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CROATIA

Technical report: First mission to Croatia*

Prepared for the Government of the Republic of Croatia
by the United Nations Industrial Development Organization

Based on the work of Mervyn Richardson,
consultant in industrial chemical pollution control

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* This document has not been edited.

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ABSTRACT

INDUSTRIAL CHEMICAL POLLUTION CONTROL

Objective: To assess the hazards to the environment caused by the war in Croatia resulting from damage to the chemical industry. Mission 10-28 January 1993.

Mission: A preliminary investigative mission to Croatia 13-27 January 1993 by a UNIDO consultant enabled 18 towns and some 50 installations to be inspected. Contact was made with 84 commune and industrial officers in the towns, and a further 24 scientists and officials in Zagreb.

Conclusions: The consequences of the war in Croatia resulting from destroyed chemical factories and other installations, eg, electricity facilities, sewage treatment works, has incurred severe hazards upon the soil and water environments. In the Northern area along the catchments of the rivers Drava and Sava, emissions have the potential to contaminate drinking water resources in the countries bordering the River Danube. Similar adverse effects are predicted in inland regions and long term hazards to aquatic life in the Adriatic Sea is likely. Additionally, adverse public health effects, including congenital malformations, may be anticipated, together with short term water-borne diseases.

Recommendation: Monitoring of the identified hazards by discrete or generic methods in order to generate risk assessments are advised. Preventative measures for refuse management and disposal are of high priority. Treatment of soils and waters contaminated with recalcitrant chemicals (eg, PCBs) after monitoring and assessments of the risks, is a necessity. Short, medium, and long term recommendations, together with proposals for further studies, training is indicated for discussion at the final stage of this mission during the International Conference on the Effects of War on the Environment, Brijuni Islands, 15-17 April 1993.

MERVYN RICHARDSON FEBRUARY 1993

CONTENTS

ANNEXES

I RECOMMENDATIONS

A. Town/Installations

Short (Table 1), medium (Table 2), and long term (Table 3) recommendations on a town by town basis are detailed. The requirements for monitoring are stressed.

B. Refuse Disposal

Improvements to refuse disposal and generation of a master plan is of high priority. (qv. Annex 9.)

C. 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 dis harges 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.

D. Polychlorinated biphenyls (PCBs)

The remedial treatment for PCBs in soils and water will be a very costly exercise. In order to avoid the possibility of contamination in the future, it is recommended that their use is discontinued and an alternative dielectric used. (qv. Annex 10.)

E. Training

The training of Croatian scientists qv. Annex 19, for needs to accomplish the monitoring and assessments is an immediate requirement.

F. Joint Ventures

Joint ventures for new industries, especially those involving 'clean technologies' or 'zero waste' should be developed together, with industries such as glass recycling there is an urgent need for discussions with Western European commerce and industry. (qv. Annex 18.)

Tabie 1

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

Location/ Installation/ industry	Chemical/hazard	Proposed Action	Visit Ref No. (See Annex 8)
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.	
Thermoelectric power plant	Heavy fuel oils	Treat microbially (qv, Annex 14)	1.2
	PCBs	qv, Annex 10	
Slavonka leather factory	Chromium salts, dyestuffs, biocides	Analysis and trade effluent treatment	1.8
Vinkovci			
wheat silo	Wheat	Seek advice from FAO (qv, Annex 11)	2.1
	Heavy fuel oil	Seal pipe.	
INA oil refinery	Spent engine oil	Burn in thermoelectric power plant	2.4
Cibalia leather factory	Chromium salts, dyestuffs etc.	*Prevent discharge to R. Boset.	2.5
	Contaminated water in cellar	Rebuild effluent treatment plant	
		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. (qv, Annex 10)	7.1
	Lead paint	Soil analysis initially	
	Trade effluent	Consider mobile peroxidative plant	
Hladnjača			
Vino-Voće	Ammonia	*Refrigeration engineer to prevent	7.3
Bjelić (cold store)		further ammonia losses and to assess damage.	

Sisak			
Power plant and transformer stations	Heavy fuel oil and PCBs.	Analysis and microbial treatment/ incineration. Examination of fish from R. Onya for PCBs and genetic abnormalities.	8.1
Thermoelectric 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
Transformers	PCBs	Analysis of soil on hillside	9.1
Karlovac			
Milk factory (Reported February 1993 to be 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
Lesće			
Hydroelectric power station	—	Investigate, identify, and prevent causes of contamination.	11
Otačic			
Cosmochemica	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, toxins 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 bactenological) 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 hermaphroditism.	18.1
Drinking water supplies	—	Improvement to laboratory. More testing, eg. by Microtox.	18.2/ 18.17
Sewage treatment (Maliston 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. (See Annex 8)
Vinkovci			
Wheat silo	Dust extraction	replace	2.1
Pesticide storage area	Pesticides	Monitor soil for residues (Microtox).	2.6
Djakovo			
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			
Oriolok-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 (Praški)			
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

Metkovic (Neretva Delta)			
Agrochemical usage	—	Expert needed to assess requirements for modern pesticides, fertilizers, etc.	17
Dubrovnik			
Drinking water supplies	--	Survey of catchment required, eg. Bicelića, Trebinje, etc (Bosnia).	18.2
Incinerator	—	Remove mines from Locrum. Complete and commission 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. (See Annex 8)
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
Djakovo			
Meteor	Detergents, etc.	Apply BPEO, BATNEEC, to reduce discharges. Install trade effluent treatment plant.	3.2
Sisak			
Thermoelectric power plant	Ion-exchange resins.	Recover if possible	8.2
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
Otaćic			
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.	18.9

I. EXPLANATORY NOTE

The currency is the Croatian Dinar (HRD) which is shortly to be renamed the Croatian Krown. Its value on 13th January 1993 was 1 US$ = 795 HRD and on 27th January 1993 1 US$ = 915 HRD.

Croatia is suffering hyper inflation and devaluation and hence all services to non-Croatians, eg. hotels, etc. are priced in either US$ or DEM.

The Republic is contending with a very large refugee problem, consisting of either Bosnian or Croatian. This is pacing an enormous strain on their own and the UN resources. For example, most hotels are accommodating refugees, sometimes at the rate of 10 per hotel room. This incurs a priority problem that needs urgent consideration as lack or damage to sanitary facilities which, if not adequately and quickly rectified, will, in all probability, lead to severe public health problems in the summer months.

III. INTRODUCTION

The need for the mission originated from the war in Croatia and the damage inflicted on chemical and associated installations with resultant hazards and risks to the environment, both within Croatia and to neighbouring countries, especially to the east.

The Government of the Republic of Croatia with the cooperation of the University of Zagreb had initiated interest in these problems in the early months of 1992.

This report summarizes the initial assessment of the hazards to the environment resulting from an initial survey in January 1993 and is annexed with an issue paper to be discussed at an international conference entitled "The Effects of War on the Environment", to be held at the Brijuni Island, Croatia 15-17 April 1993. Proposals for follow-on action are detailed in a project proposal.

The mission to Croatia 13–27 January 1993 was preceded by a briefing at UNIDO Vienna, 11–12 January 1993 with the backstopping officer, and a number of other UNIDO officers, a subsequent debriefing took place on 27–28 January 1993. In addition, the consultant contacted companies and experts to get information on aspects pertinent to the report, (see page 34).

He was accompanied for all but 3 days of the mission in Croatia by Dr. Josip Čiček, MD, PhD., Senior Adviser to the Ministry of Environmental Protection, Spatial Planning and Housing, and on the remaining 3 days accompanied by Professor Dr. Slobodan Rendić, Faculty of Pharmaceutical Chemistry, University of Zagreb. A professional driver and a car was provided for all visits. The consultant returned from Dubrovnik to Zagreb by air unaccompanied. The official counterpart for the mission which the consultant met on 3 occasions was Dr. Viktor Simončić, Vice Minister to the above Ministry.

Three days were spent in Zagreb, largely to advise on the organisation of the International Conference (Brijuni Islands 15-17 April 1993) (see Annex 3), and to meet the academic community in Zagreb, scientists from which will need to play a vital role in monitoring and assessment of hazards to the environment, and general advice in reconstruction.

During the 12 days, visits were made to 18 towns, and to some 50 installations, local commune offices, etc, involving travelling ca. 4000 km by road and ca. 1200 km by air. During these visits contact was made with ca. 85 representatives from industry, communes, etc, and a further 25 scientists and officials in Zagreb. A meeting of the Conference Organising Committee held on Tuesday 17th January 1993 resulted in drafting of the second circular for the conference (qv, Annex 3).

The original objectives of the mission to assess the hazards to the environment caused by the war were achieved. However,no risk assessment (qv, definition in Section II. Background) were feasible due to the lack of monitoring data — this vital requirement is the subject of a follow-up project. With the exception of Zadar (from which it was necessary to withdraw rapidly because of pending aerial attack), all the towns originally scheduled were visited. However, some installations were not visited, either for personal security reasons or lack of time. For the latter, more detailed surveys are recommended (qv, annex 5). In addition, other industrial towns such as Vukovar, Knin, etc, currently in Serbian occupied territory need to be visited.

As pollutants in water (and air) do not recognise national boundaries, the overall environmental consequences to transboundary, rivers, eg, the River Danube, or the Adriatic Sea, cannot be assessed without similar missions to Bosnia, which it is estimated has suffered even worse environmental damage, and to Slovenija and other regions of Croatia such as Istria. With the exception of the Sisak oil refinery and the PVC works at Zadar (not visited), the chemical works were largely involved with formulation of preparations, articles, etc, rather than synthetic chemistry. The latter, in the majority of cases, usually lead to greater pollution. In this context catchment quality surveys (qv, Section IV) at other towns such as those reported to cause air pollution (qv, Annex 6) are advised. It should be noted that there is far more synthetic chemical operations undertaken in Bosnia, eg, Tuzla.

For the subsequent proposed project, monitoring, either specific chemicals or generic, ie, the Microtox® test (qv, Annex 7) is vital. Hence, it is recommended very strongly that initially 1 Microtox unit is acquired and installed immediately at the University of Zagreb, to be followed by units at the University of Osijek and the Biological Institute at Split. The 2nd and 3rd instruments to be considered for purchase only after satisfactory progress and results have been obtained from the first Microtox installed at the University of Zagreb. It is advised that the Zagreb instrument should be installed in Professor Rendić's department.

The plans for the final part of this mission, viz: the Brijuni Conference, are now firmly in place. At the conference the mission consultant will deliver the plenary lecture. The conference will allow ample time for discussion and for lectures from UNIDO representatives, officials from the Croatian Government (central and local) and Croatian academia, and from experts from a number of countries. This will enable the recommendations contained in this report and those included in the issue paper to be debated.

The influx of refugees, both Bosnian and Croatian, is causing a significant strain on the infrastructure and the environment. The problems to the latter are enhanced by either the total lack of sewage treatment or damage caused by the war to existing installations. Similarly, waterworks (and their laboratories) require updating. One of the foremost problems identified were indiscriminate rubbish disposal; failure to tacklethis mounting problem quickly and adequately is likely to lead to very significant public health problems, especially during the summer months. It is suggested that WHO should engage an expert who is familiar with the problems, and the geography of Croatia to undertake a detailed survey.

Finally, it is stressed that there is a massive requirement to undertake monitoring of the environmental hazards identified during the course of this mission, and as outlined in the Recommendations (Chapter II). When such data are available, a risk assessment, to be followed by risk management, can commence.

IV. BACKGROUND

The scene in Croatia over the past 2 years has changed dramatically. In addition to the loss of life due to the war, thousands of homes, hotels and countless factories have been destroyed, transport and communications severely disrupted with damage to road, rail and almost total obliteration of airport facilities. However, the people have a determined will and faith to reconstruct and have a solid economical base on which to build.

The major aims and objectives of this mission are, however, to assess the hazards and risks inflicted upon the environment from damage caused by the war to chemical installations.

A. Effects to environmental media

Ignoring occupational health problems, which are themselves considerable, and concentrating on effects to the external environment, it is necessary to consider effects to all environmental media — air, land and water.

A.1 Air

The effects of air pollution have now long passed. But it is necessary to consider this during reconstruction, particularly so when burning waste from damaged factories, and especially if this waste were to include halogenated materials, eg, PVC, brominated fire retardants, PABs, PCBs, used in electrical switchgear, transformers, etc, that the utmost care is taken. However, it should be noted that air pollution, particularly in the direction of the prevailing wind, must have incurred very significant air pollution at the height of the conflict, eg, the fire at Sisak oil refinery. Air pollution should be given very serious consideration as the conflict continues in Bosnia.

A.2 Land

The contamination to soil in some areas is considerable, and if the hazards and risks of the pollution remain unassessed could easily lead to both pollution of water resources and crops. It should be remembered that in the late 20th century foodstuffs , raw or processed, are transported to many countries often thousands of kilometres distant. This is in addition to Croatia wishing to feed a tourist population, and to promote export of foodstuffs including world-famous wines, cheeses and processed meats.

The adverse effects to land are, in particular, related to damage to pesticide installations, oil refineries, electricity, transformers, munition storage, etc.

A.3 Water

The contamination of the water environment is by far the most important and covers adverse effects to groundwater (cf, (land (A.2) above), surface waters and the ocean.

A.3.1 Groundwater. When this has been contaminated, especially with persistent pesticides, traditional water resources, wells, etc. can take decades to recover. Remedial measures such as purification with activated carbon, especially for small rural communities, would be prohibitively expensive. Other techniques such as air stripping, or treatment with hydrogen peroxide may need to be considered.

Such contamination of the limestone karst areas could lead to, or already incurred, chronic adverse conditions.

A.3.2 Surface water. Some of the major rivers, eg. the Rivers Drava and Sava running West to East are badly polluted, even when it enters Croatia. The continuing discharges from damaged chemical factories particularly at Gospić, Karlovac, Osijek, Vinkovci, etc, are increasing this problem. Problems which are enhanced by lost sewage treatment facilities or in many cases no such provision. Pollution of rivers which are transboundary do not stop at boundaries, and this pollution load can thus incur potential health effects to potable water resources derived from the River Danube. Hence, the discharges to these rivers need most urgent attention to preserve drinking water quality to Serbia, Romania, Bulgaria, Moldavia, Ukraine, etc.
Whilst little note was taken of fishing (the initial assessment was however undertaken in January), fishing for a ready source of food is widely undertaken along the Danube and is a major industry in the Black Sea. Consideration is also needed for surface waters used for irrigation. The fragile ecology of the Danube delta should not be forgotten, with its profusion of aquatic and avian species.

A.3.3 Adriatic Sea. The devastation to the chemical industry along the coast is of major concern if discharges continue to the Adriatic Sea unabated. This is again enhanced by discharges of raw sewage. There is little tidal action in the Adriatic Sea and it is considered possible that 'pockets' of contamination could move along the coast rather than be dispersed by dilution. This has important consequences for the re-establishment of a tourist industry and upon a growing but small medium enterprise fishing industry. Fish, and particularly invertebrates upon which fish feed, are known to bioaccumulate or biomagnify such pollutants, and particularly so PCBs (qv, Annex 10). The highly indented coastline prevents free movement of polluted water.
In addition to the Microtox® test (see Annex 7 [1]) further aquatic monitoring making use of algae, daphnia and the 'D' oyster embryo test, will need to be deployed, enhanced with sophisticated chemical analysis where necessary.

B. Economy

Croatia sees itself moving forward as a democracy and to encourage a free market economy with the long term view of her integration into the European Community.

Croatia has an area of approximately 56 500 km^2 and a population of 4 740 000, currently enhanced with 1 million Bosnian refugees. Hence, it is a small state with a mixture of high density of populations in major cities, eg, Zagreb (the capital), having some 20% of the population, Rijeka, Split, Šibenik, being major industrial conurbations, with about 5% each.

The Adriatic Sea, with its natural beauty, has a coastline which is one of the most indented in the world and which extends to about 6000 km. These indentations could lead to major problems if the waters are found to be contaminated. (See above A.3.3.)

Tourism and the Sea

The coast has provided a major economic structure for Croatia as it supported tourism on a massive scale, maritime affairs, including fishing, ports, shipbuilding, etc.

Agriculture

Equally vital is the potential of its agricultural land (comprising some 56% of the area of Croatia) it is, therefore, paramount to ensure that this remains unpolluted, and that areas polluted by the war are rectified with all speed. Simultaneously, advise on the best possible use of pesticides, fertilizers, etc, are required, especially so in Slavonija and the Neretva delta region.

Energy

Croatia possesses considerable energy potential with a capacity to produce approximately 3 million tonnes of oil and almost 2 billion m^3 of natural gas per annum. It also has large areas of forest, some of which were destroyed during the war and should be utilized for wood products, including furniture, and perhaps pulp and paper. (See Annex 13.) taking into account ecologically sustainable development.

Mineral deposits

With the exception of some low quality bauxite deposits, its known mineral resources are limited.

C. Professional human resources

If professional human resources are good with excellent universities and academic institutions based at Zagreb, Rijeka, Split, Dubrovnik, Osijek, etc.

Hence, it has the necessary skilled trained and highly-educated personnel to undertake much of the assessment work for itself.

