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ENVIRONMENTAL ASPECTS OF INDUSTRIAL
DEVELOPMENT IN DEVELOPING COUNTRIES.

SUMMARY REPORT OF FIVE CASE STUDIES. (1976).

by

Jack B. Carmichael

Prepared under the joint UNIDO/UNEP
Environmental Programme

id. 76-954

CONTENTS

INTRODUCTION

Background of the project

Following the United Nations Conference on the Human Environment held at Stockholm in 1972, the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP) initiated an integrated programme covering the environmental effects of industry in developing countries.

As part of this programme five case studies were prepared on the environmental effects of four industries; these covered an integrated iron and steel mill in Brazil (no. 1), the cement industry in Iran (no. 2), the chemical industry in India and Turkey (nos. 3 and 4), and the textile industry in Thailand (no. 5).1/ Work on the studies was scheduled to start in September 1973 and to be completed in December 1974. This report is an evaluation of the results and a synthesis of the conclusions.

In addition to indicating priority areas for data gathering, the studies provided the opportunity to develop initial guidelines for a methodology of assessing environmental factors. An analysis of the studies revealed gaps in the present knowledge of environmental assessment and suggested methods by which these gaps could be closed. As a result of the project experience the guidelines have been reformulated and are presented here as annex II.

The planning, development of the initial methodology, and field work on this project were carried out under the direction of Alexander Anderson, Chief of the General Industrial Techniques Section of UNIDO. Jack Carmichael, who joined the staff of UNIDO after the field work had been completed, was given the assignment of revising the draft case studies. He prepared this summary and analysis and elaborated the revised methodology for environmental assessment. Certain background information for the summary report was prepared by Ray Curnow, a UNIDO consultant, who was present during most of the briefings and debriefings of the teams.

1/ UNEP project number 0402-73-002; UNIDO project number UF/INT/73-002.

Relationship of the project to UNEP objectives and priorities

At its first session, the Governing Council of UNEP[2] requested the Executive Director to perform the following tasks to which this project is related:

(a) To examine the degree to which the location of new industry is being or may be influenced by environmental factors and the risks and opportunities this may create especially for developing countries;

(b) To assist countries, as appropriate, in the formulation of guidelines for project appraisal which take into account the environmental aspects;

(c) To encourage the exchange of information and co-operation in the field of low-waste and non-waste technology;

(d) To encourage comprehensive studies designed to safeguard against possible negative effects of the international transfer of technology, particularly from the developed to the developing countries; and to evaluate the effectiveness of such safeguards as may be devised.

Further, as part of the future plan of action of UNEP[3], the Governing Council noted the intention of the Executive Director to initiate preliminary work on particular environmental problems of specific industries.

The short-term objective of the project was to evaluate the physical and economic effects of giving insufficient attention to the environmental aspects in the establishment and operation of industrial projects.

The long-term objective was to provide a basis for the integration of the environmental factor into future projects. This may be achieved through the formulation of suitable standards, the illustration of pollution effects through case studies, the comparison of modern best practice with existing practice, the development of guidelines for site selection, the assessment of needs for new technological processes, and the examination of current and desirable legislation. Finally, the reality of the enforcement of legislation should also be explored.

2/ UNEP/GC/10 Annex 1, Decision 1 (1), Section III D.

3/ UNEP/GC/10 Annex 1, Decision 1 (1), Section IV.

Relationship of the project to UNIDO objectives

UNIDO, as co-operating agency with UNEP, has undertaken these projects because of an underlying belief that decisons taken in the process of industrialization should consider environmental implications both as regards pollution and in the socio-economic sphere. This project is part of six projects which have been carried out by UNIDO as co-operating agency with UNEP. The full list is as follows:

Environmental considerations in the leather producing industry

Case studies of four industrial development projects in the developing countries

Study on the development of integrated industrial complexes

Environmental considerations in the iron and steel industry

Study on synthetic versus natural products - pilot project on the rubber industry

Incorporation of environmental elements in UNIDO in-plant training programmes during 1974

I. CASE STUDY ACTIVITIES

Location of industrial sites

The location of the plants and a short description of their settings are given below. The studies were made of basic heavy industries common to most countries.

Case study no. 1 had to do with an integrated iron and steel plant, Cia Siderurgica Nacional. The plant is situated on the floor of an inland valley in Brasil, with a city nearby.

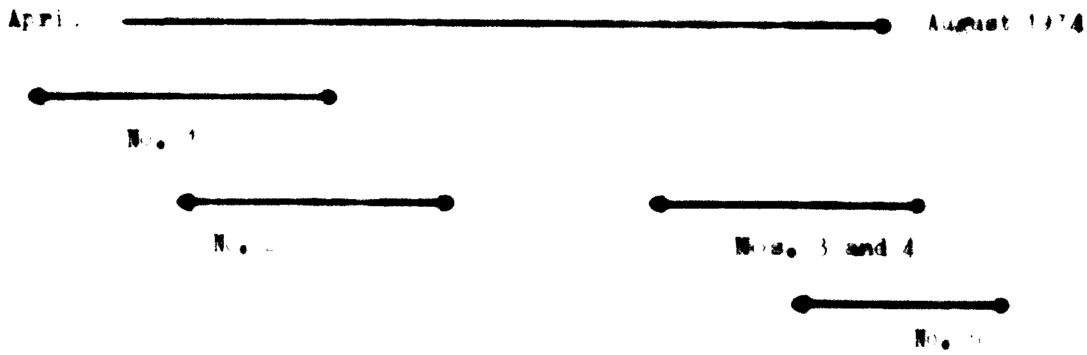
Case study no. 2 covered a series of cement factories in sparsely populated areas of western Iran.

Case studies nos. 3 and 4 concerned chemical plants in the Calcutta, Bombay and Delhi areas of India, and in the Izmit and Bandirma areas of Turkey.

Case study no. 5 covered textile mills (weaving and finishing) in Greater Bangkok in a semi-tropical delta area near the sprawling capital city.

Period of the project

All case studies were executed between April and August 1974. The studies were carried out sequentially, with a deliberate overlap so as to complete the field activities by the end of July. The actual order was as follows:



The studies lasted an average of six weeks. An appropriate period for a satisfactory case study from a data collection and analysis viewpoint is likely to be several months. This period would allow for consideration of seasonal fluctuations in local effects and the interaction of climate and pollutants.

