was neither properly understood nor evaluated as a particular economic activity of great importance for the integral development of Croatia. Even the indices proving the direct dependence between underdeveloped water management activities and the unsatisfactory development of most other economic activities and municipal and urban underdevelopment did not receive proper attention.

Unfortunately, even such incomplete water management works, structures and systems suffered in the period from May 1991, and October, 1992, considerable damage and destruction by war activity of the enemy.

## War damages on flood control and drainage works and systems

A flood control project of a certain area (or country) is a costly, complex and long-term process which may take decades. Protection of urban settlements from floods is a complex issue as a part of the integral project of flood protection of the entire area for longer return periods compared to protection of agricultural and forest land. The basic purpose of flood control works and structures is to prevent:

– direct damages: loss of lives, damages in industrial and other structures, infrastructure in particular, reduction of land value;

– indirect, of secondary damages: losses in transport, losses in land use, losses of wages, reduction of production and trade, lack of infrastructure maintenance;

– immensurable damages: social problems, environmental damage, general insecurity regarding lives and property.

Floods belong to the category of natural disasters of catastrophic and long-term consequences – from the loss of human lives to destruction of property and nature. Flood protection is a long lasting proces requiring large financial resources, good planning and sound implementation of optimum design solutions. There are numerous examples showing that the largest human settlements and almost all kinds of economic activities have been developed close to rivers and in the areas with sufficient water resources. However, and unfortunately, in spite of all constant warnings by water management experts suggesting appropriate

designs and solutions, the issue of financing construction, expansion and regular maintenance of flood control works and systems has not been solved in an adequate manner. This has directly resulted in slowing down of the development of agriculture, hydropower, transport (navigation), tourism, and a part of other industrial activities. Also, due to the inadequate degree of completion and safety of flood control works and structures, great damage was inflicted to settlements, infrastructure and practically all economic activities.

Even the major part of the existing flood control works (mainly dikes, regulation of certain streches of major watercourses, construction of relief and lateral canals) was constructed after great floods causing damages which were higher than the costs of proposed flood control measures implemented later. This was proved by disastrous floods in Zagreb (1964), Osijek (1965), and Karlovac (1970). In addition to damages caused by floods of the major rivers (Sava, Drava, Danube), there are frequent and increasing damages caused by torrents, i.e. excess surface water in mountain catchement areas (Zagreb and Samobor, 1989, and 1990, and in particular in the parts of Lika, Dalmatia, Istria, Croatian Litoral, and to a smaller extent also in Slavonia and Baranja). Such floods are accompanied by soil erosion on agricultural and other land. In connection with these floods it is necessary to keep in mind the damage to settlements, roads and railways, and industrial plants. The floods are regularly followed by degradation of surface and ground water quality.

The experience of developed countries has proved the feasibility of multipurpose projects or water management works, structures and systems including flood control, water use and water resource protection aspects. This concept can and should be applied in the process of development of water management activities in Croatia.

In order to understand and assess the extent of war damages and flood control works, structures and systems it is necessary to know their present status of construction and complection, with relevant data for the end of 1990 (Table 1).

Table 1 – *Status of development and damages on flood control and drainage works and systems*

