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UNITED NATIONS INDUSTRIAL
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ENVIRONMENTAL DIMENSIONS IN THE CHOICE OF INDUSTRY AND TECHNOLOGY

TURKEY

(TS/TUR/74/003)

Report of a UNIDO mission participating in a seminar held at Ankara from 17 to 19 December 1974

id.75-5863

Explanatory notes

Use of a hyphen (-) between dates representing years signifies the full period involved, including the beginning and end years, e.g. 1971-1973.

A slash (/) between dates representing years indicates a crop year or financial year, e.g. 1971/72.

The following exchange rates are used in the conversion of country currencies to United States dollars:

Country	Currency	Exchange rate per US dollar in 1974
Turkey	Lira (LT)	1,610.00

The following abbreviations are used:

B.A.T.	best available technology
BOD	Biochemical Oxygen Demand
B.P.T.	best practicable technology
Btu	British thermal units
cfm	cubic feet per minute
COD	chemical oxygen demand
IULCS	International Union of Leather Chemists Societies
ppm	parts per million
PVC	polyvinyl chloride
SS	suspended solids

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INTRODUCTION

The Government of Turkey, which is committed to a policy of rapid industrialization in its third five-year development plan (1973-1977), is endeavouring to minimize consequential environmental damage and pollution. In pursuance of this aim, government departments have been holding seminars on various aspects of the environmental situation with the aim of clarifying the departmental viewpoints and, by disseminating the seminar results, of keeping the general public and industrialists aware of the need for action and vigilance in this sector. Indeed, the five-year plan stresses the need for extensive public education in this field.

In September 1974 the Government of Turkey requested the participation of the United Nations Industrial Development Organisation (UNIDO) in a seminar on Environmental Dimensions in the Choice of Industry and Technology. The seminar was organized by the Ministry of Industry and Technology and was held in the Conference Hall of the Standards Institute of Turkey, at Ankara, from 17 to 19 December 1974.

Contribution of UNIDO

The assistance requested of UNIDO, as described in the Project Data Sheet, was to provide two experts; one was to prepare a paper on the environmental impact of the chemical industry and the other was to prepare a similar paper for the leather industry. Both experts were expected to spend two weeks in Turkey before the seminar in order to survey these industries, and based on their findings, to incorporate into their papers sections dealing with the actual pollution problems associated with these industries in Turkey.

They were to identify the short- and long-term needs of Turkey in the abovementioned fields and possibly to draft some project proposals. A staff member of UNIDO was also to attend the seminar to speak on the general environmental considerations of industrial development.

Owing to recruitment formalities the two UNIDO experts were not sent to the field early enough to allow them to survey the industries in sufficient depth, as proposed in the project description. The chemical industry expert arrived only four days prior to the seminar and was unable to visit the industrial sites as had been envisaged. He did, however, visit governmental and university departments and received some briefing, which allowed him to appreciate fully previous studies of the effect of Turkish chemical industries on the environment.

The leather industry expert arrived 10 days prior to the seminar and was able to visit the leather industry at Kaslicesme, Istanbul, for several days as well as the Leather Research and Training Institute at Pendik. He learned some details of the effect of the Turkish tanning industries on the environment and could suggest possible measures to improve the industries' environmental impact, indicating the cost of such mitigating measures.

Chapters I, II and III of this report consist of the three papers presented to the seminar by UNIDO: "Avoiding the environmental impacts of the chemical industry", by R.W. Coughlin, expert for the chemical industry; "Environmental dimensions in the choice of industry and technology: environmental impact of the leather industry", by D. Winters, expert for the leather industry; and "Environmental awareness in industrial development and the environmental programme of UNIDO", by J.B. Carmichael and A.E. Anderson of the Industrial Technology Division of the UNIDO secretariat.

The role of the seminar and the contribution of UNIDO should be viewed as part of a wider activity in the environmental field. The Turkish authorities have various research and training projects underway that are typified by the following work:

(a) Middle East Technical University postgraduate studies on environmental engineering;

(b) Water pollution and environmental hygiene studies conducted by the Istanbul Technical University, the Hydrobiology Institute of Istanbul University, and Ankara, Ege and Hacettepe Universities;

(c) Environmental research in progress at the Scientific and Technical Research Organization of Turkey where air pollution studies are now in progress;

(d) Other research on environmental pollution undertaken at the Institute of Refik Saydam (medicine), the Directory of Meteorology, the Nuclear Research Centre, the Institute of Metallurgical Research and analysis and the Turkish Coal Corporation.

Summary and conclusions

In the course of their presentations the UNIDO experts suggested the following:

(a) That immediate studies should be made of existing and proposed emission and discharge standards in other countries. The results of such studies together with studies of the economic and ecological position of Turkey could provide a framework for national standards in this field;

(b) That minimum environmental control and improvement plans could be initiated economically. The philosophy proposed was that acceptance of even the lowest standards accepted elsewhere could be useful and lay the basis for future improvements;

(c) That future seminars on the environment in Turkey should include more technical discussion;

(d) That Turkish research on environmental problems should be elaborated and presented publicly (e.g. lignite production, Izmit Bay pollution and the proposed nuclear power plant);

(e) That there was a strong case for an in-depth study (technical/economic) of the Turkish tanning industry to assess at what level the balance of environment/economy would be best served.

I. ENVIRONMENTAL AWARENESS IN INDUSTRIAL DEVELOPMENT AND THE ENVIRONMENTAL PROGRAMME OF UNIDO

J. B. Carmichael*

and

A. E. Anderson**

Over the past decade there has been an increasing awareness of environmental problem throughout the world. The careless development of a mining project has fouled a watershed. The indiscriminate dumping of toxic industrial effluents has wiped out a fishing resource. More and more, proper environmental considerations are being recognized as an integral part of planning for the future.

A hypothetical view of the impact of national environmental awareness is shown in figure I. The diagram represents the process of development and implementation of pollution control standards in the United States of America. It is meant to serve as a conceptual guide rather than a literal model for the experience of any particular country. For the hypothetical case shown in the diagram, it is assumed that national environmental awareness has reached a sufficient level to precipitate political action, and this action has taken the form of environmental legislation. At the same time, industry has noted the heightened national environmental awareness and subsequent political action. Reaction has been mixed. Certain far-sighted industries have begun to plan for future effluent treatment programmes. Other industries have stated public opposition to environmental requirements, claiming that economic disaster will result.

The environmental legislation has established a new pollution law with effluent standards. An environmental agency has been created to enforce the law, and an institute for environmental research and monitoring has been established. The first task of the new institute will be to gather data on environmental effects resulting from effluent discharge from a few of the major polluting industries. These data will be supplied to the environmental agency as the agency prepares to move to obtain industrial compliance with the new law.

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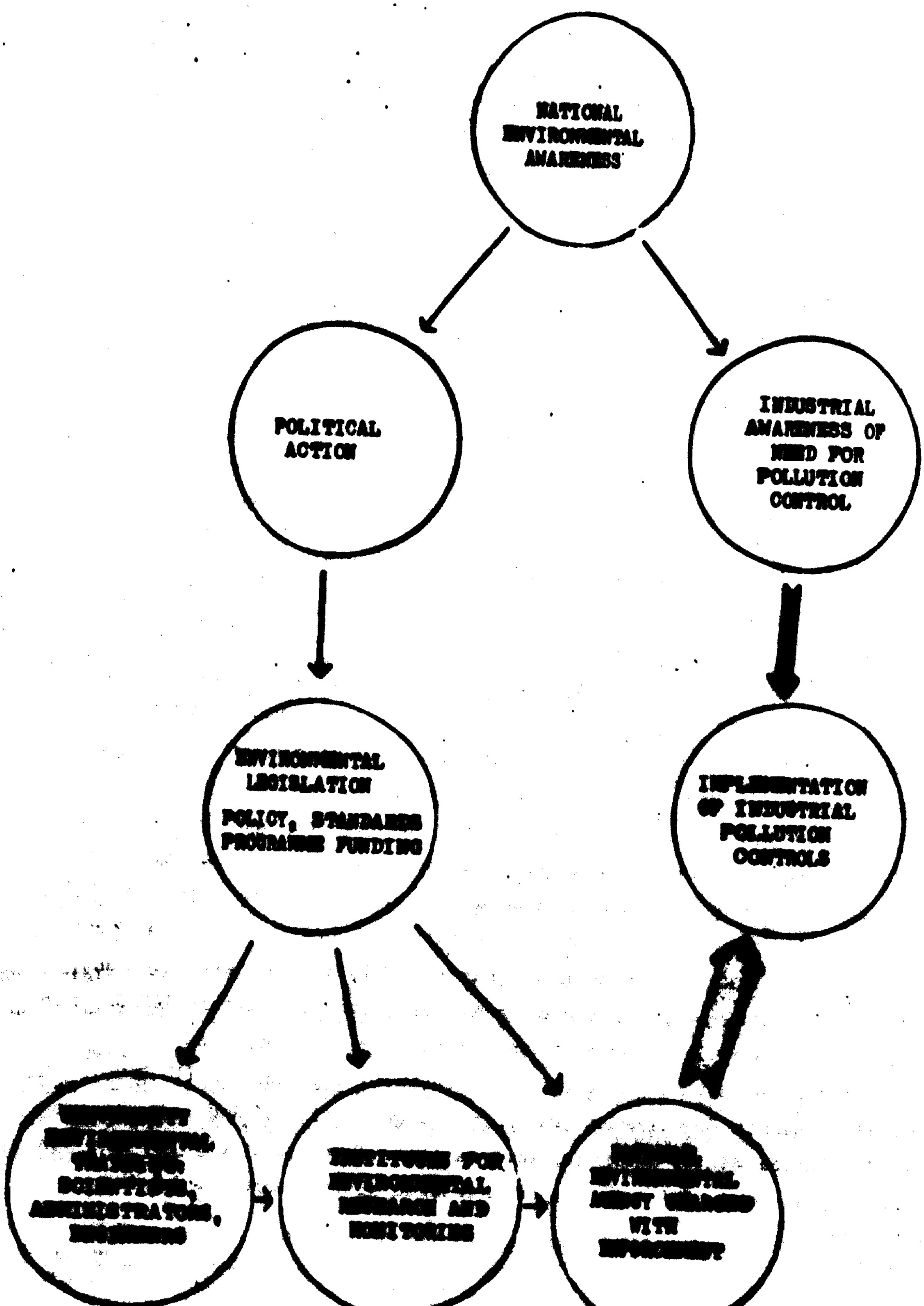

Figure I. National impact of increased environmental awareness

The environmental legislation has also established special funds for evaluation in a few of the country's best universities. Eventually these indigenous environmental programmes will be the feeders of trained scientists, administrators and engineers to the national environmental agency, the environmental institute and industries.

This hypothetical example is greatly oversimplified. For example, no arrows showing feedback from one institution to another are shown. In practice, the institute for environmental research and monitoring would be much more effective in meeting the environmental needs of the country if a substantial input from industry were encouraged and utilized in project conception, design and execution. Nevertheless, the diagram may serve to demonstrate the effect of the awareness of the environmental problem that has occurred in many developed countries and that is now occurring in developing countries.

International awareness of the environment

Increased awareness of the environment culminated in the United Nations Conference on the Human Environment, held in Stockholm in 1972. More than 100 proposals for action to preserve and improve the human environment were developed. A central theme of the conference was that considerations of environmental effects ought to be a fundamental part of project planning. The essential philosophy was embodied in a Declaration of Principle. The first principle stated was: "Man has the fundamental right to freedom, equality and adequate conditions of life in an environment of quality that permits a life of dignity and well being and he bears a solemn responsibility to protect and improve the environment for future generations". The founding of the United Nations Environmental Programme (UNEP) and the establishment of environmental evaluation, training and monitoring functions within UNIDO, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Pan-American Health Organization (PAHO), the Organization of American States (OAS), the United States Agency for International Development (USAID) and others are an integral part of the pattern of increased global awareness of the environment.

The goal of industrial development has been adopted throughout the developing countries as a major solution to the problems of poverty and underdevelopment. However, industrialization has up to the present often resulted in the generation of unutilized wastes, and the release of these wastes affects the environment in many ways.

A legitimate question is often raised in the developing countries: How can an economically and socially advantageous industrial development programme also be tailored to protect the natural environment and to develop a desirable human environment? Countries on the threshold of economic development do not wish to forego industrialization for the sake of the environment. However, they can plan industrial development in such a way as to avoid environmental disruptions that may cause serious hazards to human health or the contamination or depletion of natural resources. Each country will have to decide, in the light of its own geographical, economic and political circumstances, the role of environmental policy in development planning.

Consideration of the effects of industrial development on the environment entails a technological assessment of these effects. As there is an increased scientific understanding of the environmental disruptions associated with given industrial practices, there will be greater appreciation among political leaders of environmental problems, the technology available to solve these problems and their cost.

Environmental analysis

Environmental analysis is the process of evaluating those aspects of a project or development plan that cause environmental change. The major potentials for environmental damage must be identified and the magnitudes of the effects estimated. Delineating means of mitigating environmental damage is the next step. Allowing the environmental damage to occur rather than mitigating or preventing this damage involves trade-offs, which a decision-maker must identify and understand in order to choose among available alternatives.[1]

[1] Jack B. Carmichael, Environmental Considerations in the Planning and Evaluation of Development Projects, monograph (Washington, D.C., Organisation of American States, 1974).

Pre-project environmental analysis

Pre-project environmental analysis may begin at the earliest stages of planning. Environmental analysis may be incorporated as a part of a survey to identify possible development projects for a country or a region. The following guidelines are designed for use in the survey or pre-project phase to assist in identifying projects and in gathering preliminary environmental information. The guidelines are presented as a series of questions directed to the planner.[2/]

General questions

A. Relation to national plan and policies

1. Do the developments contemplated as a result of the study relate to the country's national plan?

2. Do stated goals exist for national or regional environmental conservation, such as a national environmental policy for water resources and water quality, forestry, mineral resources, or others? If so, does the proposed study contain any developments or projects in conflict with these national goals?

B. Physical aspects of the study

1. Is the region under study a unified physical unit? Failure to consider effects of the project on activities in the upper or lower reaches of a river basin, for example, may lead to serious consequences.

2. Have constraints imposed by the natural environment been considered in the recommendation of projects?

(a) Do land uses proposed by the projects make sense under prevailing geographical and ecological conditions?

(b) Have the relative occurrences of floods, earthquakes, tidal waves, eruptions and other catastrophic events been considered in recommending projects?

C. Information generated by the pre-project study

1. Will the study generate sufficient information and data to enable the country to identify and evaluate anticipated beneficial and negative

2/ Adapted from "Guidelines for development planning" (Washington, D.C., Organization of American States, 1973).

environmental effects of the suggested development projects? Have the economic costs of mitigating negative effects been estimated? What further programmes and data are required to produce this information?

2. How long is the period of the industrial development? Will studies during this period be of sufficient duration to evaluate possible long-term environmental effects?

3. Will the study adequately consider the wishes and needs of the people of the region? Will proposed developments be designed to utilize their labour?

4. Does the time sequence of the contemplated industrial development allow for sufficient training of individuals from the country and the region, so that persons will be available with the skills required to manage and operate the completed projects?

5. Will the study utilize cost, discount and other economic and environmental data supplied by the Government? What data must be generated through the study?

6. Will the study attempt to quantify economically environmental costs that have been identified? Will these then be included as part of the costs of the development of the region?

D. Effects on other countries

Will the projects under consideration have possible adverse effects on other countries? By what means will these be dealt with? Are there established procedures for consultations?

Discussion

If the pre-project environmental analysis is begun early enough, alternatives can be considered before important irrevocable decisions have been made. As an example, a river basin survey would be conducted prior to making economic development decisions. The survey would establish the present ecological condition of the river, land-use patterns, human settlements, water uses, the present level of water quality, and the capacity of the river to absorb wastes. Utilising this information, a decision could be reached on the site location, technology capacity and effluent treatment required for a proposed pulp and paper mill.

An exercise in trade-off analysis would involve choosing among various levels of pollution from a proposed pulp mill at different costs to the mill and degrees of degradation of the river.

Project environmental analysis

The purpose of this section is to present means of analysing the environmental effects of particular projects that have been chosen for implementation. The first rule is always to begin the environmental analysis at the earliest possible stage. Project changes will be easiest to implement then.

The most direct and easiest approach to the environmental analysis of a project is to use a set of check-list questions or statements that guide the analysis towards the key problem areas. Guidelines of this sort have been developed by the World Bank. The various sorts of information that should be obtained and evaluated are listed under major project and environmental categories.

General methodology for environmental assessment[1]

A. Linkages between the environment and the resources under development

1. The current state of the eco-system at the site should be reported, along with expected project effects upon important eco-system components;

2. When applicable, alternatives to the project or possible future amendments to the project should be discussed with the intent of minimising adverse environmental effects.

B. Project design and construction

1. Short-term effects are the major concern under this category. The objective is a well-designed project and consolidated construction plans that will protect the flora and fauna and prevent erosion;

2. Proper considerations should be given to the health and safety of workers during project construction. Health screening of the work force and periodic examinations are suggested.

1/ Adapted from Environment, Health and Human Ecologic Considerations in Economic Development Projects (Washington, D.C., World Bank, 1974).

C. Operations

1. Prior to project approval and construction, there should be assurance that the operations of the completed project will be adequately managed. The operations phase of the environmental analysis should include a plan with provisions for:

(a) Raw materials management;

(b) Wastes management;

(c) Installation and maintenance of environmental controls and safeguards;

(d) Monitoring for environmental effects of plant operations;

(e) Occupational health and safety.

D. Socio-cultural factors

This analysis should deal broadly with short-run construction effects and long-run project operation effects on people.

1. Project effects on persons indigenous to the area must be considered:

(a) If relocation of people is necessary, a comprehensive plan must be prepared;

(b) Any social disruptions to the indigenous people from noise, air or water pollution should be identified.

2. Project effects upon the work force. The socio-cultural needs of the construction and operational work force should be considered where appropriate. This is especially important if workers live at the project site.

E. Health effects

1. Proper consideration for health should include a sufficient knowledge of [illegible] disease [illegible] and controls should be introduced where the development of a project may cause the spread and increased influence of a disease.

2. [illegible] construction and operation should be described. Any occupational health and safety programme should be presented.

3. Any potential for creation of new health hazards, such as introduction of new pests or diseases, should be recognised.