Project teams

As envisaged in the original project description, the team was to have been composed of a team leader, an industrial technologist and an environmental economist. It was thought best, however, to use different teams with individuals of different backgrounds in order to gain a broader experience from the project. This decision was necessitated in part by the comprehensive nature of the visits which had to be completed in a comparatively short time. The teams were composed as follows:

Team	Discipline	Affiliation
No. 1		
S. Chandrasekhar	Iron and steel technologist	M. N. Dastur and Co. (India)
P. Mukundan	Iron and steel technologist	M. N. Dastur and Co. (India)

Team	Discipline	Affiliation
No. 2.		
A. Afifi	Cement technologist	National Cement (Egypt)
J. van Zuilichem	Project evaluation economist	UNIDO consultant
Nos. 3 and 4		
M. C. Geerling	Engineer	UNIDO consultant
R. M. Kretel	Water consultant	Consultant (Switzerland)
J. van Zuilichem	Project evaluation economist	UNIDO consultant
No. 5		
P. Marstrand	Biologist	University of Sussex (UK)
A. Barnett	Cost-benefit economist	University of Sussex (UK)
M. Howes	Anthropologist	University of Sussex (UK)

Only the teams engaged on case studies nos. 1 and [illegible] had known each other before. Team no. 5 had strong local contacts in the country visited through an earlier unrelated project.

Project procedures

Briefing was carried out at UNIDO headquarters at Vienna immediately prior to the field trips. Both Governments and the United Nations officials in each country were informed as to the purpose and nature of the visits, and local counterparts were requested. The industrial sites were chosen as a sample of basic industrial activities known particularly to give rise to environmental concern. These had been identified beforehand; last-minute adjustments to more appropriate plant sites (but not changes of industry) then became the responsibility of the team leader. As is inevitable in field work, a certain amount of administrative confusion arose. For example, the cement study originally consisted of a three-man team which was sent to Iran as two separate units that never joined together. Consequently, two separate reports were prepared, one of which was sketchy in coverage and discarded.

On return to UNIDO headquarters, the mission personnel were debriefed by UNIDO staff.

II. SUMMARIES OF THE CASE STUDIES

Case study no. 1: An integrated iron and steel plant in Brazil

During May 19[illegible], a team of two UNIDO experts studied the environmental impact of an integrated iron and steel plant (coke ovens, blast furnace, open hearths and rolling mills). The study was carried out in Volta Redonda, Brazil (population 180,000) at a plant operated by Companhia Siderurgica Nacional. The plant has a rated annual capacity of 1.[illegible] million tons but now exceeds that figure and produces 1.[illegible] million tons. About 1[illegible],000 people are employed in the plant.

The plant is located in a valley and the township of Volta Redonda is spread over this valley and on the hillsides. The plant does not utilize any air pollution control equipment. Also there is overfiring at the boilers in the thermal power plants. Heavy smoke and brown fumes are emitted during smelting and from the power plant. The iron oxide fumes produced during the oxygen injection causes about 90 per cent of particulate emissions. About 3 to 12 tons of SO_2 per day are emitted into the atmosphere. For example, the coke ovens are charged using cars of old design. As coal enters the hot ovens, copious brown fumes belch out of the charging holes into the atmosphere.

Prevailing winds are from the southeast and cause the bulk of the air pollution to drift over a zone to the northwest of the plant. About 3,500 people of low income live in the zone; these people complain about the bad smell of the gases and soiling of clothes and buildings from soot and brown dust. When the direction of the wind changes, as happens frequently during the six-month rainy season, air pollutants are distributed over the entire city and cause a general nuisance. No air pollution monitoring data were available.

Another major air pollution problem occurs in the working environment inside the steel plant. The arc furnaces and cupola have no air pollution control facilities; for example, the most serious internal air pollution occurs in the production of castings during a process of shake-out in which the sand is shaken loose from the castings. This is done in an open space and the dust collector is inadequate to collect the fine, very dry SiO_2 particles. As a result, an average of seven workers working at the shake-out are absent each year from 3 to 12 months because of the lung disease silicosis.

There are limited facilities for treatment of waste water at the plant. The discharges into the River Paraiba (average flow of 300 m^3/sec) have reportedly killed all fish life at distances up to 50 km downstream from the plant. The water pollutants are produced at the blast furnace, coke ovens, and rolling and finishing mills. Toxic effluents include ammonia spent liquor, sulphuric and hydrochloric acid containing effluents from galvanizing and pickling, water containing oils from the rolling mills and from blast-furnace gas cleaning. The most toxic effluent is the ammonia spent liquor which includes about 1,000 ppm of phenols, 50 ppm of cyanide and 2,000 ppm of free ammonia. An estimated 400-500 m^3/day are discharged without treatment into the river. The blast-furnace gas cleaning results in a discharge into the river of about 60 tons of suspended solids plus cyanide.

The major pollution abatement process at the plant is the recovery of 340 tons of $FeSO_4$ per month from depleted pickling solution.

The plant produces about 12,000 tons per month of solid wastes. Much of this is either stock-piled for future resource recovery or used as fill for leveling low-lying areas around the plant. However, the plant granulates blast-furnace slag for sale to a nearby cement plant and recovers iron scrap from blast-furnace scrap and slag.

Case study no. 2: The cement industry in Iran

The study of the environmental effects of the cement industry in Iran consists of a general survey of pollution problems encountered in the manufacture of cement and the results of case studies of six Iranian cement works.

Cement manufacture begins with limestone and clay-like raw materials which are dust-initiating in nature; the cement itself is a fine powder. A dust problem is therefore present at nearly every stage of manufacturing in both the wet and dry process.

In the wet process, water is added during the grinding of raw materials. The homogenised slurry is then kiln dried. Less dust is produced in this process, but the process is very energy consuming in the stage of water evaporation (total energy consumption of 1,200-1,500 kcal/kg of product).

In the dry process, the raw materials are ground to a powder in the absence of water. Dry-process techniques have recently advanced considerably in the blending and homogenization of the raw mix. Here the energy consumption is only [illegible]30 kcal/kg of product.