| Type of works | Unit | Development status | Damaged or occupied |
|---|---|---|---|
| Completely regulated rivers and watercourses of ameliorated areas | km<br>% | 1.175<br>31,0 | 312<br>26,6 |
| Partey regulated rivers and watercourses of ameliorated areas | km<br>% | 1.394<br>36,7 | 378<br>27,1 |
| Flood protection dikes - return period 10 to 500 yrs | km<br>% | 2.733<br>62,5 | 602<br>22,0 |
| Relief canals with dikes - return period 25 to 100 yrs. | km<br>% | 196 42,3 | 38 19,4 |
| Lateral canals with dikes return period 10 to 50 yrs. | km<br>% | 584<br>38.6 | 194<br>25,5 |
| Reservoirs with dams (28) and corresponding structures (7) | $m^3$<br>% | 284,7x106<br>30,8 | 81,8x106<br>28,7 |
| Flood storages with dams (38) and other facilities | $m^3$<br>% | 1442,9x106<br>32,8 | 392,5x106<br>27,2 |
| Erosion and torrent control - 947 watercources with 28.000 s.km catchament area | km<br>% | 7.570<br>21,3 | 2.420<br>32,0 |
| Completed surface drainage systems | ha<br>% | 600.054<br>33,5 | 160.110<br>26,7 |
| Partly completed surface drainage systems | ha<br>% | 518.830 29,0 | 136.400<br>26,3 |
| Completed subsoil drainage systems | ha<br>% | 161.530<br>19,6 | 62.380<br>38,6 |
| Other flood control works and structures: 75 sluices, 82 pumping stations, 6 spillways, 26 syphons, 7 relief canals, 594 flap valves, 23,145 tube nad slab culverts | unit<br>% | 7 do 23145<br>23 do 48 | 2 do 8480<br>28,6 do 36,6 |
| River regulation for navigation - 4 th category - 360 km, 3 rd category - 200 km | km<br>% | 560<br>16,0 | 410<br>73,2 |

In connection with the given basic data, it is necessary to distinguish direct damages occurring in the regions which are accessible from those in the areas that are temporarily occupied and therefore unaccessible. The latter condition applies in particular to the territories of 16 municipalities, as follows:

Beli Manastir, Benkovac, Donji Lapac, Drniš, Glina,Gračac, Knin, Kostajnica, Obrovac, Petrinja, Slunj, Titova Korenica, Vojnić, Vrginmost and Vukovar.

It is essential to perceive the degree of damage on separate flood control works and structures with the following observations:

1. Reduction of the natural and regulated discharge profile of rivers and major watercourses in ameliorated areas by improvised crossings for heavy weapons and military vehicles due to destriction of a number of bridges;

2. Damages and reduction of dike profiles by digging in of trenches, tank shelters, etc;

3. and 4. Damages on relief and lateral canals, with same observations as in 1. and 2.;

5. Damaged and destroyed sluices for regulation of water levels and discharges in rivers, inflow and outflow canals of pumping stations. The damage is particularly large on the destroyed dam on the Bosut river near Vinkovci and on pumping stations in the Central Sava Basin (12 pumping stations for drainage of Jelaspolje, Crnac-polje and Lonjsko polje.);

6. Due to temporary occupation by the enemy and war activities in the Central Sava Basin a part of the Lonjsko Polje Flood Storage is stil unaccessible;

7. Reduction of discharge profiles of torrential watercourses, caused by crossing of heavy weapons and vehicles, resulting in increasing erosion processes in

the channels and catchment areas of such watercourses;

8. Due to damaged surface drainage works (reduction of discharge profiles of drainage canals) and temporary occupation of a part of the amelioration areas, in the 1991/92 season it was impossible to sow 296,510 ha of agricultural land, which is 22.6 percent of the total area sown in the previous 1990/91 season (1,326,785 ha));

9. Due to damages on surface amelioration works and to direct war activities, the possibility of drainage by subsoil drainage systems was greatly reduced or impossible, on 62,380 ha, mostly in the region of Slavonia;

10. Damages on other amelioration works and structures include damaged or destroyed slab and tube culverts, flap valves, syphons, canal linings and outlets. Particularly large damage was inflicted on 18 pumping stations (out of 82), and without these stations drainage of the major parts of the Bosut, Bid, Vuka catchment areas, as well as of Jelas polje and Crnac polje, part of Lonjsko polje and part of Dalmatian catchment areas. In addition to damages on pumping station structures, war activities resulted in great damages on the mechanical and electrical equipment of the 18 pumping stations (capacity 96.9 cu.m./sec., power 7,815 kW);

11. River navigation on the Drava, Danube and Sava rivers has become practically impossible due to enemy activities, so that at present river transport in Croatia does not function at all.