F. Long-term considerations

1. Indirect effects that might occur as a result of the project are an important long-term consideration. If, for example, a project will attract large numbers of people to the area over a long period of time, this should be recognized and reported. Such an indirect effect will eventually require the provision of an urban infrastructure with the need for health care and other services;

2. Possible regional development effects may be a long-term consequence of the project, either through project expansion or the establishment of other related development projects. These may have important environmental consequences for the region;

3. Possible occurrences of catastrophes and their consequences for the project should be evaluated as a part of this section.

<u>Environmental analysis and cost-benefit analysis</u>

Cost-benefit analysis is the appraisal of all the "goods and bads" that may result from a project. The following types of benefits and costs are generated by a project:

1. Benefits and costs for which market prices exist:

(a) The first case is when these prices correctly reflect social values, e.g. non-price-supported farm commodities, costs of construction inputs;

(b) The second case is where prices do not reflect social values, e.g. price-supported farm commodities, or labour inputs that would otherwise be unemployed.

2. Benefits and costs for which no market prices exist; these are often termed intangible costs and benefits:

(a) Certain intangible benefits can be approximated in money terms by inferring what consumers would be willing to pay for the product or service if a market existed, e.g. local water-based recreation;

(b) There are other intangibles for which no market process may be readily envisaged that will allow a monetary evaluation. Two examples are the maintenance of a beautiful view or a historic site.

The theory of cost-benefit analysis takes into account the benefits and costs that may be measured by market prices and the intangible costs and benefits that will usually result from the construction and operation of a project. A good cost-benefit analysis not only includes benefits and costs measured monetarily, but also intangible or non-quantifiable benefits and costs described in whatever terms possible.

However, whatever the desirability of formally incorporating environmental analysis into cost-benefit analysis, a great deal more work is needed before a framework can be devised and before one can have as much confidence in measures affecting environmental impact as in economic measures.4/

Despite this shortcoming, descriptions of expected environmental impact must form a part of project evaluation. They can be incorporated into the cost-benefit analysis through the trade-off analysis of particular issues. A practical illustration of a situation requiring such a trade-off analysis occurred in connexion with a recent World Bank project for construction of a nickel refinery in a Latin American country. The question arose, should the company be required to spend $US 400,000 to construct a diffuser pipeline in order to mitigate possible ecological damage that would result from the point discharge of 30,000 gal/min of cooling water that will be 20° warmer than the ambient temperature of the receiving body, an unpolluted lake? An answer to this question would require an expert evaluation of the likely ecological damage and the economic and aesthetic consequences.

Environmental analysis may be effectively utilized as an aid to cost-benefit analysis through the identification and evaluation of such key trade-off questions.

In certain cases, a project may be economically acceptable when evaluated using cost-benefit criteria, but an environmental analysis may indicate unacceptable effects. When environmental controls are incorporated into the project, the cost-benefit ratio may be reduced so that the project is

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4/ C.W. Howe, *Benefit-Cost Analysis for Water System Planning*, Water Resources Monograph No. 2 (Washington, D.C., American Geophysical Union, 1971).

unattractive. Are there some general guides that have been developed in trade-offs of economic feasibility versus environmental quality? The experience of the World Bank has been that countries intitially viewed the environmental analysis of projects with great alarm, fearing very high costs of control. The experience of the World Bank has been that incorporation of acceptable environmental safeguards has averaged about 3 per cent of the over-all project cost. This level of expenditure would discourage only economically marginal development projects.

Environmental programme of UNIDO

The Environmental programme of UNIDO has been conceived to encourage environmental planning as an integral part of the process of industrial development so that adverse environmental effects may be minimized. Least-cost methods of pollution control are sought, utilizing technology appropriate to the developing country. There are two major components of the programme: UNIDO technical assistance and the UNIDO/UNEP joint programme. The UNIDO technical assistance programme involves direct aid to developing countries. All UNIDO technical assistance projects are implemented through the United Nations Development Programme (UNDP). Projects may be long-term (six months to several years) and financed through the regular UNDP country programme (Indicative Planning Figure) or short-term assistance (one to four months) for urgent needs and financed under the Special Industrial Services (SIS) programme.

UNIDO technical assistance programme

The operational programme of UNIDO involves direct technical assistance to developing countries. A formal request for assistance from the Government is submitted through the resident representative of the UNDP. The request may have been formulated by the national authorities. Often requests are formulated through the combined efforts of the national authorities and the UNIDO staff and senior industrial development field adviser. Upon receiving the request, the resident representative of the UNDP carries out preliminary negotiations with the Government on the nature of the request and the source and availability of funds. The resident representative then transmits the request to UNIDO for a technical evaluation. Official requests should normally describe the project, its objectives, duration, experts and equipment required, and host Government cost-sharing and counterpart contribution.

If evaluation of the request reveals that revision or further information is necessary, UNIDO guides the Government in the redrafting required for project approval. UNIDO proceeds to recruit qualified experts for the work. Prior approval of a candidate by the host Government is always obtained before appointment. 5/

Requests for urgent short-term assistance are appropriate under the SIS programme. Medium-term advisory missions and pre-investment and pilot projects consisting of experts, equipment and/or fellowships may be financed through the normal procedure of the UNDP.

SIS programme

UNIDO provides aid at short notice to developing countries wishing to solve urgent problems. Under this programme, administered jointly by UNIDO and UNDP, experts are sent for brief periods to advise on the solution of urgent technical problems. When a UNIDO expert is requested by a developing country to work on an environmental project under the SIS programme, the emphasis is often upon clear and present dangers. The expert may be asked to identify any clear and present dangers to human health or the natural environment resulting from an existing and planned industrial project. When such dangers are identified, alternative means of eliminating or mitigating the danger must be suggested. A UNIDO expert sent on an SIS environmental project will be expected to analyse the trade-offs involved in dealing with the environmental problem at hand.

What are the possible technical solutions for totally or partially solving the problem? At what economic costs can alternative solutions be achieved? Does the seriousness of the problem justify the expense required for a given solution?

Longer-term environmental assistance projects might concentrate on monitoring projects to ascertain accurately the extent of pollution emission. The varied environmental effects of plant operations and pollutant emissions might be catalogued and studied. The expert may be asked to analyse the relative effectiveness of alternative control measures and maintenance required to ensure continued high performance of a recommended control measure. He may be expected to estimate capital and operational costs of the proposed environmental control programme.

5/ Background information for this section was adapted from "Industrial development and the environment" (UNIDO/ITD.31).

UNIDO/UNEP environmental programme

In 1973, UNIDO began a joint investigative programme with UNEP which covered a wide range of environmental problems. Under this programme, UNIDO sent teams of experts to the field in 1974 to prepare environmental reports on the cement industry in Iran, the textile industry in Thailand, the chemical industry in Turkey and India, and an integrated iron and steel mill in Brazil. UNIDO anticipates carrying out a second set of field case studies in 1975, covering other industries such as pulp and paper mills and petrochemicals manufacture. Utilizing the results of these studies and studies by other international organizations (most notably the World Bank), UNIDO has evolved and is further developing a methodology for environmental impact analysis for industrial projects in developing countries. UNIDO is also preparing the case studies in a concise and analytical format in order to produce useful guides for planners and decision-makers in developing countries.

The case study results also fit into another central theme of the UNIDO/UNEP programme: The development of workable guidelines for planning integrated industrial complexes with minimised pollution.

Integrated industrial complex with minimised pollution

The objective of the work of UNIDO on integrated industrial complexes is to establish criteria for mixing industries in an industrial estate so that:

(a) One industry may utilise the product of another industry;

(b) Raw materials that are extracted from the waste of one industry may be utilised by another industry;

(c) The waste from one industry may provide a "neutralising" medium for the non-reusable waste from another industry;

(d) Treatment of the final waste stream from the complex will be less than separate treatments of the individual waste streams.

The starting point for the analysis of the industrial complex is the analysis of the pollution cycle for each industry in the complex.

A typical industrial pollution cycle is shown in the block diagram figure II, in which a typical existing system is indicated by the unbroken line. Included in the systems are not only the industry itself, but also transport and the consumer who contributes to the over-all pollution through product use and discard.

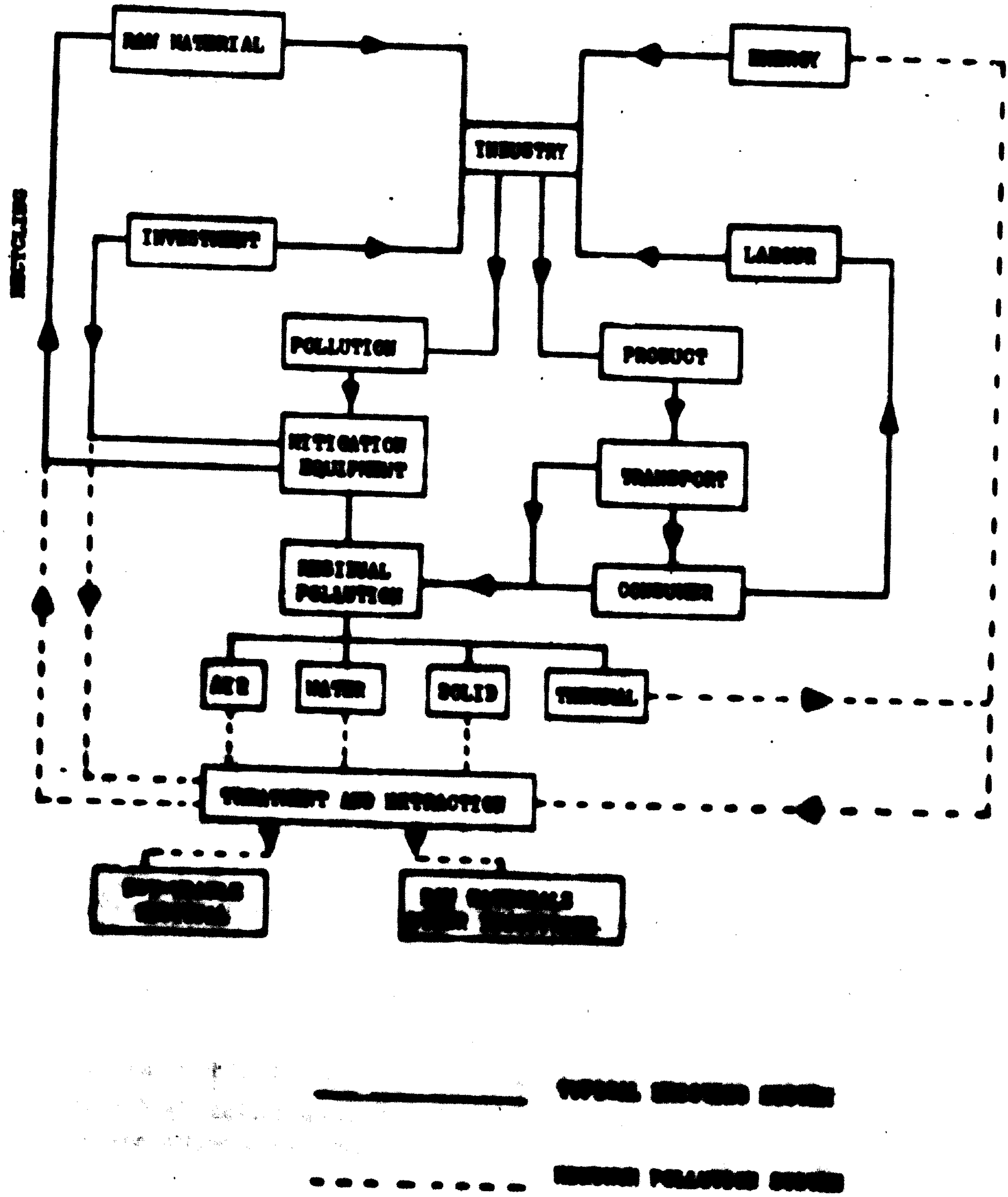

Figure II. Pollution cycle

The dotted lines in the diagram indicate modifications to the system which might be made to achieve minimum pollution. All efforts are in the direction of recycling and utilization of wastes. The removal and/or disposal of pollutants from the system without possible reuse is a cost that should be avoided whenever reuse is possible. 6/

Technical solutions now exist for treatment of air, water and solid wastes. However, the problem of waste energy utilization, while the subject of a large amount of study, has not been completely solved. The average efficiency of thermal processes is only 35 per cent and at present the remainder serves no useful purpose. In conventional fuels alone, the equivalent of 3,900 million tons of fuel per annum serves only to heat the atmosphere.

Not all potential raw materials can be extracted from the pollutant residues since quantities and extraction costs may make an operation economically unfeasible. Large-scale industries, however, may produce large quantities of by-products and residues which could become raw materials for other industries.

The non-reusable waste products must be treated by conventional methods. Examples are removal of harmful gases, waste-water treatment prior to discharge into sewers or water courses and controlled dumping, incineration or composting of solids.

The concept is illustrated in the block diagram figure III. Although each of the individual industries shown will typically have a pollution cycle similar to that in figure II, for clarity only simplified cycles are shown here.

In order to achieve viability of the pollution treatment process, it has been assumed that the complex would be concentrated around a major industry such as an iron and steel plant or chemical works. Experience may, however, show that this is not essential.

In this model complex, major industry A would feed its products as raw materials for ancillary industries B, C and D. Residual pollutants from each of these four industries would then be passed in a common extraction and treatment plant.

6/ Alexander E. Anderson, "Environmental considerations in the location of industry" (UNIDO/ITD. 297).

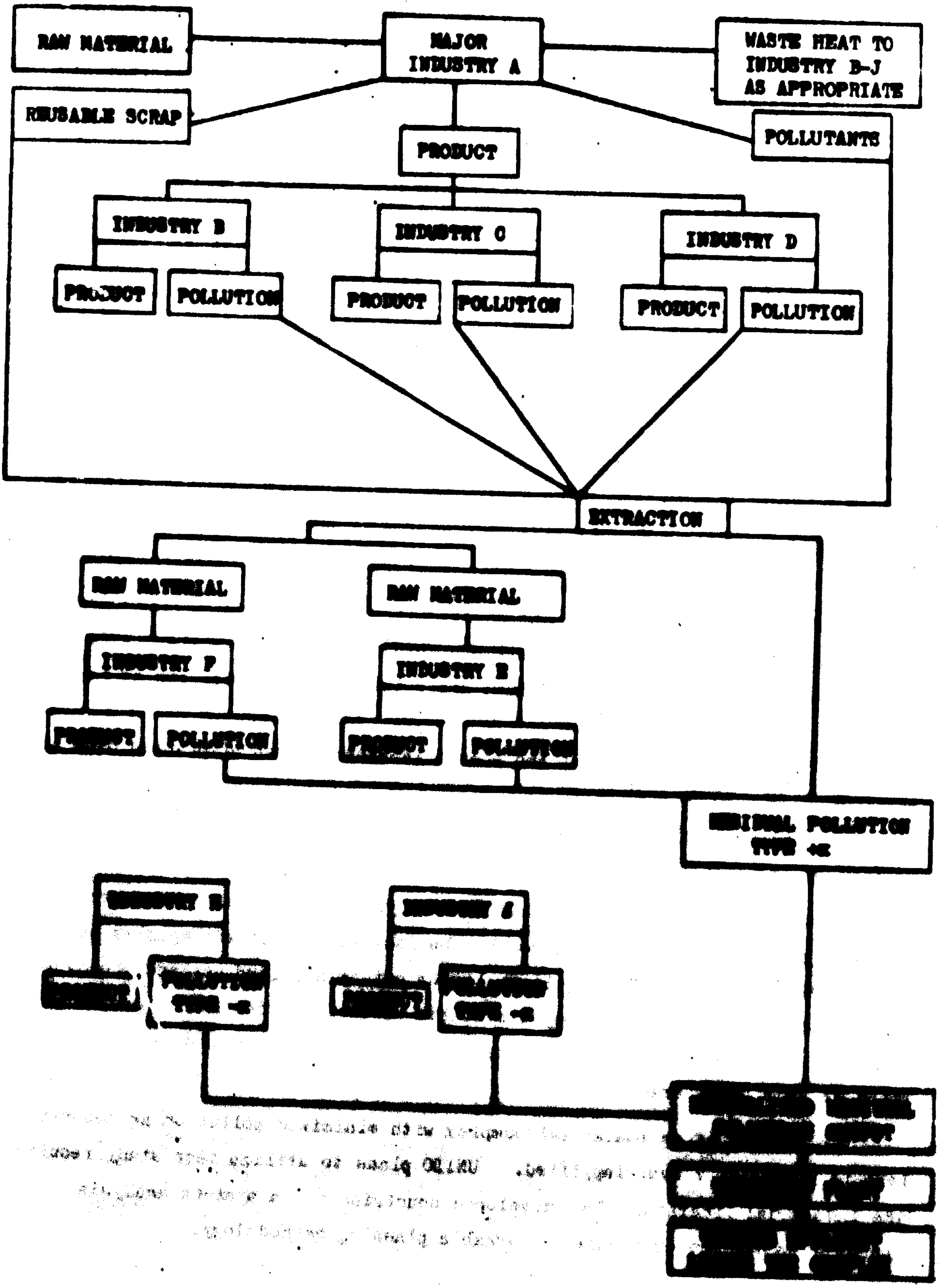

Figure III. Minimum pollution industrial complex

The output from the treatment plant provides some of the raw materials for industries F and E and gives a pollutant residue which, when added to that of industries A, B, C and D, is designated type +x, which may represent a liquid effluent that is highly acid, for example.

Industries H and J are of a type that provides a non-reusable residue which has been designated type -x. Here, -x represents a highly basic effluent that will neutralize the non-reusable acidic pollutants from plants A, B, C, D and E.

The neutralized residual pollution output would then pass to an appropriately designed treatment plant from which the final treated effluent would emerge from the complex.

There are many variations on the theme of complex development, and UNIDO appreciates the difficulties that are likely to arise. The advantages of the integrated complex are several:

1. Minimum waste of resources;
2. Minimum residual treatment costs;
3. Reduction of transport costs and, provided the estate area is not too large, reduction in both traffic volume and pollution by utilisation of non-polluting transport;
4. Creation of commercial and social infrastructures of planned size and amenity;
5. Fullest exploitation of the total labour market owing to the wide variety of industries.