Specialist training and academic potential

Croatian professionals do, however, need specialist training (qv, Annex 19) of which it is anticipated that the International Conferences entitled 'Effects of War on the Environment' to be held at Brijuni Island 14—17 April 1993 with its many discussion panels will enlarge upon the many needs. As the academic institutions have the manpower trained in the basic skills they should be encouraged to undertake much of the chemical analysis and monitoring necessary to undertake the investigations pertaining to a number of the hazards identified in this initial report.

It is also important to stress that at least in the initial stages that generic measurements (see below) [1] should be considered as a priority to gain a rapid risk assessment, rather than to spend excessive time and scarce resources at least initially on expensive techniques such as gas chromatography-mass spectrometry (GC-MS). Other techniques which are of growing interest are immuno assays, again, some of these have the advantage of being portable.

D. Economical considerations during reconstruction

In 1990, ie, prior to the war, Croatia imported US$ 4.4 billion and exported US$ 2.9 billion of merchandise, resulting in a balance of trade deficit of approximately US$ 1.5 billion. Their principal exports were machinery and transport vehicles (30%) (imported 21%), and secondly chemical and petroleum products (15.5%) (imported 33%), food and beverages (12%) (imported 16.5%).

Over 60% of their exports were to OECD countries balanced by imports of 59%, the principal EEC countries being Italy, Germany FR, France, Great Britain, and the Netherlands, with an additional 17% to the Soviet Union (imports 9.7%), a market which, by 1993 is projected to have diminished significantly.

Contrary to the deficit indicated above, Croatia realizes a considerable surplus in the provision of service, with tourism taking first place (about 50%), followed by international traffic (mostly maritime) and investment projects abroad.

Having regard to the importance of the tourist industry, it is necessary to give high priority to environmental pollution, especially along the highly indented coast, islands, etc. This has to include the removal or making safe of chemical contaminants arising from the war, coupled with the requirements of adequate sewage treatment and provision of pure and wholesome drinking water supplies, now under risk from pollution as a direct consequence of the war and especially so where the vital resources originate from Bosnia, eg, Dubrovnik.

In addition, with modern sophisticated requirements for water leisure activities, consideration needs to be given to adequate means for water treatment, *ie*, both drinking and bathing waters.

Chlorine and other biocides

Classically, chlorine has been the preferred disinfectant, but transportation (in particular), (large scale) manufacture and storage of liquid chlorine leads to a number of hazards, which are neither necessary nor acceptable. Chlorine can be very conveniently electro-generated in situ or use can be made of alternative disinfecting agents, such as ozone, in situ generated chlorine dioxide, quaternary ammonium salts, etc. (See Annex 12.)

Hence, in the reconstruction, consideration should be given to the acquisition of such electrolytic devices and to the manufacture of relatively high cost chemical biocides which can be used as preventatives in other industrial sectors.

Croatia has a good reputation for its wood products, furniture, etc. and hence it is in her interests to synthesize a number of biocides in current use and which are known not to cause environmentally adverse effects, *ie*, the use of the following should cease: drins, pentachlorophenol, trialkyl and triaryl tins, organo mercury compounds, etc., and greater use be made of modern sophisticated biocides. (qv, Annex 17.)

Such specialty compounds, together with pharmaceutical chemicals and agrochemicals, can form the basis of a high value, low pollution based industry. Such chemicals will be invaluable for increasing the durability of many products from textiles, papers, paints, rubbers and latex, plastics, leather goods. In addition, consideration should be given to food preservation, antioxidants, etc.

New chemical production

Consideration for other industries which will support the well being of Croatians nationals, refugees and tourists alike needs to be given high priority, such industries would include soap and detergent products, furniture, glass recycling, etc. (qv, Annex 18 for proposed joint venture opportunities).

Because of the relatively low population of Croatia, with the exception of petroleum-based products, it is considered that the production of basic heavy chemicals should not form a priority for the Sava basin area, as these can be readily imported from the North, Austria and Hungary in particular. Similarly, with the possible exception of Rijeka, such chemicals can be imported by sea. This would apply especially to chemicals where Croatia does not have the necessary raw materials or where there is already over production in Western Europe of basic heavy organic chemicals, solvents, acids, and alkalis.

Croatia's future should be in the specialty chemical market. (See Annex 17.)

Because of the significant national potential for tourism, great care will be needed to be taken to give the utmost consideration to waste minimization, recycling of domestic and allied products, eg, packaging, paper, glass, plastics, food cans, etc.

E. Hazards and Risk Assessments

In order to understand the underlining principles involved in hazard and risk assessments, it is necessary that these terms are defined clearly.

E.1 Definitions

E.1.1 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].

E.1.2 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 a 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.

E.1.3 Risk assessment. Risk assessment is the combination of 4 aspects:

Hazard identification;

Risk characterization;

Exposure assessment, ie, 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.

E.1.4 Risk management. Risk management also needs to be considered, but this is outside the scope of this report. However, this is the management, decision-making, and active hazard control process involving consideration of political, social, economic, and engineering factors with relevant risk assessments 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.

E.2 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].

E.3 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 [22]. It is based on the reduction of luciferase activity in marine bacteria *photobacterium phosphoreum*.

F. Removal of recalcitrant organic compounds from soil and water

F.1 Microbial Removal

Undoubtedly the cheapest and most effective means for removing aliphatic and aromatic compounds, particularly petroleum based substances, is by microbial action, either by bacterial or enzymic systems. Such treatment can include certain halogenated substances, but these tend to be more recalcitrant and hence can be slow in action. There are available a number of effective commercial preparations which utilize *Bacillus, Pseudonomas, Streptomyces, Actinomyces sp.* etc., often in combination with yeast. (See also Annex 14.)

F.2 Monitoring

Water movements containing recalcitrant substances can be undertaken by monitoring using the Microtox® techniques (see above) or by microbial tracers, especially bacteria phages. Such tracer techniques are preferable to using radio-isotopes or dyestuffs such as Rhodamine WT [23].

F.3 Incineration

Only as a last resort should it be necessary to consider incineration at temperatures >1000 °C, but the inherent advantages offered by the cement industry must not be neglected.

In some cases a pragmatic solution is to plough-in waste with activated sludge from sewage works receiving domestic rather than industrial effluents. Unfortunately, few such sewage works exist currently in Croatia.

G. Legislation

There is a clear need to establish a pragmatic legal system for controlling discharges from factories, tourism and other man-made activities. These should be based on the Directives (and individual country statutory powers) of the European Communities.

Data for specific limits can be obtained from these Directives, and also from the legal file [17] of the United Nations Environment Programme/International Register of Potentially Toxic Chemicals, Geneva.

In assessing discharges to any environmental media, consideration will need to be given, best practical environmental options (BPEO) so as to ensure that a restriction on a discharge to one medium does not incur an unwarranted discharge to another media. Simultaneously, it will be necessary to ensure that no adverse effects occur to the factory workplace environment.

During both the reconstruction, and more particularly to the repair of existing installations, care will be necessary to ensure that the best available techniques not entailing excessive costs (BATNEEC) are applied and that full considerations are given to integrated pollution control (IPC) via best practical means (BPM).

It must be stressed that within BATNEEC, techniques are considered, rather than just technologies, and that training, supervision, management, and qualifications are given the necessary priority.

III. ACTIVITIES

A. Mission itinerary (January 1993)

Sun.10 Arrive Vienna

Mon.11 Briefing UNIDO

Tue.12 Briefing UNIDO. Evening meeting with Austrian Federal Environmental Agency.

Wed.13 Arrive Zagreb. Meeting with Dr. V. Simončić, the counterpart (Vice Minister of Environment), Dr. Damir Subašić (Croatian Radwaste Management), Professor Dr. Slobodan Rendić (University of Zagreb), The British Council and the British Embassy.
Evening briefing meeting with Dr. Josip Čiček (for counterpart who accompanied me on all visits except where stated below), and Professor Rendić. Night at Palace Hotel.

Thu.14 Visit to Osijek. Night at Hotel Osijek.

Fri.15 Visits to Vinkovci and Djakovo. Night at guest house of commune of Djakovo.

Sat.16 Visits to Našice, Pakrac, and Lipik. Evening debriefing with Dr. Čiček. Night at Palace Hotel, Zagreb.

Sun.17 Zagreb. Meeting with Professor Rendić, re conference report drafting. Night at Palace Hotel.

Mon.18 Slavonski Brod. Night at Palace Hotel.

Tue.19 Zagreb. Meeting with Croatian Chemical Society. Discussions with Drs. Čiček, Rendić, and Simončić regarding remaining visits, together with Minister for Industry, Shipping and Energy.
Afternoon. Planning meeting with conference organizing committee — redraft programme. Meeting with Rector of the University of Zagreb.
Evening. Draft reports. Night at Palace Hotel.

Wed.20 Visit to Sisak. Night at Palace Hotel.

Thu.21 Visits to Delnice and Korlovac (with Professor Rendić). Night at Palace Hotel.

Fri.22 Visits to Ogulin, Ojačić and Gospić. Long evening drive to Zadar. Night at hotel; Zadar.

Sat.23 Depart Zadar, because of impending attack, visited Šibenik.
Afternoon. Report drafting. Night at Bellevue Hotel, Split.

Sun.24 Split and Metkovic. Night in Hotel Argentina, Dubrovnik.

Mon.25 Visits in Dubrovnik. Night in Hotel Argentina, Dubrovnik.

Tue.26 By air to Zagreb.

Meeting with Croatia Academy of Science and Arts, Professor Rendić (to finalize conference programme) and Professor Dr. Marko Branica (Rudor Bosković Institute).

Night at Palace Hotel.

Wed.27 Press conference at Ministry. Meeting with Ministerial advisers (Dr. Simončić unavailable, in Geneva, Dr. Čiček absent returning by car and ferry because of hostilities at Zadar).

Return to Vienna by air. Debriefing at UNIDO.

Thu.28 UNIDO debriefing, with staff members.

Evening return to London.

B. General position

Zagreb, the capital, was found (in principle) to be similar to any other European capital. The only noticeable difference from a visit in October 1990 (when I was appointed a visiting lecturer to the Department of Pharmaceutical Chemistry, University of Zagreb), was a reduction of private cars. This was reflected by traffic density in other towns and particularly so by traffic on the Adriatic Highway.

There were no signs of conflict or unrest in Zagreb and this was reflected in the majority of the towns visited, or passed through during the mission. However, in towns bordering Bosnia or Serbia, or within the UN protected zones there was a distinct atmosphere of unrest; when shots were fired (or seen at night), at or near 7 of the towns inspected during the mission.

A detailed description of the towns and installations visited and which have incurred damage to either their chemical factories, vital services, eg, electricity, sewage, water supplies, are detailed on a town to town basis in the chronological order of the mission in Annex 8.

It should be noted that in the majority of these towns and in many villages driven through there was substantial damage to domestic dwellings, hospitals, etc.

Damage to the industry, which at the time of attacks and shortly afterwards, caused substantial air pollution, is now causing severe environmental adverse effects to the water and soil. Some of these are likely to be long lasting, and for which detailed risk assessments are required urgently. In order to achieve this, a substantive monitoring programme, either for individual pollutants, eg, cadmium, mercury, PCBs, etc, or for general toxicity, eg, by the Microtox® test (qv, Annex 7) is recommended. A number of general problems are outlined below.

C. Refuse Disposal

One of the greatest problems facing the Government of the Republic of Croatia is indiscriminate dumping of rubbish. Normal household garbage and industrial waste, enhanced with significant quantities of building debris,

broken glass, etc., is, at many locations, being simply dumped by the roadside, in layby's, in former beauty spots, in small bays by the coast, etc. (See Annex 9.)

A master plan to prevent further ravages of the environment, contamination of soil and water is a most urgent requirement, and the Government should receive expert advice without delay. Such advice is required to advise on alternatives to such disposal means, for example: develop professionally managed landfill sites; consider incineration; introduce facilities and philosophies for recycling; and, in the longer term for industry to consider 'zero waste' technologies.

Equally, advise on how to improve existing landfills, eg, by compaction, lining with plastic sheeting in geological sensitive areas, eg, in the Lipa Region, requires to be addressed, together with preventative measures against flooding of these sites.

New, adequately managed, and prepared sites are required urgently in areas where the former landfills are now in Serbia, Bosnia, or UN protected zones, and even of greater priority where these were, or still are, in sensitive drinking water catchment areas, eg, Dubrovnik.

The re-siting of landfills in North East and East Croatia, in general, should not incur too great a problem; whereas in the south (narrow coastal areas), the Islands (not visited), and Central (Lipa) Regions which are situated on the limestone karst, far greater considerations and costly alternatives may need to be considered (see also Annex 9).

D. Polychlorinated biphenyls (PCBs) from electrical transformers, condensers, etc.

In most (if not all) towns visited during the mission these electrical devices had been severely damaged resulting in massive spillages of PCBs (largely thought to be Askarel) to soil, groundwater, and in some cases to surface waters. Such leakages apply to many other towns which sustained attacks. At some of these towns, eg, Dubrovnik, it was reported that 50+ transformers/condensers had been destroyed; the release to all environmental media is estimated to be in the order of 250+ kg for the Dubrovnik Region alone.

These spillages will result in the requirement for a massive and expensive clean-up operation which will need to be preceded by chemical or biological monitoring. (qv. Annex 10.)

E. Wheat silo, Vinkovci

Because of its size, 10 000 tonnes of contaminated wheat, and the ongoing deterioration likely to lead to fungal growth and thus promoting the formation of aflatoxins and rodent problems, this is the single largest problem in isolated mass terms. Further details are given in Annex 11.

As an urgent and interim measure, it is advised that this site should be treated with fungicides and rodenticides.

F. Sewage treatment works

Even prior to the conflict, many Croatian towns had either no sewage treatment facilities or limited — at the most, primary treatment only. The effects of the war is that many of even these limited facilities have been destroyed.

Currently, many towns have their population increased by 25+% by refugees (either Croatian or Bosnian), and this lack of sewage treatment will incur a severe biological load an even the largest of the rivers, eg. Drava or Sava, both tributaries of the river Danube. This excessive load is predicted in the summer months to lead to significant levels of pathological organisms in such rivers and hence lead to water-borne diseases in third and downstream countries such as Bulgaria, Rumania, etc. Many of the so-called bankside filtration facilities in these countries may be inadequate to handle this increased load. It is predicted that this situation is likely to be worse in 1993 than in earlier years because of the refugee situation.

Notwithstanding this, the general appearance of the Adriatic Sea was noticeably cleaner than in October 1990, no doubt, and this is possibly due to significant decreases in leisure activities — tourism (including marinas etc). A matter which should receive attention in the future.

In addition, toxic chemicals from existing and damaged, and more particularly newly operating industries, eg, the leather factory at Vinkovci, can only lead to polluting, recalcitrant and hazardous chemicals being released to the environment. Such discharges have to be controlled/treated at source.

The interior of Croatia, particularly in the Lipa Region, has the potential to incur substantial pollution to aquifers if raw sewage is allowed to be discharged to rivers, eg, the damaged sewage treatment works at Gospić needs priority action.

If the aquifers in the Verebit mountains become polluted, it could well take decades for these to recover sufficiently for their continued use as potable water resources without advanced treatment.

G. Potable water resources

From limited observations, the question of the continuing purity and wholesomeness of Croatia's drinking water supplies requires a detailed review by a Registered Professional Water Chemist. (qv. Annex 4.)

There is a vital requirement to maintain high standards for potable water resources, especially if these are to be used for hydroelectric power, particularly re-pumped facilities, eg, near Delnice.

The return of tourism, particularly at the coast, will incur increased demands for both electricity and water, enhanced in turn by the refugee problem.

From personal and prior knowledge, it is known that pre 1990, the potable water supply was of a good and acceptable purity. However, the damage to the chemical industry, the explosions at the munition dumps (Delnice and Ogulin), and destroyed sewage treatment works (eg, Gospić) may well have contaminated these interior water supplies and hence detailed specific and generic (Microtox) monitoring is required.

Using the Dubrovnik waterworks laboratory as an example, the question of bacteriological and chemical testing of potable water needs detailed review by a specialist consultancy for advice on modernization of both equipment and techniques. (See Annex 16.)

Additionally, both levels of chlorine residues in water and chlorination techniques need to be reviewed. In turn, there are significant hazards in the road (or sea) transport of liquified chlorine gas, especially so in mountainous terrain, and also the Adriatic Highway or ferries etc, especially those near the area which remain under conflict, eg, Zadar. Hence, it is recommended that chlorine for municipal water supplies and swimming pools, etc, is electrogenerated *in situ* (qv, Annex 12).

H. Generic testing

The complexities of discharges from many of the damaged chemical factories, electric power installations, etc. has led to a complex mixture of chemicals and these have led to contamination of soil and waters. Any attempt to consider specific chemical analyses would be difficult and involve excessive costs. Hence, there is a need to obtain simple indications of toxicity with speed and ideally to obtain such data in the field, ie, is an area of soil or water contaminated or otherwise?