Best control measures for dust depend on the stage of operation and include cyclones, bag filters and electrostatic precipitators.

The six case studies of cement works were chosen to represent the full range of environmental impact. The Abayek Cement Works, for example, operates with minimum pollution levels because the best practicable pollution control technology is skilfully employed. At the other extreme, the Loshan Cement Works operates with very high dust levels. Furthermore, recent advances in pollution control technology are not well known or understood so that future developments are viewed from an old-fashioned technological standpoint.

The Loshan Cement Works is a Government-owned plant established in 19[illegible]. There is a single production line with an annual capacity of 100,000 tons of Portland cement. This is a dry-process plant with an energy consumption of 950 kcal/kg of product. The dust loss is at least 5 tons/day through a 45 metre chimney. The dust arrestment equipment consists of five kiln cyclones and six inadequately maintained cloth bag filters. Plant personnel have the erroneous impression that no suitable electrofilter is available for the Loshan Works and that the use of electrofilters causes explosion risks. Thus expansion projects do not include plans for utilization of an electrofilter.

The Abayek Cement Works is a new plant built by the Faro and Khuzestan Cement Company. One evidence of the lack of pollution emission is the abundance of fertile terrain in the plant vicinity. This plant operates with the most up-to-date dry-process technology. Energy consumption at this plant is 800 kcal/kg of product. The daily capacity of the works is 3,500 tons. Both the kiln and the two cement-grinding mills are equipped with electrostatic precipitators. The flue gases of the kiln are also monitored for pollution control. The efficiency of the electrostatic precipitator on the kiln is said to be 99.97 per cent.

This project was developed by Iranian engineers, starting with raw materials prospecting and continuing through engineering design and evaluation of quotations from the equipment companies. The equipment from various manufacturers has been well co-ordinated in the production lines.

Th[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the p[illegible] [illegible] [illegible] and [illegible]. These have created more [illegible] working [illegible] [illegible] the growth of the [illegible].

[illegible]

Th[illegible] [illegible] [illegible] [illegible] sector. Th[illegible] fact[illegible] [illegible] [illegible], [illegible], [illegible] fertilizers, pharmaceuticals [illegible]. Th[illegible] [illegible] [illegible] [illegible], New Delhi and [illegible] areas.

Th[illegible] [illegible] chemical plants [illegible] [illegible], [illegible] insecticides, polymers, and plastics [illegible] factories. Six [illegible] some form of effluent treatment but [illegible] primary. Of the seven factories with substantial [illegible], only three incorporated treatment by a modern [illegible]. F[illegible] practised some form of resource recovery from waste streams [illegible], [illegible] as separation and reuse of waste oils and regeneration of spent acid. [illegible] problems were reported owing to poor in-plant working conditions at two [illegible] chemical plants visited.

The following examples were chosen to give a representative sampling of environmental conditions at the 13 firms.

The Mohan Meakin Brewery in the Bombay area does not treat its effluent but rather utilizes the sewage and industrial waste waters to irrigate and fertilize about 120 ha planted with wheat.

The Modipon Limited Nylon Factory produces 2,000 tons per year of Nylon-6. About 10 per cent of the nylon produced is waste. This is reprocessed into caprolactam and recycled, thus minimising pollution. This plant represents a good example of the beneficial effects of industrialization. A small village in a poor rural area has been developed into a prosperous little town with a health centre and cultural facilities.

The DCM Chemical Works Limited at Najafgarh (Bombay) includes a chlor-alkali electrolysis plant, a bleaching powder plant, sulphuric acid and hydrochloric acid plants, fertilizer (superphosphate) plant, and a fat-hardening plant. The chlor-alkali plant uses diaphragm cells which thus avoid the mercury pollution so frequently associated with mercury cells. The hydrogen produced is used in the manufacture of hydrochloric acid and for fat hardening. Solid wastes are sun-dried and land-filled. The waste water contains about two grams of solids per litre and is disposed in the main sewer. A major environmental hazard with this plant is that the mechanism for filling chlorine cylinders has neither an alarm system nor an automatic shut-off valve to prevent overfilling. However, no incidents of chlorine poisoning have occurred since the factory began operations in 1949.

In the case of the DCM fertilizer plant, the major hazard appears to arise from the use of primitive hand-operated sieves which cause large clouds of dust. Material transport, on the other hand, occurs using slow-moving belts and is practically dust free at the discharge points.

In the New Delhi area the Hindustan Insecticides Limited plant was visited. This is a Government-run enterprise and officials are concerned about pollution problems. The workers' representatives, however, are unaware of possible long-term health hazards from pollutants and are concerned instead that pollution-abatement measures might affect employment. This area has traditionally suffered from unemployment.

This plant produces DDT as a 50 per cent wettable powder and utilizes cyclone separation and a bag filter to prevent dust losses. The effluent from the process is highly acidic and contains a high DDT concentration. Prior to discharge the effluent is neutralized to a pH of 8-8.5 and the DDT is removed by a filtration system which includes activated carbon. The treatment system was recommended by the National Environmental Engineering Research Institute. The spent sulphuric acid used in the DDT manufacture is recycled after regeneration.

A plant in which good environmental practice is not maintained is the Indian Dyestuffs Industries Limited. This plant produces about 80 different dyestuffs and several intermediates, including aluminium chloride and sulphuric acid. Most of the batch equipment have vents to the open air. No information has been gathered regarding gaseous discharges from this equipment. The equipment for making aluminium chloride does have a washing device to prevent escape of chlorine.

A total of [illegible],000 m^3/day of liquid effluent leaves the plant. The only treatment is occasional neutralization of highly acid wastes. Within the factory, poor production techniques result in spillage of all kinds of liquids. Both the floors and equipment are kept wet. Also the workers are constantly exposed to the products because equipment is loaded and unloaded by hand. About 300 to 400 workers suffer annually from dermatitis caused by contact with the chemicals. The total work force is 1,300.

Case study no. 1: The chemical industry in Turkey

The study of environmental effects of the chemical industry in Turkey concentrated on factories in the Izmit and Bandirma areas. Both are highly industrialized. In general, the management personnel of the factories were not aware of the negative effects that the various effluents were having on the environment.