Table 2 shows the amount of war damages on flood control and drainage works, structures and systems, expressed in German Marks (DEM).

Table 2 – *War damages on flood protection and drainage systems*

| Type and location of damaged objects | Damage, DEM |
|---|---|
| Dikes and other protection works on the Sava and major tributaries | 23,844,375 |
| Dikes and other works on the Drava, Danube and major tributaries | 6,314,650 |
| Surface and subsoil drainage systems with hydrotechnical structures | 30,649,725 |
| Office premises of water management organizations in Vinkovci, Slavonski Brod, Nova Gradiška, Novska, Daruvar, Osijek, Darda, Karlovac | 9,107,750 |
| Machinery, vehicles and equipment of water management organizations in Vinkovci, Slavonski Brod, Nova Gradiška, Novska, Daruvar, Osijek, Darda, Donji Miholjac, Karlovac, Zagreb | 5,937,500 |
| Total | 75,854,000 |

The above amount refers only to direct damages caused by war activities in the areas which were accessible by end of September, 1992. However, indirect damages resulting from reduced or completely discontinued operation of these works and systems are considerably higher. The damages might even be higher if intensive rainfall occurs, resulting in high water levels and discharges in rivers and drainage canals. In particular, it is necessary to keep in mind possible damages to settlements, industry, infrastructure and natural resources, first of all in the lowland parts of Croatia.

Great damages have also resulted from the impossibility to sow the crops on 296,510 ha of agricultural land. Counting with the average yield of wheat of 4,7 t/ha, the total loss amounts to 1,393,597 tons of wheat in the total value of DEM 404,143,130 (the estimates are based on ten years averages for the 1980–1990 period, i.e. 290 DEM per ton of wheat, and the yield on ameliorated land of 4.7 tons per hectare). In this context it is important to know that the actual areas under wheat in the same ten-year period were 282,638 to 337,963 ha or, on the average, 308,216 ha per year. In the above estimates wheat was used only for comparison as the principal crop taken as the basis for determining the prices of other crops.

Due to temporary occupation of a part of ameliorated areas it is impossible to organize financing and performing of regular maintenance of damaged and undamaged hydrotechnical works and structures for flood control and drainage. This has resulted in further damages and reduction in proper functioning of such works requiring, in turn, larger financial means for their reconstruction and maintenance after the end of the war.

### War damages on water use works, structures and systems

Water use is of existential importance in human life, and at the same time essential to all economic and other activities. With respect to various ways of water use it is necessary to define, correctly and timely, the balance of surface and ground water resources in Croatia. This includes defining of present and future water requirements of various water users, keeping in mind the varying distribution of available water resources in relation to the locations of water users.

Unfortunately, insufficient attention has been paid to evaluation and protection of natural surface and ground water resources in relation to the actual requirements. This has been proved by the shortage of good quality water for both supplying of population and for industrial, other economic and municipal activities. Also, water is not used sufficiently for power generation, and the quantities of water used for land irrigation in Croatia are negligible.

A part of the problem of underdevelopment of water use works and systems is the fact that most of them are old and are not functioning properly, which is manifested by losses in the pipelines, supply networks and water use devices and equipment.

This leads to problems in the process of urbanizing of settlements and development of municipal activities. Underdevelopment of water supply impedes the development of modern tourism in the parts of Istria, Croatian Littoral and Dalmatia, as well as in some tourist locations in the inland parts of Croatia.

In connection with the above problems, it is important to know the basic indices of the existing status of development of water use works and systems serving the following purposes:

1. Water supply to population. Public water supply systems supply 61.7 percent of the population, or 2,937,132 (out of the total of 4,760,344 at the end of 1990). The total water consumption is 196,508,000 cu.m. per annum, and the average 183 l/day per capita. The remaining 1,823,212 inhabitants (38.3 percent) are supplied from private water supply works, mostly with drinking water which does not meet the required drinking water standards.