The Microtox® test [1] is capable of indicating whether a sample is toxic (at least to *Photobacterium phosphoreum*) or otherwise. The apparatus is robust, rapid, and peer reviewed procedures. As detailed in Annex 7, it is recommended that a unit is purchased immediately for the University of Zagreb, and further units for the University of Osijek and the Biological Institute at Split should be considered in the medium term.

I. Wood industry (including pulp and paper)

Croatia has a large natural resource with its wood industry and this needs further development.

The conflict has resulted in an immediate requirement for wood for building purposes and for furniture production, both of which are needed for housing refugees and will also be needed in Bosnia. In addition, there is a large potential for export.

Consideration should also be given to the pulp and paper industry (see Annex 13), but any feasibility study for such a proposal would need to stress the requirements for 'clean technology'.

J. Soil contamination with mineral oils, etc.

In many places, eg. Osijek, there are significant areas (ca. 60 000 m^2) contaminated with mineral oils ranging from heavy fuel oils to light lubricating oils, transformers oils, etc. As indicated in Annex 14, these need to be decontaminated by microbial processes. Where such spills are near to receiving waters there is significant urgency.

K. Asbestos

The destruction of roofs, walls, and more particularly insulation, of buildings has led to significant quantities of asbestos, some of which is undoubtedly crocodilite. The greatest care is necessary in handling such debris, its storage, and disposal (see Annex 15). Failure to deal with this serious matter will result in adverse health effects which will be probably be delayed for 2 or so decades and will affect the general public and workers alike.

L. Speciality chemicals

As indicated in the Background (Section IV), there is a good case to consider the development of the chemical industry for synthesis of high value speciality chemicals. Some examples of biocides are listed in Annex 17, and this in turn should mean that air pollution at the towns listed in Annex 6 should diminish, leading to an improved and more prosperous lifestyle.

M. Joint ventures

Many of the processes for such chemicals (qv, Annex 17) and for other projects detailed above, and in the Recommendations (Section I), should be considered for Joint Venture projects with Western European countries and some proposals are given in Annex 18.

N. Training

Training in a variety of disciplines will be necessary and some proposals are listed in Annex 19. It was pleasing to note during the mission that scientists at the various academic institutions demonstrated a clear and advanced understanding of the scientific principles involved in the devastation to the environment as detailed in the visit (qv, Annex 8). Croatia, during its programme of reconstruction and development will need to draw increasingly and extensively on this reservoir of knowledge and expertise. Some detailed training, especially in hazard and risk assessment (see Section V.E and references [2—4], and in toxicology/ecotoxicology, will be necessary, together with enhancement of laboratory equipment and supplies.

O. Slavonija region

During the early part of the mission it was noted that wetlands had incurred damage and these problems need advice from biologists who specialise in such conservation.

Additionally, and to the immediate East of Zagreb, there is a large pig farm with no provision for treating manure. This, coupled with excessive use of fertilizers has led to excessive levels of nitrate in water supplies, in turn leading to cases of methaemoglobinaemia.

The highways have maintenance depots every 100 km or so, but negligible control is exerted over the quality of the asphalt used. Indeed, much of the asphalt is imported from Albania and containing many contaminants (eg, PAHs), hence road repair should not be considered as a means for hazardous waste disposal, only as a means of disposing of building debris, but excluding asbestos.

P. Future visits/inspections

Two weeks was inadequate to provide even a basic assessment of the damage caused to the environment, because of the massive scale of the devastation. The mission did, however, indicate that the damage to the environment is considerable and that such remedial work is required (qv, Section I. Recommendations). Other towns (some in occupied regions) and many other installations need to be visited and the damage assessed (qv, Annex 20).

Early recognition of the damage is vital, together with the appreciation that some of this damage may be irreversible, or could cause adverse health effects, which may not become manifest for 1 or 2 decades [24], or pollute drinking water in other countries or foodstuffs exported. Furthermore, lack of professional advice, eg, in refuse disposal management has led to the development of an even greater problem.

Q. Additional consultations and advice

During the compilation of this report the consultant interviewed and obtained advice from a number of companies and experts — these are listed in Annex 21.

R. A multidisciplinary approach

Croatian scientists also need to receive training in multi-discipline, multi-process techniques so that they can advise 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.

VI. CONCLUSIONS

The effects of war on the natural environment are considerable. Many of the damage to the environment as detailed in this report (qv. in particular Annex 8) will undoubtedly lead to pollution of soil and water. The effects resulting from the many and, in some cases, massive spillages of PCBs are very serious (qv. Annex 10).

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 effects will result in the Adriatic Sea.

The spillage, and in particular, loss of sewage treatment facilities 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. (See also Annex 20.)

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.

Simultaneously with i) — iv) above, serious consideration is advised for joint venture projects (see Annex 18).

Details for a follow-on project proposal is appended.

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.

ANNEX I.

19 November 1992

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

UC/CRO/92/164/11—51

Title:	Specialist in Industrial Chemical Pollution Control
Duration:	6 weeks (42 days)
Duty station:	Zagreb with travel within the country (approx. 2 weeks), Brioni Island (1 week, 12-17 April 1993), rest home-based.
Time required:	As soon as possible

Purpose of the Project: To assist the newly independent country of Croatia to assess the damage caused to its chemical industries, the risks and hazards involved due to chemical pollution and participate in an international meeting to discuss plans and action to monitor the pollution and take measure to contain short/medium and long term effects.

Duties: The consultant, in collaboration with UNIDO officers, and in consultation with project counterparts in Croatia is expected to assess the overall damage caused by the war and the influx of refugees to the industrial infrastructure and appraise the pollution (especially chemical) due to various factors. Based on his/her assessment he/she is expected to submit a detailed report giving facts and figures on the damage to the country's industrial bases (mainly chemical industries) and actions to be taken to monitor hazards and risks of chemical pollution and plans to contain the pollution from causing further damage. He/she should advise the type of organization that should be set up to look into the problems of hazards and risks on chemical pollution on a short/medium/long term basis.

The consultant is expected to organize a discussion panel in a conference to be arranged by the Government of Croatia. His/her report will be used as an issue paper for the conference. He/she, along with UNIDO staff members, should actively participate in the panel, assign topics for discussion and assist in writing a report on the panel discussions, the conclusions and the final recommendations.

Qualifications: Chemist or chemical engineer with extensive experience in chemical industry or government institution dealing with effluent control, waste management and in restructuring chemical industries. He/she must have held senior position giving advice to management and/or government bodies in planning to control industrial pollution (specially chemical industries). Experience in organizing meetings in international conferences would be an added advantage.

Language: English

Background information: The newly independent Croatia was born in the midst of ending the cold war and an internal civil war fought along ethnic lives. During this process the country lost most, if not the major part of its industries base, especially the chemical industries. In order to assess the damage and also the effect of chemical pollution, the Government of Croatia is arranging an international meeting during April 13—17 April 1993 to discuss hazards and risks of chemicals monitoring and evaluating the devastation caused by the war on chemical industries. The Government requested UNIDO to take an active role in the conference and accordingly UNIDO will prepare an issue paper covering a broad area dealing with chemical pollution and submit in the conference for discussion.

ANNEX 2.

Senior counterpart Staff: Dr. Viktor Simončić, Vice Minister, Republic of Croatia, Ministry of Civil Engineering and Environmental Protection, Av. Vukovar 78/III, 41000 Zagreb, Croatia.

Dr. Josip Čiček, Senior Advisor to the above Ministry.

Professor Dr. Slobodan Rendić, Department of Pharmaceutical Chemistry, University of Zagreb, 1A. Kovačiča, 41000 Zagreb, Croatia.

Dr. Z. Karakaš, Minister is Chairman and Professor Rendić, Dr. B. Kurelec (Ruder Boskovic Institute), and the consultant are Co-Chairmen of the 'International Conference on the Effects of War on the Environment' to be held at the Brijuni Islands, Croatia, 15-17th April 1993.

Second circular Brijuni Conference

ANNEX 3

PRELIMINARY PROGRAMME

Thursday 15th April

Chairman: M. Šunjić, *Rector, University of Zagreb, Croatia*

Co-Chairmen:
S. Rendić, *University of Zagreb, Croatia*
M.L. Richardson, *BASIC, Great Britain, and Consultant for UNIDO, Wien, Austria*
Z. Karabat, *Minister of Civil Engineering and Environmental Protection of The Republic of Croatia, Croatia*

09.00 Opening Ceremony

10.00 The Case for Croatia - The Ravages of War

11.00 COFFEE

Chairman: M. Šunjić, *University of Zagreb, Croatia*

11.30 M.L. Richardson, *Consultant for UNIDO, Austria*
The Assessment of Hazards and Risks to the Environment Created by War Damage to Industrial Installations in Croatia

12.30 A. Tchakmakorian-Aeschbacher, *United Nations Industrial Development Organization, Austria*
UNIDO Activities

13.00 LUNCH

Chairman: S. Rendić, *University of Zagreb, Croatia*
A. Tchakmakorian-Aeschbacher, *UNIDO, Austria*

15.00 L. Richert, *University of Karlsruhe, Germany*
War Against Life

15.40 R. Tatchell, *Global Tick Management Services, Great Britain*
War Risk Avoidance and Third World Livestock Development

16.00 A. Jurta, *Institut für Europäische Umweltpolitik, Germany and the Regional Environmental Center for Central and Eastern Europe, Hungary*
Possibilities of East-West Cooperation in the Field of the Environment - Croatia after the War

16.20 M. Schneider-Jacoby, *Stiftung Europäisches Naturerbe, Germany*
The Effects of War Activities on Nature Park: Lonjsko Polje, Croatia

16.40 N.M. Smirnov, *Academy of Science, Russia*
Regional Natural and Social Disasters Resulting from Armed Conflicts and Revolutions

17.00 Discussion

19.00 DINNER-PARTY in surrounding of the Islands of Brijuni - location depending on the weather conditions

Friday 16th April

Chairman: J. Čitek, *Ministry of Civil Engineering and Environmental Protection, Croatia*

09.00 N. Gebremedhin, *UNEP, Kenya*
UNEP's Approach to Environmental Security

09.30 P. Carl, *Central Institute for Electron Physics, Germany*
Kuwait Fire and the Monsoons (War and Climate)

10.00 D. Sobolić, *Croatian Radioactive Management Agency, Croatia*
The Radioactive Waste Management in the Areas of Croatia Affected by War

10.20 COFFEE

Chairman: B. Kurtelec, *Institute Ruđer Bošković, Croatia*

10.40 L. Hast, *Engineering Products, Great Britain*, and H. Winkler, *Peroxidation System, Germany*
Chemical oxidation of hazardous organics contaminants in water - the process effectiveness (preliminary title)

11.10 F. Abram, *ACER Environmental, Great Britain*
The Effect of Petrochemical Materials on Marine Life

11.30 V. Prevršić, *Institute Ruđer Bošković, Croatia*
Strategic Framework in Environmental Management: War and its Aftermath

12.00 LUNCH

Chairman: M.L. Richardson, *BASIC, Great Britain*

13.30 J.A. Hoskins, *MRC Toxicology Unit, Great Britain*
Contamination of the Air with Mineral Fibers Following the Explosive Destruction of Buildings and Fire

14.00 G.H.G. Martin, *Great Britain*
War Risks
Environmental Toxicology

14.30 R. Emel, *Centers for Disease Control, USA*
Measuring the Exposure of Firefighters in Kuwait to Volatile Organic Compounds

14.50 B. Samimi Eidenbenz, *International Center for Environmental Technology and Nutritional Industry, Switzerland*
Measures and Methods for Remediation and Restoration of Contaminated Environmental Media, and Reconstruction of Industrial Plants Damaged by Warfare Activities

15.15 M.L. Richardson, *BASIC, Great Britain*
Principles of Risk Assessment

15.15 Round-table discussions, on the foregoing topics

During round-table discussions tea and coffee will be available.

FREE EVENING

Saturday 17th April

Chairman: V. Prevršić, *Institute Ruđer Bošković, Croatia*

09.00 J. Goldblat, *Arms Control Center, Switzerland*
Protection of the Environment in Time of Armed Conflict

09.30 S. Kačić, *Croatia*
International Aspects of the Effects of War on the Environment (preliminary title)

09.50 B. Vukas, *University of Zagreb, Croatia*
Humanitarian International Law and the Protection of the Environment in Armed Conflict

10.05 N. Vejić, *University of Zagreb, Croatia*
Protection of Dams in Armed Conflicts: The Case of Peruća

10.20 M. Sertić, *University of Zagreb, Croatia*
Protection of Cultural Property in Time of Armed Conflict

10.35 COFFEE

Chairman: B. Vukas, *University of Zagreb, Croatia*

11.05 J. Matoušek, *Tech. University Brno, Czechia*
Effects of Conventional Warfare on the Man-made Environment

11.25 B. Jackson, *Great Britain*
Public International Law of the Use of Biological and Chemical Weapons

11.45 V. Filipović, *University of Zagreb, Croatia*
Shiping in the War in Croatia

12.05 LUNCH

13.20 R. Ivanković, *University of Zagreb, Croatia*
Protection of the Adriatic Coast: Cultural and Environmental Aspects

14.00 J. Sell, J. Wade, *European Council for the Village and Small Town*
The Reconstruction of Historic Settlements: Opportunity or Liability?

13.30 Round-table discussions

15.30 CLOSING REMARKS AND END OF CONFERENCE

18.30 CONFERENCE DINNER

Please notice that the programme will be subjected to change

ANNEX 4 .

List of companies and experts contacted during February 1993

to advise on aspects pertinent to the report

— Mr. R. Hunt, Principal, Chiltern Water Management Services, High Wycombe, England.

— Mr. Duško Pavlović, Managing Director, Multihold (UK) Limited, Palladium House, 1-4 Argyl Street, London, W1V 1AD, England.

— Ms Sonja Kvesic, The Royal Society, London, England.

— Mr. Ognjen Car, Croatian Chamber of Commerce, London, England.

— Mr. Gerald Bailey, Managing Director, Microbics (UK) Limited, Hitchin, Hertfordshire, England.

— Mr. Philip Down, Perkin Elmer, Beaconsfield, England.

— Mr. John J. Guilfoyle, Associate, Watson Hawksley, Consulting Engineers, High Wycombe, Buckinghamshire, England.

— Mr. Douglas Milne, DNV Technica, London, England.

— Mr. Kevin Prophet, Wallace and Turner, plc, Tunbridge Wells, Kent, England.

— Dr. Geoff Frost, International Biochemicals (UK) Limited, Slough, Buckinghamshire, England.

— Mr. Antony Jones, Partner, Tillyards, Surveyors, London, England.

— Dr. Paul Pritchard, Brown and Root Environmental, Leatherhead, Surrey, England.

— Dr. E. Fassold, The Federal Environmental Agency, Vienna, Austria.

— Mr. Neil Tasker, Buckman Laboratories Limited, Manchester, England.

— Dr. Lionel Hatt, Engineered Products Limited, Banbury, Oxfordshire, England.

— Dr. Helmut Winkler, Peroxidation Systems Inc., Langen, Germany.

— Mr. Derek Cheney, Trent Marketing, Sutton, Surrey, England.

— Mr. Martin Hunt, The Royal Society of Chemistry, London, England.

— Mr. J. Kurton, Blue Circle Cement plc, Greenhithe, Kent, England.

— Mr. J. Tarleton, Biosphere, Consultants, London, England.

— Mr. Robin Griffith, Clifford Chance, Solicitors, London, England.

ANNEX 5.

Recommendations for Future Visits

1 Osijek

It is estimated that 5 working days will be required to assess fully the damage at this town. In particular, assessment is required for the 60 000 m^2 of oil soaked land, PCBs from transformers, chemicals at Drava Safety Measure Products, Lio Textile Manufacture, and in particular the Slavonka leather factory, believed to be discharging chromium to the River Drava.

2 Vinkovci

There is a need to visit other installations in UN Protected Zone, Vrapcane, Mirkovic, etc, and to inspect dam on river Boset and leachate to the Bazjas Canal (2 days required).

3 Cement works, Našice, Split and headquarters in Zagreb (1 day each).

4 Slovonski Brod

It is estimated that a further 5 days will be necessary to visit the other installations, including heavily damaged riverside factories.

5 Sisak

There is a requirement to inspect the iron and steel works, riverside installations, and also the installations at Sunja and Petrinja (currently in UN Protected Zone) A minimum of 5 days should be scheduled.

6 Delnice

A visit to the hydroelectric scheme lakes above Delnice, together with a full upland catchment survey is recommended. It is puzzling as to why the water, when pumped from the fifth lake back to the upper lakes, becomes contaminated. Also the source(s) of this pollution needs to be identified and prevented. This water resource is a vital asset which needs protection. It is estimated, because of the difficult access to some of the terrain, that 5 days may be required for a thorough catchment survey, which would need to include an inspection of the wood industry, particularly so if any treatment, including stripping of bark is undertaken on the ground above these lakes.

7 Karlovac

At least 5 days will be necessary to visit the other damaged installations, including those in the UN protected zone. In view of the importance of the wood industry, this will require special attention. The

question of waste disposal, sewage treatment and potable water supplies, and taking into account the large number of refugees, will require detailed investigation.

8 Ogulin

Visits and detailed surveys of munitions dump, and the industry at Praški (in Serb occupied territory), and winter ski resorts. Five days estimated.