Seven chemical plants were visited in this study, including manufacturers of inorganic chemicals and a pulp and paper mill. Water pollution problems existed at all seven plants. In no cases were any waste-water treatment facilities present. In two plants heavy discharges of mercury were observed. Discharges of air pollutants presented problems at three plants. Five plants had equipment for air pollution abatement including bag filters, cyclones, wet scrubbers, and electrostatic precipitators. Poor factory working conditions resulted in health problems at two plants.

Izmit Bay was found to be seriously polluted by effluents from local industry, especially a pulp and paper mill. In Bandirma, atmospheric pollution by heavy industry may be the cause of reduced crop yields in the area.

Within the Izmit area, the chemicals industries are second in importance in all manufacturing. This industry occurs mostly along one bank of Izmit Bay and its effluents are discharged into the Bay. The major polluter of the Bay is the Government-owned Seka Pulp and Paper Mill. The discharged wastes are of high strength and acidity (biochemical oxygen demand of 4,600 ppm, pH of 2.4). However, this plant will be closed in five years and a new plant on the south coast of Turkey will replace it. The new plant will include a biological waste-treatment plant.

[illegible] in the area is the privately owned Koruma Tarım İlâçlari. The plant produces chlorine, caustic soda, DDT, benzene hexachloride, hydrochloric acid, sodium hypochloride and sulphuric acid. Major pollution occurs from the mercury cells in the chlor-alkali plant. Losses are 120 grams of mercury per ton of caustic produced. This amounts to one ton of mercury discharged per year. The effluent discharges into Izmit Bay. The laboratory at Koruma is well staffed and equipped to analyse mercury concentrations but these facilities are rarely used and workers have shown no interest in the mercury concentrations of discharges or products. In addition, about 350 kg of SO_2 are emitted daily from a stack only [illegible] metres high. This occurs in the sulphuric acid production unit.

The DDT production at Koruma was designed with a spent-acid recovery unit. However, this unit has never functioned properly and the spent acid containing chlorinated products is simply discharged into the Bay. This is a serious source of pollution.

In contrast, the benzene hexachloride unit at Koruma is of modern design and functions without hazard to the workmen or the environment. The reaction vessel is well sealed and there is no exposure to the ultraviolet light. Work is remote-controlled from outside. Unreacted benzene is evaporated and recycled.

In summary, there were instances of bad environmental practice observed at most of the industries visited. Several instances of mercury discharge occurred with no monitoring or attempts at control. There were, however, a number of individual cases of modern, well-designed reaction vessels for particular products that were operating without causing environmental degradation.

Remedial measures are often suggested in the report. For example, the Superphosphate Gubre Fabrikasi plant uses rapidly moving belts to transport the superphosphate, and heavy clouds of dust are produced at discharge points. The experts recommended the use of wide belts moving at low speeds equipped with cyclones and dust bags at the discharge points. Unfortunately, this plant discharges waste fluoride without treatment into Izmit Bay.

Fishing catch data obtained by the team in the Bandirma area indicated a relative constancy of catch over the period 1965–1973 even though a greater number of larger boats enabled the commercial fishermen to travel farther out to fish in 1973 than in 1965. The experts suspect that pollution is the reason for the need to fish a greater area to obtain the same catch.

A number of crops in the Bandirma area have reduced yields per ha in 1972 compared to [illegible]. The experts concluded that the effects of pollution on crop yields are likely, but cannot be directly traced. However, pollution has been shown to contribute to the decreased yield of wild apricots in the Bandirma area.

There is a chemical industries group at the Government-financed Tübitak Institute. This group is concentrating on pesticides in food products and on environmental contamination by boron compounds. There are large spillages and effluent discharges containing boron in the Bandirma area. In the future, this group will also study the effects of the heavy losses and discharges of mercury by the Turkish chlor-alkali industries.

In 1972 the chemicals and fertilizer sectors contributed 15.[illegible] and 2.3 per cent respectively to the Turkish manufacturing output of about LT 1[illegible]0 billion. The expected percentage figures for 1977 are 14.[illegible] and [illegible] respectively. The average growth rates projected are 13.3 per cent for chemicals and 2[illegible] per cent for fertilizers.

With regard to pollution legislation in Turkey, there is one law on pollution control and general hygiene. This is a regulation which permits the closing of factories that are causing sufficient environmental damage.

<u>Case study no. 5: The textile industry in Thailand</u>

The report summarizes the functions of all government agencies dealing with the environment. The Sanitary Engineering Section in the Ministry of Public Health is the group that gathers samples for water pollution analysis.

Three textile mills were selected for study. At Factory I where no dyeing is carried out, studies were confined to effects on plant personnel. At Factory II where neither spinning nor weaving are carried out, the study was based exclusively on the external pollution caused. Factory III was selected for a complete investigation because the plant carries out spinning and weaving (greatest potential for damage to the workers' health) and also dyeing (greatest potential for environmental damage). Some studies were also carried out in a fourth factory.

A major health problem in the textile industry is noise. Government data on 33 factories indicate noise greater than 90 decibels occurs in both spinning and weaving operations.

In Factory III a total of 137 workers in a work force of 1,601 (3.6 per cent) received clinical treatment for respiratory ailments in April 1964. Smaller numbers reported dermititis (61) and auditory problems (24).

The team concluded that an approximate total of 50 per cent of the workers exposed to those factory environments would be likely to suffer respiratory damage, and another 15 per cent would likely suffer hearing damage. The costs of prevention were calculated to be about 20 per cent of the cost of lost wages and productivity.

In the matter of water pollution, the small canals, called klongs, are of great importance to the well-being of the people. Fish consumption in Thailand is about three times that in the United States and is mainly from fresh water. Thus industrial pollution of the klongs has serious implications.

Two factories were selected for study of water pollution effects. One (Factory II) had primary and secondary treatment which reduced the bio-chemical oxygen demand (BOD) and suspended solids to below 20 and 30 ppm respectively. The other factory (Factory III) had only primary treatment (alum dosing and sedimentation) which is insufficient.