2. Water supply to industry from public water supply systems covers 58 percent of the requirements, with the total annual consumption of 281,463,000 cu.m. The remaining industrial plants are supplied from their own individual water works and systems, using various technical solutions and varying water quality. There is also a shortage of appropriate reservoirs for water required in the production process during the periods of lower source yields.

3. Fisheries. The requirements of the existing 42 fishponds of the total area of 15,210 ha (in the Sava, Drava and Danube catchment areas) are 445,300,000 cu.m. per annum, which is 37 percent of the natural potential for construction of the total of 41,000 ha. The average yield is 0.6 to 1.2 tons of fresh-water fish per hectare.

4. Irrigation of agricultural land covers only 0.8 percent of the natural potential for irrigation of 680,000 ha (out of the total of 1,326,785 ha sown in 1990/91). The average irrigation standard is 1,600 to 4,200 cu.m./ha, and the average annual water quantity used for irrigation has been, up to the present 15,718,000 cu.m. on 5,420 ha, mostly in the territories of the municipalities of Metković, Zadar and Vukovar.

5. The use of water for power generation in 1990 amounted for 54.3 percent of the total technically utilizable hydrotechnical potential (12,000 GWh). Up to the present, 16 power plants have been built with the total installed power of 1,852 MW, and the average annual potential output is 6,524 GWh.

6. Other ways of water use refer to the requirements of the municipal services, transport, civil engineering, mining, and sport and recreation. Although no systematized data are available, the basic statement is that water for the above purposes is underutilized.

Unfortunately, even such underdeveloped water use works and systems suffered great damages due to the war in the period from May, 1991, to October, 1992. The data on war damages are systematized in the municipal centers which are also the sites of local water supply (and sewage) services, and the basic indices are shown in Table 3.

In addition to the damages of various degrees shown on the table, it is also necessary to take into account the damages to office buildings, machinery and equipment of the public water supply (and sewage) services in the municipal centers.

Table 3 – *Damages to works and structures in various municipalities*

| Municipality | Damaged works and structures |
|---|---|
| Daruvar | pumping station, treatment plant, part of supply network |
| Dubrovnik | pumping station, water tank, main pipeline |
| Duga Resa | water intake, pumping station, treatment plant, power transformer, part of supply network |
| Đakovo | drilled wells, reservoir for silos, part of supply network |
| Gospić | source, pumping station, main pipeline, part of supply network |
| Grubišno polje | drilled well and part of supply network |
| Karlovac | intakes, pumping stations, transformer, part of supply network |
| Nova Gradiška | dam, reservoir, filter plant |
| Našice | intake, elevated tank, part of supply network |
| Novska | intake and pressure pipeline |
| Ogulin | water intake and power transformer |
| Osijek | pumping station, treatment plant, part of main pipeline and supply network |
| Otočac | pumping and filter station, tanks, part of main pipeline and supply network |
| Pakrac - Lipik | water intake, part of main pipeline and supply network |
| Sisak | water intake and part of supply network |
| Slavonski Brod | water intakes, elevated tank, part of supply network |
| Šibenik | water reservoir, part of main pipeline and supply network |
| Vinkovci | drilled wells, intakes, part of supply network |
| Zadar | source-intake (occupied), part of pipeline and supply network |
| Županja | drilled wells - water intakes and part of supply network |

It is important to note that no data are available regarding the status and damages on water supply facilities on the territories of the following 16 municipalities:

Beli Manastir, Benkovac, Donji Lapac, Drniš, Dvor, Glina, Gračac, Knin, Kostajnica, Obrovac, Petrinja, Slunj, Titova Korenica, Vojnić, Vrginmost and Vukovar.

Due to enemy activities, occupation or damaging of the water supply works (sources) the situation in water supply to population is the most severe in Zadar, Pakrac and Lipik, Dubrovnik, Osijek, Daruvar, Gospić, Otočac, Karlovac, Nova Gradiška, Slavonski Brod, Vinkovci and Županja.