9 Zadar

As no visits were possible, it is estimated that at least 3 days will be necessary to assess damage to the large industrial site.

10 Dubrovnik

In view of the extensive damage, a further 3 days will be necessary.

In summary, a further 41 working days, excluding long distance travelling time and meetings with government and other officials in Zagreb, are required. Many of these visits should be made, preferably by industry sector experts, eg, cement, agricultural, sewage, drinking water, etc.

Care (and some delay) will be necessary for many of the installations in the UN protected zones, or those areas still under conflict.

ANNEX 6.

Towns known to cause air pollution

During discussion with scientists in Zagreb the question of atmospheric pollution was discussed. Even prior to the war many towns caused severe atmosphere pollution, and this was confirmed by observation, both during the surface travel and the return air journey from Dubrovnik.

Inland Towns	Coastal Towns
Zagreb	Rijeka
Slavonski Brod	Pula
Kutina	Zadar
Ivanić-Grad	Šibenik
Sisak	Split
Karlovac	Trogir
	Dugi Rat

The inland towns are also known to pollute rivers; and, the coastal towns, the sea to the extent that many neighbouring bays are highly polluted.

Equally at these towns, workers suffer from respiratory complaints and other adverse health effects.

When considering remedial policies, it is vital that due consideration is given to an integrated risk assessment so that all adverse effects of chemicals are investigated.

ANNEX 7.

Quotations and details for analytical chemical equipment

There is an urgent need to undertake substantial monitoring of soils for contaminants such as PCBs, mineral oils, etc. and waters — river, potable, and marine.

As an urgent short term measure there may be no alternative but to send samples to other countries for analysis, eg. Vienna for PCBs; Budapest for GC-MS, and other sophisticated analysis using the new EC funded Analytical Chemistry Laboratory; Brno for cytochrome P-450 assessments; Italy; or, other western European countries. In the short/medium term, facilities at academic institutions in Croatia need to be enhanced rapidly.

In view of the widespread and significant nature of environmental pollution, simple, rapid and robust methods for toxicity measurements are advocated. One of the preferred methods is the Microtox® test, Microbics (UK) Ltd., Hitchin, England, and Carlsbad, USA. This is a peer-reviewed technique, recently reviewed in depth [1].

It is recommended that one set of equipment, at a cost of US $40 000 (quotation attached) is purchased without delay and be housed in the Department of Pharmaceutical Chemistry, Faculty of Pharmacy and Biochemistry, University of Zagreb under the direction of Professor Dr. Slobodan Rendić, one of the co-chairmen of the Brijuni conference.

At this central location, the equipment must be utilized fully to assess the toxicity of soil and water samples, at the locations indicated to present high hazards (Table 1) to the east of Zagreb, in the interior, eg. Delnice, Ogulin, Otačić, Gospić, etc. and on the coast.

If it were possible for such data to be made available in adequate time for the Brijuni conference, results could be discussed by the global experts present.

In addition, consideration needs to be given to equipping a laboratory in Zagreb, again possibly Professor Rendić's, with state of the art equipment such as GCs, HPLCs, GC-MSs, atomic absorption, spectrometry, etc. A quotation for such equipment is appended.

Prior to such an additional commitment, it would be a requirement for Professor Rendić to demonstrate clearly by publication of results in learned scientific journals of the results of his Microtox surveys. His department could then be considered for enhancement with the equipment outlined above, and to be developed as a centre of excellence in environmental chemistry. Simultaneously, with this enhancement, consideration could be given for the provision of a Microtox initially, and later by a selection of other equipment at the University of Osijek

and the Biological Institute at Split. The latter has the advantage of being able to undertake conveniently marine surveys from their m.v. Bios.

Simultaneously with the above, training would be necessary in techniques for information retrieval, validation, and interpretation, hazard assessment, risk assessment, and finally risk management. Professor Rendić is fortunate in his having attended The Royal Society of Chemistry's teach-in and conference on 'Risk Management of Chemicals', Guildford, England, in July 1992.

ANNEX 8.

Details of visits to towns

1. Visit to Osijek, Thursday 14th January 1993

Contacts:

— Ljiljana Belajdžić, dipl. ing grad.
Deputy Secretary of the Secretariat for Town Planing

— Berislav Šmit, dipl. oec.
Main-Secretary of the Secretaria. for Economics

— Cupec Sonja, dipl. ing. arh.
Service for territorial planning, Director

— Ivica Peko,
Chief-Secretary of the Secretariat for Town Planing

— Šenberger Zomislav, dipl. ing. kem.
Saponia, Kemijska, Prehrambena,
Farmaceutska Industrija P.O.
54000 Osijek, Matije Gupca 2,
054 551 622 (direct 551 844), fax 556 327

— Zvonimir Horvat, dipl. ing. kem.
Assistant Gen. Director
address as above
direct line 51 622 105

— Karmen Domladovac
Interpreter, City Council Osijek,
Skupština Općine Osijek,
Trg. Ante Starčevića 2
54000 Osijek
054 31 622, fax 054 31232

— And 14 others.

The town of Osijek and its industry has received significant war damage. Some of the areas of destruction to industrial premises including the Saponia works (see below) and the thermoelectric power facility (see below) are in the UN protection zone and attempts at reconstruction is obviously not under consideration. Some work has commenced at other installations.

In common with other towns, refuse as a mixture of industrial waste, building debris, including glass and domestic garbage, is simply being dumped, often by the roadside, and in the medium term is likely to lead to

a public health hazard. See also Annex 9. This serious matter is aggravated by the former landfill being in Serbian territory, but it is stressed that this was too near to the River Drava.

Representatives from a number of the damaged industries and leading members of the local council attended a meeting in the afternoon. It should be noted that Osijek (population 104 500) has no sewage treatment works, a matter which needs to rectified during a master plan for reconstruction. Effluent flows to the river Drava and hence to the river Danube. In common with all other areas visited in the North East area of Croatia and largely the region of Slavonia all effluent flows either direct to the river Drava or Sava and then to the river Danube, and hence incurs a hazard for drinking water supplies, flora and fauna for all downstream countries viz. Serbia, Romania, Bulgaria, Moldavia, and Ukraine. These pollution hazards could in the medium terms lead to ecological damage to both the fragile ecosystem of the Danube delta and the Black sea.

Little monitoring has incurred since the commencement of hostilities in late 1990 and this is a matter of urgent concern. As previously indicated, there is a current requirement for monitoring, albeit generic monitoring, for which Microtox is recommended.

The local University would appear to have the necessary personnel of a suitable standard to work in the cooperation with the local water authority. (qv, Annexes 7 and 19)

In addition to the industries detailed below, it should be noted that the hospital was destroyed and radioisotopes, including technetium, iodine and gold were washed to the river Drava. Whilst the first 2 have in all probability decayed adequately by early 1993 this is not the case for the gold which needs to be located and recovered.

A further general issue is that many of the roofs of industrial buildings were constructed of asbestos (type generally unknown) and no care of containment of asbestos fibres is being taken, indeed such debris is being openly dispersed into the environment by the roadside. Urgent and at least common sense precautions are a matter of immediate consideration. Both monitoring and training are a matter of considerable urgency. (See Annex 15.)

Time only permitted an inspection of the Saponia factory (in the UN protected zone) and there is an immediate requirement to asses the hazards related to the damage to the other enterprises listed below.

It should be noted that there is an area of wetlands to the east of Osijek.

1.1 <u>Saponia. Manufacturers of Detergent, Soap, Cosmetics, including Lipsticks, Toothpaste, Shampoos, etc.</u>

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 Djakovo, 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 quickly, with the view of reporting progress at the Brijuni conference in April 1993.

1.2 Thermoelectric power plant

Approximately 7000 tonnes of heavy fuel oil were lost, some burnt but it is estimated that 1500 tonnes has contaminated an area of 200 x 300 = 60 000 m^2 of land to an unknown depth. This is currently

seeping to the drainage system and to channels leading to the river Drava. It was requested that oil analyses were carried out urgently but it has to be remembered that the stretch of the river involved is in the UN protected zone. Leakage has been occurring since September 1991. The soil is porous and the rainfall 700 mm a^{-1}

1.3 Chonia Electric Enterprise (HEP)

Leaks of transformer oils (mineral oil) has occurred, quantity unknown. Other transformers which were not damaged contained PCBs (quantity approximately 30 tonnes).

1.4 Drava Safety Measure Products (no representative at meeting)

Product range includes phosphorus and sulfur (for matches).

1.5 'IPK' agricultural combine

Agricultural and food products, including sugar cane. Processes 6000 tonnes/day for 100 days/year. (Further details to follow.) It is well known that the processing of sugar from beet or cane leads to a polluting effluent. Consideration should be given to anaerobic digestion, such a plant would also be invaluable for digestion of the wheat damaged at Vinkovci.

It was noted that this effluent contained suspended solids 3690 mg L^{-1} with a BOD of 5000 mg L^{-1} 0_2

1.6 INA Oil Storage

Only atmospheric contamination occurred. No damage to petrol stations.

1.7 Lio Textile, manufacture of linen

Chemicals include dyestuffs (imported from Austria and Germany), and mothproofing agents. No details of damage or discharges available.

1.8 'Slavonka' manufacturers of leather clothing involving chrome processes

There were large discharges, and these were reported to continue, for chromium (2-10 g/l in effluent), enzymes and dyestuffs largely aniline based. No data of concentrations in river Drava available and hence urgent needs for monitoring, for which there are no facilities available.

1.9 Gas distribution

Initially there was an emission of 156 000 m^3 of methane. Currently they are experiencing problems with leakages of ethyl mercaptan which can only monitored by its odor.

1.10 Water laboratory

It was that this was reasonably well equipped and that in conjunction with the Public Health Laboratory they had the equipment to undertake many of the usual water analyses. eg. pH. conductivity. temperature. dissolved oxygen. BOD. COD. metals (with a 5 year old Perkin-Elmer atomic absorption spectrophotometer). anionic detergents. ammonia. nitrate. phosphate and oils/fats. However. they had few reagents. and taking of samples in the occupied zones was rarely. if ever. undertaken.

2 Visit to Vinkovci, Friday 15th January 1993

Contacts:

— Marijan Rubie dir. DP Silos-Mlinovi
Anti Sliskovic. dipl. ing., Director
56 21 047. fax 56 21 291

— Pero Mijakić (Fin-Komercijazni Rubovodioc DP Mlin-Pekara.

— Ivan Trebor. dipl. ing.,
Predsjednik Izvršnog Vijeća.
Skupština Općine.
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56000 Vinkovci
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— Dražen Svagelj
dr. Dopred sjednik Izvrsnog vijeca
56000 Vinkovci
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56 11 537. fax 210 99.

— Željko Klemenčić. BSc (Ing) Agriculture Adviser (who accompanied us on the inspections)
Renew and Development Institute.
Jurja Dalmatinca 37
5600 Vinkovci
56 21 047/17 922. fax 21 047

— Dubravka Viahovic. Secretariat of Environmental Planning
56 17 922

Vinkovci is an important railway town with 39 settlements and rail connections formerly from 6 directions. However, because 26 of the settlements are under temporary occupation, no data are available, those of particular significance are the villages of Privlaka. Otoki Nuštar and Jarmina. It has a population of 35 000 now increased to 45 000 with refugees. In common with other towns visited, domestic, building and industrial garbage is being dumped indiscriminately by the roadside. The former sanitary landfill site (in the forest area Vrapcane by Mirkovci) is now in the UN protected zone and the replacement site is now immediately adjacent to the Bazjas Kanal which is clean water and used for crop irrigation. Monitoring of the canal and the receiving river Boset is recommended, initially by Microtox. It will be important to find a new location for the landfill. The River Boset is a slow moving river (frozen at the time of the mission) which is dammed and pumped to the river Sava. An inspection of the dam was not possible for security reasons.

The River Boset in summer is prolific with *Lemna gibba* and it was thought that this might be used for feeding avian species. However, no analysis of the river has been possible (and is still not possible) for 2 years. The river is 35—40 m wide, 1—2 m deep — many wells in this location in Chernozem soil; the wells are between 50—150m deep. The flow of the river has been reduced from 50 $m^3 sec^{-1}$ to 2 $m^3 sec^{-1}$, resulting in a substantial increase in surface dirt — a report dated 17th February 1993 indicated that the flow has almost stopped. Some remedial work undertaken to the sewage treatment facilities in late 1992/early 1993 has been bombed and as a result raw sewage is flowing to the river Boset.

2.1 Wheat Silo

One of the 3 problems at this location was the damaged wheat silo containing some 10 000 tonnes of wheat which was wet from rain (snow) and was sprouting and starting to become mouldy. It is very likely that aflatoxin would occur leading to a hazard to both the intact installation and neighbouring domestic properties. Attempts to dispose to land had failed, largely because of pieces of roof (asbestos) and grenades, etc, in addition, some of the wheat was burnt. This is a large and urgent problem as not only will the silo be required for the 1993 harvest, but fermentation will soon commence, together with infestation with rats and birds.

It is suggested that the FAO be requested to send an expert to advise if partial recovery of this asset is feasible; alternatively, the feasibility of blowing the grain into the Našice cement kiln should be investigated.

A further alternative would be deep ploughing to a depth of at least 30 cm.

The second problem was the loss of 40 000 L of heavy heating oil, some has already been lost to the river Boset and some had solidified in the pipe to the River Boset and, further, is likely to liquify when the temperature increases. The simple intermediate remedy would be to seal the outfall end of the pipe. However, this is currently in an area suffering sporadic bombardment.

The third problem is that the dust extractors to the otherwise intact silo were destroyed leading to direct atmospheric emission, coupled with explosion hazards.
It is estimated that the emission is 1100 tonnes a^{-1}.

2.2 A number of transformers in the location were destroyed, one of which is known to have leaked 25 tonnes of its 30 tonnes of PCBs to soil. Urgent monitoring is essential (qv, Annex 10).

2.3 Aluminum and Copper Wire

There were reported to be many kilometres of such wire with partially burnt insulation. There is a requirement to reuse this wire.

2.4 INA/Spent Engine Oil

This is currently collected at the rate of 8000 L $month^{-1}$ with a current stock of some 60 000 L. INA is unable to process this and is now leaking to the environment.

Hence, there is an urgent need to find a means of its destruction, ie, the Našice cement works) or a thermoelectric power plant.

2.5 Leather Factory Cibalia, Manager, Nenad Jerković

This factory prepares leather from hides, including dyeing, but has no downstream processes. The factory was largely destroyed (effluent treatment plant totally destroyed). It is anticipated that a limited production will recommence by the end of January, with effluent being discharged direct to the neighbouring River Boset.

During the conflict the chemical stock was removed to the cellar (also used as a shelter). This cellar is now full of contaminated water. Advice on its treatment is sought urgently.

There is also a bund from a damaged heavy fuel oil tank, full of oil and only some 5 m from the River. At the time of the inspection, attempts were being made to pump some of this to fuel a boiler furnace. However, it was reported on 17th February 1993 that this is now leaking to the River Boset.

It is recommended that production should not commence until the treatment plant is refurbished, particularly in view of the significant potential to discharge chromium salts.

2.6 Pesticide Storage Area

This was totally destroyed and is now a clear site. A list of chemicals stored to follow.

2.7 Oil contaminants

The industrial zone is burnt and 4 large tanks of heavy fuel oil are leaking to the sewers and the environment which threatens the river Boset and the water supply system. (This was reported after the mission — no visit was made for security reasons.) Additionally, heavy fuel oil is leaking from tanks at the power station.

2.8 Air exhaustion systems

Many are destroyed including the cyclones at the asphalt plant. (It is noted that the asphalt probably has a high PAH content, quality unknown and imported from Albania.)

3 Visit to Djakovo. Friday 15th January 1993

Contacts:

— Anivn Rajmer. Director. 'Dahcovack'
'Vodovrej' Water Supply.

— Slavko Stilinović. dipl. ing. chem. 'Meteor'
Rukovodilac. Industrial Zona BB
54440 Djakova
054 841 333. 843 033. fax 054 841 356

— Milan Pološki. Director of Meteor
Milka Cepecic BB
(as above)

— Vlado Penava. 'Energa'. Djakovo

— Nikola Hores. Sekretar Za Privreda

— Mirko Sabljar.
Urbanista Pri Sekretarijatu Za Privredu

The major problems for the town of Djakovo is the loss of 3 of its 6 water supply reservoirs. leading to a gross water shortage for distribution purposes.

There was no damage to the limited sewage treatment plants.

Apart from some loss of lube oil to underground water reserves. there were few problems. However. the following should be noted:

3.1 Agriculture store

This was totally destroyed and has been rebuilt. A list of chemicals is to follow.

Soil samples should be analyzed. when the list of pesticides is available.

3.2 Meteor works

Production of household formulations. polishes. shampoos. etc.
This was not damaged during the war. but the resultant loss of sales has meant that they will be unable to install a proposed effluent treatment plant.

As only 9 m^3 day^{-1} are involved and the plant is modern and efficient. it would appear that application of BATNEEC would improve the position.
The plant would discharge to the Jošava. Bia. Boset. and Sava rivers.