There is a further question that has not yet been raised. Where within a region should the industry and complex be located? This encompasses such parameters as geography, meteorology, labour potential, land use and the overall characteristics of the eco-system within which it is desired to create an industry. A scheme for the necessary investigation of site is outside the scope of this brief example.

The concept of an industrial complex with minimised pollution as described here is necessarily oversimplified. UNIDO plans to utilise case study results, the industrial literature from developed countries and a systems analysis approach to develop eventually a workable planning methodology.

Conclusion

The sole purpose of UNIDO as an organisation is to aid developing countries in formulating and implementing programmes of industrial development. Such industrial development programmes often involve the deliberate modification of the natural environment in order to achieve economic objectives. In the absence of environmental planning, industrial development projects may result in irrecoverable losses of ecological, health and socio-cultural values.

UNIDO is prepared to respond to particular environmental problems identified by the developing countries and is carrying out model studies that will have broad applicability throughout the developing countries.

It is in the developing countries that the opportunity most often arises to set up industry from the grass roots. UNIDO believes that this process should proceed with the maximum environmental design information. All share the responsiblity to improve and preserve a quality environment for future generations.

II. AVOIDING THE ENVIRONMENTAL IMPACTS OF THE CHEMICAL INDUSTRY

Robert W. Coughlin*

With respect to managing the orderly growth of industry to prevent an adverse environmental impact, an important new word has been coined from the words "equilibrium" and "ecology". . "Ecolibrium" (eco = home; libra = balance) refers to the required balance in our earthly home between organisms and their environment which may be sought without sacrificing productivity and growth. It is possible, and even most efficient, to have both industrial growth and a favourable environment. It is pragmatic that the natural and proper use of air and water is and has been to dirty these vital commodities. Whether they are used in our own bodies, in the organisms of the natural eco-systems we seek to preserve, or in the industrial organisms man designs and builds, water and air get soiled. But just as we grow, use and re-grow food, therefore, we should continually clean, use and reclean our air and water. This means that, like land, air and water are really basic resources and industrial users should clean, reclean and reuse these basic commodities. Another viewpoint is that air, land and water are like industrial machines; just as we would maintain a paper-making machine or a truck, we should also maintain the production capacity of air, water and land. Simultaneously, we must all strive to ensure that true costs shall be placed on air, land, water, energy, or any other essential resource for that matter; only when these vital commodities are priced fairly may we expect the world to recognize their true value and use them with thrift. In order to reflect the true internal costs associated with the use of air, water or land, these costs should be included in the price of the chemicals, power or goods produced. This is the proper way to finance the renewal of these vital environmental commodities. The inclusion of such costs will promote thrift in the use of manufactured goods and thereby conserve resources. By ensuring the proper use and rejuvenation of the vital resources of air, land and water, those who manage industrial development will cause their true costs to be reflected in the cost of manufactured goods and help all of us on this planet to achieve the goal of "ecolibrium".

To better understand the nature of the true costs of air, water and land, we should consider the economic losses that result when we do not take good care of these basic commodities. Clean water has great industrial value;

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you cannot make chemicals, paper and many other products using dirty water. If company "A" upstream releases dirty water from its process to a river and company "B" downstream must then clean the water so it can be used in its own process, who should pay the purification costs, company "A" or company "B"? If company "A" is made to clean its effluent so that the river will be clean downstream for company "B", should company "B" be allowed to release dirty effluent just because company "C" does not yet exist downstream of company "B"? Clean water also benefits other industries such as fishing. Table 1 shows how the annual fish catches have decreased in Izmit Bay in recent years; the decrease represents a tremendous economic loss and it may be directly attributable to growing water pollution. Polluting effluents released to Izmit Bay are such that a fisherman now needs 15 nets in order to catch the same quantity of fish that could be caught in one net 25 years ago. The total value of the fish catch sold at the Istanbul fish market decreased from 157,500,000 Turkish Lira (LT) in 1969 to LT 14,580,000 in 1973. Table 2 shows how the fish catch has decreased in recent years in the region around the Marmara Sea. Think of how much seafood and corresponding wealth could be recovered for Turkey as a return on investment in pollution control equipment to permit the waters to again become clean and bring back the fish! Then add to that the potential value of the waters for recreation and attracting tourists who would bring more money into the Turkish economy.

Pollution of the air causes great economic loss in the form of corrosion of metals and stone (e.g. the damage to many national treasures and monuments in Europe, especially in Italy, owing to air pollution). Another cost of air pollution is the additional money spent to clean clothing and other articles soiled by polluted air. But the major cost of air pollution is the harm it does to man and domestic animals. This is well documented by statistical studies on the correlation between air pollution and an increased death rate, hospital admissions, and lost time from work resulting from increased respiratory illness in many of the large cities of the western world, e.g. New York and London. In the United States cattle have died from fluoride emissions from phosphate fertiliser plants; essentially all such fluoride air pollution has now been brought under control. Why should the owner of a factory enjoy a lower manufacturing cost by polluting the air and thus oblige other citizens and the government to pay higher medical bills, and cause loss of working days and increased costs?

Table 1. Annual fish catch in Izmit Bay
(Tons)

	1963	1964	1965	1972
Red mullet	-	2	3	disappeared
Anchovy	30	28	35	disappeared
Jack mackerel	50	10	13	a/
Turbot	1	2	1	disappeared
Mullet	15	48	49	a/
Spanish mackerel	7	8	14	disappeared
Blue fish	4	7	11	disappeared
Atlantic bonito	-	24	341	a/
Pilchard	3	6	10	disappeared
Mackerel	300	9	16	disappeared
Others	66	83	127	a/
	426	277	620	86a/

Source: Based on "Environmental aspects of industrial development in developing countries: case study of the chemical industry in Turkey" (UNIDO/ITD.334).

a/ Total catch data available only for 1973.

Table 2. Annual fish catch in Marmara Sea region
(Kilogramme)

	1970	1971	1973
John dry	1 040	130	-
Sea bream	675	630	500
Beasbed rockling	1 527	865	-
Grenybus	200	-	-
Barracuda	2 750	1 610	-
Turbot	428 324	324 163	156 000
Angel shark	10 560	5 220	-
Gurnard	23 391	18 443	13 690
Blue fish	1 043 756	1 216 190	847 000
Atlantic bonito	1 489 025	1 584	882 000

Source: Based on "Environmental aspects of industrial development in developing countries: case study of the chemical industry in Turkey" (UNIDO/ITD.334).

Dirty water and air, noise, odours, dumps and waste material lower the value of land; that is, the land becomes less desirable and will therefore bring a lower price. Build a luxury hotel or a resort next to a stinking dump and see how many customers come back!

Impact on air

Emissions from chemical manufacturing to the air may be gases, dusts, fumes and aerosols. Often the primary emissions are odorous and toxic; sometimes they are at first innocuous but react later in the atmosphere to form undesirable secondary products. It is almost impossible to generalize about the nature of the emissions, except that they are closely related to the nature of the given chemical process and often include the final product, intermediate products and the raw materials of the process. It is obvious that the various types and locations of potential air pollution emissions from a particular process are best understood and assessed by studying flow charts, material balances and equipment layout for a process. Emissions from a chemical process almost invariably include combustion products such as fly ash, oxides of sulphur and oxides of nitrogen, in amounts that depend on the composition of the fuel and the conditions of combustion, because modern chemical processes require large amounts of energy to drive pumps, compressors, blowers, boilers, and distillation and evaporation units.

In general, we may expect emissions of organic vapours of intermediates and solvents from the paint, resin and plastics industries. Sulphuric acid manufacture leads to emissions of the gas SO_2 as well as aerosol mists containing SO_3 and H_2SO_4. The manufacture of other acids also leads to acid mists, e.g. oxides of nitrogen from nitric acid plants.

Phosphate fertiliser plants, which use phosphate rock and sulphuric acid as raw materials, often produce emissions of sulphur dioxide gas as well as gaseous and particulate emissions of ammonia and fluoride. Fluoride emissions may cause severe damage to vegetation and animals feeding on such vegetation. Such kinds of industry are probably of great importance for a nation that is shifting from an agrarian to an industrial economy, because the manufacture of fertilizer produces an important product for an internal market.

Table 3 shows some other types of air pollution emissions from other inorganic chemical industries.

Table 3. Miscellaneous inorganic chemicals and associated air pollution emissions

Inorganic chemical produced	Major air pollution emissions
Calcium oxide (lime)	Lime dust
Sodium carbonate (soda ash)	Ammonia - soda ash dust
Sodium hydroxide (caustic soda)	Ammonia - caustic dust and mist
Ammonium nitrate	Ammonia - nitric oxides
Chlorine	Chlorine gas
Bromine	Chlorine gas

Source: A. C. Stern and others, Fundamentals of Air Pollution (New York, Academic Press, 1973), p. 364.

Petroleum refineries are responsible for the following kinds of air pollution: hydrocarbons from leaks, loading, sampling etc.; sulphur oxides from boilers, treaters, regenerators and flares; carbon monoxide from regenerators and incinerators; nitrogen oxides from combustion sources and regenerators; odours from air and steam blowing, condensers, drains and vessels; and; particulate matter from boilers, catalytic crackers, regenerators, coking and incinerators.

From steel plants we may expect emissions of metal oxides, smoke, fumes, dusts, organic and inorganic vapours and gases; if steel scrap is melted, it may contain grease and oil which then give rise to considerable organic gases and fumes. Smelting of non-ferrous metals often leads to emissions of sulphur oxides and fluorides; metal oxide dusts and fumes can be particularly toxic, especially from metals such as lead, zinc, cadmium, arsenic, mercury, vanadium, manganese and bismuth.

Cement, stone, clay, talc, chalk, asbestos and glass production give rise to considerable dusts and particulate emissions. In general the smaller the particle size, the greater the health hazard from these dusts. The extremely hazardous carcinogenic action of asbestos is now well known.

The Kraft pulp process for paper manufacturing produces emissions of particulate matter, sulphur oxides from the oxidising zone of recovery furnaces and very odorous reduced sulphur compounds from the reducing zones. Such plants require extensive controls which are expensive.

To speak at length about air emissions from organic chemical manufacturing would be beyond the scope of this paper. Emissions may arise from raw materials, intermediates and final products of any such process. As two examples, consider the manufacture of the important monomer acrylonitrile, and the important precursor of rayon called viscose. Acrylonitrile manufacture gives rise to organic wastes that are usually incinerated thereby producing oxides of nitrogen; hydrogen cyanide gas, vapours of acrylonitrile and related organic compounds may also be emitted from process equipment. Viscose manufacture leads to emissions of gases containing H_2S, CS_2 and NH_3.

Figures IV, V, and VI show some of the effects of various concentrations of sulphur oxides, particulate matter and nitrogen oxides respectively. The figures are largely self-explanatory; the distressing effects shown in those figures have led the Government of the United States to set the ambient air quality standards shown in table 4 and the new-source emission standards shown in table 5. The United States Environmental Protection Agency is currently developing emission standards for the chemical industry on a process-by-process basis.

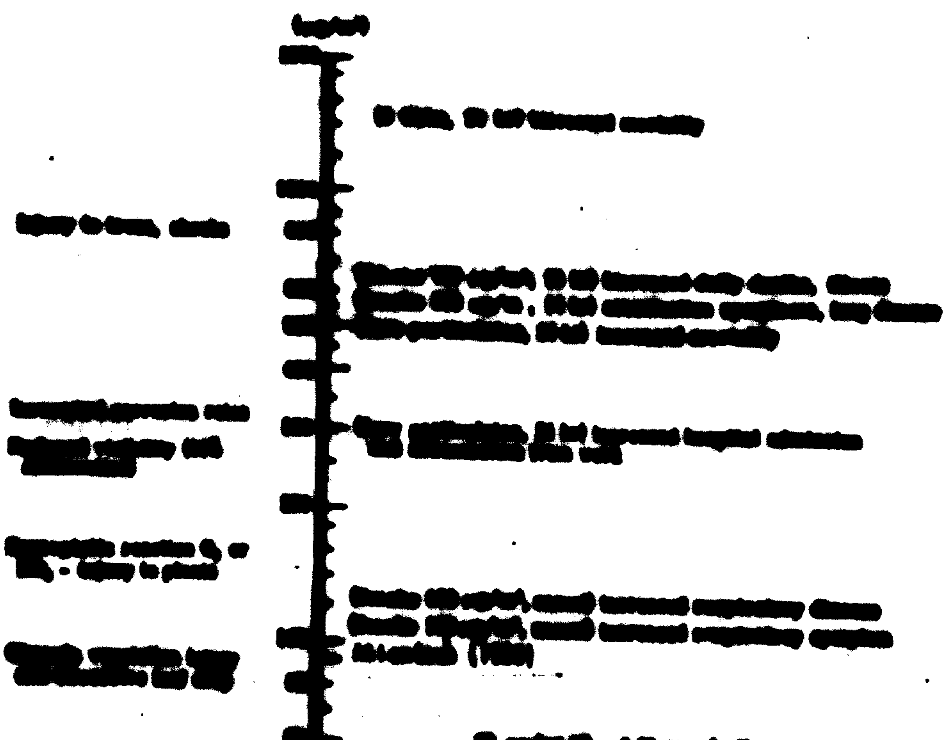


Figure IV. Air-quality criteria for particulates

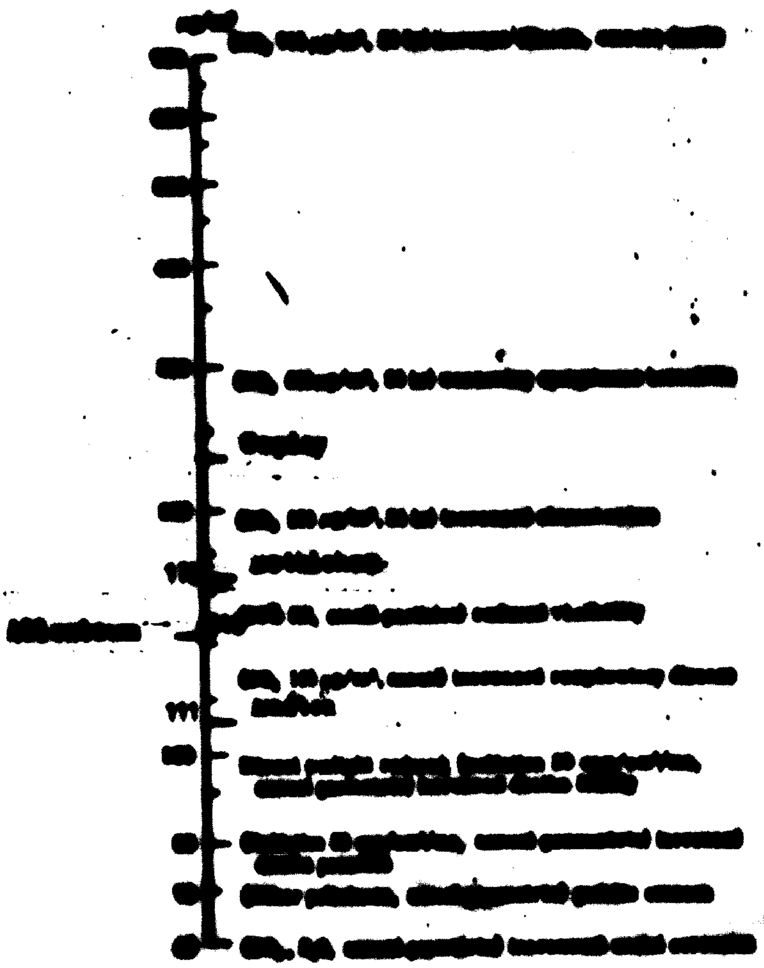


Figure V. [illegible]

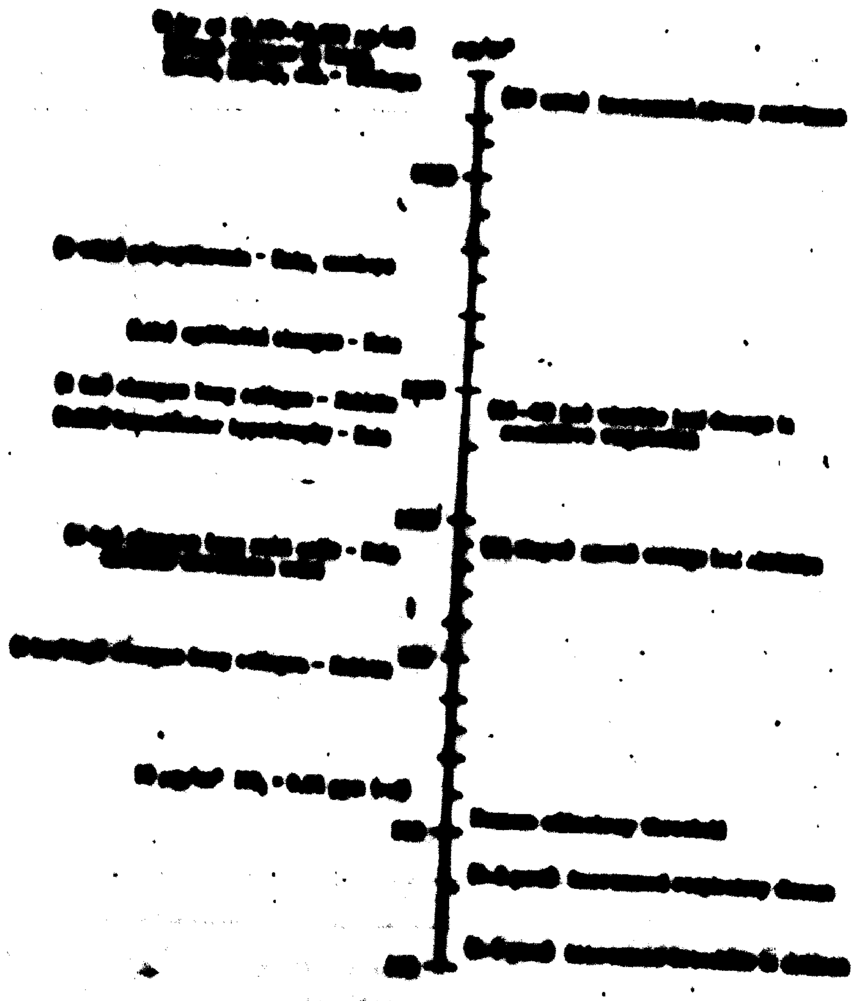


Figure VI. [illegible]

Table 4. National air-quality standards in the United States

Substance	Air-quality standard ($\mu g/m^3$)	
	Primary (human health)	Secondary (all other effects)
Sulphur dioxide		
Annual arithmetic mean	80	60
24-hour max[a]	365	260
3-hour max[a]	-	1 300
Particulate matter		
Annual geometric mean	75	60
24-hour max[a]	260	150
Carbon monoxide		
8-hour max[a]	10 000	10 000
1-hour max[a]	40 000	40 000
Oxidant		
1-hour max[a]	160	160
Nitrogen oxides (e.g., NO_2)		
Annual arithmetic mean	100	100
Hydrocarbons		
3-hour max (6-9 a.m.)	160	160

Source: A. C. Stern and others, *Fundamentals of Air Pollution* (New York, Academic Press, 1973), p. 155.

a/ Not to be exceeded more than once per year.

