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SURVEY OF WATER POLLUTION PROBLEMS CAUSED BY INDUSTRIAL ACTIVITIES IN ONE SRI LANKAN REGION *

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* This document has not been edited.

Abstract

SURVEY OF WATER POLLUTION PROBLEMS CAUSED BY INDUSTRIAL ACTIVITIES IN ONE SRI LANKAN REGION

(Research Proposal)

The quality of water in Sri Lanka is a very important local issue due to the effects of industrialization and urbanization. The survey discussed in this proposal is a preliminary survey in the field of water pollution in Sri Lanka. The results of the survey will be used in the UNIDO project called: Modern Technologies for the Treatment of Industrial Effluents in South Asian Countries.

This survey will consist of a general inventory of water pollution in Sri Lanka, an inventory of environmental policies and an analysis of one selected industry. The proposal for the survey outlines in detail the research background, aim, and relevance, elaboration of objectives, and methods and techniques to be used.

CONTENTS

1. INTRODUCTION

You just started reading the proposal for the research called: **"Survey on water pollution aspects caused by industrial activities in one Sri Lankan region"** . This survey will be prepared in Vienna and in the Netherlands in March and April 1990, and will be carried out in Sri Lanka within the period May-October 1990.

The survey serves as M.Sc. graduation at the Eindhoven University of Technology, in the framework of the graduate course "Technology and Society". To be more precisely, one of the specialization possibilities within this course is offered through the program "Science of Technological Development." The program educates students in technical as well as socio-economic topics. Students who finished their first year at a technical faculty can specialize during three years in subjects in the intersection of technology and social sciences. During the final year the M.Sc. research is to be conducted.

In my case, I have been studying Chemical Engineering for two years, after which I decided to choose the program "Science of Technological Development" with specialization in Environmental Pollution. I will finalize this program with the M.Sc. research in Sri Lanka.

The research will be conducted under auspices of the UNIDO (United Nations Industrial Development Organisation). The research is a preliminary phase of the UNIDO project called: **"Modern Technologies for the Treatment of Industrial Effluents in South Asian Countries"**.
My contribution to this project will be:
1) An general inventory of the scale and nature of the industrial water pollution in Sri Lanka, followed by an inventory of the data on water pollution problems caused by industrial activities in a certain region in Sri Lanka (see 5.1.);
2) An inventory of the environmental policies (concerning industrial water pollution) imposed by the Sri Lankan government;
The two inventories being a framework of reference, the most essential part of the research takes place in the form of a comparative case study:
3) An analysis of one selected industry with a substantial contribution to the Sri Lankan water pollution. In a comparative case study one Sri Lankan enterprise will be compared with a Dutch firm. In this fourth part of the survey the research instrument EIA (= Environmental Impact Assessment) will be a guideline.

In this research proposal, chapter 2 treats the present situation in Sri Lanka with respect to the water balance and the environment, the environmental policy institutions and the economic/industrial policies. Chapter 3 is about the major aims

and relevance of the research. In chapter 4 the problem is defined. This problem definition is elaborated in chapter 5, preceded by the selection of the research area and a discussion of effluent tolerance limits. Chapter 6 explains the methods and techniques that are going to be used in the research. In the following chapters 7, 8, 9, 10 respectively the processing of the results, the time planning schedule, the command of the language and the scientific monitoring are treated. The appendix contains the personal motivation.

2. RESEARCH BACKGROUND

2.1. Environmental problems in Sri Lanka

Due to the exploitation of natural resources, urbanisation and industrial growth promotion, Sri Lanka is confronted with mainly the following environmental problems:

1) deforestation,
2) soil erosion,
3) danger to coast and coastal areas,
4) danger to wild life,
5) pollution of inland waters,
6) industrial pollution.

The first five aspects are not under consideration in this research. The emphasis of the research will be the industrial water pollution. The major consequences of this industrial pollution are (a) problems involving water resources and (b) problems involving administration and enforcement of environmental legislation. (a) is discussed in chapter 2.2.; (b) comes up for discussion in 2.3.

Literature about Sri Lanka's industrial pollution is very scarce. Only some superficial descriptions are available about the major polluters. [ref 2, 1978] gives the following list:

- State enterprises: heavy industries like cement, chemicals, steel and petroleum products industry,
- Private corporations: chemical production, textile production, food processing, paper manufacturing.

The industries mentioned above use large quantities of water in their manufacturing processes. The fact that State Enterprises are among the major poluters may be an indication for insufficient environmental jurisdiction or inefficient environmental policy instruments.

Rivers in Sri Lanka are polluted mainly by the effluents of the following industries [ref 8, 1978]:

- asbestos product processing factories,
- coconut fibre mills,
- timber saw mills,
- sugar cane wastes (bagasse).