On the basis of field survey and systematized data on damages, the amount of direct damages was estimated for works and systems in 20 municipalities (excluding 16 municipalities temporarily occupied by the enemy). The summary data are given in Table 4.

Table 4 – *Direct damages expressed in DEM*

| Damaged facilities | Damage, DEM |
|---|---|
| Sources and intakes, main pipelines and supply networks | 22,445,000 |
| Reservoirs, elevated tanks, pumping, filter and treatment plants | 4,438,000 |
| Local water supply facilities in small settlements (to pop. 5,000) | 4,750,000 |
| Private water supply facilities for population and farms | 3,875,000 |
| Industrial water supply facilities (technoiogical water, etc) | 3,212,000 |
| Premises, machinery and equipment of water supply services in 16 municipal centers | 10,750,000 |
| Total: | 49,470,000 |

It is necessary to estimate the damages resulting from the shortage of water to meet the requirements of population and a considerable number of industrial capacities with various production programs. In particular, the health and environmental consequences of the lack of good quality water in the mentioned settlements are serious.

Occupation of the territories of 16 municipalities and parts of some others, damaging of water supply facilities and shortage of water resulted in decreased production on irrigated land, as well as in damages to livestock breeding.

A particular problem is temporary occupation and damaging of water sources and intakes for water supply to Zadar, Pakrac, Lipik, Karlovac, where the situation is most critical. Naturally, this leads to health problems and thus to increased medical costs.

Damaging of water supply facilities resulted in deterioration of water quality, which also requires increased costs in order to restore the original status. It is also important to mention that during the war the public water supply services did their best to repair the damages and provide existential water supply to population (in Osijek, Vinkovci, Slavonski Brod, Nova Gradiška, Karlovac, Gospić, Otočac, Zadar, Šibenik, Dubrovnik). Unfortunately, many workers were wounded or killed while doing their job.

**War damages on water pollution control facilities and systems**

Urban and economic development of any country requires continuously increasing water consumption, and the quantity of effluent is increased accordingly. At the same time there is the problem of proper and timely protection and conservation of surface and ground water resources. The programs of treatment of waste water from settlements and industry include defining of protective zones around water intakes. This is the responsibility of water management organizations in co-operation with other experts dealing with environmental issues, i.e. conservation of soil, air, water and vegetation.

Waste water treatment may considerably decrease the degree of pollution in order to prevent or reduce pollution of the recipient (rivers, lakes, sea). The part of the program is constant monitoring of water quality and timely undertaking of preventive actions in control and conservation of surface and ground water and other natural resources. Simultaneous monitoring of pollution and its causes makes it possible to undertake the required measures and works for water treatment. However, in our country there is still no permanent solution of waste disposal, which is one of the most frequent sources of pollution.

Among all water management activities, the lowest degree of development refers to water treatment plants, and the sewage network is also underdeveloped. At the end of 1990, only 31 percent of population were connected to public sewage systems. Another problem is thesmall number of existing facilities with equipment for treatment of sewage from settlements, industry and livestock farms. This may be seen in Table 5.

Table 5 – *Sewage treatment plants*

| Catchment area | Existing | In construction | Number of municipalities |
|---|---|---|---|
| Sava | 6 | 7 | 55 |
| Drava and Danube | 9 | 1 | 16 |
| Istria and Littoral | 23 | 7 | 19 |
| Dalmatia | 40 | 1 | 25 |
| Total: | 78 | 16 | 115 |

Regarding the number of treatment facilities in the regions of Istria, Croatian Littoral and Dalmatia, the largest part was built within the scope of touristic settlements or large hotel capacities. In relation to the number of population, the situation is the most critical in 55 municipalities in the Sava river catchment area, and a particular problem is the fact that even the town of Zagreb has no sewage treatment plant. Also, sewage problems in Osijek, Rijeka, Split, Karlovac, Sisak, Nova Gradiška, Slavonski Brod, Vinkovci, Pula, Šibenik, Zadar and Županja should not be neglected.