Table 5. Summary of standards for new or substantially modified sources

1. Steam generators (> 250 million Btu/h heat input)
   - (a) Particulate matter
     - (1) 0.1 lb/million Btu heat input (0.18 g/million calorie)
     - (2) No more than 20% opacity visible emissions, except for two minutes in any hour visible emissions may be as great as 40% opacity.
   - (b) Sulphur dioxide
     - (1) 0.8 lb/million Btu heat input (1.4/million calorie) when oil is fired
     - (2) 1.2 lb/million Btu heat input (2.2 g/million calorie) when coal is fired
   - (c) Nitrogen oxides (as NO_2)
     - (1) 0.20 lb/million Btu heat input (0.36 g/million calorie) when gas is fired
     - (2) 0.30 lb/million Btu heat input (0.54 g/million calorie) when oil is fired
     - (3) 0.70 lb/million Btu heat input (1.26 g/ million calorie) when coal is fired
2. Incinerators (> 50 tons/per day charging rate)

   Particulate matter

   0.08 grains/st cu ft corrected to 12% CO_2 (0.18 g/NM^3)
3. Portland cement plants

   Particulate matter
   - (1) 0.30 lb from the kiln per ton of feed to the kiln (0.15 kg/metric ton of feed)
   - (2) 0.10 lb from the clinker cooler/ton of feed to the kiln (0.05 kg/ metric ton of feed)
   - (3) No more than 10% opacity visible emission from kiln and cooler
   - (4) Less than 10% opacity visible emission from all other sources in the plant
4. Nitric acid plants

   Nitrogen oxide (as NO_2)
   - (1) [illegible] lb/ton of acid produced (1.5 kg/metric ton)
   - (2) Less than 10% opacity visible emission
5. Sulphuric acid plants
   - (a) Sulphur oxide

     [illegible] lb/ton of acid produced (2 kg/metric ton)
   - (b) Acid mist
     - (1) 0.15 lb/ton of acid produced (0.075 kg/metric ton)
     - (2) Less than 10% opacity visible emission

[illegible] Washington, D.C.

Some examples of air pollution emissions in Turkey include SO_2 from the Seka pulp and paper mill at Izmit, Hg from the Seka chloralkali plant at Izmit, SO_2 from the Koruma sulphuric acid plant at Izmit and the Etibank sulphuric acid plant at Bandirma. The Seka pulp and paper mill emits about 11 tons of SO_2 per day but the plant is scheduled to be closed within about the next five years. The Seka chloralkali plant experiences Hg losses of about a ton per year, a significant part of which is in the waste hydrogen vented to the atmosphere. The insidious poisoning caused by mercury is well known. Aside from the widely publicized Hg poisonings of many people from eating fish caught in the coastal waters of Japan and reported in the international press, there have also been losses of working time in the Seka chloralkali plant, amounting to about LT 36 500 per year and attributed to attacks of chronic and acute bronchitis, possibly owing to the inhalation of chlorine. The Etibank H_2SO_4 plant at Bandirma emits about 50 kg SO_2 per hour through a 50 m stack, or about 0.06 mg SO_2/m^3 or 3.7 kg SO_2/ton H_2SO_4; fugitive dust from the pyrites cinder waste dumps at this plant were once troublesome but they have now been brought under control. The Koruma H_2SO_4 plant at Izmit emits 350 kg of SO_2 per day through an 13 m stack or about 17.5 kg SO_2 per ton H_2SO_4. These SO_2 emissions are compared with USEPA new source standards in table 6.

Table 6. SO_2 emissions, kg/ton H_2SO_4

Etibank, Bandirma	Koruma, Izmit	USEPA standard
3.7	17.5	2.0

It should be mentioned, on the positive side, that practically no acid mists are discharged from the Etibank H_2SO_4 plant. It should also be mentioned that there are phosphate fertilizer plants in these regions where it appears that air emissions of fluoride are well controlled; these phosphate plants are discussed later in this chapter.

Impact on water

Just as in the case of air pollution, the effect of the chemical industry on water depends on the particular process or processes involved. In general it is possible that raw materials, intermediates, final products and by-products as well as unwanted wastes will be released from chemical processes to streams and other natural waters.

Two important effects on water are: (a) the introduction of specific toxic or poisoning agents such as cyanides and heavy metal cations and (b) the introduction of chemical reagents which react with and thereby deplete the dissolved oxygen in water bodies below the level that will support higher aquatic life. Such reaction with dissolved oxygen may be biologically mediated or it may, in the case of many compounds, proceed without the presence of micro-organisms. Such oxygen-demanding compounds are often organic chemicals, but some inorganic compounds (e.g. NH_3) can cause large depletion in oxygen concentrations. Although most toxic and oxygen-demanding impurities (with a few exceptions such as nitrate ion) can be removed from water to make it potable by using well-accepted treatment processes, great concern still remains over the destruction of aquatic life either by toxic materials or through the depletion of oxygen content below levels that will sustain life. There is also the great danger that toxic substances will be concentrated by the food chains of nature in the higher forms of aquatic life such as fish. These kinds of processes have led to the well-known cases of mercury and cadmium poisoning in Japan from eating fish caught in coastal waters to which industrial waste has been released.

In general, any chemical industry that uses or manufactures organic compounds has the potential for releasing such compounds to waterways either through leaks, accidental spills or deliberate discharge of waste materials. Petroleum refineries and petrochemical complexes are troublesome in this regard, especially owing to leaks from process streams into process cooling water.

In addition to air emissions from the processes mentioned above, water pollutants also arise from the manufacture of acrylonitrile and viscose. Acrylonitrile processes may be expected to produce water as a reaction product; this water contains $(NH_4)_2SO_4$, nitrites and related compounds, and it should be purified by a combination of chemical and biological treatment. Aqueous waste from viscose manufacture contains considerable dilute acid (H_2SO_4), $(NH_4)_2SO_4$ and suspended sulphur; it must be neutralized, purified of dissolved solids by precipitation and of suspended solids by flocculation before release to waterways. Table 7 lists the main liquid waste and gives suggested treatment for several other organic chemical processes.

Especially troublesome industrial water pollutants are toxic heavy metal cations such as lead and mercury and toxic anions such as chromate and cyanide. Such substances can be discharged by the non-ferrous metals industries, from metal plating and pickling, photographic processing, and production of steel and coke. The release of phosphates is thought to be at least a partial cause of over-fertilization and eutrophication in receiving waters; although most phosphate comes from municipal waste, significant phosphate can be contributed by chemical processes such as the manufacture of phosphate fertilisers.

Acid waste-waters, which can come from a large variety of chemical processes, clearly adversely affect aquatic life, and it is usually required that they be neutralized. Often the neutralization introduces large quantities of calcium that is difficult to remove.

Wastes containing substituted aromatic compounds, phenols and ammonia are often discharged from coke-oven operations. These aromatics and phenols are especially difficult to treat by biological means such as activated sludge and, for complete removal, adsorption by active carbon may be necessary. Such phenols can cause obnoxious tastes and odours in drinking water supplies when the water is chlorinated, thereby producing chlorophenols which make their presence known to man's olfactory senses even when their concentrations are as low as a few parts per billion. The ammonia in coke-oven waste discharged to streams is eventually oxidized to nitrate, thereby depleting oxygen in the waters and contributing nitrate ions which are especially toxic to the new-born and young children.

The paper and pulp industry produces a waste-water that has a high oxygen demand owing to the presence of the degradation products of cellulosic fibre, and a very high colour content owing to the presence of tannins and other compounds. The total concentrations of suspended and dissolved solids are high.

Table 7. Organic chemical industry pollution survey results

Product	Process	United States production, [illegible] (million lb)	Main liquid waste	Suggested treatment
Styrene	Styrene is produced by the high temp. dehydrogenation of ethyl benzene	3,500	a water-styrene-ethyl benzene mixture containing some oil is a major waste load	The tars and polymers produced in the final separator could be incinerated rather than sent to a waste-water system
Vinyl chloride and polyvinyl chloride (PVC)	1. The reaction of acetylene and HCl forms vinyl chloride 2. Ethylene processes involve direct chlorination and dehydrochlorination	2,700 mil lb vinyl chloride	The vinyl chloride waste stream (8 gal/ton product) contains organics, NaCl FeCl, NaOH and NaClO$_3$ The PVC process waste stream is about 2 000 gal/ton product and has a COD of 1 200-1 500 mg/l	The use of oxychlorination processes greatly reduces waste loads from the vinyl chloride process Changes in polymerization may affect to some degree the waste loads from the PVC process
Ethylene	Produced from ethane propane refinery off gas and other sources. The process involves cracking, compression, and purification	12,500	1. Oily compressor water 2. Coke and tar in furnaces 3. Spent caustic 4. "Green oil" produced as a polymerizing product during acetylene hydrogenation	1. "Green oil" can be be used as plant fuel 2. Recovery of alkali values of the spent caustic stream 3. Process condensate may be stripped with live steam to remove all non-phenol contaminants. These may be removed by contact with fresh feed

Source: Industrial Pollution Control Handbook (Cleveland, Ohio, Chemical Rubber, 1974).

Suspended solids in waste-water occur from a number of industries. The paper industry may release to streams great quantities of undesirable short fibres and related particles; the paint, pigment, talc, gypsum, asbestos, cement, steel and non-ferrous metals industries frequently discharge waters containing various amounts of suspended particles of raw materials, intermediates, final products, by-products and waste products.

Some further appreciation of the possible complexity of the impact of the chemical industry on the aquatic environment may be appreciated by consulting the appendix to this chapter which shows a listing of stream quality criteria for the Ohio River Valley in the United States. Note that the chemical constituents are specified for public water supplies, whereas the criteria for aquatic life limit any toxic substance without giving specifications. To assess the impact of a particular chemical process installation on the aquatic environment, the various possible effluents should be determined together with criteria such as these and data on stream-flow rates and existing water quality.

Some examples of water pollution in Turkey are discussed below. The major problems appear to be in the Izmit-Marmara Sea area. At Izmit the Seka pulp and paper mill releases about 5 million gal/day of aqueous waste which has a pH of 2.4 and a Biochemcial Oxygen Demand (BOD) of 4,000 ppm; this high-strength waste should be neutralized and subjected to biological treatment. The Seka chloralkali plant releases significant amounts of mercury in the recycle brine bled from the process; together with the Hg released with the vented hydrogen this amounts to a total Hg loss of about a ton per year. Mercury could be removed from the brine by chemical reduction and settling; alternatively the electrolytic cells might be redesigned to reduce the Hg loss. In the Koruma chloralkali plant there are similar problems with loss of Hg in the liquid effluent, although excess Hg is removed from the H_2 by cooling and the H_2 is used to make HCl, thereby avoiding release of H_2 and Hg to the air.

These two chloralkali plants at Izmit produce a large amount of solid waste as a precipitate, which occurs from treating the incoming brine with Ba Cl_2, NaOH and Na_2CO_3 to precipitate sulphate, magnesium and calcium. These precipitates are flushed into Izmit Bay. A better practice would be to use the precipitates for landfill.

One of the worst situations at Izmit appears to be the Koruma DDT plant which releases to the bay about 4,800 tons per year of 78 per cent H_2SO_4 which also contains significant amounts of chlorinated waste products. One approach would be to neutralize the acid and remove chlorinated organic compounds by adsorption. A far more attractive alternative would be to sell the acid to the Gubre phosphate fertilizer plant at Yarimca 15 miles north of Izmit. It might be necessary to remove chlorinated organic compounds, however, before the H_2SO_4 waste could be used to manufacture phosphate. With regard to the Gubre phosphate fertilizer plant at Yarimca, it is fortunate that fluorides are prevented from entering the air by water-scrubbing but, unfortunately, the fluoride-scrubbing effluent is released untreated to the Bay. Neutralization and precipitation of the fluoride using lime should not entail great additional costs.

Bandirma Etibank has a sulphuric acid plant and a plant that produces boric acid and borax from the minerals Colemanite ($2CaO.3B_2O_5.5H_2O$) and Tinkal ($Na_2O.2B_2O_3.10H_2O$). In the filtration purification steps, much of the final borax and boric acid is lost and discharged through a 5 km pipeline into the Marmara Sea; 32,000 tons per year of borax are produced, but 5,000 tons per year are left behind in the filter cake and lost - a very significant amount; 25,000 tons per year of boric acid are produced, but 2,000 tons are discharged each year owing to inefficient filtration - again a very significant fraction. These filtration problems will probably be studied and solved in the Scientific and Industrial Research Institute now under construction at nearby Gebze. The Etibank sulphuric acid plant, mentioned above in connexion with air pollution, also produces a waste stream of dilute H_2SO_4 which is used in the boric acid plant. This is an example of solving a waste problem with a localised profit benefit. There is also a privately owned phosphate fertilizer plant at Bandirma in which the fluoride is removed by scrubbing with sea water; this has led to blockages of the scrubbing tower packing owing to the deposit of insoluble sodium silico fluoride (Na_2SiF_6) formed by reaction between the NaCl in the sea water and H_2SiF_6. This problem might be solved by using a spray tower, but would probably require a larger tower to achieve the same removal of fluoride.

Noise, thermal, visual and solid waste pollution

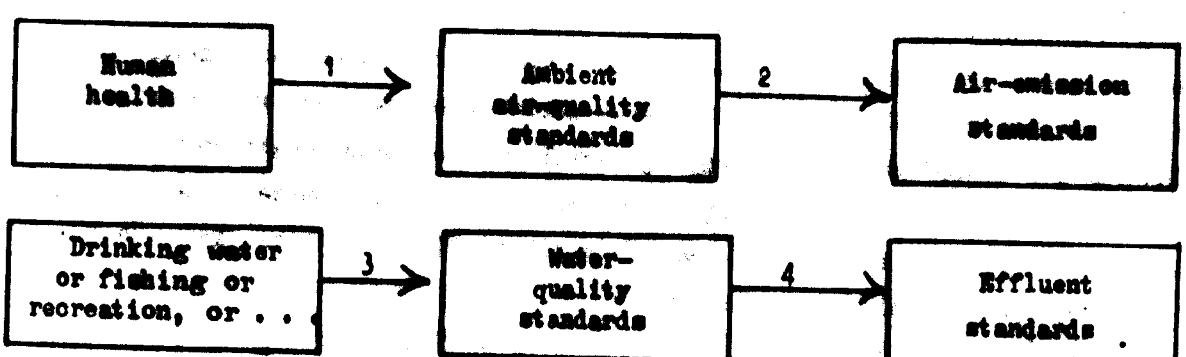
Chemical plants produce noise arising from compressors, pumps, blowers, flares, flames, steam-jet ejectors and, of course, maintainance work. They also produce thermal pollution by heating water in condensers and coolers and then discharging it to streams where the increased temperature can interfere with aquatic life and the general ecology of water bodies in ways not yet fully understood. The visual pollution from denuded vegetation, choked and oil-coated waterways, festering waste lagoons, large process units not designed with any aesthetic purpose in mind, and general untidyness is associated with industrialized districts in general, irrespective of where they may be found in the world. Such visual pollution is no stranger to those who live or work near industrial chemical installations, and it can be seen in a variety of heavily industrialized districts in countries throughout the world. Solid wastes also accumulate from chemical operations. When a solid, insoluble by-product cannot be sold for use in another industry or in another chemical process it accumulates and must be disposed of. Although the chemical process industries have their share of such solid wastes, the situation is usually not so distressing as in the cases of, for example, mine tailings, cement dust, fly ash and municipal garbage waste. Such solid wastes frequently accumulate in the chemical industry as the result of practicing air and water pollution control; that is, such solid wastes frequently are the dusts collected from effluent gases and the sludges and precipitates that are produced when water is treated to purify it before release to streams.

Standards for regulating pollution

The air-emission standards and water-effluent standards to which the chemical industry is subject in the United States are based on achieving certain ambient air-quality standards and certain stream water-quality standards. The ambient air-quality standards are based on public health considerations; water-quality standards are usually based on the most demanding use to which the water body is put: public water supply, industrial water supply, fishing for recreation or food supply, that is, preservation of the highest forms of aquatic life or recreation such as swimming. One way to distinguish between the two general types of standards is to say that air-quality standards and water-quality standards describe a desired condition of situation of air or water, whereas air-emission standards or water-effluent standards prescribe abatement actions and limit polluting activities. Air-quality standards are usually set with the public health in mind, that is, to define a certain quality of air that will ensure the health and safety of those who breathe that air; the air-emission standards are then set and imposed as regulations by law in order to achieve the desired ambient air quality. Likewise with water; first it must be decided to what purpose a body of water is to be put (e.g. drinking supply, fishing, recreation, industrial water supply), and the water-quality standards are set accordingly. Effluent standards or regulations are then set in order to achieve the water-quality standards.

In each instance there are certain minimum federal standards that must be met. Actual pollution control regulations, however, and their enforcement are usually left to the individual state or other local body with the proper jurisdiction; for example, the Delaware River Basin Commission or the Ohio River Valley Water Sanitation Commission. The regulations and enforcement activities of these bodies must meet at least certain minimum federal laws and guidelines; if they do not, the Federal Government can exercise the option to enter the situation and enforce federal laws.