4 Visit to Našice Cement Works, Saturday 16th January 1993

Contact:

— Krešimir Knežević, dipl. ing., Direktor
Tvornica Cementa Našice,
54500 Našice
Kralja Zvonimira 2
0560 13 911 (home), 0560 13 626, 13 606, 14 612, fax 28 107

The purpose of this visit was at the suggestion of Mr. Carl Rydeng (UNIDO-IO/T/CHEM) for high temperature incineration of hazardous wastes.

The plant is natural gas fired and hence no addition to fuel can be considered.

They make 1500 tonnes cement clinker d^{-1}.

In principle, they could be considered for disposal of some of the residues from Osijek and possibly the wheat from Vinkovci. However, there would be a need for a visit from a UNIDO cement expert.

In addition, there are 3 factories at Split, 2 oil and 1 coal fired, with a total of 5500 tonnes d^{-1}. However, the greatest need for incineration appears to be in the Slavonija region.

The Našice plant had incinerated 2 x 5 tonnes of pharmaceutical waste in 1992 and had encountered some problems, but had received no expert advice.

Contact should be made also with Mr. Posavec Darko, Incema-Zagreb Association Croatian Cement Industry. Unfortunately, insufficient time was available when in Zagreb to contact Mr. Darko, but it is understood that the counterpart will be making urgent contact.

Pharmaceuticals

Later in the mission, the question of the disposal of out of date pharmaceutical chemicals arose again. It is the opinion of this consultant that far more consideration needs to be given to disposal of pharmaceutical waste. Whilst high temperature incineration is a good technique, care is necessary if this needs to be advised by a chartered chemist (qv, Annex 4). Furthermore, biodegradation by sewage enhanced by enzymes/bacteria may be far more effective, cheaper and convenient.

Of overriding importance, however, is why have pharmaceuticals donated by the World Aid agencies become out of date? Obviously, some improvement to stock control management is a matter of very high priority.

5. Visit to Pakrac, Saturday 16th January 1993

Contacts:

— Marina Varkovic, eca ponc.
Pourcremko, Za Gospodarstvo
Pakrac 046 83030

— Mr. Franjo Širac, dip. ing geol.
Promočnik Povjerenica
Za Komunalno-Stambene Djelatnosti,
Graditeljstvo i Urbanizam
046 83 034

The town of Pakrac (and neighbouring Lipik) is totally destroyed. No building was seen which had not sustained damage.

It was interesting to note that the River Pakra (flowing to the R. Sava) is now far less polluted and contains fish, a very useful source of food for the population — a population existing under appalling conditions.
No quality data are (or were) available for this river.

5.1 Wood industry

The major industry is wood, making chairs, building wood, including window frames, etc. They use a substantial quantity of nitro cellulose lacquer, organic solvent-based adhesives (Rakol, Germany) which were used to start many of the fires. Sadolin wood lacquer and preservatives, and a blue dyestuff, assumed to be copper arsenite, or at the best, copper sulfate/sulfite

In common with other locations, there is a need to review the use of wood preservatives and to use preservatives known to have been tested adequately for environmental impact, eg, the use of 2-(thiocyanomethylthio)-benzothiazole (TCMTB), RN: 21564-17-0 (Buckman Laboratories SA, Ghent, Belgium) or any available alternative.

There were asbestos roofs at the wood factory and care will be needed during its reconstruction. Limited production has recommenced, but without any dust extraction. Note should be taken of the recommendations of International Agency for Research on Cancer [25].

The United Kingdom Occupational Exposure Limits 1992 quote 8 h TWA of 5 mg m^{-3} soft wood, and maximum exposure limit of 5 mg m^{-3} hard wood, together with a cautionary note that hard wood is capable of causing respiratory sensitization, and is assigned risk phase R-42.
Obviously much care will be necessary to avoid recontamination of the river Pakra.

5.2 Clay building blocks (largely air bricks) production

This factory has recommenced production. It is fired with natural gas.

5.3 Petrol stations

There was only limited damage to the petrol station which is now fully operational.

5.4 Sewage and water facilities

Such limited sewage treatment as was available is now destroyed and the construction of a sewage treatment plant is a necessity for the redevelopment plan.

Some urgent consideration is also necessary for water supplies and their monitoring.

6 Visit to Lipik, Saturday 16th January 1993.

Contact:

— Predrag Perkov, Dipl. Ing., Direktor
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041 537 491, 537 592, fax 041 537 592.

There are 2 major industries in the Lipik: the above glass works, and the factory bottling the Lipik mineral water. Both are now functioning.

6.1 Lipik Glass Factory

The glass factory is working on a limited scale, making speciality glasses for ships, cars, buses, aircraft, etc., and some double-glazing panels. Glass is made from local silica and sodium carbonate, now imported from Romania (formerly from Tuzla, Bosnia).

Their major former production of plate glass has ceased (totally destroyed), and would need to be replaced by a high technology plate glass facility.

In view of the urgent need for glass for windows, this is of strategic importance, but there is only likely to be a limited home consumption after 1-2 years, which might possibly be extended by a further 1-2 years for supplying urgently needed windows for Bosnia, when the conflict ends.

The cooling water plant was only partially operational, and causing significant problems.

A joint venture with a Western European partner should be considered.

It is noted that PVC window frames were not available, only wood.

It was also observed that the very large chimney has large shell holes and had the appearance of being in a very dangerous conditions, and should be either repaired or demolished with urgency.

6.2 Lipik Mineral Water Factory (not visited)

This is now in full operation and supplying excellent quality and tasting mineral water throughout Croatia.

It has a very large requirement for glass bottles (plastic does not appear to be used).

In view of the great quantity of broken glass, a glass recycling plant both for Slavonija and for the coast, eg. Split, should be considered as an urgent joint venture projects.

It is noted that the only glass recycling plant is the Straža bottling factory near Zagreb — not visited due to time restrictions.

6.3 Lipik Horse Stables

These were totally destroyed with some 98% of the blood stock white horses being killed; it is understood that sufficient breeding pairs remain in Serbia and that on the cessation of hostilities, a joint venture project (with perhaps Austria) would be welcome.

7 Visit to Slavonski Brod, Monday 18th January 1993

Contact:

— Ratko Lovrić, dipl. inz. grad., Secretary
Zastite Okolisa Prostornog Ukeđenja i Graditeljstva
Pelra Kresimara IVII, S. Brod.
055 232 494, fax 055 232 516
and his Deputy, Tomislav Crhković, who accompanied us on the inspections.

Population 60 000 — 80 000, which is currently doubled because of refugees (largely from Bosnia) and which is causing many acute hygienic and related problems. The town and surrounding areas received approximately 14 000 grenades, 14 rockets, and 100 heavy bombs. However, the majority of the damage appeared to have been targeted to industrial sites as distinct to residential properties (cf. visit to Pakrac).

The town is a heavy industrial centre. The following enterprises are the principal employers:
Duro Daković Holding, heavy engineering (see below);
Poduzeće 'Slavonijatrans'. Paint works. Not burnt, but some spillage of organic solvents;
HPT Post Office;
DP 'Novogradnja'. Building materials;
IN Ruščica. Oil tanks, with some spillage;
Benzinske crpke. Gas stations;
MIB. Modna industrija Brod. Railroad partially damaged;
HŽP. Agrochemical storage. Not damaged;
'Elektra'. Electric supply transformer damage. Some PCB leakage;
'Slavonija' DI. Paint and wood impregnation. No damage, but data on chemicals used (and wasted) required;
'Oriolik' — Oriovac. Furniture factory. Almost totally destroyed (see below);
'Hladnjača Vino—Voće' Bjeliš. Fruit and wine cold storage. Damage to ammonia refrigeration (see below);

7.1 Visit to Duro Daković Holding d.o.o.

— Vladimir Bičenko, dipl. ing.
Sef Kabineta Direktora
55 000 Slavonski Brod
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055 232 139, fax, 055 232 007.

— Mr. Damir Grbavac, dipl. ecc.
Direktor Sektora za
Restrukturiranje i financiranje
055 232 898, fax 055 232 007

— Mr. Nenad Belić, dipl. ing. (chemist)
Odjel za Kadrove i Odnose s Okruženjem,
055 232 998, fax 055 232 007

— Mr. Jahor Grndgarac, Technical director
D.D. Poduzećc Za Energehlia i Infrastructure
055 241 949.

There was damage and leakage from transformers at 26 substations, some of which could be PCBs. There is lack of knowledge as to whether oil leakage from transformers is factually PCBs and a quick test to ascertain if soil is in fact contaminated by PCBs or less harmful oils is of significant necessity, eg, a Beilstein test may be sufficient). There was also leakage of hydraulic oils, again thought to be PCB, and thermal heating oil, which is either Mobil Therm/30 or INA Trans Therm 2000, Bosnia. Again, it is not known if these contain PCB and a full specification is awaited.

In addition, some of the thermal oil was discharged to a channel to the River Sava in July 1992.

There were many tonnes of broken glass dumped in a 1000 m^2 landfill outside the town, now covered with top soil.

Cutting oils. No information available.

There was also some loss of radioactive materials, but no data available.

Some of the spilt oils (PCBs?) was adsorbed on wood dust/shavings. Some conveyed to a rather (un)sanitary landfill, now covered with soil. It should be noted that the town has no sewage treatment works. Because of the high refugee influx, this could well lead to severe public health problems in warm weather, both for Slavonski Brod and for downstream towns abstracting drinking water from the rivers Sava and Danube.

Two tonnes of paint were destroyed, which contained nitro dyestuffs. Some lead based paint was also released to the environment.

They use a considerable quantity of nitric acid in poor working conditions, but no losses! One tonne of hydrochloric acid was lost.

They were considering a water treatment plant for the factory complex, but this has now low priority. A package system based on peroxidation may now be a better choice.

7.2 Visit to Oriolok Oriofleke

— Mr. Stjepan Pišonić, dipl. oecc., Direktor, and
Tugomir Marin, dipl. ing., Direktor
Oriolok Oriofleke
Dp Za Proizvodnju i Promet Namještaja i Poliuretanskih Masa
Oriovac, M. Gabrića 11
055 431 000, 431 022, 431 033, fax 055 431 215.

Manufacturers of chairs, beds, car, bus seats, etc.
The factory was attacked by phosphorus grenades and was totally destroyed on 27th July 1992. However, some reconstruction and limited production has recommenced. There is a very large market for their products, currently for rehousing as a consequence of the war and joint venture capital suggestions would be welcomed.

Some soil monitoring is recommended for phosphate, chromate, bromide, tin (trioctyl tin).

There may also be problems associated with the insulation material Okipoc-stilopoc, thought to be urethane based.

Considerable numeration capacity will be needed to dispose of the part burnt textile remains.

7.3 'Hladnjača Vino—Voće' Bjeliš

This is a large foodstuffs cold store. We arrived too late to interview management, but saw the shift engineer.

They were bombed on 15th, 19th and 20th August 1992. There was heavy damage, which destroyed the condensers and the store was without refrigeration for 3 days — did this lead to food deterioration?

They store 40 tonnes of ammonia and 10 tonnes was lost in August. It should be noted that there was a distinct odour of ammonia, and some expert technical assistance was requested.

NOTE: There were a number of badly damaged installations on the north bank of the river Sava but it was deemed to dangerous to visit these.

8 Visit to Sisak, Wednesday 20th January 1993

Contact:

— Dr. Andrija Prelošiana, Deputy Minister to the Local Council
Ul. Stjepana i Antuna, Radića 36
44000 Sisak
044 22 777, fax 044 24 339

He explained that there had been considerable damage to the thermoelectric power plant (see below), with spillage of heavy oil both from the plant and from 12 transformer stations (in various locations in the commune), and spillages of PCBs, some near schools. On the day of the visit it was reported that a further transformer had been shelled at Sunja (in the UN zone), only 35 km from Sisak; iron and steel plant (no time available for inspection); an ammonia refrigeration plant, also at Sunja in UN protection zone, visit not advised; and to INA oil refinery (see below).

8.1 Visit to Electricity Board and a substation with transformer

Contact: Krešimir Belović, RM Direktor
Hrvatska Elektroprivreda, DP Electra-Sisak
44000, Kralja, Tomislava 42
044 43 263, fax 44 43 263, and
Zvonimir Kež, address as above.

From the 12 damaged transformers only mineral oil had been released to the environment. However, a number of condensers had released the PCB Askarel $C_{12}H_5Cl_5$ to soil.

A soil and some water samples had been sent to Zagreb for analyses and the results will be made available. As a result of the analysis, some of the soil had been sent to France for incineration.

An *in situ* technique for removal of PCBs from soil (and water) is an urgent requirement. The soil type is clay, but is limestone on higher ground to the south in Bosnia.

At both Sanja and Kostajnica, 35/10Kv transformers and condensers had leaked mineral oils and PCBs to the River Onya, 5 km distance, and which is a good quality fishing river. (Examination of fish tissue would appear to be important.)

8.2 Visit to the Thermal Electric Power Plant

— Dr. Ivica Vukelić, Dipl. Ing. Str.
Rukovoditelj Proizvodnje
44103 Sisak—Cret BB
044 40 262, fax 044 32 076

There had been discharges of heavy fuel oils, 17 different types of lubricating oil and PCBs to both soil and to the River Kupa. The River Kupa was used for drinking water supplies and was previously contaminated with PCBs from Slovenia which had resulted in the installation of an activated carbon plant (there was inadequate time to inspect).

The electricity plant has to produce significant quantities of de-ionized water necessitating the use of both strong acid and base (and mixed bed) ion exchange resins.

This plant requires the use of hydrochloric acid, 50% sodium hydroxide solution, hydrazine hydrate, aluminium sulfate, and calcium hydroxide.

During the conflict 600 tonnes of heavy fuel oil had been spilt in part to the River Sava.

NOTE: The Rivers Kupa, Onya, and Sava confluence at Sisak.

The use of sodium hydroxide solution offers a unique opportunity to utilize the sodium hydroxide at the Saponia works at Osijek and every endeavour should be made to use this.

There was much confusion over the standard specification for the sodium hydroxide solution. Whilst the plant had a laboratory, they did not check the 25 tonne road tanker deliveries. This being undertaken centrally in Zagreb.

Arrangements were made to receive the true specification of the sodium hydroxide supply and that at Osijek. It should be noted that this should be considered as priority action.

In November/December 1991, after bombing, the ion exchange system froze, resulting in breakdown (both chemical and physical) of some 80 m^3 of ion exchange resin, particularly the strong acid form. This was supplied by Bayer, Leverkusen, Lewatit S.

During one shelling attack, one of their hydrogen tanks was hit and burnt out.

8.3 INA Oil Refinery

— Mr. Ivica Billege, dipl. ing., Direktor,
INA Rafinerija Nafte Sisak, 44103 Sisak-Hrvatska,
A. Kovačića 1, PO Box 59
044 512 244, 40 422, fax 044 30 857.

— Vladimir Posavec, dipl. ing.
Rukovoditelj Sektora ordžavanja
044 32 640, and

— Janko Barić, dipl. ing. kem. (environmental specialist)
Služba za razvoj,
044 32 244

The refinery had received 222 shells, and was hit 32 times, causing massive fire damage. The last shelling was on 23rd July 1992. The total cost of the damage was 149 M US$.

90 000 m^3 of oil and refined products had been lost, of which 1000 m^3 was discharged to the River Sava. Leakage had lasted for 2—3 days. To date, they had spent 24 M US$ on repair/replacement work. 5000 tonnes of scrap iron had been recycled in the nearby steel works.

For fire fighting, they had received assistance from Italy and had used many tonnes of 4—S and Lite water foam, much of which flowed to the River Sava.

There had been massive air, water, and soil contamination since the first attack in July 1991.

An inspection showed massive areas of soil contaminated with oil. I advised that this could be effectively treated *in situ* with activated sewage sludge (town of Sisak?), and fortified with enzymes and bacteria.

The refinery is 2.5 kilometres in length.

9 Visit to Delnice, Thursday 21st January 1993

Contact:

— Mr. Josip Horvat, dipl. ing. grad.
Predsjednik Izvršnog Vijeća
Skupština Općine, Delnice
051 811 055

— Čop Bogumil-Upravitelj
Hrvatska Elektroprivreda
D.P.—Elektroprimorji—Rijeka
Pogor Skrad, Igorski Kotar
Ul. Goranska 11
051 810 624, 810 604, 817 652, 817 658, fax 051 810 620.

— Muhamedagić Ismail, dipl. ing., Direktor
Sektora Za Razvoj,
Delnice, Drvno Industrijsko Poduzeće,
51300 Delnice, Supilova 20
051 812 004, 812 024, 812 415, fax 051 812 429

Delnice is a pleasant mountain town. It has a high rainfall, with approximately 50% going to an inland river and 50% to the sea. The ground is loose karst.

There are 4 artificial lakes higher than Delnice, used as storage for hydroelectric power which feeds a fifth lower lake, thereby driving turbines. Sometimes, this 5th lake at Fužine is pumped to one of the 4, and then causes pollution. There was insufficient time available to visit these lakes.

It is intended to use the four lakes as a drinking water resource for Rijeka and Opitija.