In the case of Factory II, the catch of fish in the klong has remained about the same as before the factory was built. In the case of Factory III, the condition of the klong downstream from the plant is black and turbid and the villages have complained in the newspaper that Factory III has seriously degraded the klong. Before the factory, one hundred families had engaged in fish farming with ponds filled with klong water. All families have now apparently ceased production. Furthermore, all fishing in the klong has been eliminated.

There are four available alternatives for the problem of wastes from the textile industry:

(a) No treatment;
(b) Conventional primary, secondary and tertiary treatment;
(c) Maximum reutilization of water and chemicals;
(d) Selection of different process chemicals.

Only the first two have been considered as alternatives in Thailand.

A large section of this report deals with technology transfer. Japan is by far the largest foreign investor, holding over 30 per cent of the total foreign capital. The dominant motive is developing and maintaining overseas markets. The overwhelming majority of technology transfers occur through joint ventures. These transfers are usually in the form of know-how. The level of product and process technology transferred is fairly low. Factory III has benefitted especially from technology transfer. The company was started by a Thai who is now company president. He formed a joint venture with a Japanese manufacturer in the mid 1960s. The firm carries out both weaving and dyeing processes. The success is evident by the fact that the firm is able to meet the high quality demands of the European market. All machinery is Japanese. Top and middle management in the firm was almost exclusively Japanese in the beginning and remains dominated by the Japanese.

Regarding pollution as related to technology transfer, the problem was recognised in all the factories visited. However, very little attention was given to local conditions when solutions were sought, and often solutions were not pursued until outside pressure was applied (usually complaints). Several companies sought help from a Japanese water-treatment firm with offices in Bangkok. This firm appeared not to have considered local conditions in deciding on treatment methods.

In the case of Factory III an approximate cost of water pollution was calculated for an average family living on the klong. A net economic loss of about ฿130 per family per year was estimated. If these losses were internalised, the internal rate of return for Factory III would be reduced from 25 per cent to about 20 per cent.

Factories II and III exceeded the average profits of all firms in Thailand by a considerable margin. This indicates that at least these two factories could adopt more effective environmental programmes without much effect on the level and composition of investment.

The conclusion is that the net impact on society of the textile plants is not as beneficial as the effect reflected in the company accounts. There are obvious effects of pollution which have not been taken into account. The long-range effects of the pollution of the Thai textile industry are still uncharted.

III. AN OVERVIEW OF THE CASE STUDIES

A general failing of the case studies was that each team proceeded to work on the environmental effects of industry without consistently following the methodology presented at the briefing. (Presented in annex I). This may have been because the procedures outlined were too lengthy and important tasks were not distinguished from those that were less important. In an attempt to overcome these shortcomings, a new methodology has been prepared (see annex II).

In the case of the integrated iron and steel plant in Brazil, the team worked on a single plant. In the case of the cement industry in Iran, the team worked on six plants chosen to illustrate environmental effects ranging from quite bad to very good. In the case of the chemicals industry study in India, UNIDO requested that the team visit a small number of plants for the purpose of carrying out detailed environmental studies. The Government of India responded by suggesting a list of some 30 companies. This list was eventually pared to the more manageable number of 13, but this was far in excess of an effective number for detailed environmental studies. For the future, UNIDO should insist that environmental case studies be carried out on a minimum of plants, preferably an in-depth study of one to three plants within a particular developing country.

Team no. 1 (iron and steel) paid special attention to the effects of pollutants within the plant and discovered substantial detrimental effects on the health of the workers. However, the team did not evaluate the negative effects of discharges from the plant on water quality and stream ecology down-stream from the plant.

Team no. 2 (cement) made a qualitative evaluation of relative environmental safeguards and contamination to rank the six cement plants visited. This work was not carried out using a methodology that could be utilized to study other industries in other countries, but it was at least useful for the purposes of the cement study.

In contrast, team no. 3 (chemicals) examined each industrial plant in isolation and made no effort to compare environmental effects of different plants or to develop a ranking of environmental effects for the different plants visited.

Missing from all the reports, except the report of team no. 5 (textiles), is an economic analysis of the costs of pollution abatement. Such costs would include the economic costs of air pollution abatement in the existing facilities, resource recovery possibilities, and the ability of the plant to absorb the net economic costs of pollution control.

Team no. 4 (chemicals) identified a chlor-alkali plant which utilized mercury cells, but the team did not consider environmental damages from mercury discharges. Furthermore, laboratory facilities were not sufficient to allow for mercury analysis. In addition to the environmental effect, two economic losses occur. One results from the discharge of one ton (worth about $15,000) of recoverable mercury annually. In addition, excess hydrogen that could be used for hardening edible oils cannot be so used because of excessive mercury concentrations in the hydrogen. No economic analysis was available for evaluating the trade-offs involving pollution <u>versus</u> resource recoveries.

Team no. 5 (textiles) spent a great deal of effort in analysing the economics of over-all textile plant operations in Thailand. This analysis was important and was presented along with the conclusions on the economic effects of instituting various environmental controls. The analyses of transfer of technology by team no. 5, although interesting, were not relevant to the theme of environmental impact analysis.

Discussion of revised methodology

For future case studies a revised methodology has been prepared, which centres on five work areas (for detailed breakdown see annex II):

1. Pollution and environmental effects within the plant
2. Pollutants leaving the plant
3. Effects of pollutants leaving the plant
4. Economics of pollution control for the plant
5. Legal implications of pollution

Work area 1 would be a survey within the plant of the working conditions of the employees. For example, do hazards exist there to health as a result of the exposure of workers to toxic chemicals, vapours, or particulates? If so, the situation should be thoroughly documented. What is the offending material and process? How many workers are affected and what are the health effects?

Interview workers to ask their state of health. How much time is lost from work owing to this hazard? What economic loss does this represent? In the case studies used for this report, teams no. 1 (iron and steel) and 5 (textile) did the best work on analyzing in-plant hazards to the workmen.

In work area 2, every effluent leaving the plant would be identified and characterized. Each effluent should be described as completely as possible by its physical and chemical properties. If an effluent treatment is utilized, it should be described and effluent analysis should be obtained both before and after treatment. The physical analysis should cover temperature, flow, and concentration of suspended solids. A screen analysis should be made of particulate emissions. Chemical analysis should include the gross characterization of the waste by a five-day BOD and chemical oxygen demand (COD) analysis. Specific analyses should be made for any impurity that is a hazard to the environment. If such data are unavailable, this should be so stated.