It is important to mention that in the United States most water- and air-quality standards have been set after considering a vast amount of data that are nevertheless still insufficient for firm conclusions. Furthermore, the effluent and emission regulations are set to achieve certain water- and air-quality standards, again with much but still insufficient information as to how the quality of natural water and ambient air is influenced by various effluents and emissions. These uncertainties can be shown diagramatically as follows:



Note that arrow 1 represents all of the poorly known, difficult-to-measure and controversial scientific and medical data regarding the relationships between human health and the quality of the air breathed. Similarly, arrow 3 represents the equally controversial and poorly known criteria linking aquatic life and water quality or linking human health and the quality of drinking water. In spite of the uncertainty (especially as to long-term and cumulative effects), there are still certain limits that are well known, for example, what concentration of carbon monoxide in the air leads to death by asphyxiation of the average human or what quantity of cyanide ingested causes fatal poisoning of the average human. There are also many uncertainties represented by arrows 2 and 4, and these have to do with the effects of such variables as meteorology, geology, topography and the natural assimilative and self-cleansing aspects of the bodies of air or water in question. In these matters also there are certain extreme limits that can be known with reasonable certainty. It must be remembered, however, that in spite of the scientific and technical controversies and uncertainties about the relationships represented by the arrows, essentially all the industrial nations of the world have now set standards and made regulations and rules governing emissions to the air and discharges to waterways.

Because there will always be uncertainty in these relationships, which are used by our governmental bodies to set emission and effluent standards (that is, the standards themselves are not legislated but set by bodies of administrative government), such standards remain subject to challenge in the courts of the United States. In other words, it would be appropriate for an aggrieved party to bring suit in a court of appropriate jurisdiction in an attempt to have a standard changed on the basis of newly uncovered information or old information which had been overlooked or neglected in the original process of setting standards. It would be wise for any nation now developing environmental control legislation and enforcement bureaucracies to try to build into the system the option for later adjustments and remedies for standards that may be set unrealistically at first. Whether these opportunities for challenge and change would be through judicial suit or other means would of course depend on the particular type of government; and of course it should be possible for the challenges to be made from either direction, that is either for stricter or for relaxed standards.

Another interesting approach to pollution regulation might be termed blanket regional regulation or land-use management. Some examples of this in the United States are Dade County in Florida which has outlawed the sale of phosphate-containing detergents and Suffolk County on Long Island where the sale of detergents has been banned entirely. In June 1971 the State of Delaware, by the combined action of its governor and legislators, passed a coastal zone law which bans new heavy industry along the entire 100-mile coastline of that small State. This law thwarted plans for $750 million of industrial development, including a new oil refinery. The Delaware Coastal Zone Act defines heavy industry in a way intended to itemize characteristics associated with steel mills, pulp and paper mills and petrochemical-oil refining complexes. The Coastal Zone Act lists eight characteristics of "heavy industrial use", which are shown in table 8.

Talbe 8. Delaware Coastal Zone Act: heavy industry characteristics

Land area in excess of 20 acres and some of the following:
Smoke stacks
Tanks
Distillation or reaction columns
Chemical processing equipment
Scrubbing towers
Pickling equipment
Waste treatment lagoons

Source: Coastal Zone Act, State of Delaware, United States of America.

Finally, in discussing the regualtion of pollution, two very important information-gathering activities should be mentioned. First there is the requirement for preparation and filing with appropriate governmental agencies "environmental impact statements" for any newly contemplated project ranging from housing developments to the construction of chemical factories to developing an SST aircraft. These statements must be prepared by any private citizen, industrial corporation or even any governmental body planning a project and they must include a full discussion and assessment of all environmental effects, favourable and unfavourable, of the contemplated project. The other device of interest here is the requirement for obtaining a permit by registering with the state or local jurisdiction all air-pollution and water-pollution sources above certain sizes; such registrations are done by completing forms which indicate full specifications and particulars. The registration can then be used as the basis for carrying out routine or random inspections by enforcement personnel.

Abatement of pollution - water

Biological treatment by the activated sludge process often cannot be carried out on wastes from chemical processing until certain contaminants are removed or reduced in concentration to the extent that micro-organisms can grow in the waste-water and metabolize the biodegradable constituents. This preliminary physico-chemical treatment is often accomplished by coagulation and precipitation; beyond this, remaining dissolved components can often be removed by adsorption, dialysis, reverse osmosis, electro-dialysis, ultrafiltration, ion exchange or other such "advanced" techniques. Figure VII shows various processes or unit operations for removing various types of water pollutants. In this figure the pollutants are divided according to whether they are organic or inorganic and further, within either of these categories, according to whether they are soluble, colloidal or suspended. Figure VIII is a related diagram intended to show how the various unit operations can be applied to achieve various levels of removal ranging from screening for coarse solids to such techniques as dialysis and ion exchange for removal of inorganic ions.

It is interesting that United States laws, which require that effluent waters from new plants be treated by the "best available technology", are bringing about increased frequency of some of the more sophisticated purification processes. The result is that many industries are being led to practice almost complete water reuse where the effluent regulations are so severe that water purified for release to streams is sufficiently pure to use over again in the process.

Abatement of pollution - air

The many techniques for curtailing particulate emissions are summarized in table 9 where they are compared as to the particle-size ranges for which they are effective, removal efficiencies, space requirements, maximum operating temperature, induced pressure drop and annual operating cost. Some general

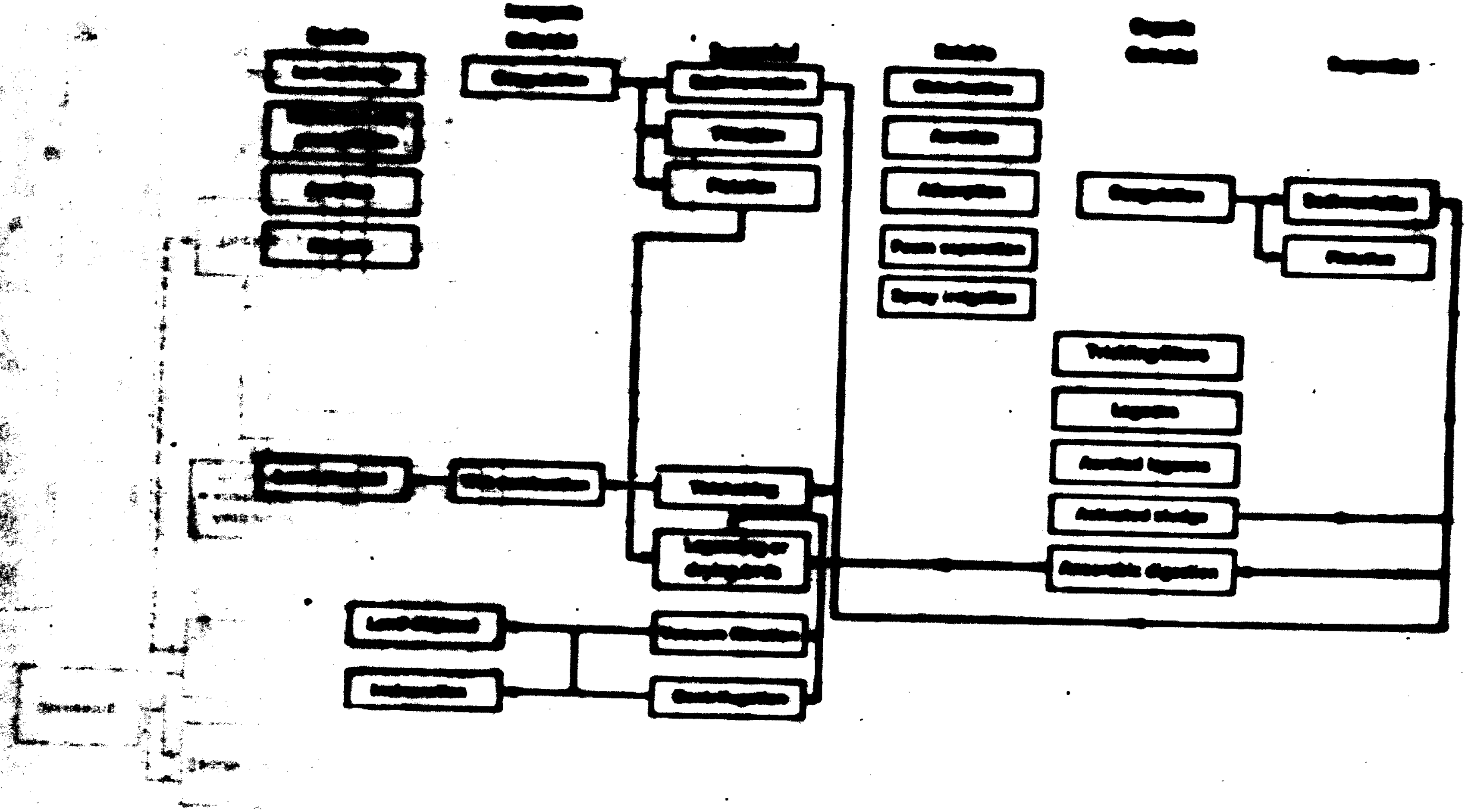


Figure VII. Processes for the removal of industrial waste pollutants

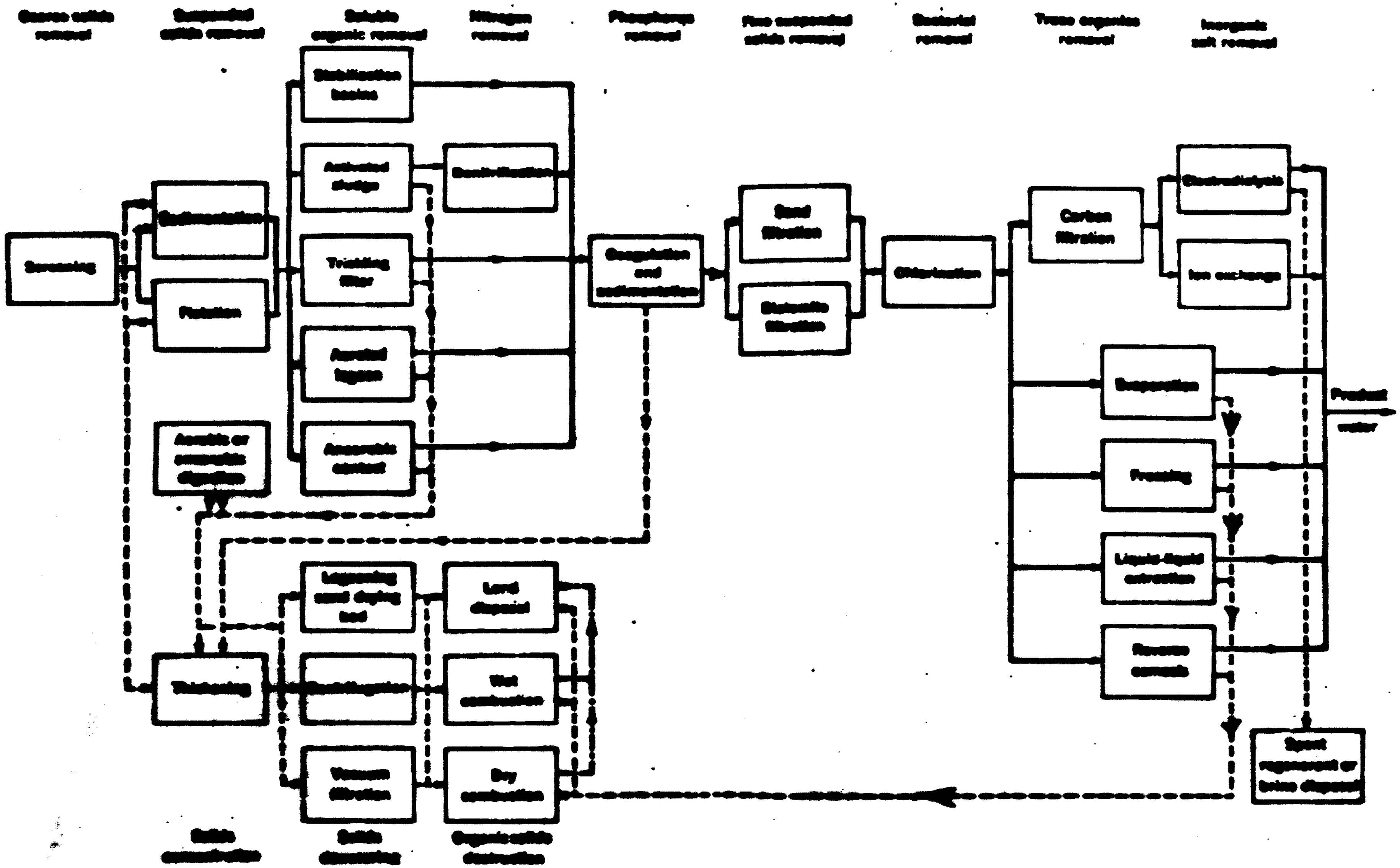


Figure VIII. Treatment of waste waters to effect various degrees of contaminant removal techniques applicable to the removal of certain gaseous pollutants are compared in table 10 regarding pressure drop, installed cost and operating cost. Sulphur dioxide still remains a very troublesome gas to remove, and many different types of SO_2 control systems are under development; a number of these are listed in table 11.

Scrubbers are worthy of particular mention because they can be employed to remove both gaseous and particulate pollutants. Some different types of scrubbers are listed in table 12.

Finally, a very important method of pollution control should be mentioned, that is, process improvement or process modification; this approach is applicable to both air and water pollution control. Aside from such obvious things as improved housekeeping (to prevent spills for example), it includes combustion modification, gas cooling and heat recovery, incineration, operating existing equipment at lower throughputs or modified temperatures, and of course proper design or modified design of stacks and diffusers for accomplishing the greatest possible dilution of emissions and effluents before they interact extensively with the environment.

Table 9. Comparison of particulate removal systems

Type of collector	Particle size range (μ)	Removal efficiency	Space required	Maximum temperature (°C)	Pressure drop (cm, H_2O)	Annual cost ($ per year/(m³)a/
Bag house (cotton bags)	0.1-1.0	Fair	Large	80	10	7.00
	1.0-10.0	Good	Large	80	10	7.00
	10.0-50.0	Excellent	Large	80	10	7.00
Bag house (Dacron, nylon, orlon)	0.1- 1.0	Fair	Large	120	12	8.00
	1.0-10.0	Good	Large	120	12	8.00
	10.0-50.0	Excellent	Large	120	12	8.00
Bag house (glass fibre)	0.1- 1.0	Fair	Large	290	10	10.50
	1.0-10.0	Good	Large	290	10	10.50
	10.0-50.0	Good	Large	290	10	10.50
Bag house (Teflon)	0.1- 1.0	Fair	Large	260	20	11.50
	1.0-10.0	Good	Large	260	20	11.50
	10.0-50.0	Excellent	Large	260	20	11.50
Electrostatic precipitator	0.1- 1.0	Excellent	Large	400	1	10.00
	1.0-10.0	Excellent	Large	400	1	10.00
	10.0-50.0	Good	Large	400	1	10.00
Standard cyclone	0.1- 1.0	Poor	Large	400	5	3.50
	1.0-10.0	Poor	Large	400	5	3.50
	10.0-50.0	Good	Large	400	5	3.50
High-efficiency cyclone	0.1- 1.0	Poor	Moderate	400	12	5.00
	1.0-10.0	Fair	Moderate	400	12	5.00
	10.0-50.0	Good	Moderate	400	12	5.00
Spray tower	0.1- 1.0	Fair	Large	540	5	12.00
	1.0-10.0	Good	Large	540	5	12.00
	10.0-50.0	Good	Large	540	5	12.00
Impingement scrubber	0.1- 1.0	Fair	Moderate	540	10	11.00
	1.0-10.0	Good	Moderate	540	10	11.00
	10.0-50.0	Good	Moderate	540	10	11.00
Venturi scrubber	0.1- 1.0	Good	Small	540	88	20.00
	1.0-10.0	Excellent	Small	540	88	20.00
	10.0-50.0	Excellent	Small	540	88	20.00

Source: A. C. Stern and others, Fundamentals of Air Pollution - (New York, Academic Press, 1973), p. [illegible]

a/ Including water and power cost, operating cost, capital and insurance costs.

Table 10. Comparison of gaseous pollutant removal systems

Type of equipment	Pressure drop (cm, H_2O)	Installed cost ($ per m^3)	Annual operating cost ($ per m^3)
Scrubber	10	2.45	3.50
Absorber	10	2.60	7.00
Condenser	2.5	7.00	1.75
Direct flame afterburner	1.2	2.10	2.10 + gas
Catalytic afterburner	2.5	2.90	7.00 + gas

Source: A. C. Stein and others, Fundamentals of Air Pollution (New York, Academic Press, 1973), p. 422.

Table 11. Possible SO_2 control systems

Method	Remarks
Limestone - dolomite injection (dry)	Calcined limestone reacts with sulphur oxides. Then dry particulate control system.
Limestone - dolomite injection (wet)	Calcined limestone reacts with sulphur oxides. Removal by wet scrubbers.
Alkalised alumina sorption	Sulphur oxides removed by sorption on solid metal oxide. Metal oxides then removed with particulate recovery system and regenerated.
Catalytic oxidation	SO_2 is catalytically oxidized to SO_3 and then scrubbed and recovered as sulphuric acid.
Caustic scrubbing	Caustic neutralises sulphur oxide compounds. Only in use on small processes.

Source: A. C. Stern and others Fundamentals of Air Pollution (New York, Academic Press, 1973), p. 424.

Table 12. Summary of basic types of scrubbers

Basic type	Specific type	Water vs. gas flow: Concurrent or counter or cross	Water circulation: Gpm per 1,000 cfm	Draft loss: Inches water gauge	Per cent collection efficiency on fine cost: Low	Moderate	High
Impingement baffle	tangential inlet wet cyclone	concurrent or cross	3-5	1-4	X	X	
	spiral baffle wet cyclone	concurrent	1-2	4-8	X	X	
	single plate	concurrent	2-4	1-8	X	X	
	multiple plate	concurrent	3-5	6-12		X	
Packed tower	fixed bed	concurrent or counter	10-20	2-4	X		
	fluidized bed	counter	15-30	4-12	X	X	
	flooded bed	concurrent	2-4	4-8		X	
	multiple bed	counter	20-40	4-12		X	
Submerged Orifice	wide slot	concurrent	15-30	2-15	X	X	
	circular slot	concurrent	15-30	2-15	X	X	
	multiple slot	concurrent	15-30	2-15	X	X	
Venturi	high-pressure		5-7	30-100			X
	medium-pressure	cross or	3-5	10-30		X	X
	low-pressure	concurrent	2-4	3-10	X	X	
	flooded disc		5-8	30-70		X	X
Miscellaneous and combination scrubbers	cross-flow packed	cross	1-4	2-4	X	X	
	centrifugal fan	concurrent	1-2		X	X	
	multiple venturi	concurrent	4-6	20-80		X	X
	combination venturi	concurrent	5-7	15-60		X	X
	combination fan type	concurrent	2-3			X	

Source: R. D. Ross, ed., Air Pollution and Industry (New York, van Nostrand-Reinhold, 1972), p. 370.