Obviously this is a vital resource for Croatia as this hydropower is distributed along the coast as much of the southern coast receives its power from the hydropower-sources near Mostar in Bosnia and future supplies are unpredictable. Similarly, there is a drinking water shortage in Rijeka. The very recent problems with the dam on the river Cetina (near Šibenik) will make electricity supplies for the south coast and islands even more difficult.

The area is crossed by the oil pipeline from Rijeka to Sisak, currently not in use because of the hostilities in Bosnia. It is a single skin pipe, 960 mm diameter, and hence is vulnerable to leakage, attack, and sabotage. It was thought that when this pipe was broken in Bosnia, a massive oil leakage to the limestone karst occurred.

There are also plans for a new motorway and railway.

The town currently draws its drinking water from Brod na Kupi.

There is considerable use of wood for the building industry. The wood is exported to Germany and elsewhere. Treatment is with copper sulfate/sulfite, with a second stage of acrylic impregnation, alkyl resins, poly vinyl acetate, urea formaldehyde, nitrolac, etc (cf. Pakrac). It was suggested that 2-(thiocyanomethylthio)-benzothiazole (TCMTB), RN: 21564-17-0, Buckman Laboratories, Ghent, might be a more environmentally suitable fungicide.

Regrettably, there was inadequate time to inspect the wood facility.

9.1 Visit to Transformer Unit

This was destroyed and has now been rebuilt.

1550 kg of Trafo oil had been released together with a quantity of condenser fluid, probably PCBs. Whilst much had been collected in a sump, some had escaped to the roadway and the general surface water drains, together with some to the adjacent hillside at the time of the explosion. Trafo oil is produced in sealed transformer units in Zagreb by Zade Končar. It will be necessary to receive details.

9.2 Visit to destroyed Munitions Dump

20 000 tonnes of ammunition has been stored and 4% (approximately 800 tonnes) of explosives had detonated leaving a crater 250 m in circumference.

The store had consisted of 20 stores and contained 10—15 different explosive materials, but only one store had initially and deliberately exploded.

The area is karst, and monitoring for cadmium, thallium, strontium, lead and mercury is recommended.

The TNT originated from Bosnia 'Vitez' and a number of shells etc. had been made in Russia, thus making identification of the constituents impossible. As a result of the explosion, 10 000 windows were broken in Delnice but there was no knowledge of the location of the broken glass and other building debris.

The town had no sewage works.

NOTE: Following the visit to Ogulin (see below), it is vital that this area is monitored for heavy metals, eg, cadmium, mercury, lead, thallium, etc. In addition, there is the possibility that chemical weapons were stored at Delnice, and also at Ogulin, and monitoring, perhaps only by Microtox is advised. This is a vulnerable area and the future drinking water supplies have to be maintained and an assessment of an aerial contamination from this major explosion is needed urgently.

10 Visit to Karlovac, Thursday 21st January 1993

Contacts:

— Boris Naglić, dipl. ing. grad.
Sekretar Sekretarijata Graditeljstva Stambenih i Komunalnih Poslova i Zaštite Okoliša Općine Karlovac
Križanića 11
047 23 677, 23 262, 21 011, fax 047 25 217

— Vlado Jelkovac, dipl. ecc.
Voditelj ureda
Banjavčićeva 9, 47000 Karlovac
tel/fax 047 24 080

— Kuri Vjevoslav, dipl. ing. rudeava
Strvoni Suradnic za Vodoprivredu, Rudarstuo i Zaštitu Okolisa
Sekretaritat Graditelisova
Stambenim i Komunalnim Poslova
1 Zaštite Okoliča-Općine, Karlovac
21 011 (central)

— Evemić Zdravko, fin. manager
Farno Poduzeće, Komunolnik Djeletnost, Karlovac
047 22 123, 047 23 675.

The town of Karlovac is on the confluence of 4 rivers. It has no sewage treatment works and the water supplies are abstracted from shallow wells only 10—15 m from the rivers.

The population is approximately 60 000 currently enhanced with some 10 000+ refugees.

Some 50% of the town is under UN protection.

Mr. Jelkovac emphasized that the first priorities were being given to reconstruction and the refugees, and a low priority to the environment.

The following installations were damaged:

i) Textile factory, but no loss of chemicals

ii) Manufacture of electric and diesel engines. No environmental damage.

iii) A number of transformers had been damaged.

iv) Town heating facility. Only empty heavy oil tanks damaged.

v) Brewery. Only loss of ammonia from refrigeration plant.

vi) Technical gas plant Impresnacija. No environmental damage.

vii) Wood treatment works. No details available.

Visits were made to the following:

10.1 Water Treatment Plant

No service reservoir direct to distribution, chlorine residues only 0.05 mg L^{-1}. They have a requirement for 500 m sec^{-1}, with even greater requirements when the refugee 'prefab' village is completed. This will also entail a greater pollution load on the river system. It should be noted that the rivers are widely abstracted for drinking water supplies downstream, including Zagreb, either directly or via the so-called bankside filtration.

10.2 Sanitary Landfill

This is full, and they have a requirement to dispose of 120 m^3 day, and increasing because of the refugees, and have stored garbage for 2.5 years. This has become an acute problem which has been enhanced by the reconstruction work and the refugees.

There is a hazard of flooding, which would contaminate drinking water supplies. Sometimes there are fires and emissions of methane in the landfill sites.

10.3 Milk Factory

i) They have received severe damage to oil storage tanks, but leakage (50 holes) had been repaired and much of the oil recovered. However, there remains some soil contamination.

ii) They had lost 15 m from their chimney with loss of filters, and hence there is ongoing air contamination.

iii) Damage to the cold store. Refrigeration plant had resulted in a loss to the atmosphere of 5 tonnes of ammonia and some leakage was still occurring. Expert assistance was requested.

iv) They had lost part of their cleaning in place (CIP) facility, resulting in both excessive use of water (of which there is an acute shortage) and some lack of hygienic quality.

v) Their new laboratory had been destroyed totally and very little quality testing now takes place.

vi) Their spray drain is damaged and out of commission, this had been inspected by Mr. Lequien from UNIDO, Vienna.

It should be noted that they were working at 20% capacity, as 80% of the milk supplies had originated from Bosnia, and these were now regarded as lost, until at least the end of hostilities, when there will be a substantial delay as it was assumed that the Bosnians or Serbians had used the cattle for food.

NOTE: This factory was destroyed totally on 17th February 1993.

10.4 INA Oil Distribution Depot

Two 5000 m^3 capacity diesel oil tanks had been hit resulting in a major fire in which 9000 m^3 of diesel oil was lost, mostly to the atmosphere, little or no fire fighting was possible. However, some diesel oil had been discharged to the soil beneath the bund which had been penetrated with rockets/grenades. This will lead to diesel contamination of groundwater and some monitoring microbial/enzymic treatment is recommended..

There is also fire damage to neighbouring trees — the state of recovery in the Spring will provide some measure of environmental aspects, and this would form an ideal project for the local school children.

11 Visit to Ogulin, Friday 22nd January 1993

Contacts:

— Nokola Magdić, dipl. oecc.
Predsjednik IV SO Općina Ogulin
0401 29 94

— Rendulec Kreškovič, dipl. ing. grad.
Voditeg Ureda Za
Obnovu
0401 29 94

— Branko Puškarić, dipl. ng. grad.
Direktor Zavoda Za Prostorno Planiranje i Graditegstvo
0401 29 94

There were no industrial damages to the town, but it is predicted that there is damage to the sulfur-cellulose factory at Plaški (35 km S.E.) currently in Serbian territory (obviously no visit was possible) but this had resulted in massive environmental damage. At this factory wood was converted to paper for packaging, its effluent discharges untreated to the River Dretucja. Formerly, it had 3 phases of wastewater treatment. Former population of Praški 5000, and current population unknown.

The town of Ogulin has no sewage treatment works. The population of Ogulin is 11 000 + 1400 refugees. Ogulin obtains its drinking water from the River Modrus at Vilumj.

Ogulin has a large wood treatment facility plus 3 more at neighbouring towns at which Sadolin is used widely. This wood is used for furniture, especially heavy furniture and chalets. Nearly 80% of the furniture is exported to Germany, Austria, etc.

Other wood treatment chemicals includes those obtained from Chromos (Zagreb), KGK (Karlovac), and Belinuj (Ljubljana). A recommendation was made to use more environmentally safe fungicides, such as 2-(thiocyanomethylthio)-benzothiazole (TCMTB), RN: 21564-17-0.

They also have some metalworking industry, including electroplating of zinc and lead, plus use (and discharge) of hydrochloric acid and bromide. There is no use of cyanide, chromium or cadmium.

There is no knowledge of records of any analysis having been undertaken. Similarly, thee are no wastewater treatment facilities.

At Ogulin, and in particular at Plaški, the wastewater is discharged (untreated) to the underground, which is karst, and forms the source of downstream potable drinking water resources for the coast, and in one case at least, by a natural subterranean river to one of the islands.

At Jasenak and Vreto there are winter sports (largely skiing), 1000 hotel beds. This wastewater is untreated and thus forms an unacceptable hazard to the River Vitinj which is used as a downstream drinking water supply.

An environmental risk assessment was undertaken and details will be made available.

The River Lesće is used for drinking water for Karlovac. It is understood that uncontrolled dumping of toxic waste at the over-extended landfill at Ogulin has led to hazardous chemicals being identified at the hydroelectric power plant at Lesće — no details now available.

There is obviously a requirement for an intensive monitoring programme.

11.1 Munitions dump

The was a large military depot at Oštarije, which was mined, burnt with a large explosion causing significant damage to the karst and trees. It is understood that this depot contained over 400 different types of weapons and in all probability 8 types of military chemical poisons, including defoliants, organo phosphorus compounds, ie, storage of neurotoxins, psychotropics, lachrymatory, respiratory, and skin irritants. The depot is only 5 km from Ogulin. Time did not permit an inspection. It was stressed that the Yugoslav army did have chemical weapons. It is believed that the karst is contaminated with mercury, cadmium (lead, thallium, strontium etc.), and that Dr. Srečko Bužičevic in Zagreb has analytical data for cadmium and mercury. The explosion occurred on 13th October 1991.

On returning to Zagreb, Wednesday 27th January, I met Dr. Ladislav A. Palinkaš and co-workers from the mining-geology-petroleum engineering faculty, University of Zagreb, Pierottijeva 6, 41000 Zagreb, tel. 441 839, fax 440 008, who presented me with copies of 3 papers describing both atmospheric and soil determination of lead, zinc, nickel, and mercury at Zagreb, and at the Istrian bauxite depots. [26-28].

They had also undertaken a wide but surface only survey of the soil from the area of the Ogulin explosion and found cadmium and mercury levels of 200 fold that of background, ie, up to 20 mg kg^{-1} dry weight, with the area of mercury contamination encompassing he town of Oštarije and, in part, the towns of Josipdol and Ogulin, the outskirts of Tounj and part of the Mrežničko Ježero; the area of cadmium contamination was further to the east and completely enveloped the town of Tounj.

This explosion obviously caused major environmental damage, public health hazards and in all probability has contaminated the groundwater. Water analyses are urgently required.

Treatment of the ground (broken limestone karst with poor accessibility in some areas) requires urgent treatment with either elemental sulfur or sulfides to immobilize the cadmium and mercury compounds. Obviously, as the explosion occurred 16 months ago, any contamination of the groundwater will be a major problem, which is likely to affect drinking water supplies in Bosnia, Croat, and Serb held territories.

12 Visit to Otočic, Friday 22nd January 1993

Contacts:

— Željko Fajdetić, dipl. oec.
Sekretar gospodsarstva, graditeljstva i stambeno komunalnih poslova
Republika Hrvatska
Skupština Općine Otočic
Ulica Kralja Zvonimira 8
048 71 117a, 048 71 048, fax 048 71 131

— Peter Brajković, dipl. oec.
Direktor računovodstveno financijskog
i općeg sektora
Cosmochemia Tvornica kemijskih proizvoda s.p.o.
48220 Otočic, A. Starčevića 6
Croatia
048 72 359 (d), 048 71 306, 71 326, 71 346 (c), fax 048 71 366.

— Ana Majetić, dipl. ing.
Rukovodilac proizvodnje KSP
(address as above)
048 71 303

The principal industrial company is Cosmochemia, which suffered 85 M DEM damage. Immediately prior to the conflict, they were able to move the majority of their hazardous chemicals to Rijeka and some to a local artificial cave, thus preventing discharges to the local river which is used for drinking water abstraction.

This location is environmentally sensitive being located on karst. An environmental impact assessment was carried out 5 weeks ago by a Dutch company who wished to build a new phosphate detergent factory, however, this was refused.

Just prior to the conflict 3 lorry loads of their final products of household and allied products were despatched to Sweden to the company IKEA, which was their major customer — now lost, and they are looking for a joint venture partner. Their major product range includes: candles; household chemicals; detergents; rubber additives; use of nitro dyestuffs of which no details were available.

IKEA required products to 'zero defects' standards and hence their good manufacturing practice must have been good, but is now most certainly almost non existent, which is reflected in their very poor attitude to handling of refuse. This is a matter which is likely to lead to vermin in warm weather, and should receive immediate attention.

As is common with many towns visited, Otočic is lacking in adequate landfill facilities which exacerbates the problems at Cosmochemia.

A list of several hundred chemicals was tabled and this will follow. Many are, however, no longer used because of the damage they have sustained.

Great concern was expressed over their 12 underground storage tanks which were not damaged during the fire, but may have suffered internal damage.

Initially during the discussions, the tanks, 50 m^3 each were thought to contain acetone, white spirit, ethanol, butyl glycol, petroleum spirit, xylene, toluene, benzene, isopropanol, nitrodyestuffs, shellcol, and turpentine. There was great concern by both the counterpart and the local council that these could be leaking to either the river Gacka, which enters the karst as a drinking water source for the coast and islands. The tanks were built in 1979-82 and have not been inspected. The damage occurred in October 1991. The tanks (exterior appeared to be in good order) and the factory, which sustained moderate damage was inspected. Whilst their candle operation remains in operation, only a limited amount of other production was in hand.

Information was given that they were unable to empty the tanks because no transfer pump was available. A very old Russian-built transfer/metering pump was located near the tanks which was not functional but appeared to require little repair. They were of the opinion that the World Aid Agency would donate a pump!.

I put in hand measures to have the contents of the tanks emptied by a pump or a road tanker to be sent from INA Rijeka and to have the contents of these tanks destroyed in view of the likelihood of the leakage. However, an inspection of the factory revealed the use of a detergent transfer pump, which could be used to pump out the contents of these underground tanks.

Further enquiries showed that the tanks in fact contained:

Ethylene glycol 2.5 tonnes;
Acetone 5 tonnes
Xylene/toluene mixtures 7 tonnes (as mixture)
Petroleum spirit 15 tonnes
White spirit 5 tonnes.

The other tanks were alleged to be empty.

The time schedule did not permit an inspection of the interior of these tanks, which in any case would have required the use of protective clothing and breathing apparatus.

By use of the detergent pump they estimated that the tanks could be emptied and the contents used usefully for normal production within 10 days. The counterpart agreed to inspect the tanks during February and to report the position.

Ana Majestić agreed to prepare a poster and comment (in German or Croatian) at the Brijuni conference, in April on these environmental aspects. For the record, their boiler consumes 100 kg heavy fuel oil h^{-1}.

NOTE: The town has no sewage treatment facility.

13 Visit to Gospić, Friday 22nd January 1993

Contacts:

— Mile Fajolić — Tajnile IV opć—Gospić

— Autrica Blažević—sek. zs. st. hom. opć. Gospić

— Žeflick Zdinić—Tvorics balenja, 'Tesla', Gospić

— Božio Milković—direktor hom. produzecć 'Uslugs', Gospić

— Mira Figurnjar—Direktor Fomly ev. Obnizi.

Gospić is a badly damaged town on the River Lika.

The following were considered:

13.1 Sewage treatment works

Prior to the conflict the town had an effective 3 stage (primary treatment, surface aeration and digested sludge) wastewater treatment plant, which is now destroyed. This is a loss of a vital asset which needs very urgent attention.

The River Lika flows through the Veribit mountains and is used as a source of drinking water (and hydropower) for the coast (and islands). In addition, damage (possibly permanent to the karst) is conceivable.

Also, after the conflict, some wastewater and drinking water pipes were interconnected. The town itself receives much of its drinking water supplies from wells largely upstream of the now raw sewage outfall. No monitoring has taken place for over 2 years.

This sewage works was built in 1975 and served as a major asset to protect river (also supporting a number of trout farms) and drinking water supplies. Monitoring of the river, fish, fish for genetic damage, drinking water quality, etc, is an urgent requirement.

The estimated cost to repair the sewage works is 4 M DEM.

However, a most careful risk assessment is necessary as further military action was reported at Gospić on Saturday 23rd January 1993, ie, within 15 hours of the inspection.

13.2 Hotels

Both the new and old hotels are destroyed and they (the local council) would welcome a joint venture enterprise with a Western European hotel chain — but see note above concerning the conflict!