More specifically, the Kelani Ganga river (this is the river that flows into the Indian Ocean very near Colombo) is polluted by effluents of industrial projects with capital intensive high technology such as [ref 8, 1978]:

- a steel rolling mill,
- a tire factory,
- a petroleum refinery,
- a fertilizer factory.

Undoubtedly many modern industries have arisen since 1978 due to the industrial growth promotion and liberalisation policies. Especially in the Free Trade Zones, where establishment under favourable conditions was possible, concentrations of private enterprises emerged. More recently, UNIDO [ref 18, 1989] gives

the following list of the major polluters in South Asia:
- sugar, paper and carbonated beverages manufacturing,
- fruit canning and dairy industry,
- rubber, palm oil, fish, tapioca and coconut processing,
- tanneries, distilleries and brewery industry,
- metal processing and finishing,
- fish and pig farming.

Guided by the lists given above a selection will be made of those industries, which are referred most frequently as major contributors to the waterpollution. A selection will be made before the research in Sri Lanka starts.

2.2. The water balance of Sri Lanka

Sri Lanka is an island with an area as large as the Benelux. It counts approximately 16 million inhabitants. In case of water resources most cities, situated along the coast, are dependent on rivers from inland, reservoirs and groundwater. The island has about 10.000 open waterreservoirs (3% of the total land area), which are intensively exploited. Furthermore long water supply channels have been dug from watersources to the villages. Problems arising in this supply network in rural areas are the following:
- drying up of sources,
- waterborne diseases,
- overfishing,
- pollution of reservoirbeds through drainage of pesticides, fertilizers and cattle droppings to the surface and ground water),
- eutrophication by deposition of phosphates.

This rural pollution will not be under consideration in my research.

Agricultural and industrial wastes as well as sewage effluents from cities are drained in lakes, reservoirs, estuaries and rivers. In this way they pollute the watersupply network and the groundwater, resulting in e.g. heavily polluted channels in the cities, danger of bacterial/viral contamination (typhus, cholera) along the rivers. The heavily polluted channels are characterized by an unbearable smell of H_2S. Of course the quality of the sanitary and drinking water supply is endangered by this. Also droughts, as a result of delayed monsoons, cause problems in the water supply in urban areas. Especially Colombo is partly dependent on rainwater. Due to coastal pollution tourism is decreasing, which is a substantial income source for Sri Lanka.

The (mainly urban) water pollution caused by industrial effluents will be the subject of my research.

2.3. Institutions to monitor the water quality

On Sri Lankan environmental policies little data are available. Only the institutions involved can be found in literature [ref

2, 1978]. The institutions are divided in governmental and non-governmental agencies.

The Ministry of land and Land Development supervises the governmental Water Resources Board. Its tasks are (among other):

- the formulation of national policy on use and control of water resources.
- the prevention of pollution of rivers and streams etc.
- the formulation of national policy on disposal of sewage and industrial wastes.

The Ministry of Industries and Scientific Affairs (MISA) controls all state corporations of which some are reported to be among the heaviest polluters of Sri Lanka.

Under supervision of the Ministry of Local Government, Housing and Construction the National Water Supply and Drainage Board is operating. This Board formulated the "National Water Supply and Drainage Board Law", which includes penalties for the foulding of waters, penalties for wasting water and penalties allowing drains or sewers to flow into water.

In 1981 the Sri Lankan government started to conduct environmental policies more actively and it founded one central authority: the Central Environmental Authority.

Furthermore Sri Lanka knows some non-governmental organizations. The one relevant to my research is the Sri Lankan Environmental Federation. One of its goals is to identify significant environmental pollution directly affecting health.

The institutions mentioned above will be contacted in the framework of my research in order to obtain some support and useful data.

2.4. Economic and industrial policies

Practically since independence in 1948 Sri Lanka is dependent on foreign expertise. In the early sixties importsubstitution is promoted. Policies are characterized by active state involvement. Unfortunately these policies are not successful. In the late Sixties the emphasis moves to the private sector. Export promotion and liberalisation of import restrictions take place. Private foreign investment is attracted.

Between 1970 and 1977 the government and therefor its policy becomes strongly socialist oriented. Heavy essential industries come under state ownership. Small labour-intensive industries based on local raw materials are promoted. To stimulate regional development and employment industries have to be moved to rural areas. (by that time, 90% of the industrial production of Sri Lanka is situated in and near Colombo). The industries are characterized by a low capacity

utilization (about 40 to 50%) and a low added value (70% of the raw materials are imported). Foreign investors are welcomed more and more. In 1972 the first "Export Processing Zone" is proposed.

After 1977 trade liberalisation is really given shape. The new government (UNP) uses the following goals: economic growth, attraction of foreign capital, removal of import restrictions and growth of the private sector. "Investment Promotion Zones" are constructed with modern infrastructure and favourable investment conditions. An Export Development Board is founded. The National Development Bank has to promote private investment.
The development strategy involves the following industries: export industry, medium/small scale industry, industry meeting local mass consumption needs, industry based on indiginous raw materials, industries outside the Colombo District, all within the private sector exclusively.