Appendix

WATER QUALITY CRITERIA OF THE OHIO RIVER VALLEY WATER SANITATION COMMISSION

Minimum conditions applicable to all waters at all places and at all times

1. Free from substances attributable to municipal, industrial or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits.

2. Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial or other discharges in amounts sufficient to be unsightly or deleterious.

3. Free from materials attributable to municipal, industrial or other discharges producing colour, odour or other conditions in such degree as to create a nuisance.

4. Free from substances attributable to municipal, industrial or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

Stream-quality criteria

For public water supply. The following criteria are for evaluation of stream quality at the point at which water is withdrawn for treatment and distribution as a potable supply:

1. Bacteria. Coliform group not to exceed 5,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 per cent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

2. Threshold-odour number. Not to exceed 24 (at 60°C) as a daily average.

3. Dissolved solids. Not to exceed 500 mg/litre as a monthly average value, nor exceed 750 mg/litre at any time. For Ohio River water values of specific conductance of 800 and 1,200 micromhos/cm (at 25°C) may be considered equivalent to dissolved-solids concentrations of 500 and 750 mg/litre.

4. Radioactive substances. Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1,000 micro-microcuries per litre at any time.

5. Chemical constituents. Not to exceed the following specified concentrations at any time:

Constituent	Concentration (mg/litre)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Cyanide	0.2
Fluoride	2.0
Lead	0.05
Selenium	0.01
Silver	0.05

For industrial water supply. The following criteria are applicable to stream water at the point where the water is withdrawn for use (with or without treatment) for industrial cooling and processing:

1. Dissolved oxygen. Not less than 2.0 mg/litre as a daily-average value, nor less than 1.0 mg/litre at any time.

2. pH Not less than 5.0 nor greater than 9.0 at any time.

3. Temperature. Not to exceed 95°F at any time.

4. Dissolved solids. Not to exceed 750 mg/litre as a monthly average value, nor exceed 1,000 mg/litre at any time. For Ohio River water, values of specific conductance of 1,200 and 1,600 micromhos/cm (at 25°C) may be considered equivalent to dissolved-solids concentrations of 750 and 1,000 mg/litre.

For aquatic life. The following criteria are for evaluation of conditions for the maintenance of a well-balanced, warm-water fish population. They are applicable at any point in the stream except for areas immediately adjacent to outfalls. In such areas cognizance will be given to opportunities for the admixture of waste effluents with river water.

1. Dissolved oxygen. Not less than 5.0 mg/litre during at least 16 hr of any 24-hr period, nor less than 3.0 mg/litre at any time.

2. pH. No values below 5.0 nor above 9.0, and daily average (or median) values preferably between 6.5 and 8.5.

3. Temperature. Not to exceed 93°F at any time during the months of May through November, and not to exceed 73°F at any time during the months of December through April.

4. Toxic substances. Not to exceed one-tenth of the 48-hr median tolerance limit, except that other limiting concentrations may be used in specific cases when justified on the basis of available evidence and approved by the appropriate regulatory agency.

For recreation. The following criterion is for evaluation of conditions at any point in waters designated to be used for recreational purposes, including such water-contact activities as swimming and water skiing:

Bacteria. Coliform group not to exceed 1,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per 100 ml (MPN or MF count) on any day.

For agricultural or stock watering. Criteria are the same as those shown for minimum conditions applicable to all waters at all places and at all times.

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III. ENVIRONMENTAL DIMENSIONS IN THE CHOICE OF INDUSTRY AND TECHNOLOGY: ENVIRONMENTAL IMPACT OF THE LEATHER INDUSTRY

Summary of the effects of the Turkish tanning industry on the environment

David Winters*

On the basis of published data about hides and skins and assuming a typical average level of water usage, the Turkish leather industry's input of raw hides and skins is around 32,000 metric tons of fresh salted hide and skin, or about 4.1 million hides per annum (13,666 daily).

The average international water usage for tanning is about 50 l/kg, i.e. 1,000 l per 20 kg of hide. Thus, to process all domestic hides and skins by tanning would consume water and produce effluent of about 4.1 million m^3 annually or 13,666 m^3 daily. In addition to this large volume of liquid effluent, solid wastes of up to 30 per cent of raw hide input may be produced.

The effluent is dark in colour, smelly with high concentrations of soluble and insoluble, organic and inorganic matters (typically a Biochemical Oxygen Demand (BOD) of circa 1,000 mg/l coupled with suspended solids (SS) of circa 2,500 mg/l). Although this effluent has no high toxicity, it can only be described as offensive and noxious; when discharged in volume it may have local ecological effects, although few separate studies have been made of the ecological effect of this effluent.

In areas such as Kazlicesma, the Istanbul suburb, where some 50 per cent of the country's tanning activity is located, the effect is patently apparent for all to see. The roads in the area are honeycombed with sewage channels - often over-flowing - which lead to discharge points on the edge of the sea. Piles of odorous solid wastes line the streets.

Without doubt the impact of the industry on the environment could be greatly improved. Effluents could be processed to acceptable standards and the solid wastes could be better disposed of. It is suggested that a "reasonable" standard of effluent treatment could be obtained for the Turkish tanning industry at a cost of some $US 3.1 million, that is about 3-4 per cent of the $US 60-80 million currently said to be the fixed capital of the tanning industry.

To obtain even this relatively low capital sum from the industry would be difficult today, however, since the industry is striving to improve quality -

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* UNIDO Consultant in the leather industry.

all of its resources are apparently being spent for re-equiping machinery. Thus to use the limited resources to combat hazards to the environment may slow down the progress being made in exports.

The industry could service loan capital for environmental improvement, at less than 1 per cent of leather production costs and with no effect on exports.

Problems are encountered owing to economies of scale. Units producing fewer than 200-300 hides/day could not support effluent treatment plants at a secondary stage, without serious financial loss. Indeed, tanning units producing 100 hides/day would not have the capacity to handle more than primary settlement and decantation.

Only at the level of about 1000 hides/day (10 per cent of the total Turkish tanning industry) would a tannery be able to support an effluent treatment plant with almost no effect on its global competitiveness.

Reference has been made to a "reasonable" standard of effluent treatment. It must be clearly understood that at no tannery in Turkey could one economically treat effluents down to potable water standards. Even the 20/30 BOD/SS standard may well be too stringent for tanneries to fulfil.

Prior to the introduction of effluent control legislation it is essential that the tanners be acquainted with future requirements. At that time major efforts should be made to make the tanners aware of the available "best environmental processes". The adoption of "environmentally sound tanning processes" could achieve over 50 per cent reduction in volume of effluent and greatly reduce the cost of subsequent treatment plant.

The tanning industry and the environment

In this paper an attempt is made to outline the current impact of the tanning industry on the environment and to suggest paths that may be followed, by industry and Government, in order that meaningful improvements may be achieved. Some capital costs are quoted so that the cost of improvement may be measured against achievement.

In defence of the leather industry it should be recognised at the outset that the tanning industry is environmentally and socially necessary, as it processes [illegible], putrefying raw hides and skins into an environmentally acceptable final form. [illegible] (1)* has stated that the value of one kg of

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1/ Numbered references are presented at the end of this paper.

raw cowhide is:

As a BOD charge in effluent treatment: -4.8 to -7.2 US cents
As a nitrogenous fertilizer: 0
For leather manufacture: + 24 to + 48 US cents

Thus, on the basis of 20 kg of hide, each raw hide is a potential liability to society and the environment costing from 96 to 144 US cents. When contrasted with the $US 5-10, which is the amount such a hide realises as a raw material for subsequent tanning, or $US 15-30 for the tanned leather, it is obvious that the tanning operation is potentially, economically and socially, advantageous.

The question then may be put, can the tanning industry improve its environmental impact and at the same time retain its undoubted economic advantage to society?

With conscious effort great improvement could be made at realistic cost. The fields for action are:

(a) The employment of better environmental processes;
(b) Improved treatment and disposal of effluent and solid wastes.

When it is realised that in addition to the large volume of chemicals used and discarded by the tanning industry some 33 per cent of the original protein purchased by the tanner is disposed of additionally either in the effluent or with the solid wastes, it is obvious that the problem is severe.

It may be assumed that utilising typical traditional processing techniques, the volume of effluent produced by tanning per kg of salted hide may well be over 50 l. Thus, a 20 kg hide may require more than 1,000 l of water for processing. This forms the effluent which could have as its major characteristics total solids of about 10,000 mg/l, suspended solids of about 2,000 mg/l and a BOD_5 of over 1,000 mg/l. (See appendix I for full typical analysis.)

A modern "best environmental" process may have only 25 per cent of the water usage suggested above. At such levels the concentration of the effluent may be increased, but, of prime importance, the volume will have been reduced making it more amenable and economical to treat.

To process large volumes of effluent without attempting to reduce the volume can only make for uneconomical yield. Bailey (2) quotes figures in the United Kingdom to show that by using trade effluent charge formulae the cost of effluent treatment related directly to volume varies from 29 to 60 per cent. These figures are derived from municipal sewage works processing composite domestic and industrial wastes, but the same relationship between effluent treatment plant total costs and volume costs could be expected at treatment plants for tanneries or serving industrial estates, since many of the necessary units are designed on flow, e.g. pumping, screening, primary and secondary sedimentation tanks. Thus, the introduction of "best environmental" processes becomes a matter of prime importance and urgency to ensure that treatment charges shall be at realistic levels.

Modern processing techniques ease the cost of effluent treatment and may also reduce the volume and cost of chemicals used in the tanning operation, thus partially offsetting the cost of treatment. To incorporate fully all the available advantageous "best environmental" processes may require a newly constructed tannery. However, many of the processes require little or no plant modification, and others require only minor "plumbing" alterations.

Treatment of tannery effluent does not differ greatly from treatment of any effluent of similar general composition. Tannery effluent possibly contains several chemicals which may give concern to environmentalists, but there is no need for these chemicals to cause any great problems. Sulphide present in the effluent at the level of 100-[illegible]00 mg/l may be economically treated separately in a simple plant (3). Chromium VI (a toxic material) should not be present and chromium III (lesser toxicity) at the concentration found in practice, circa 70 mg/l, should not have any effect on the effluent treatment process, provided proper primary mixing, balancing and settling of the effluents have been effected (4).

In this paper reference is made to "treatment of the effluent" from tanneries. This phrase is deliberately vague; it does not reveal at what standard or level tannery effluents could be treated economically. Realistically, if industry is to expand and develop at the same time that its negative impact on the environment is lessened, expectations must be adjusted accordingly. Technically, there is no problem in producing demineralised water from trade effluent, but the price to be paid may be far higher than an economy could stand. Bailey (2) suggests that by treatment at a secondary stage (biological) the cost would be some 20 per cent of a full effluent treatment including reverse osmosis (RO). Yet even this secondary stage may well achieve about 95 per cent removal of BOD. This may not produce drinking water, or even achieve the frequently quoted standard of BOD/33/25/30 mg/l, but it would certainly make a great improvement in environmental conditions and would appear economically realizable in most countries.

The possible financial and economic effects of effluent treatment are outlined in a later section. The degree to which any particular country may advance is governed very much by its affluence and the priority it attaches to the environment. With domestic sewage the options are clear; with industrial effluent it must be expected that industrialists will claim that account must be taken of global competitiveness. They will not be easily coerced or persuaded to invest in effluent treatment more than industrialists in other countries. However, given the present world-wide activity in this field it would appear realistic to institute progressive measures in the coming decade that would encourage the use of "best environmental" process techniques. Coupled with treatment units, this approach could achieve at least a tenfold improvement in effluent standards (90 per cent reduction in BOD) and lay the foundation further improvement in the future.

The international tanning industry is conservative in its approach to technical innovation. For that reason little notice seems to have been taken of the fact that in general tanneries consume twice as much water as their technical process seems to demand.

Thus a tannery employing a process that nominally requires 17 l/kg of water may well use over 30 l in practice, the over-use generally being attributable to uncontrolled washing processes.

Although the tanning industry is said to be conservative, the International Union of Leather Chemists Societies has attempted to remedy the situation in the environmental field. In 1969 it instituted an Effluent Commission which has since issued reports of five major meetings.

Alternative and current technology - "best environmental processes"

Relatively simple process adjustments may cause drastic reductions in volume of effluent. A 50 per cent or more reduction in volume is easily obtained. Total pollutants may also be greatly lessened. Some of the process modifications suggested would require minor plant and plumbing alterations before being introduced into existing tanneries, but such modifications could easily be incorporated in planning for new developments.

For those not familiar with the tanning industry it may be necessary to state that hides and skins may be processed in a variety of vessels. The three major vessels in use today are:

(a) Pits. Usually made of timber or concrete, these are set mostly below floor level. No agitation is usually supplied. The hide requires water of from 5 to 10 times its own weight for normal processes;

(b) Paddles. These are open-topped, timber, horizontal, semi-cylindrical vessels which are agitated by a paddle. Water requirements are somewhat similar to a pit;

(c) Drums. This is the most modern low-price system of timber construction. The drum revolves at from 2 to 16 rev/min., mechanical action is produced by shelves or pegs inside the drum. Water requirement is from zero to three times the hide weight.

The water used in the above processes is known as the "float" and is calculated as a percentage of the hide weight, i.e. 100 per cent float = water to same weight as hide.

Many of today's processes may simply be described as environmentally unsound, because they use large quantities of water, employ and emit by way of effluent excess chemicals, and make little or no provision for re-cycling or regeneration of process liquor.

There are too many processes in use throughout the world to be covered even briefly here. By "current processing techniques" is meant methods in use today. Generally two categories exist:

Environmentally "sound"

Environmentally "unsound"

Those that are environmentally sound are mainly dealt with here. It is, of course, quite possible to process good leather by an "unsound" process, thus producing maximum effluent. This effluent could then be completely processed. Such a project is expensive in capital and running costs and must not be encouraged.

Generally the unsound techniques are those that have high water consumption; many use running water washes in place of batch washes, or high float levels, i.e. over 100 per cent. Thus, these poor technologies would require well over 50 l water/kg raw stock processed, which would at times even exceed 100 l compared with a possible level of 25 l or less/kg(5,6).

Likewise, excess chemicals will be used and discharged; e.g. for unhairing, 4 to 10 per cent lime is "unsound" (although often used), whereas a "sound" process would either re-cycle lime(7) or use levels down to 1 or 2 per cent (8) of lime, or alternate materials.

Likewise, in tanning one has the option of "unsound" processing with only some 70 per cent of tanning agent being fixed to the pelt, the remainder being released in the effluent. This may be compared with processes fixing 90 per cent of tanning agent which are "sounder". "Sound" processes for "no float" (9) and re-cycling(10) are outlined later and must be major industry objectives.

When a recent report showed water usage for production of full chrome upper leather ranging from 3.7-13.3 gal/ft^2, the variations were truly evident.

General lowering of water consumption

This in itself is a useful advance environmentally; it may well cause higher polluted effluents, but at least the volumes to be treated will be lessened. Frendrup and Ludvik reported(8) in 1971 a 50 per cent drop in water usage, basically by using batch-washing processes in place of continuous techniques. These figures no doubt also reflect the use of shorter floats. In Sweden(5) a figure as low as 25 l/kg was reported using automatic drums. This is in line with the figures quoted in 1973 by Herfeld(6) for water consumption using a rapid semi-continuous process; coupled with low floats, such a process, he suggests, requires 25-30 m^3 water per ton of raw material, which he compares with the 150-200 m^3 used some 20 years earlier (still used by some conservative tanners). The above techniques require virtually no alteration in tannery plant.

A much more radical attack on the problem is made by D. A. Bailey (2). In 1972 he suggested the segregation and reuse without treatment of tannery waters. His four categories were:

Fresh water (new)
Fairly clean (reusable)
Moderately clean (reusable for dirty jobs)
Dirty water (disposable)

Although Bailey's techniques would require catchpits and extensive replumbing, he shows a possible saving of even greater amounts, i.e. from 4,000 units down to 1,600, a 60 per cent reduction without changing basic processes.

There is little doubt that most tannery processes can be conducted using floats at the 30 to 50 per cent level, compared with the more orthodox usage of floats of 100 to 300 per cent. The drive mechanism of tannery drums may need to be strengthened and made more positive to overcome the greater initial torque requirements.

The author feels that the continued use of paddles and pits using floats of up to 700 per cent cannot yet be accepted as technically or environmentally sound processing unless the pits and paddles are used on a re-cycle basis.

Specific lowering of water consumption

Italian workers have shown (11) how, with semi-treatment of segregated used waters, a large volume may be reused. (Not as simple as Bailey's proposal.)

German workers (12) have shown that by using a "one-shot" process (soak to bate), one may make over 50 per cent reduction in water usage in this heavy water-consuming section of processing.

Davis and Scroggie (9) in Australia, by advocating the use of spent chrome liquors for pickling, automatically suggest possible water savings as well as lower pollutant levels.

Blasej *et al.* (13) had shown the possibility of reusing lime liquors after partial treatment, but more recently a much greater advance has been suggested by Money and Adminis (7) in Australia, where in small-scale trials they managed to re-cycle, without treatment, lime liquors up to 20 times (suggesting indefinite use).

Similar savings in water consumption may well result from the usage of no float chrome tannages, as proposed by many authorities.

Improvements in beamhouse processing

It has long been accepted that the traditional depilation method - lime and sulphide - in addition to being wasteful in regard to chemical usage is the largest contributor to high levels of pollutant: suspended solids, dissolved protein, sulphide and high alkalinity being the major factors.

The industry has for years attempted to utilise new processes, e.g. enzyme depilation, oxidative processes, dimethylamine, caustic soda; as a replacement for lime, these subjects employ the bulk of the research work expended in this field.

In 1967/68 Kubota et al. (14, 15) suggested that an enzyme/calcium chlorite depilation gave smoother grain than a limed pelt. But as their process included 2 per cent calcium chlorite, it was only a partial advance over the traditional lime process (minimized sulphides).