13.3 Trees

Apart from physical damage to trees, many are showing signs of phytotoxicity damage, this is thought to be an after-effect of the continuing fires, or possibly other air pollution. It is recommended that a school project should be instituted to record the condition of the trees over the next 5 years. This type of damage to trees is also known to be extensive at Bihac in the Serbian occupied area.

13.4 A large excavator, estimated weight 10 tonnes, has been in the river adjacent to the sewage works for 20 months. Its hydraulics are known to contain PCBs and hence its recovery, or at the very least the PCB's recovery, is a high priority. The immediate area cannot be reached by heavy cranes and it is thought by the author that this excavator might be recovered by heavy lift helicopter.

13.5 Electricity transformer

Transformers received damage, but no leakage recorded, but such recording may not have been possible because of the severity of the damage, loss of documents, and personnel.

13.6 Battery factory

A former battery factory (small batteries, not car batteries) have been totally destroyed, resulting from emission of manganese dioxide, zinc chloride, ammonium chloride, but no cadmium, nickel, mercury or lithium (except as impurities).

Monitoring is required with urgency.

13.7 A vehicle (car, lorry, bus) depot/repair facility was destroyed but is now in partial operation.

During the conflict a lagoon of 1—5 tonnes of spent engine oil was burnt or discharged to the river Lika.

13.8 There is a woodyard (not inspected) — preservative use unknown, and it is likely that this will be enhanced, probably taking the area of the former battery factory. Much care will be necessary over the use of wood preservatives. A recommendation was made to use more environmentally safe fungicides, such as 2-(thiocyanomethylthio)-benzothiazole (TCMTB), RN: 21564-17-0.

13.9 There was also a major loss of ammonia from the town cold store and food processing facility.

13.10 There are major health hazards associated with a wholly inadequate landfill facility, enhanced with a requirement to deposit significant quantities of building debris and a gross shortage of refuse. Vehicles (80%), were destroyed during the conflict.

14 Visit to Zadar, 23rd January 1993

We arrived in Zadar late on the evening of Friday 22nd January, having been required to make a number of detours for security reasons, largely on the Isle of Pag due to growing unease at the Maslenica Bridge. That day (Friday) 2 workers had been killed by gun fire whilst repairing the bridge on the Adriatic highway.

The morning of the 23rd January showed an air of uneasy (electric!) calm, both the post office and the council offices (Department of the Environment) were closed, together with many shops (except a few food shops). The counterpart made enquiries at the police station and after a brief interview with the local Minister for Internal Affairs, we were advised to leave as quickly as possible as an aerial attack was anticipated. The local Serbian radio station at Knin was calling for total mobilization.

The counterpart agreed to try and obtain the necessary information on his return by road (as the author returned to Zagreb by air from Dubrovnik on Tuesday 26th January 1992), but this also proved to be unsafe.

For the record, the hazardous industries damaged by the war include the Visitin soya bean factory and the PVC factory, including synthesis of ethene chloride.

It was reported that there had been substantial leakage of heavy fuel oil and transformer oils to the sea.

It should be noted that Zadar is suffering from an acute drinking water shortage (yet the hotel taps leaked!) and the drinking water had a strong chlorophenol off-flavour.

The question of drinking water supply and quality requires urgent investigation.

15 Visit to Šibenic, Saturday 23rd January 1993

Contact:

— Ms Živana Lambaša Belak
Min. ekoloskop inŕemjerslvo savjetnik ra reškhi cojekova okoleča,
Opinski sekreterjet neroja i honszenje proslova Skupshino epcine Sibenic
057 22 766, fax 059 25 487

No visits were possible because of being Saturday — despite notice being given. The counterpart will, however, make further contact on his return visit.

15.1 Tvornica Lakih Metala

There is a partially destroyed aluminium smelter, no longer in operation as the source of bauxite is now in Serbian occupied territory. Apart from some oil spillage and possible damage to transformers it is not thought that there is additional environmental damage.

No other metals were handled. The smelter is planned to be recommissioned. Very great care will be needed with the transformers (PCBs), better control of air omissions and means of disposal of waste require to be formulated.

15.2 Welding Electro Factory

Only mechanical and electrical damage. No discharges reported.

15.3 Electricity Transformers

A large number has been damaged, and counterpart to ascertain if there was any PCB leakage. Substantial monitoring is required.

15.4 Building Factory

No chemicals, but major emissions of silica continues to the atmosphere.

15.5 Harbor

There was a major import facility for phosphate rock — now unlikely to recommence.

15.6 Vegetable Oil Reservoir (Probably 5000 m^3)

Burnt with major discharge to sea. Fire was on 17th—18th September 1991, but no oil observed in sea. However, because of the highly indented coastline, the shelter of the islands and negligible tides, some monitoring is recommended.

15.7 Wine and Alcohol (Industrial) Factory

Major fire and loss to sea. Monitoring, especially for chromosome abberations in fish leucocytes is recommended. The quantity lost is estimated to be in excess of 5000 tonnes.

15.8 Former aluminium smelter — Lozovac

It should be noted that the former aluminium smelter at Lozovac resulted in the deposition of 'red' mud. This has now been covered over and trees planted.

15.9 Sewage Treatment

Whilst there is primary treatment at Vodice and Primonsten, the primary treatment works at Šibenik has been destroyed. This is of importance, when mass tourism returns to the area.

15.10 Water Supply

This is largely from Jarvga. A number of supply pipes, 1200 m of 600 mm, and 700 m of 500 mm were destroyed, together with some chlorination stations (on a small term basis).

15.11 Hydro Electric Power Plants

It should be noted that the hydro electric power plants at Roshaslor and Skratin are of major strategic importance, and the former very near Serbian territory (cf. later damage to Peruca dam).

In common with other towns Sibenic has a major problem with inadequacies of sanitary landfill facilities and shortage of refuse collection vehicles.

16 Visit to Split, Sunday 24th January 1993

Contact:

— Dr. Tomislav Zvonarić
Marine Chemist, Institute of Oceanography and Fisheries,
PO Box 500
58000 Split
058 46 688, 46 755, fax 46 593

This Institute only has responsibility for the coastal rivers and the sea, and coast around the islands.

The Institute has modern laboratory equipment, including a 3 year old Perkin-Elmer atomic absorption and a Varian gas chromatograph. They are also able to continue to support a modest library. In addition to their shore based facilities, they have a floating laboratory, the m.v. Bios.

They have undertaken many projects with academic institutions in other countries, and many of the scientists have published widely in peer reviewed journals.

For the coast, this Institute, with its boat, would be an ideal location to base a Microtox.

Dr. Zvonarić mentioned a significant problem with a chloroalkali works which was located in the industrial zone to the north of Split and which resulted in them recording mercury contamination in sediments of up to 1000 ppm Hg. They were unable, and would require specialist training, to undertake analyses for alkyl mercury compounds.

Via their sister Institute in Zagreb, samples of PCB contaminated waters were analyzed, results to be submitted.

Dr. Zvonarić was of the opinion that the PCBs were Askarel 4.5.2—4.5.3, but this remains unconfirmed.

17 Visit to Metkovic, Sunday 24th January 1993

The town of Metkovic is located on the Neretva river, downstream from Mostar and is located only a few kilometres from the Bosnian border. It is also an important inland port. South of Metkovic is a very fertile agricultural area, supporting much fruit and wine growing.

Prior to the war the local community were able to transfer most of the hazardous chemicals, including pesticides, to Rijeka. This transfer was undertaken as a precaution at a number of towns, especially in this area.

The non-availability of agricultural pesticides is now leading to problems with efficient crop management. Secondly, because of the high cost of imported pesticides, farmers are reluctant to spend the necessary money. This is resulting in lower crop yields.

It is recommended that advice is sought from an agrochemical expert, who can recommend the most effective use of modern pesticides, fertilizers, etc.

18 Visit to Dubrovnik, Monday 25th January 1993

Contacts:

— M.S. Željko Šikić
President of the Executive Council of the Municipality of Dubrovnik
Pred Dvorom 1, Dubrovnik
38 050 412626, fax 38 050 28398

— Dr. Adam Benović
Biological Institute
PO Box 39, 50000 Dubrovnik
050 27 937

— Ivan Vukić, Jan IV 80 Dubrovnik Sadužen za Industroju i Energetica
Direktor Poduzeča Tup—Dubrovnik
050 32 608, fax 250 86

— Žejan Consuo — Direktor Zavoda za Prostorno Planica
Nje i Zattitu Ozolisa
tel/fax 050 26 386

— Živana Lambaša Belak
Mr. ekoloskop inrenjerstvo
okoliša, Opcinski sckretenjet resuoja i konshesja proshona
Skupshno opcine Sibenic
059 22 766, fax 059 25 487

— Ms Branka Martinović - 'Vukovic'
Zavod za Prostorno—Planizorne i zastin coujenove okoline
22 477 26 386, fax 26 050
She is responsible for town planning and environmental protection and accompanied us on the inspections.

— Dr Franco Kržinić
Director of the Biological Institute and for all biological protection matters
411 511

— Mr. Ivan Vukie
Engineer, Deputy for Industrial renewal in Dubrovnik
23 648.

18.1 Visit to Biological Institute and Aquarium

They maintain excellent liaison with Mr. Viličić of UNEP Athens.

They are very short of finance as they now solely rely on funding from the local commune (which is itself underfunded) and World Aid. Prior to the war, a major part of their revenue came from admittance charges to the aquarium. I was the first visitor for 2 years. They are hopeful that income will return to a limited extent this year. As a result, they have only funds for salaries and maintenance of the aquarium (not even for heating their offices). In addition, their well-equipped boat has been sunk.

They have been unable to undertake any monitoring for about 2 years.

The Rudor Bosković Institute in Zagreb had previously undertaken metal analyses, enhanced by work at a Germany Institute, and they had also carried out some analyses by an ancient polarograph.

Their main concern was high level of mercury found in both water sediments and in fish, particularly in the area off the Malanica bay, where there was a chloroalkali plant which ceased production in the mid 1980s. No analyses for alkylmercury compounds had been undertaken.

Prior to 1990, some analysis of PCBs had been undertaken at Rovinj.

In view of the very significant discharges to the aquatic environment, we discussed the possibility of them undertaking examination of fish for chromosomal aberrations, sister chromatid exchanges, examination of leucocytes in fish blood, etc. Whilst they have an adequate microscope, they would need extensive training, which would need to be fully financed. They do not even have funds for *per deum* expenses for a visiting scientist.

It should be noted that their major interests is in plankton.

A visual examination of the fish (approximately 50—60) in the aquarium (fed continuously with fresh seawater) only indicated malformations and sores on one fish only. However, in view of the environmental hazards, it is recommended that this simple observation should be recorded on a weekly basis. Similarly, the Institute should liaise with local fishermen and record incidence of abnormalities. They would welcome collaborations with other institutes.

They stressed the importance of sediment analyses.

18.2 Drinking Water Supplies

It was emphasised that drinking water for Dubrovnik came from the nearby river and whose source was in Bosnia from Bilećko jezero, the town of Bileća was known to contain significant chemical industry (believed to be largely destroyed. Downstream from Lake Bileća, but upstream of the water abstraction

point, the Bosnian town of Trebinje had machine tools, weapons, paint, carpet (mothproofing agents) and vinyl acetate/chloride industries. It should also be noted that there was also at least one power station in the area burning brown high-sulfur, high-ash lignite coal. Therefore, it is recommended that the catchment of the river Bilećko is studied in depth as soon as safety of access can be determined.

It should be noted that during the conflict they were without water supplies for 120 days and were supplied by ship from Italy.

18.3 Waste Disposal

Prior to the war they deposited their domestic (and industrial) waste in a landfill (but too near to the catchment of the River Bilećko in Bosnia. The site was some 22 kilometres from Dubrovnik. This now means that refuse is tipped down a 60 m cliff, direct to the sea at the back of the hospital. This refuse contains building debris, glass, asbestos, household, industrial, and clinical waste, including amputated human limbs, etc. In fact an arm was 'caught' by a local fisherman only a few days previously. This tip is only 200 m from a tourist beach. In addition, they are receiving frequent complaints from the Italians.

An incinerator was nearing completion on the Island of Locrum prior to the war and subject to any damage inflicted by the Serbs would cost about 1 M US$ to complete. It was not possible to inspect the incinerator as the whole island is heavily mined, and their removal is likely to be both hazardous and expensive.

It should be noted that some hazardous waste was removed by the Italians.

The local community president stressed a very urgent need for assistance with waste disposal. There is at least 1500 tonnes of building debris within the old town of Dubrovnik alone, and they have no funds to remove this; they are in need of both training and facilities to separate garbage and in particular for incineration facilities.

Throughout the area of the commune (Bosnian border to the north of Kator bay and to the south and the Island Locrum (now uninhabited because of mines), and 4 other islands, they are generating an estimated quantity of 700+ m^3 day^{-1} for the estimated 50 000 population area, approximately 1000 $kilometres^2$ enhanced by Bosnian refugees (2000) and Croatian (8000). These refugees are located at the hotels at Plat, Cavtat, etc. This is a major and urgent problem, and without an integrated approach will lead to a major health problem in the warmer months.

In addition, they are proposing to rehabilitate the hotels to take tourists, housing the refugees in tents; however, they have not considered any plan for Autumn 1993.

18.4 Maliston Bay, Neum Hotel complex

This is a large (30 000 bed) compact hotel complex on the Bosnian coastline.

The area is heavily mined, both land and marine. Urgent assistance is needed to remove these ca. 2000 mines, and to reopen the sewage pumping station, known to be mined, without destroying the 20 km outfall pipe.

It is believed that the hotel complex is currently occupied by Bosnian refugees and causing pollution to the Maliston Bay, which is an important source of income to the Croats from mussel beds. It is reiterated that no monitoring has been undertaken for over 2 years — that is, monitoring for metals, organics, or pathogenic organisms.

18.5 Chicken and Egg Farm

This enterprise was shelled resulting in the death of about 10 000 chickens, breakage of 1000+ eggs, and discharges of chicken feed, including substantial quantities of phosphate.

The farm is located on the karst with the possibility of contaminating the drinking water supplies. No visit was possible for security reasons. However, the stench is described as atrocious and is hence obviously a public health hazard.

18.6 Sewage Disposal

Whilst this consisted of only primary treatment with a 2 km outfall, it is partially destroyed, and all discharges are direct to the sea.

18.7 Visit to Limestone Quarry, Rogoza

This is one of 3 destroyed during the war.

It is of strategic importance for building materials as currently these have to be brought in by sea or road (4 hours fast car drive from Split!).

They were working hard to reopen one quarry within the next 6 weeks, but without the dust extraction plant. Prior to the conflict, dust was emitted causing a nuisance to the downstream village below, including a school, etc. They commented upon silica dust, but this was not substantiated by observation.

However, there was neither a chemist nor chemical data available. Some analysis of the ground is hence a high priority.

It was estimated that the quarry can produce 65 $m^3 hr^{-1}$ of dust, or 120 tonnes d^{-1}.

18.8 At the town of Gruž (about 8 km to the south of Dubrovnik)

There is a small electricity generating station burning coal (when available). There were reports of dust and smoke as the chimney had been partly demolished, and the electro-static precipitators removed by the Serbs.

18.9 Paint Factory in Centre of Town

Visit scheduled too late in the day to obtain access). This factory was only slightly damaged and has returned to almost full production.

It was not known if they manufactured marine paints, containing substances such as tributyl tin oxides. The counterpart agreed to attempt to locate this information.

18.10 Graphite Factory No. 1, North Side of Dubrovnik

This factory has suffered major damage. It used to manufacture silicon carbide/carbon electrodes, by a process of heating carbon and silica dioxide with a tar mixture, largely consisting of naphthalene and anthracene of low purity.

The factory previously emitted significant air emissions, including carbon monoxide and had little worker protection.

The Serbs removed the atmospheric protection equipment.

It was reported that a Mr. Morgan and a Mr. Horvat, from Austria, wished to purchase the plant and recommence production. This is ill-advised unless the factory could be equipped fully with both air and worker protection using the best available techniques.

At this location, factories such as an electronic assembly are to be advocated, ie, clean technologies only.

It is proposed that this type of industry should only be located at areas of already high pollution, such as Kutina.

18.11 Graphite Factory No. 2, Centre of Town

This is located at the rear of the hotel Petka and adjacent to some flats.

Whilst there is limited production of the graphite electrodes, as described above, the main production is sintered copper brushes for electric motors, including generators and starter motors for cars, and heavy vehicles (such as military vehicles).

Because of the war it is of strategic importance, but in view of the emissions of soot, tar, carbon monoxide, etc, it is inappropriately located.

The operating temperature is about 650 °C and wish the tar binder, consisting of naphthalene, anthracene, etc, leads to emissions of PAHs. Again, some of the air extraction system was removed by the Serbs.

They are now unable to transport waste products to INA at Rijeka or Sisak, because of the hazards of using the Isle of Pag ferry, ie, because of the loss of the Maslenica bridge near Zadar, and these wastes are now being discharged to the sea. This should be given urgent consideration for incineration at the cement works at Split.

This is a most undesirable type of industry to be located in the centre of a basically tourist town, and rather than expending funds, consideration should be given to relocation to Split as the nearest industrial centre, where at least the waste products should be incinerated in the cement kilns.