The description of the effluent treatment should include any dilution of the waste or mixing of waste streams as well as the process of treatment itself. The quantities of every impurity leaving the plant should be specified per day or week as well as per ton of finished product.

Work area 3 would encompass the effects that the plant effluents have on the external environment. Direct health effects should be determined. In the case of air pollution, the effects on the surrounding area should be documented through interviews with persons in the community and with physicians. Any monitoring data that are being obtained either by private industry or by the Government anywhere near the plant should be reported. For example, combustion flue gases may contain particulates, sulphur dioxide, oxides of nitrogen, carbon dioxide and carbon monoxide. If any of these have been monitored at government or industrial monitoring stations, the information should be reported.

In the case of water pollution, a search should be made to ascertain the existence of water quality data for the body of water which receives the effluent. In the case of a stream, the availability of water quality data should be ascertained upstream and downstream from the effluent discharge point. The team should ascertain the effect of the discharge on downstream users of the water. Any downstream water quality data that can be found ought to be reported. The team should strive to find out what have been the effects of the discharge on plants and animals, that is, the ecology.

In addition to an analysis of ecological effects, work area 3 should seek answers to the question: What are the socio-cultural effects of the industry? In other words, how has the industry changed the lives of those who live in the community? There will have been direct economic benefits to those who work at the factory. As a result of the factory, have these economic benefits improved the quality of life of the workers and their families? What percentage of the community work force is employed by the factory? On the negative side, how many people receive negative benefits (social costs) owing to the plant?

Team no. 1 (iron and steel), for example, reported that 3,500 inhabitants out of a total population of 130,000 suffer almost continuous exposure to severe air pollution. The entire population experiences occasional exposure to severe air pollution when prevailing winds shift. On the other hand, 13,000 people are directly employed by the factory and receive direct economic benefits. If the average family size is four to five members, this means that 40 to 50 per cent of the community receives direct economic benefits from the plant. The team should have tried to balance these against the social costs of the air pollution.

Work area 3 should conclude by reporting economic costs of water pollution which have occurred because effluents from this plant have damaged another resource. Reduction of fishing catches owing to discharges of effluents is one example. Air pollution damage to crops is another. Additional costs for treatment of intake water by a downstream industrial user or municipality ought to be included.

Work area 4 would concentrate on the economics of pollution control at the factory. This work would consist of two parts: for the first part, the team should concentrate on the over-all economics of the plant operation with the objective of ascertaining the ability of the plant to bear pollution control costs. For the second part, the team would concentrate on the possible reduction of effluent treatment costs by analysing potential means of reducing waste generation in the plant. Such means might include the reprocessing of a waste stream for product recovery or for water recycling. The data could be incorporated into a brief estimate of the economic costs and benefits that would occur from waste-reduction practices and from waste treatment.

Work area 5 would concern the legal implications of pollution: what environmental control legislation exists in the country, region and the city. Government officials should be questioned as to the enforcement of any existing [illegible] asked at the plant if any enforcement measures [illegible] by the Government to reduce pollutional discharges.

A major problem in all the case studies was the difficulty in unearthing relevant information. In many instances, the required information simply did not exist.

UNIDO proposes that to avoid this difficulty in future case studies, a staff member or the team leader should be sent to pre-screen proposed plants. He would select the plants to be studied on the basis of the best available information.

Another modification under consideration is to extend the duration of the case study field work to allow the team to obtain certain data. The team might work with plant chemists, for example, to gather data on factory discharges.

Some broader implications of the case studies

One contribution of the case studies has been the broader dissemination of environmental information and the wider recognition of the need for environmental analysis, even if on a minor scale. Many of the points on the environmental check-list (annex I) had not been thought of before by the officials in the developing countries. This was true both in the more primitive and the technologically advanced plants.

On the negative side, the data required for an environmental analysis of the plants visited were often unavailable. This reflects both the relatively recent emphasis on environmental concerns and the inadequacy of what is currently known about environmental parameters in the developing countries.

Certain experiences from the case studies are relevant to another UNIDO/UNEP joint project of co-location of industries based both on cross-utilisation of wastes with minimisation of pollution. As noted in the analysis of individual case studies, some utilisation of wastes is starting to be practiced. Team no. 1 found that the iron and steel plant in Brazil recovered 140 tons per month of $FeSO_4$ from depleted pickling solutions. This product is sold to outside consumers. Additionally, this plant granulates 200 tons per month of blast-furnace slag which is sold to a nearby cement plant. Iron scrap is also recovered from blast-furnace scrap and slag. The deliberate reduction of [illegible] by mixing streams to achieve neutralization was also found to be practised. However, in general the case studies showed a lack of knowledge of [illegible] options for the disposal or reuse of wastes.