Heidemann et al. (16), in a general review of unhairing processes, examined the relative merits of all the alternatives then available, and concluded that from the effluent processing aspect: "Protein removal from effluent is much easier in liquors from the reductive process than from the oxidative, from which proteins are only precipitated incompletely, and only after strong acidification".

Herfeld and Schubert in 1969 (17) investigated dimethylamine sulphite using low levels of calcium chloride and hydroxide, as well as caustic soda. Using a composite of these materials, they obtained satisfactory unhairing without hair-dissolving, thus yielding a much improved effluent.

However, these newer processes have not always yielded top quality products, have required complex controls in operation and have not been accepted extensively by tanners.

Perhaps the search for new unhairing processes will not now be so important as Shuttleworth (18) suggested in 1972; that upper leather can be successfully limed using only 0.5 per cent lime and that the residue of the process may be converted to soluble bicarbonates.

If the work of Money and Adminis(7) is found commercially acceptable, it is an even more logical path for environmentally minded tanners to follow. Although their trials used a 200 per cent float, they suggest that re-cycling should be possible for 20 times at least. This process is reported to give a seven-fold reduction in lime and protein in the effluent, on a 20 times re-cycle basis, but if longer re-cycling was possible, even greater effluent/pollutant reduction could be expected. A further advantage of the re-cycling process is that during re-cycling it is possible to filter the liquor, e.g. using a 150 mesh stainless-steel screen, which removes the greater part of the hair debris and fat.

The disadvantage of re-cycling in general is that it is necessary to have efficient means of drum drainage, large capacity liquor storage chambers, together with the necessary pipes and pumps to direct the re-cycling. This, however, may be a small price (in capital terms) to pay for such a large reduction in obnoxious effluent.

Improvement in tanning processes - chrome tan

It has long been recognized that tan effluent (be it chrome, vegetable, or other materials or mixtures) is the second most powerful pollutant process in use in the leather industry. Chrome is perhaps a potential hazard, but a sense of proportion must be kept. Sykes quotes the London Sunday Times of 5 March 1972, reporting: "Chromate is 50 times more toxic than cyanide". Sykes correctly points out that the Sunday Times was referring to hexavalent chromium vapours, which have no relevance to the trivalent chromium in general usage in tannery processing. It is pertinent also to note that Bailey (4) in the United Kingdom stated that at normal levels of tannery effluent the trivalent chrome present did not greatly affect normal effluent processing at standard sewage works.

However, as in many areas of the world where no sewage disposal plant exists, there is an acute need to obtain non-polluting tanning processes. Thus, the dry chrome tannages, typified by Mall, and which are said to produce a strong grain coupled with favourable area yield, appear to offer great hope. Many of the larger chemical companies offer similar processes and the technique is gaining commercial acceptance. Even such processes, however, do yield some chrome effluent, but as chrome is easy to precipitate, only minor "plumbing" alterations are necessitated to remove these traces of chrome. In Holland it is reported(5) that a "no-float" process is operating successfully with elimination of chrome from the effluent.

The "no-float" chrome tanning does make increased physical and mechanical demands on the drums. Thus, without re-equipage such a process is not always possible.

The logical alternative is a low, 30 to 50 per cent, float which is less demanding on the drum, but does not give such good chrome uptake. Uptake rates of chrome from conventional processes are said to be from 75 per cent to 90 per cent of the amount offered to the pelt(19).

Thus the practical alternatives available are:

(a) The "no-float" systems or 40 to 50 per cent floats with maximised fixation, and preparedness to treat the 10 per cent or so of chrome not fixed;

(b) Adoption of a re-cycling process as suggested by Davis and Scroggie(9): "A commercial scale trial of a previously proposed method of re-cycling of chrome-tanning liquors has been performed in which the spent liquor is used as a basis for preparation of the pickle liquor for the following pack of hides to be tanned. The method has been shown to be practical for commercial operation, and to produce leather of comparable quality to that produced by conventional chrome-tanning. In addition to assisting in the disposal of tannery effluents, the re-cycling method offers substantial savings in reagent costs". The saving in chrome is said to be some 20 per cent! In addition the Davis and Scroggie re-cycling has the added advantage of a massive saving of neutral salts normally used in conventional pickling.

A host of workers have proposed the precipitation and subsequent reuse of chrome from effluents, but to date there is little confirmation regarding the commercial acceptance and quality aspects of such reuse systems owing to the need for high levels of analytical control in the solubilising and reuse process.

<u>Improvements in vegetable tanning process</u>

In Turkey several hundred unmechanised tanneries still operate using traditional rural tanning techniques. Such rural processes are generally gross local pollutants (owing to lack of equipment), but because of their widespread geographical dispersion they only cause local problems of an insidious nature and would prove uneconomical to treat. The dispersal of rural tan effleunts may be likened to sweeping the dust under the carpet; if swept together they could be processed. Environmentally, one must hope for a degree of centralization and rationalization of tanning activity if serious improvement in pollutant levels is to be expected.

Vegetable tannins are used for a wide variety of end-product. Discussion in this paper is limited to processes such as sole, harness and other leathers, which may be produced using similar systems by varying the percentage of tannin and degree of astringency to obtain the necessary variations in property. These processes are the largest users of vegetable tanned leathers.

There are four main types of commercially acceptable processes to reduce effluent:

(a) The well-accepted L.I.R.I. (20) process is an almost perfect example of a "no effluent" process in the tanning phase, and is gaining commercial acceptance in the United States of America as river boards tighten their standards. This pit process is simple and requires only a means of liquor heating and circulation. The L.I.R.I. process yields only minute quantities of vegetable tannin-tainted liquor, and its only drawback is its time of processing. A later adaptation used pit and drum after the Calgon pre-treatment and obtained a virtually effluent-free process in an appreciably shorter time;

(b) A somewhat simpler, low effluent system is that proposed by Atkinson and Cutting(21) in 1963. This is a pit-drum process designed for speed of tannage (4 days); it is itself a re-cycling type of process with spent-drum liquor being used to regenerate the pits. This process has the advantage of requiring minimal alteration to existing equipment in most tanneries;

(c) Although not so effluent free, drum tannage preceded by a pretan is possible. Several rival processes are available; basically they require a low-float pickle followed by a pretan, e.g. 1 to 2 per cent chrome powder. After this pretreatment the hides may be drum-tanned with a short float. This type of process minimises effluent, as the liquor residues in the drum may form the base for later packs;

(d) A more recent method of vegetable tannage has been proposed by Atkinson and Scoworoft(22). This entails a heavy soda sulphate preconditioning followed by a drum tannage with virtually no float. This process produces almost no vegetable tannin effluent, but it does produce relatively high concentrations of sulphate. In areas where sulphate is easily disposed of (near the sea?) the method is ideal environmentally.

It may be noted that all of the above processes use extract as opposed to locally leached material. There seems little doubt that efficiency (percentage uptake) is far improved at the high tannin levels being employed.

Thus, if any effluent is produced, it is a small-volume, high concentrate, which is storable and worthy of treating. If we compare these small volumes (circa 10 per cent) with the counter-current processes of the past producing large volumes of low concentrate effluent, we may appreciate the advantages.

Effluent and waste treatment and disposal for tanneries

Effluent treatment

In general the treatment of tannery effluent follows the main process line adopted in the treatment of any sewage. Bailey suggests the following:

> "The treatment of sewage involves the removal of polluting solids, both suspended and dissolved, from the water in which they are carried. Both physical separation by sedimentation and biological oxidation are employed and by this means a clear innocuous liquid can be discharged to the river, whilst the solids which have been removed remain to be disposed of separately."
>
> "Briefly, the essential steps are:
>
> (i) Primary sedimentation in specially designed continuous flow tanks to remove solids that settle out;
>
> (ii) Biological oxidation either by treatment on percolating filters or in an activated sludge plant;
>
> (iii) Final sedimentation to remove solids resulting from the oxidation stage;
>
> (iv) Final disposal of the sludges, arising from the two stages of sedimentation, by anaerobic fermentation followed by either drying on drainage beds or filtration in mechanical plant such as vacuum filters or filter presses."

Although the processing is uniform, a large choice is left to the discretion of the treatment engineer. Indeed, within the leather industry much research has been conducted to find the most beneficial way of blending effluent from various processes in order to yield the most efficient and rapid sedimentation. An example of this is the work quoted by Van Vlimmeren and Van Meer(23) who discuss the possibilities of "mixing the alkaline beamhouse liquors and acid liquors from pickling and chrome tanning, decreases in pH to values between 8.5 and 9.5 leads to a precipitation of part of the proteins and in consequence to a reduction in COD of about 35 per cent. However, this procedure is accompanied by the formation of large quantities of sludge". These authors also examine possible easing of sludge treatment and handling. A large number of technical papers have been produced giving details of correct "blending" conditions to achieve efficient sedimentation but they are perhaps too technical to discuss here.

Disposal of solid wastes

This is still, perhaps, the greatest environmental problem for the leather industry. The Commission of the International Union of Leather Chemists Societies (IULCS) (24) from 1971 included this subject in its terms of reference. Van Meer classified solid wastes:

Untanned wastes

Tanned wastes

Sludge and solid wastes from effluent treatment

Untanned wastes, i.e. fleshing and trimmings, traditionally were used for glue; now perhaps they are used more for phenolics. Animal feedstuff is a possible end-use, but rendering for fats could also be economical. If not utilised, these wastes may quickly give rise to smells; thus even if uneconomic, they must somehow be processed. Fertiliser may also be a suitable end-use, provided the wastes are sulphide free.

With regard to tanned wastes a limited demand is noted for leather shavings etc. in "leather board" production, but demand does not equal supply; thus today the incineration of surplus shavings may be necessary (5, 19).

In Eastern Europe much effort is being expended on the processing of tanned and untanned fibres into leather substitutes. This work shows great promise, but as yet it is not perhaps suitably developed and simplified to be applicable to all countries.

Sludge and solid wastes - dewatered and dried sludges - could be incinerated together with leather dust and shavings (24). However, a final ash is still left. Little is recorded about the composition of incinerated material. Perhaps it can be returned to the ecological cycle as a fertiliser (this would depend on the percentage of Cr_2O_3 and other constituents), or else it could be returned in polythene sacks for burying, which is a questionable solution.

Dr. Feikes (19) quotes current solid waste disposal in the Federal Republic of Germany as being:

70 per cent tipping (with safeguards)

2 per cent composting

28 per cent incineration

Indeed, the situation is ripe for solutions to be found for economic solid waste disposal. It would appear that the amount of solid waste that can be utilized is dependent on local conditions. It is noticeable that in countries with low levels of material resources, high levels of utilization of wastes are recorded. India is an example where uses for most materials have been suggested. However, solid waste utilization appears greatly dependent on labour costs, and in the "developed world" the trend is unfortunately away from utilisation as being too costly, and efforts appear directed mainly towards disposal at the lowest possible cost.

As mentioned elsewhere in this paper it is possible to achieve up to 95 per cent removal of BOD (approaching a standard BOD/SS of 20/30 at some 30 per cent of the cost of a full treatment). Thus, in the following histogram the "secondary biological treatment" approaches this level of purification at economic cost. (See figure IX.)

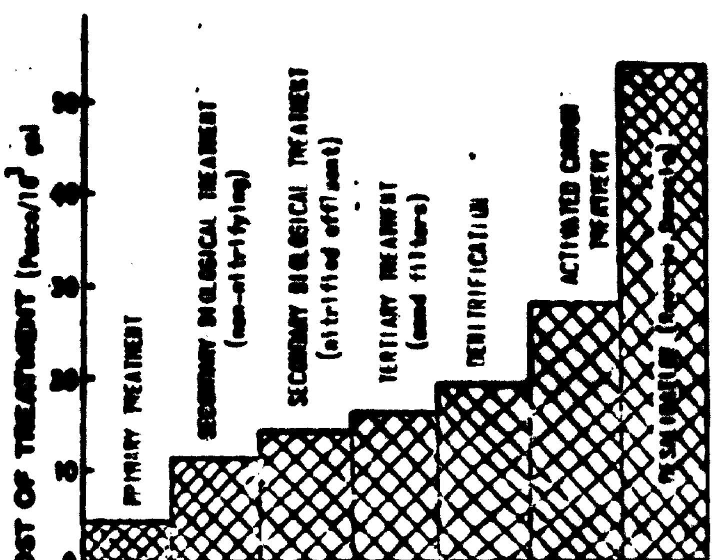

Figure IX. The cost of treating domestic sewage to various standards of purification

Possible financial and economic aspects of pollution control for the tanning industry

A simple assessment may be made to quantify the possible costs of installing treatment plant to process the effluent from Turkish tanneries, but initially it may be of interest to see what the treatment costs would be, taking as a basis current treatment costs in Western Europe.

If it is assumed that Turkey processed all of its hides and sheepskins produced annually, (25) it may perhaps be assumed that it used an input of:

2.9 million cattle at •	20 kg =	58,000 metric tons raw material
16.0 million sheep at, say,	1½ kg =	24,000 metric tons raw material
		82,000 metric tons raw material per annum

This could perhaps be expressed in terms of a 20 kg hide equivalent as 4.1 million hides per annum, or 13,666 hides daily. Assuming a water usage of 50 l/kg, such a production could be expected to yield up to 4,100,000 m^3 effluent annually or 13,666 m^3 daily.

Current costs of mixed effluent treatment in the United Kingdom are perhaps 12.5 n.p. (30 US cents) per 1,000 gallons (4.545 m^3).

Thus, the Turkish tanners who could produce 4,100,000 m^3 of effluent per year would need to pay $US 270,627 annually.

But the question both Turkish industry and Government may ask is, how much will effluent treatment cost in Turkey?

There can be no clear answer to such a question. Capital and running costs will depend on the standards of improvement aimed for, and locality and availability of land, but of even more importance is the unit size. Recent Environmental Protection Agency figures published in the United States of America (10, 26) give capital costs for two major levels of treatment:

(a) B.P.T. ("Best practicable control technology currently available") is basically pre-treatment followed by activated sludge. (Pump, screen, equalise and primary clarification, followed by an aeration basin, secondary clarifier, graded media filter and chlorination coupled with the necessary sludge handling plant.)

(b) B.A.T. ("Best available technology economically achievable") suggests B.P.T. treatment plus nitrification and denitrification.

An abstract of these figures on a 1970 basis is given in table 13.

Table 13. Capital cost of tannery effluent treatment plants

Tannery production capacity	Effluent volume (m^3)	(A) B.P.T. standard capital cost	(B) B.A.T. standard capital cost	B.P.T. standard capital costs per 20 kg hide
(daily)		(thousand dollars)		
2,268 kg = 113 hides a/	76	366	527	3,238
6,804 kg = 340 hides a/	227	473	721	1,391
15,876 kg = 794 hides a/	530	667	1,065	840
45,360 kg = 2,268 hides a/	1,514	1,162	1,797	512

Note: The original data assumed an effluent of 4 US gal per lb raw hide = circa 33.38 l/kg hide.

a/ Assuming hides at an average of 20 kg.

The large United States variation in capital cost per hide, owing to economies of scale, seen in table 13 for tannery effluent treatment, i.e. the sixfold reduction in capital costs per unit for a twentyfold increase in plant size, may be attributable to the high percentage of relatively sophisticated chemcial engineering and plant employed. It may well be that using low cost effluent plant, the economies of scale will not be so vast, since it appears that excavation and similar labour-intensive activities are less variable. Indeed, data published from a recent Indian seminar (27, 28) show less than 100 per cent capital cost per unit reduction given a tenfold increase in plant size.

A wide disparity may be seen between the $US 3,288 and $US 512 postulated in the United States and the $US 114 and $US 69 suggested in India. Much of the difference is attributable to vastly different labour costs, but much is also due to the use of low cost techniques. Obviously, costs will vary from location to location even within a given country, as questions such as the production process employed, availability of land and the soil structure may have a large bearing on the actual cost.

The data quoted in tables 13 and 14 are from desk studies, and it is interesting to compare them with an actual costing figure of $US 227 capital cost per 20 kg hide for an effluent treatment plant (tannery raw hide input around 24,000 kg daily) for a plant in Africa for processing effluent down to a BOD/SS of about 25/30 (29).

Table 14. Capital cost for vegetable tannery effluent treatment plant (US dollars)a/

Tannery production capacity (daily)	Capital cost per kg hide processed Treatment stage b/ (I)	(II)	(III)	Stage III: capital cost to treat effluent from a 20 kg hide
1,000 kg - 50 hides c/	2.07	5.33	5.73	114.60
2,000 kg - 100 hides	1.96	4.80	5.07	101.40
4,000 kg - 200 hides	1.60	4.13	4.33	86.60
8,000 kg - 400 hides	1.47	3.87	3.67	73.40
10,000 kg - 500 hides	1.39	3.33	3.48	69.60

Note: Assumed effluent produced = 34 l/kg hide at BOD of 5,000 mg/l.

a/ Rupee to $US conversion at Rs 7.5 = $US 1.

b/ Treatment stage I - Effluent mixed and settled. SS removed 76 per cent;
Treatment stage II - Above plus anaerobic and aeration lagoons (BOD less than 100);
Treatment stage III- Pasveer oxidation ditch in place of aeration lagoons (BOD 25 to 50).

c/ Assuming hides at an average of 20 kg.

If it were assumed that no effluent treatment plant existed in Turkish tanneries, and high standards were required, e.g. a BOD/SS of 24/30 in all the tanneries, the capital cost could be about: 13,666 hides x say $US 227 or $US 3.1 million. It may be somewhat foolhardy to quote possible capital costs when so may imponderables exist, and the figure of $US 3.1 million must be taken as an indication of the order of magnitude. Variations in this expected capital cost are extremely large. Some rough guides may be indicated:

(a) 100 per cent or more increase in capital cost could be expected if sophisticated treatment plant were installed, as opposed to plant of a medium technical level;

(b) But up to 50 per cent savings could be obtained in capital cost if all plant and equipment were designed on an ultra low-cost philosophy;

(c) And 50 per cent or more savings could be obtained if standards were less stringent than a BOD/SS of 25/30.

With such large deviations in capital cost estimates for effluent treatment it must be expected that cost of effluent treatment plant, compared with the existing capital value of the tanneries (replacement value) will vary tremendously. Thus for an extra small tannery in the United States (113 hides at 20 kg daily) the capital requirement for control facilities to B.P.T. level is 149 per cent of plant replacement value, but at a large tannery in the United States (20 times greater capacity) the cost is down to 37 per cent of plant replacement value.