Other emissions at the site include formaldehyde and ammonia, used to generate hydrogen as a reducing atmosphere; the 2 hydrogen units each produce 6—7 L min^{-1}. There was also a number of drums of triethanolamine, but no person present was aware of its use.

They also undertake a limited production of metal impregnated bakelite, again involving the use of tar and resins.

There is also a hazard from the broken asbestos roof.

18.12 Wine Cellar, North of Dubrovnik

The external metal vats were totally destroyed by tank shells.

However, the old wooden vats, about 30 each of 13 000 — 15 000 L capacity, showed very little sign of damage, except that the Serbs had removed the stop valves. The owner indicated that he would

require some 4 M DEM to restore the cellar. I requested that, for immediate action, the wooden vats should have the outlets blanked off and filled with water to avoid these beautiful vats cracking and leaking. It is hoped that by the time this report is finalised this very simple remedial action will have been executed.

Even if this cellar cannot reopen, these vats, if preserved as indicated, could be used elsewhere at another devastated or otherwise winery.

The owner also indicated that he would require a further 2 M DEM to replace the wines which had been unattended for 2 years.

The storage yard contained several thousand glass wine bottles, some 60+% of which were undamaged, it is recommended that these be transferred to other cellars, eg, at Korcula, or Isle of Hvar, without delay and the many tonnes of broken glass sent to Rijeka for recycling.

During the bombardment of this factory, significant quantities of detergents, and sodium hydroxide were washed to the nearby semi-saline river estuary, which supported good fauna and flora, and which now needs to be fully assessed for damage.

18.13 Harbor area

Many warehouses containing unrecorded items were destroyed, washed, or leached into the sea. Some of these warehouses were completely raised and are now vacant.

It is hoped that these dock areas will be used only for clean technology and light industry, etc.

18.14 Marina

Over 200 yachts were destroyed and burnt, including oil and gasoline storage, with massive leakage to the sea.

18.15 Food Refrigeration/cold store

This was totally destroyed with the loss of almost 6 tonnes of ammonia to the atmosphere.

18.16 Transformers

At least 50 transformers, some containing mineral oil and condensers containing PCBs were burnt or severely damaged, resulting in massive soil pollution from both mineral oils and PCBs. A large scale monitoring programme is advised.

18.17 Visit to the Local Water Works Laboratory

This laboratory continues to provide a limited amount of chemical and some bacteriological testing. The equipment is hopelessly out of date and the laboratory is in need of total refurbishment with modern equipment.

It is recommended that a WHO expert/Registered Professional Water Chemist assesses the situation urgently. It should be noted that this (and presumably other) water laboratories are underfunded as they cannot afford to use membrane filtration and rely on multiple tube techniques for coliforms.

It was reported that they undertook determinations for:

i) Ammonia, nitrate, chlorine residues, pH, and coliform on a daily basis; and,

ii) i) above, plus metals by atomic absorption, conductivity, taste, etc, on a weekly basis. However, equipment for undertaking some of even the more basic tests was not in evidence.

The (c) group of analyses for pesticides, including lindane, malathion, atrazine, etc., detergents (anion, cation, and non-ionic, PAHs, organic solvents, etc., used to be undertaken quarterly in Split, Opatica or Zagreb. No such analyses have been performed for over 2 years.

It should be noted that PCBs can only be analyzed with difficulty and at great expense in Zagreb or Rovinj.

Croatia has no facilities for analyses of dioxins etc.

It is doubtful if the sad state of this water laboratory is the only case in Croatia, but time did not permit inspections at other, or indeed less devastated or remote (to Zagreb) locations.

19 Visits in Zagreb, Tuesday 19th January and Wednesday 27th January 1993

19.1 Ministry of Industry, Shipping and Energy.

This Ministry has responsibility for the chemical industry.

Saw: Ms Ivana Halle, Chemical Engineer and

Mrs Liga De Polo, Secretary,

and Mr. Damir Begović, Minister

all based at 78 Av. Vukovar.

They confirmed that the PCB Askarel was imported from Germany.

19.2 Croatian Chemical Society

et the President Professor Dr. Krešimir Humski (Ante Kovačića 1), and Dr. Kata Galić, from the Faculty of Food Technology and Biotechnology (Pierottijeva 6), Dr. Branko Kurelec of the Rudor Boskovic Institute plus 5 Croatian members of The Royal Society of Chemistry, London.

19.3 University of Zagreb

Met the Rector Professor Dr. Marijan Šunjić, Trg. Maršala Tita 14

(41) 464 233, Fax 462 244.

Dr. Šunjić is Chairman of the Scientific Committee of the Brijuni Confer3ence, and is hopeful that the University can play a major role in the scientific requirements which are likely to originate from the mission report.

19.4 Wednesday 27th January 1993

After a press conference (not involving UNIDO), I had final discussions with Ms Višnja Jelić-Mück, senior adviser on the environment

38 41 611 922, 633 444, fax 537 203, and

Dr. Simončič's secretary as he was absent in Geneva.

ANNEX 9.

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 positioned, eg, too near important water resources, over-filled 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 building materials. Special care will be necessary for disposal of asbestos, type usually unknown; this will be of particular 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 tonnage 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, Slovonia 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 utilised 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, plastics and paper food packaging etc. Experts 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, Slovonia; 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 no alternative 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, Integrated 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.

ANNEX 10.

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 Araclors 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 toxicities to fish:

LC_{50} (20 d) rainbow trout 21 µg L^{-1}
LC_{50} (30 d) bluegill sunfish 150 µg L^{-1}
(for Araclor 1260)

Its (Araclor 1240) anaerobic removal from lake sediments is slow, maximum dechlorination rates for Hudson River and Silver Lake organisms were: 0.04 and 0.21 µg—atoms of Cl removal per g of sediment wk^{-1} respectively [16].

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

1. 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 [30].

2. When burnt PCBs can be converted to polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzodioxins (PCDDs), thus leading to extremely toxic soots [31,32].

3. The use of PCBs have been recommended for discontinuation in the former Soviet Union [33]. 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 dichlorinates the PCBs to non-toxic end-products. Plans for a mobile unit were proposed [34].

Mills et al. [35] 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 1

Recommended Sites for PCB Analyses

Town	Location	Soil	Water
Osijek	Near to destroyed thermoelectric plant	Yes	R. Drava
Pakrac	Near destroyed transformers	Yes	R. Pakra
Slavonski Brod	Duko Dakorić 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 μg L^{-1} then fish tissues should also be analyzed.

ANNEX 11.

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 <u>need</u> to treat the surface of the wheat with a fungicide, to prevent the formation of aflatoxins, and with rodenticides.

ANNEX 12.

In situ chlorine generation

The transportation of cylinders of liquified chlorine over long distances, eg. by road (including ferries in view of the loss of the Maslenica bridge), its storage and use presents significant hazards. Additionally, chlorine has to be imported from Slovenija, Romania, and other countries, itself involving transportation hazards.

The use of chlorine for municipal water treatment, hotel and civil swimming pools, food processing, etc., is a vital public health requirement.

However, chlorine can be easily electrogenerated *in situ* by electrolysis of sodium chloride solution using titanium electrodes (no mercury) under safe conditions and by relatively non-technical staff.

For water treatment, the use of ozone and chlorine dioxide should also be considered.

It is **recommended** that in order to obviate the foregoing hazards that joint venture opportunities should be investigated with western European companies.

However, it will be important to check the purity of the locally available sodium chloride.

ANNEX 13.

Wood Industry including Paper/Pulp

This is an industry which is capable of further development. However, it is an industry which can cause significant pollution and public health hazards, largely from sawdust [25].

The wood industry can lead to pollution of water resources from sawdust and resinous substances, terpinoids, etc, found beneath the bark of trees. All of these natural products require good environmental management.

Xenobiotics are widely used for wood preservation to inhibit fungal and other wood rotting organisms. In the past, a number of chemicals have been used, eg, salts of arsenic and chromium, 'drins', and other recalcitrant halogenated chemicals such as pentachlorophenol, etc. These have led to pollution of water resources and their future use must cease.

In view of the need for export of wood for construction and furniture etc, much greater care is needed to avoid such water pollution in the future. It was noticeable that the River Pakra at Pakrac was now clear and free of pollution, and was in a far better condition than had been observed by the inhabitants for many years. It is unfortunate that there are neither analytical chemical nor biological survey data available to support this.

It is **recommended** therefore that the River Pakra is now subjected to both a detailed chemical analytical survey, including GC-MS, and a biological survey.

In order to avoid contamination at towns such as Pakrac, Ogulin, Otačić, Gospić and Delnice, both surveys and the use of modern biocides such as 2-(thiocyanomethylthio)-benzothiazole (TCMTB) — Buckman Laboratories, are advocated.

The wood industry is an industry to be enhanced as there is much need for wood products, both for reconstruction and for furniture, for Croatian home and export markets.

Particular care is essential on the mountains above Delnice so as not to contaminate the hydro-electric power lakes, which are a potential water resource for Rijeka and Opatija.

The wood industry could also be developed to provide a pulp and paper industry, which itself would provide a valuable asset to recycle waste paper.

Both the location of such industries which must be of the new 'clean technology' type to ensure minimisation of pollution would need to be located near the forests, sources of available energy, and be located near to adequate water resources.

Two plants should be considered: one in Slovonia, currently at Slavonski Brod, and one on the coast inland on the Rivers Krka (Šibenik) or river Cetina (Omiš), taking care that the bay south of Dugi Rat does not become more contaminated.

Such factories could be considered as joint venture projects.

It is noted that there are existing mills at Rijeka, Zagreb, and Plaški. (See Annex 8.11.)

The use of straw as a raw material should also be considered.

ANNEX 14.

Soil Contaminated with Various Mineral Oils (transformers) and heavy fuel oils (thermoelectric power stations), Sisak oil refinery and various damaged factories, etc.

The contamination of soil with mineral oils leads to contamination of water resources, crops, trees, etc.

In view of the heavy clay nature of the soil in Slavonija in the eastern region, it is anticipated that such contamination will remain localized; whereas in the central Lipa region, ie, Ogulin,Gospić, Delnice, Dubrovnik and the coastal area, contamination with mineral oils could lead to significant hazards to potable water supplies.

Widespread monitoring will be necessary in order to undertake the necessary risk assessments.

Remedial measures include ploughing in domestic activated sewage sludge where this is readily available, eg, from the sewage treatment works at Virovitica. Such sewage sludge will need to be enhanced with bacterial/enzyme systems such as: ProRun (Trent Marketing, Sutton, Surrey, England) or CX90, (International Biochemicals, Slough, England.

For river or groundwater (where accessible) air stripping or peroxidation treatment may be effective (Engineered Products Ltd., Banbury, England).

For drinking water supplies contaminated with petroleum based oils, the only effective treatment is likely to be granulated activated carbon — which of course will be effective in removing other contaminants, but will place very large economic burdens on local communities.

It is reiterated that contaminated rivers do not recognise national boundaries.

ANNEX 15.

Asbestos

Many factories damaged had roofs, and in some cases walls, consisting of asbestos.

Despite intensive enquiries, no data were available on the physical forms of the asbestos used.

It should be noted that chrysolite and amphibole asbestos have been reported to lead to bronchial carcinomas and pleural mesotheliomas. There is sufficient evidence for carcinogenicity in humans and animals, and the IARC overall evaluation is Group 1 [36].

At many of the installations and at roadside refuse dumps, the asbestos sheeting is breaking up, leading to direct exposure to fibres. It should be noted that maximum carcinogenicity is from fibres 20 μm long and 0.125 μm in diameter.

Urgent care and training is recommended for both the removal and disposal of asbestos from these damaged buildings. As the type of asbestos is unknown, full protective clothing is essential, and disposal in properly controlled landfills is vital.

Disposal of asbestos fibre and for insulation pose even greater problems.

ANNEX 16.

Waterworks Laboratories

Based on the observations made at Dubrovnik it is recommended that the public health requirements for all microbiological and chemical analyses of potable waters, including mineral and other bottled waters, are reviewed by a Registered Professional Water Chemist. (qv. Annex 4.)

In many areas it was reported that only limited and in some cases no water analyses has been undertaken for 2 years. Water quality is scheduled to be checked by the public health service at hospitals at many locations, eg. Osijek, Vinkovci, Pakrac, etc. where the hospital either no longer exists or are working with extremely limited resources, eg, at Vinkovci; essential operations were being undertaken in basements etc. It is therefore unlikely at certain locations that even the most rudimentary water testing is being undertaken. Requests for water quality data were not fulfilled.

The laboratory at Dubrovnik, whilst functional, was equipped with primitive and very old equipment. Running costs did not enable water testing to be undertaken using membrane filtration for coliform bacteria, and whilst multi-tube is a well tried classical and adequate technique, it is far more time consuming and extravagant in both media and autoclaving capacity

As the Croats require an urgent return of tourism and a water quality of which they were formerly proud, urgent re-equipping and use of modern testing techniques is essential.

In many towns, now subject to overcrowding with refugees, coupled with damage to water treatment plants and loss of sewage treatment facilities, the availability of good quality, pure and wholesome drinking water supplies is essential to eliminate water borne diseases, particularly so when the warmer weather approaches.

Increased vermin at roadside and other unauthorised rubbish dumps will aggravate these problems.

ANNEX 17.

Specialty chemicals

It is proposed that speciality chemicals as listed below should be considered for production as high value products.

1,2-dibromo-1,4-dicyanobutane;

β-bromo-β-nitrostyrene;

1-bromo-3-chloro-5,5-dimethylhydantoin;

2,2-dibromo-nitrilopropionamide;

2-bromo-1-(4-hydroxyphenyl)-ethanone;

2-chloro-N-(hydroxymethyl)-acetamide;

2-chloro-6-methyl-4-benzylphenol;

5-chloro-4-isothiazoline-3-one;

bis(trichloromethyl)sulfone;

trichloro-S-triazenethione;

quaternary ammonium and phosphorium compounds;

methyl *bis*(thiocyanate);

polymeric imino compounds;

3,5-dimethyl-1,3,5-(2H)-tetrahydrothiaxiazine-2-thione;

glutaraldehyde;

2-n-octyl-4-isothiazon-3-one;

o-phenylphenol;

2-(thiocyanomethylthio)-benzothiozole; and,

peroxyacetic acid.

ANNEX 18.

Proposals for joint venture enterprises

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 Slovenski 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 coastal scenery is magnificent, 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 Djakovo, etc.

6 Slavonski Brod

Oriolok 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 Otačić

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 Otačić 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 copper), 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.

ANNEX 19.

Training proposals

1 Microtox®. This can be self-taught from a video — copy already made available to Professor Dr. Slobodan Rendić [1].

2 Analytical 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 Landfill 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, P—450 cytochrome activities, etc. [1].

14 General training in factory worker exposure of the British COSHH Regulations and emission standards.

ANNEX 20.

Recommendations for the Croatian Ministry of Environment

1 Introduce legislation based on current United Kingdom (EEC) practices.

2 Formulate an environmental master plan, especially for rubbish.

2.1 Consider provision for recycling glass (in particular), food cans, plastic, and paper packaging.

2.2 Increase number of sewage treatment works.

2.3 Investigate need for incinerators.

2.4 Improve domestic (and where appropriate industrial) landfill sites.

2.5 Segregate rubbish, eg, building debris, from glass, from domestic garbage, and industrial waste, etc.

3 Upland surveys to protect lakes used as potable water resources.

4 Upgrade potable water laboratory facilities.

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UNIDO COMMENTS

The purpose of this report is to provide an overall review of the situation in Croatia with regard to the damages caused to chemical and other allied industries due to the war and to assess the potential hazards that face the newly born country. While the report covers a very wide area and a number of industries, the analysis is mainly qualitative and more efforts should be made for a quantitative risk assessment, monitoring with regard to both environment pollution and health of the public.

The report covers a complex panoramic situation in which many areas re so badly destroyed and finding a solution will not be based on revious experience but would be a new type of approach suitable to the nature of the problem.

While hazard could be measured with respect to chemicals by their inherent toxicity and exposure levels it is essential to limit or eliminate the exposure by taking necessary steps.

The approach to strengthen local capability to cope with the existing situation on a medium/long term basis would be the first step so that the country can slowly build up the capacity through multilateral and bilateral assistance.

The industries covered by the authors clearly bring home the message that the problems encountered in Croatia should be approached by a multi-disciplinary team (example different branches of the Department of Industrial Operations) to provide the necessary inputs to assist the Government of Croatia in solving their problems both in overcoming war damages and moving to a free market economy.

The report also mentions that immediate solution should be found for purification of drinking water supplies, decontamination or containment of areas polluted with toxic/hazardous chemicals e.g. PCB's heavy metals, sodium hydroxide, fuel oils etc. The suggestion to make use of cement kilns and limited use of landfills with proper monitoring could be taken up as immediate measures but long term measures should be based on infrastructure building to tackle the ecological problems associated with the war damages by using high temperature incineration, bio-remedial measures etc. Tables provided in the report for a time bound action to tackle different types of pollution could be used as yardstick for rescuing Croatia from ecological disaster caused by the war and therefore, international assistance is vital to Croatia for such an action.