Table 6. gives the data on the quantity of effluent 1990, in various catchment areas.

The quantity of waste water from the population of 1,457,707 is 162,854,000 cu.m., or 19 percent of the entire quantity. The capacity of the existing treatment plants is 333,762,000 cu.m. which is only 39 percent of the requirements. However, in this context it should be noticed that the degree of treatment is between 19 and 73 percent in relation to the present standards for municipal and industrial sewage. Another part of the problem is the underdevelopment of sewage networks and collectors. In spite of the existing regulations, a large number of industrial plants have not constructed their treatment facilities. There is also the problem of

sewage from livestock farms and water drained from roads.

Table 6 – *Quantities of effluent in catchment areas in 1990*

| Catchment area | Effluent, cu.m. | Load, popul. equival. |
|---|---|---|
| Sava | 334,041,000 | 6,215,000 |
| Drava and Danube | 232,259,000 | 4,302,000 |
| Istria and Littoral | 77,086,000 | 3,983,000 |
| Dalmatia | 214,128,000 | 15,934,000 |
| Total: | 856,514,000 | 15,934,000 |

However, even such underdeveloped treatment facilities suffered considerable war damage. At the same time, deterioration of the water regime in watercourses and in parts of their respective catchment areas occured, which caused further complications and deterioration of water quality.

On the basis of available data, the estimate of war damages to sewage nad treatment facilities has been made, both for municipal and industrial sewage, and the basic indices are shown in Table 7.

Table 7 – *Estimated damages on water treatment facilities*

| Location and type of facility | Damage, DEM |
|---|---|
| Osijek - outlet, collector, part of sewage network | 6,935,000 |
| Valpovo and Belišće - sewage treatment plant | 1,141,000 |
| Gospić and Otočac - facilities and construction | 1,100,000 |
| Other drainage and sewage treatment facilities (Daruvar, Dubrovnik, Šibenik, Zadar, Vinkovci, Sisak, Karlovac) | 2,850,000 |
| Premises, machinery and equipment of public sewage services | 2,150,000 |
| Total: | 12,176,000 |

In addition to the above damages, there are damages caused by pollution of parts of catchment areas of some rivers, and thus also of a part of ground water. It must be noted that there are no available data on the status of facilities in the 16 municipalities temporarily occupied by the enemy.

**Recapitulation of war damages on water management facilities**

Table 8. shows the total war damages on water management facilities and systems in Croatia in the period from May, 1991, to October, 1992.

The amount of damages given in the table refers to direct war damages; however, indirect damages are much higher. This applies, in the first place to reduction or complete stopping of production in various industrial capacities. The particular problem is the shortage of water for regular supply to some settlements, which in turn leads to health and basic existence problems among the population. Also, war damages include increased environmental problems due to reduced functioning of damaged, and interrupted functioning of destroyed water management facilities.

It is clear that the programs of reconstruction of settlements and restoring of economic activities, as well as the successful integral development of Croatia would be impossible without the program of reconstruction of water management facilities and systems. However, a proposal of a program of reconstruction of water management facilities would be beyond the scope of this paper, with respect to the complexity of financial and technical issues related to its implementation.

Table 8 – *Recapitulation of war damages*

| Type of facilities and systems | Damage, DEM | % |
|---|---|---|
| Flood control and drainage | 75,854,000 | 54.4 |
| Water use | 49,470,000 | 35.5 |
| Pollution control | 14,176,000 | 10.1 |
| Total war damages | 139,500,000 | 100.0 |

The professionals of the Public Water Management Enterprise »Hrvatska vodoprivreda« Zagreb, in cooperation with water management organizations located in the catchment areas, municipal water supply and sewage services, municipal authorities and the Croatian Reconstruction and Development Board are now working on preparing the program of reconstruction and development of water management facilities as the basic precondition for integral reconstruction and development of Croatia. Technical solutions and provision of financial resources in accordance with the priority schedule are integral parts of the program.