Lower figures have been found in recent surveys in Africa with the large plant cited earlier showing the effluent treatment capital cost as only some 4 per cent of actual building and machinery costs. Other figures available suggest control costs 7 to 10 per cent of fixed capital for tanneries with capacities of 300 to 600 hides per day in Africa (not all producing final effluent down to a BOD/SS of 25/30). For smaller units, producing about 100 hides per day or less, the cost of control facilities may equal 20 to 50 per cent of fixed capital.

What is the effect of such capital expenditure on costs, sale prices and competitiveness? The high levels of cost suggested in the United States (not yet in operation, but due to be enforced by July 1977?) would have a massive effect on sale prices(10), (see table 15).

Table 15. Percentage change in price needed a/

Tannery size	B.P.T. treatment	B.A.T. treatment
United States hides daily		
100	9.0	13.5
300	3.6	5.8
700	2.2	3.7
2,000	1.3	2.0

a/ Such that net income remains constant.

The United States study suggests that some 30 per cent of "small" (?) tanneries (300 hides each per day) may be forced to close owing to the financial impact of installing effluent control systems. With such large benefits of economy of scale the large units are given a distinct advantage. However, if "low cost" systems are used, together with their minimal economy of scale, these gross disparities in burden will not occur.

Estimates of the oncost due to installation of effluent control facilities appear much lower in those Afro-Asian countries where pollution control is practiced, and the price uplift necessary appears to be from 0.5 to 2.0 per cent (29). This is not an unrealistic price to pay for an undoubted improvement to the environment.

The above capital costs refer to large tanning units installing their own effluent treatment plant. Such conditions would similarly apply to small production units, in any locality, which operated a joint treatment system co-operatively. Ideally, this could operate on a new industrial trading estate, but it could be made to operate in certain other locations if the tanneries were not too widely dispersed.

Is there a more economic method of installing effluent treatment plant? Yes, a unit serving both industry and domestic sewage would be socially advantageous as well as more economic, and most authorities suggest that up to 33 per cent of tannery effluent can be mixed with domestic sewage without difficulty and without affecting the operation of the process. Such a joint plant would enable maximum advantage to be taken of economies of scale. Such plants could be installed by tanners or municipalities, and the various parties could be charged according to volume and concentration.

The situation of the Turkish tanning industry

The statistics relating to the Turkish tanning industry seem somewhat conflicting. After only two days of looking at the industry in Istanbul, the figures that would seem most realistic for an estimate of total input are about 82,000 metric tons of raw hide and skin per annum.

The industry is concentrated at several major centres, as follows:

(a) 50 per cent of the total production is at Kazlicesme;
(b) 10 per cent of the total production is at Beykoz;
(c) 20 per cent of the total production is at Izmir;
(d) 20 per cent is distributed throughout the rest of the country.

There is much to be said for and against the heavy local concentration of tanners as typified by the situation at Kazlicesme. On the debit side there is no doubt that the industry in that district has created a massive local environmental problem. However, its concentration has ensured that only a limited area shall be affected. This limited area could at economic levels be given a new environmental image if the 160 tanneries pooled resources and instituted an "environmental improvement" campaign. The three aspects that urgently require attention - whether at Kazlicesme or at a relocated site - are:

(a) Removal of noxious odours;
(b) Improved disposal techniques for solid wastes;
(c) Treatment to some degree of the liquid wastes - effluent.

(a) Removal of noxious odours. The major obstacle to overcome is the solid wastes (see (b)) below. If an efficient system were adopted allowing daily removal of solid wastes as opposed to the weekly or less frequent collection and removal of solid wastes, there would be little material present to cause odours, and regular plant cleaning with disinfectants would remove nearly 100 per cent of this irritant. The costs for improved collection would be negligible and the results would more than justify such a system.

(b) Improved disposal techniques for solid wastes. Tannery solid wastes may be classified into the six categories:

(A) Raw trimmings and fleshings
(B) Limed trimmings and fleshings
(C) Tanned shavings
(D) Tamed and finished trimmings
(E) Hair
(F) Sludge

Currently, (A) and (B) are used in glue/soap manufacture, but the value is so low that receipts only cover transport costs, and there is little economic incentive to adopt daily collection owing to the increased labour and transport costs. As (A) is a putrefiable material and accounts for a large amount of tannery odour, some pressure is needed in this field.

(C) and (D) are both possible raw materials for "leather board". However, it appears that only (C) is currently in demand. Neither of these categories, however, causes odour or any problem apart from the unsightliness of the piles along the streets.

(E) - the hair - is a major problem; most hair because of lack of screens is allowed to enter the "sewers". Even hair that is recovered does not appear to be washed and utilized for lack of demand, and this is often left in piles, causing odours. Again frequent collection could be a low-cost answer, although a final, acceptable disposal means must be secured.

The sludge (F), consisting of fleshings, fats, pulped hair and insolubles from the effluent, is in most cases not recovered. Some is retained in the "sewer" channels and infrequently removed; the balance passes out to sea with the effluent. Whether effluent treatment is fully initiated or not, there appears a strong case for compelling each tannery to retain and rapidly dispose of its own sludge; simple pits, traps and screens would be more than sufficient.

(c) Treatment of liquid wastes - effluent. If account is taken of the final disposal point of treated tannery effluent, i.e., Seas of Marmara and Agean, it would realistically suggest that dissolved salts (mostly chlorides and sulphate) can cause little environmental or ecological upset and the prime necessities would be: the lowering of BOD to 50-100 mg/l. Removal of suspended solids and conversion of sulphides to a more acceptable form (to treat the composite effluent to a level between stages II and III quoted earlier) i.e., a reduction of 90 per cent of pollutants.

Economic effect of proposed improvements

Would the improvements suggested above have a significant economic effect on the Turkish tanning industry? If treatment and control of effluent are kept to realistic levels, the financial and economic effects would be at a level that might be supported by the industry without affecting its global competitiveness. It was calculated earlier that effluent treatment costs for all the Turkish tanning industry would be about $US 270,000 per annum if a large municipal plant processed the trade effluent. In addition, tanners would have to install minor screening and initial sedimentation plant to bring their discharges to a level acceptable to a standard treatment works. This on-site pre-treatment could well be some additional 50 per cent. Thus an annual charge of circa $US 400,000 could be expected.

The tanning industry could construct its own treatment plants. This, it is suggested, would imply an investment of $US 3.1 million using a medium level of technology. Servicing of the capital and operation and maintenance costs would depend on the funding source but would equal the annual charge that could be expected from municipal treatment. It may be advantageous for the tanning industry, where possible, to operate its own effluent treatment plants. The industry would be better able to control the effluent standards, and their existing commercial experience should ensure efficient operation. In the same way, the tanners would feel that their costs were direct and actual, whereas they might dispute their proportion of charges from municipally operated plant. (The variation in capital costs between the United States and Indian figures must be borne in mind.)

The suggestion that cost would be equal whether tanners or municipalities processed the effluent could only be valid in localities with a high density of tanneries (e.g., Kazlicesme).

The suggested capital cost of about $US 3.1 million for effluent treatment when seen against an existing fixed capital (plant and machinery) of $US 60-80 million (trade estimate) is some 4-5 per cent. The effect on cost of production would be well below a 1 per cent increase and thus not of significant effect in domestic or export markets. Not too high a price to pay! However, it must be stressed that this suggested cost would apply only to a medium-level technological plant, processing effluent down to 85 or 90 per cent removal of major pollutants at any location where suitable large areas of land were available for treatment plants.

Effluent treatment costs could rapidly escalate if less suitable conditions applied.

Problems of treating effluent in Turkish tanning industry

What particular problems would face the Turkish tanning industry if it should decide, or is compelled to treat, its effluent? The first question is, where is the finance to come from? No doubt assistance would be given at a national level. The percentage of capital required might be small when compared to existing investment but would be beyond the means of many tanners. The more serious question is, will any legislation and standards be equitable?

Large tanneries, e.g. Sümerbank, could well support their own effluent treatment plants. Existing and proposed tannery complexes or co-operatives could operate treatment plants equally economically on a co-operative basis. Small widely disposed tanneries, of which there are many, could not economically treat effluent. Can one exempt units under 20 hides per day? Would this lead to a proliferation of small units? Should the decision be left to the discretion of municipalities? All these suggestions are open to debate. The author is not sufficiently familiar with Turkish policy to be able to suggest a remedy.

An obvious problem would be posed at Kaslicesme where there is currently a dirth of land that is obviously suitable for an effluent treatment plant. No doubt, if relocation does not occur, land would be found and special limited land usage plant could be devised, but this would raise costs.

Although it is dangerous to postulate on the relationship of economies of scale/tannery effluent treatment plant/tannery production, it is abundantly clear from evidence elsewhere in the world that tanneries with a through-put of 1,000 hides/day (approaching 10 per cent of the total Turkish tanning industry) obtain near maximum benefit of economies of scale. Tanneries at a level of 100 hides/day are not able individually to have such effluent treatment plants since they will be some 200-400 per cent more expensive on a unit basis and thus will prove financially too heavy a burden. As the majority of Turkish tanneries are producing at the rate of 100 hides per day or less, they must co-operate or they will be unable to comply with any environmental legislation enacted.

Appendix I

Composition of typical "environmentally unsound" tannery effluent

		Chrome tannage		Vegetable tannage
pH	mg/l		ca. 10	
Total solids	mg/l		10,000 -	
Total ash	mg/l		6,000 -	
Suspended solids	mg/l	2,500		1,500
Ash in suspended solids	mg/l	1,000		500
Settled solids (2 h)	mg/l	100		50
BOD_5	mg/l	900	-	1,700
$KMnO_4$ - value	mg O_2/l	1,000		2,500
COD ($K_2Cr_2O_7$)	mg/l	2,500		3,000
Sulphide	mg/l		160	
Total nitrogen	mg/l		180	
Ammonia nitrogen	mg/l		70	
Chrome (Cr)	mg/l	70		-
Chloride (Cl^-)	mg/l		2,500	
Sulphate (SO_4^{--})	mg/l		700	
Phosphate (P)	mg/l		1	
Ether extractable	mg/l		[illegible]	

Appendix II

Amounts of pollution per ton of raw material (salt weight)

		Chrome tannage		Vegetable tannage	Range
Alkalinity	eq/t		750		
Total solids	kg/t		675		350–1250
Total ash	kg/t		375		250–450
Suspended solids	kg/t	150		75	70–200
Ash in suspended solids	kg/t	60		25	25– 60
Settled solids (2 h)	m^3/t	6		3	1.5–7.5
BOD_5	kg/t	60		85	40–100
TOD	kg/t		10		
$KMnO_4$ - value	kg O_2/t	70		120	
COD ($K_2Cr_2O_7$)	kg/t		175		120–280
Sulphide	kg/t		7		
Total nitrogen	kg/t		10		
Ammonia nitrogen	kg/t		3		
Chrome (Cr)	kg/t	4.5		0	
Chloride (Cl^-)	kg/t		160		
Sulphate ($SO_4^{=}$)	kg/t		40		
Phosphate (P)	kg/t		0.07		

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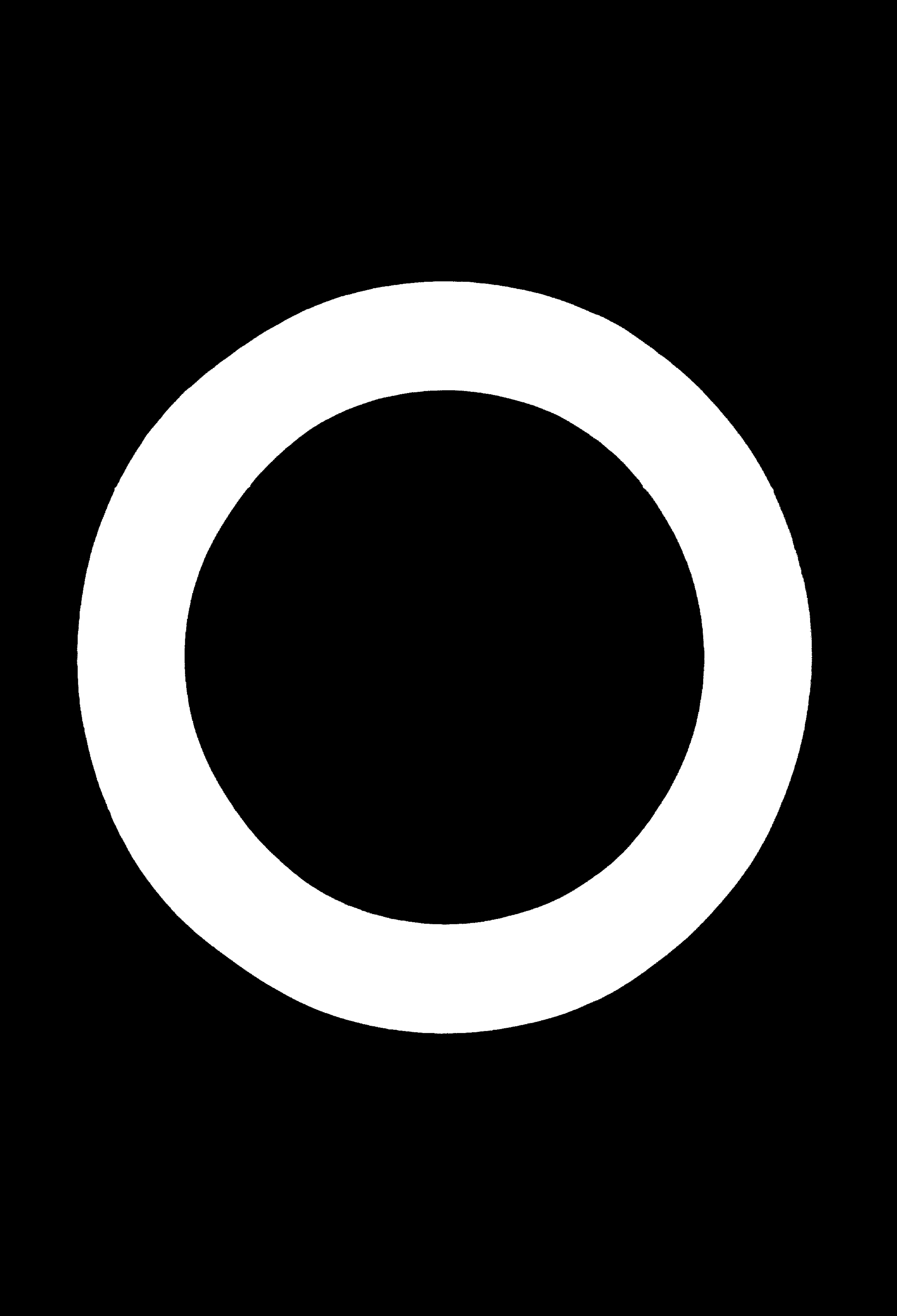

Annex

PROGRAMME OF THE SEMINAR ON ENVIRONMENTAL DIMENSION IN THE CHOICE OF INDUSTRY AND TECHNOLOGY, 17 DECEMBER 1974

Chairman: Orhan Sorguc, Acting Under-secretary of the Ministry of Industry and Technology

1. Opening statements

   The Minister of Industry and Technology

   UNDP resident representative

   Representative of UNIDO

2. Presentation of the seminar

   Mustafa Bilginer, Director of the Science and Technology Department, Ministry of Industry and Technology

3. Environmental awareness in industrial development and the environmental programme of UNIDO

   J. Carmichael, UNIDO representative

4. Subject 1: Industry - environment relations, environmental dimensions effected by industry

   (a) The subjects to be investigated from the point of view of environmental problems relating to the industrialization of enterprises

   Hasan Asmaz, Director of Turkish Association for the Conservation of Nature and Natural Resources

   (b) Industrialization and environmental problems
   Erol Ulug, Middle East Technical University

   (c) Our environmental understanding up to present time and relating proposals
   Adnan Gur, Chamber of Chemical Engineers

   (d) Necessity of reviewing Turkey's economic and social aims in view of the environmental problems
   Kemal Tosun,
   Istanbul University Faculty of Management

   (e) Sanayilesmenin yarattigi saglik sorunlari ve getirilecek tedbirler
   Yuk. Muh. Turker Kayseriliogl u

   (f) Concept of ecological balance, and the relation of this balance with the choice of industry and technology
   Necip Berksan,
   Scientific and Technical Research Council of Turkey

   (g) The influence of leather industry on the environment
   D. Winters, Leather Industry Expert (UNIDO)

(h) The influence of chemical industry on the environment
R. Coughlin, Chemical Industry Expert (UNIDO)

5. Subject II: Standards

(a) The possibility of potential universality of standards and their adaptation to Turkey
Yenor Soylemez

(b) Ekolojik ozelliklere gore duzenlenmis cevre standartlari
Aysen Muezzinoglu, Kimya Muhendisleri Odasindan

(c) Concept of ecological reservoir
Zekai Bayer, Ministry of Food - Agriçulture and Animal Husbandry (General Director of National Parks)

6. Subject III: Measures and arrangements in order to prevent environmental problems

(a) Balanced settlements and environmental problems
Fehmi Yavus, Ankara University, Faculty of Political Science

(b) The choice of industry and technology from the point of view of water products
Cemali Cetin, Ministry of Food - Agriculture and Animal Husbandry General Directorate of Water Products

(c) Fertiliser wastes as construction materials
Muharren Sargin, Ministry of Reconstruction and Resettlement, General Directorate of Construction Materials

(d) Discharges of solid wastes and their recovery
Oktay Tosum,
Ministry of Reconstruction and Resettlement, General Directorate of Construction Materials

(e) Land use planning
Ayla Damali,
Ministry of Reconstruction and Resettlement, General Directorate of Planning and Reconstruction

(f) The choice of industry and technology as a means of preventing environmental problems
Erdogdu Ekesan,
Ministry of Industry and Technology

(g) The establishment of a co-ordination and control system regarding the necessary measures in connexion with the effects of environmental problems in the field of industry
Zeki Sevinc, Chamber of Mechnical Engineers

7. Subject IV. New perspectives and application arrangements in industry: environment relations

(a) Determination of the measures, related with the solutions for the elimination of environmental problems, which will be taken by the

state and by the private sector
Ugurhan Tuncata, Chamber of Industry of Ankara

(b) New environmental perspectives at the national and international. level, and their effects and application methods in the determination of the necessary policies
Ilhan Onsan, State Planning Organization

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