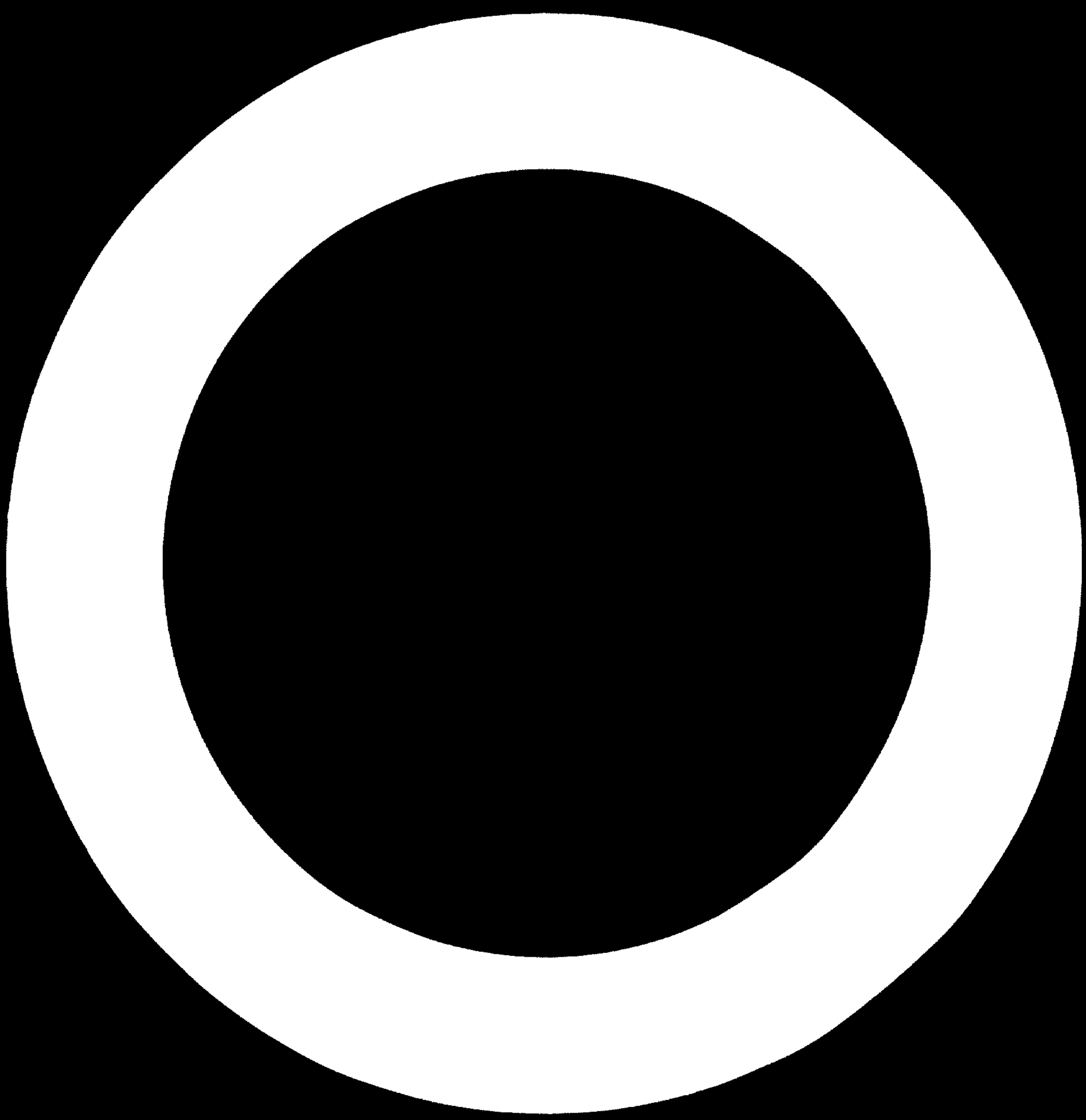
Considering the economic and social consequences of a possible policy of industrial co-location, economies and other benefits may occur such as the use of common services. A potential social benefit of a co-location policy is the possibility of achieving more varied and balanced human settlements. This avoids the disadvantages of a "one-company town". Co-location also provides employment opportunities for different types of labour, whether differentiated by sex, age or skill.

The question of the economics of the installation and operation of anti-pollution equipment should ordinarily be addressed as a facet of plant design. However, as the effects of wastes had been so rarely monitored and the often extensive effects of consequent pollution so little understood the case studies could rarely point to a justification of anti-pollution practice in economic terms. Exceptions were where anti-pollution practice had resulted either in waste recovery or reuse with direct economic gain.

Legislation with pollution control requirements is often lacking in developing countries. Detailed cost-benefit analyses of a small number of "best-practice" plants which are environmentally acceptable could serve as models for legislation. If such standards are to be enforced, a supporting infrastructure of monitoring organizations and equipment must be developed.

There is also a need to develop environmental training which is both economical and practical. One phenomenon noted on many missions to developing countries is that performance rapidly falls off when plants come under the control of local personnel only.

The case studies reveal the large gap between the problem of pollution control in industrial development and the resources available to tackle that problem in developing countries. A sound methodology for environmental impact evaluation which includes pollutional and socio-economic considerations is a necessary precursor to any governmental action to harmonize industrial activity with the environment. The revised guidelines for environmental analysis presented here (annex II) should be useful for developing countries as well as for future UNIDO case studies. Where long-term decisions are being taken, such as the establishment of a new industry, consideration and analysis of environmental effects in the planning phase should have high priority.



Annex I

BRIEFING NOTES FOR CASE STUDIES ON THE EFFECTS OF INDUSTRY ON THE ENVIRONMENT

The five individual industry case studies were designed to gather factual information about similar aspects of the industries [illegible]. The check-list of required information, supplied to each team, is reproduced here.

Guide to procedures

1. General information

(a) Contacts with United Nations officials;

(b) Liaison with appropriate applied research organizations, e.g. in the Netherlands, India, Thailand, the United Kingdom and the United States;

(c) Discussions with national and/or local authorities about industry's role in the national economy:

> Impact of industrialization on the environment, including health, well-being, economics and ecological systems;
>
> "Bench-mark" data showing general conditions before project and changes that cannot be ascribed to the project, e.g. health service care and its responsiveness to changing patterns of disease, migration, urbanisation etc.
>
> Is there any legislation concerning pollution and other damage control?
>
> Are emission and/or ground-level concentration standards used?
>
> To what extent do environmental considerations play a role in town planning and industrial planning?
>
> To what extent are scientific services available for monitoring?

(d) Discussions with factory management:

> Policy towards pollution control/profit trade-off;
>
> Effects inside factory and on environment;
>
> Role of industry in environment and community;
>
> Plans for future development.

2. Geographic and demographic situation

(a) Plans of town, industrial area, factory, other economic activities;

(b) Infrastructure as related to factory (rail, road. waterways, harbours, power supply, water supply etc.; sewer systems, disposal facilities) and other activities;

(c) Availability of personnel in the area (age and sex ratios in the community and the plant); transport of personnel;

(d) Residential and industrial area and future planning; other land use in the area;

(e) Meteorology (winds, rain, temperature, humidity, seasonal influences, sea currents);

(f) Edaphic features: soil types, hydrology;

(g) Influence of factors (a) - (f) in determining the final location of the plant.

3. Technology

(a) Identify the range of technical choices available for each process and product involved in the enterprise;

(b) How many technical choices were considered and what advice was sought before the existing technology was selected? How was the size of the enterprise determined? What do these factors tell us about the decision-making process?