## SAŽETAK

**Ratne štete u vodoprivredi Republike Hrvatske**

*J. Marušić, D. Gereš* i I. Kolovrat**

Pored problema zbog nedovoljnog stupnja izgrađenosti, u 1991. i 1992. godini učinjene su i znatne ratne štete na vodoprivrednim objektima i sustavima Hrvatske. Neprijateljskim djelovanjem srbočetničkih vojnih formacija i bivše jugovojske došlo je naročito do oštećenja i razaranja dijela vodoprivrednih objekata za zaštitu od štetnog djelovanja voda kao i na objektima za vodoopskrbu naselja i industrijskih djelatnosti. Ukupne direktne štete su 139.500.000 DEM, ali su znatno veće indirektne štete

zbog smanjenja ili prestanka funkcioniranja dijela vodoprivrednih objekata i sustava Hrvatske – imajući u vidu njihovo gospodarstveno i infrastrukturno značenje.

Ne postoje podaci o stanju i funkcioniranju vodoprivrednih objekata i sustava na području privremeno okupiranih 16 općina Hrvatske. Obnova oštećenih i razorenih vodoprivrednih objekata je preduvjet kako za gospodarsku obnovu i razvoj Hrvatske, tako i za komunalni te urbani razvoj naselja.

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*Prispjelo 15. travnja 1993.*
*Prihvaćeno 1. studenog 1993.*

# »Željezara Sisak« – Production Plans in the Post-War Time

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This paper gives the data on the production and products of »Željezara Sisak« before and during the war in Croatia. It points out the influence on the environment protection by closing of the old equipments for the production of pig iron (Blast furnace) and steel (Open-hearth furnace) and the greatest attention is paid to the development plans of the company in the post-war time. The Priority Action Plan (PAP) has to make possible to realize savings and production continuity by means of certain investments and the Investment to Meet Market Opportunity (IMO) has to insure development and long-term prospects in the world market.

## Introduction

»Željezara Sisak« is the largest ferrous metallurgy company in the Republic of Croatia. It also has 40 years experience in production and marketing. »Željezara Sisak« has an intergrated production cycle from coke, iron and steel production to steel tube and pipe production, finishing and processing.

»Željezara Sisak« is a specialized producer of a wide variety of seamless and welded tubes and pipes.

Before the war the basic production generated the folowing annual production levels:

- metalurgical coke 850.000 t
- pig iron 240.000 t
- open hearth steel 280.000 t
- electrical steel 75.000 t
- hot-rolled strip 240.000 t
- hot-rolled welded (black and galvanised) tubes and pipes 120.000 t
- cold-formed welded hollow sections 70.000 t
- hot-rolled seamless tubes and pipes 140.000 t
- cold-drawn and cold-rolled (welded and seamless) tubes and pipes 40.000 t

It must be pointed out that most of the production facilities were rather out-of-date and the production was inefficient and expensive, accompanied by high air- and water pollution expecially due to the Blast furnace and Open-hearth furnace production.

»Željezara Sisak« had exported more than 25 % of its production around the world for 40 years and after the breakdown of the former Yugoslavia the exports have grown to over 70 % of production.

During the Serbs aggression »Željezara Sisak« was shelled almost every day from September 1991 to January 1992, but sometimes it was a target of the enemies artillery until summer 1992.

Many plants were destroyed and the direct damages are estimated about 5 mil. USS and indirect damages are about 50 mil. USS.

During the war the production was not stopped except in the Blast furnace plant and in the Steelmaking plant (Open hearth furnace) and the reason for that was impossibility of the ore supply from Bosnia.

The war caused the changes in the production organization. The number of the employees has been considerably reduced (about 40 %) as well as the quantities of the finished products. The rolling mills operate in 3 shifts (some of them only in 2) instead of 4 shifts before the war.