(c) Have the techniques been modified or copied?

(d) Process description with flow sheet, including indication of discharges (quantities, analysis);

(e) What inputs are required (quantities, analysis)? What alternatives exist?

(f) What is the demand for labour inputs (training)?

(g) Capacities (design and actual);

(h) Intermediate products, especially of chemical processes (quantities, analysis);

(i) Outputs (quantities, analysis); alternative products;

(j) Discharges to be divided into gaseous, liquid and solid waste as well as dust and noise;

(k) Capital/labour characteristics of the technique.

4. **Damage control**

(a) Damaging effects of the discharges, industrial hazards and risks to third parties;

(b) To what extent are recycling, reclamation and neutralisation techniques being used?

(c) What is the nature of the ultimate discharge of gaseous effluents, including dust (stacks, quantity analysis)?

Can costs be identified and quantified?

What treatment is applied to reduce or disperse them; can costs be identified and quantified?

(d) Same as for liquid wastes:

Is there chemical and/or biological treatment [illegible]

(e) Same as for solid wastes:

Are there facilities for incineration or other procedures?

What controls of air pollution are applied to these?

(f) Same as for noise:

Are noise abatement measures being taken?

Is noise damage monitored?

Are audiologists available?

5. **Effects on the quality of life**

(a) **Internally to the plant:**

Occupational diseases including deafness and other nervous and circulatory disturbances; life expectancy;

The emergence of new social groupings within the factory situation (unionisation, etc.).

(b) **External:**

The creation of additional income resulting in changing patterns of consumption; consequences of these changes;

Consequences of changes in the distribution of income, e.g. influence on family structure, new attitudes towards social responsibilities,

leading to re-forming of social groups, etc.;

Subsequent attitudes towards work and job satisfaction;

Migration:

(i) Impact on donor community in the short and long term;

(ii) Impact on recipient community in relation to infrastructural provision for housing, education etc.; migrant/local relations;

(iii) Transfer of skills/experience acquired to workers migrating elsewhere.

6. Economics (See Guidelines for Project Evaluation a/)

(a) Economic and financial costs and benefits of the project, showing the actual values and those predicted by feasibility reports of: capital costs, running costs, financial return, economic return. (This should pay particular attention to determining all costs and benefits which are external to the project's financial accounts such as: "secondary" effects associated with the projects' inputs and outputs; the acquisition of skills; the employment of labour (including the effects of migration); the location of the plant; effects on third parties; the distribution of costs and benefits between various social groups);

(b) Identification of all economic and financial costs that are directly associated with damage control;

(c) If additional investment was made to control damage, what are the predicted economic and financial costs, and what would these costs have been if the measures had been incorporated into the original design?

What are the quantified benefits of these measures?

(d) If plans exist for improved damage control, what are the costs?

(e) What are the financial and economic costs of the various alternatives for damage control?

What effects do they have on financial and economic viability?

Which social groups incur the costs and benefits?

(f) Is research on damage control carried out? What are the costs?

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a/ United Nations publication, Sales No. 72. II. B. 11.

7. Suggestions

(a) For each source of damage, suggest, if possible, measures for prevention, abatement and control with range of costs for different levels;

(b) Indicate, if circumstances are favourable, co-operation with nearby industries;

(c) Give indications, as accurately as possible, about investment and running costs of prevention or reduction of damage;

(d) Give suggestions concerning more advanced or less damaging technologies to be used if renewal or enlargement is necessary;

(e) Where appropriate, suggest other industries which might in future be sited nearby in order to improve the performance of the region as a whole, i.e. potential utilisers of waste, sharers of disposal facilities, providers of inputs;

(f) Identify similar areas elsewhere where physical environment damage has occurred through similar industries. Inform; note reaction.

Annex II

PROPOSED METHODOLOGY FOR ENVIRONMENTAL ANALYSIS OF FUTURE CASE STUDIES

1. Survey environmental effects within the plant

(a) Working conditions: do any health hazards exist within the factory?

(b) Document hazardous materials and processes in the plant;

(c) How many workers are affected. What is the nature and magnitude of each health effect?

(d) How much time is lost?

(e) What economic loss results from time lost?

(f) Interview workmen to determine state of health.

2. Identify and characterize effluents leaving the plant

(a) Physical analyses: try to obtain data on temperature flow and on suspended solids; screen analysis (air);

(b) Chemical analysis - BOD, COD, toxic substances;

(c) Specify wastes per day and per ton of finished product;

(d) Describe treatment processes including dilutions and mixing of waste streams.

3. Determine effects that plant effluents have on the external environment

(a) Gather any relevant air and water pollution monitoring data. For the example of a stream, try to obtain data on water quality upstream as well as downstream from the discharge point;

(b) Impact of the discharge on the ecology. What have been the effects of the air or water pollutants on plants and animals? For the example of heavy air pollution, have there been noticeable declines in the production of any crops since the factory has been established? How have discharges of water pollutants changed the ecology of the receiving stream?

(c) What has been the impact of the discharge on downstream users of the water? Elimination of fishing owing to water pollution, for example, would have a substantial downstream effect which should be evaluated;

(d) Health effects: ascertain by discussions with physicians and members of the community;

(e) What socio-cultural effects have occurred? The expected benefits will come from the salaries and wages paid out to the work force. Social costs include all negative effects on people owing to the presence of the factory;

(f) Economic costs of pollution from damages external to the plant. One example is the value of reduction of the fish catch owing to water pollution discharges.

4. Determine economics of pollution control at the factory

(a) What are the over-all economics of the plant operations? Can this plant bear the costs of pollution control?

(b) Can this factory contribute to pollution control by waste reduction practices within the plant? Are there waste steams that could be processed for waste recovery, for example? Can the economic costs and benefits be estimated for waste recovery or reuse of certain waste waters?

5. Establish the legal implications of the pollution problem at the factory

(a) What pertinent legislation exists at the local or federal government level?

(b) If, for example, water pollution control legislation exists, is it enforced? By whom and how does the enforcement occur?

(c) Plant officials should be questioned as to what interest, including enforcement of regulations, has been taken by government officials regarding discharges at the factory.

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