Due to the survival in the market »Željezara Sisak« must be radically restructed in order to establish an economically viable entity which is efficient according to the Western European Standards and internationally competitive. If this could be achieved Sisak would contribute to the modernisation of the industrial, energy and other steel consuming sectors in the Republic o. Croatia.

The restructuring of »Željezara Sisak« should include closing of non-profitable facilities for iron making, open hearth steel making, strip mill and light seamless tube line. The reasons for closing were the following: very high energy consumption and low

productivity per ton of iron and steel, high production cost of pre-rolled semi-products for the light line, connected with high costs of the finished small diameter seamless tubes and intensive environment pollution (Blast furnaces and Open-hearth furnaces).

The Restructuring Study was made by BSCOS (British Steel Consultants) immidiately before the war and it is now the basis for our determination of necessary investments in order to achieve the above mentioned goals.

This Study comprises two groups of activities:

1. Priority Action Plan (PAP)
2. Investment to Meet market Opportunity (IMO)

**Priority action plan (PAP)**

The aim of the PAP is to achieve fast results with comparably small investments and to secure the continuity of production. The Plan proposes the purchase of steel for the welded tubes and pipes production. The electrical steel for seamless tubes and pipes should be produced in ladle furnace which must be installed in the steelwork. In addition the heavy and light seamless lines are to be refurbished in order to reduce the production costs. The quality of the welded tubes is to be improved to be able to substitute some welded tubes for seamless tubes and it should be invested in the treatment of effluents from the rolling mills for environment protection.

The next stage of restructuring includes radical organizational changes in the steelworks and its management, investment in education of the management and the employees and introduction of an improved business system.

Total investment amounting 37.37 mil. US$ with the internal profitability rate of 27.5 % should be carried out during the next three years.

**Investment to meet market opportunity (IMO)**

When we analyse the long-term prospects of »Željezara Sisak«, we must unfortunately face the fact that the steelwork has no long- term chances unless radical technological changes are made in the electrical steel production; futhermore, bloom casters critically need refurbishment and the outdated pilger procedure needs to be substituted for a new technology, i.e. for a new seamless mill.

This is the pre-condition for the survival and development of iron and steel making in Sisak and for the product range improvement and increasing of efficiency and competition of the production.

Since these investments require the adequate market, i.e. investors, BSCOS has named this development program Investment to Meet Market Opportunity (IMO).

The IMO should be implemented during 1993–1999 and it comprises the following projects:

– new ultra-high-power (UHP) electric arc furnace with ladle arc facility for production of 300.000 t/y of high quality steel, exclusively for seamless tubes and pipes and as substitution for the old low efficiency electric furnace

– refurbishment of the bloom caster for conti-casting of round blooms to supply the old and new seamless mill

– new seamless tube mill for production up to 150.000 t/y, as substituion for the old pilger procedure

– heat treatment equipment for the high-quality oil country tubular goods (OCTG).

Total investments are estimated at 184.8 mil $ with the internal profitability rate at 11.2 %.

After the implementation of the IMO with its 4 projects the output of finished products will not increase but the important improvement of the production range regarding high-quality special-purpose tubes and reduced production costs will be accoplished and that means that the long-term prospects of »Željezara Sisak« in the European market can be insured.

**SAŽETAK**

**Planovi proizvodnje u poslije-ratnom razdoblju**

*M. Balenović*

U radu se navode podaci o proizvodnji i proizvodima »Željezare Sisak« prije i za vrijeme domovinskog rata. Ističe se utjecaj na ekologiju zatvaranjem zastarjelih postrojenja za proizvodnju sirovog željeza (Visoke peći) i čelika (SM-peći), a glavna pozornost usmjerena je na planove razvoja poduzeća u poslijeratnom vremenu. Definirani su Prioritetni plan aktivnosti (PAP), koji treba omogućiti s manjim investicijama brže uštede i kontinuiranost proizvodnje te Investicioni program (IMO), koji treba osigurati razvoj i dugoročniji opstanak na svjetskom tržištu.

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*Prispjelo 15. travnja 1993.*
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