It is true, that all these reforms caused industrial growth: industrial export increased with 500% in 7 years time, capacity utilization increased to 70%. However, rising oil prices and droughts among other have caused a slow down of the industrial growth. A substantial part of the raw materials is still imported by which the added value remains low. Exportpromotion policies do not show the expected results. However the private sector share in total industrial production increased from 40% to 60%. This sector mainly consists of small and medium scale industries.

The Adjustment Programme 1987-1990 from the present government again proposes some structural reforms. Industrial reforms intend to accelerate industrial growth and to enlarge export-orientation of the manufacturing sector. Furthermore the efficiency of state corporations will have to be improved and import restrictions will have to be diminished with 50% at least.

In short: The Sri Lankan gc ernment still strives for a more outward oriented, international competitive and export oriented industrial sector. Fernando [ref 13] writes about this: "The experience of Sri Lanka shows, that both increased dependence on marketforces and overprotection have obstructed the development of the industrial sector in Sri Lanka." From the policies of the past years one can conclude what kind of industries have been stimulated and developed. This insight will be a support in making an inventory of the industrial activities in Sri Lanka.[ref 3,4,5,13,16].

3. RESEARCH AIM AND RELEVANCE

General aim of this research is:
A) to draw up an inventory of industrial water pollution problems in Sri Lanka for one region in the Colombo district.
B) to obtain information of one Sri Lankan and one Dutch polluting enterprise to allow comparison with respect to process technology and waste-water. The research is a preliminary phase for a large project involving entire South Asia, supervised by UNIDO (see Introduction).

1) More specifically the research will firstly draw up in detail the identifiable and known problems involving water pollution caused by industrial activities. A general inventory will be made of the Sri Lankan situation, followed by collection of the existing data on industrial activities in the Colombo District, and on water pollution and waste-water treatment in the specific region. This part of the survey will be restricted to the chosen research area (see 5.1.). Aim of this phase is to detect gaps in the data. It will also be a support to the next phases of my research.

2) The imposed environmental policies (concerning water pollution) will be evaluated. Important tolerance limits will be compared to reality (see 5.2.). Aim is to evaluate the existing water pollution policies and support the formulation of a coordinated policy with realistic guidelines and recommendations.

3) The findings of the research by so far will lead to a framework of reference in order to conduct a comparative case-study, being the emphasis of the survey.
A Sri Lankan enterprise will be compared to a Dutch firm in the same industrial sector in order to explore fundamental differences in waste-water treatment and process technology. On the one side this comparative analysis will allow the drawing up of an inventory of the existing expertise in the field of wastewater treatment and clean process technology for the specific sector. On the other side the research will try to give possible improvements in process technology and waste-water treatment for the benefit of the Sri Lankan firm.

Supported by my own findings by means of a)observation in the problem areas, b)interviews and conversations with governmental experts and experts or managers of the firms and c)if possible laboratory research, the results will lead to an overview of the present situation in the region concerned. Aim is to identify and possibly fill the found vacancies and to give suggestions and guidelines concerning the Sri Lankan water pollution policy on the one side. On the other side the findings, conclusions and guidelines will support the start-up of the Sri Lankan part of the UNIDO-project.

4. PROBLEM DEFINITION

The problem is divided in four parts.
A) Which data are available with regard to water pollution caused by industrial activities in Sri Lanka and in the specific region in particular? Waste-water drainage by industries will be assessed (values of parameters will be checked), the global consequences for the environment will be evaluated, and used wastewater treatment methods will be investigated.

B) Which policies does the Sri Lankan government have in this field? Environmental institutions, their power, their capacity, their coordination as well as the tolerance limits of relevant determinants (appendix 3) are investigated.

C) What expertise concerning wastewater treatment and clean process technology is already existing?
A comparative analysis will take place of a Dutch firm and a Sri Lankan firm in the same specific industrial sector.

D) Which gaps and shortcomings can be discovered in the aspects mentioned above?

5. ELABORATION OF OBJECTIVES

5.1. Selection of the research area

The research will be restricted to those areas, that are safely accessible. Before arrival in Sri Lanka the political situation will be discussed with experts from the UN, the Dutch embassy and "Sri Lanka Werkgroep Nederland." Secondly the selected area has to be characterized by a concentration of industries, because here severe water pollution can be expected. Thirdly the area has to be of overseeable size for a research that will be conducted within 5 months. Fourthly it is necessary to have easy connections with the place of residence by means of public transport.

Taking into account these criteria, the political instability in the north, east and south of Sri Lanka and the fact, that 90% of the industrial production takes place in the Colombo District (Western Province), the selected area will be chosen in this Colombo District. Colombo will be chosen as place of residence.

Furthermore the research will be limited to an industrial area in Colombo city or one of the Free Trade Zones (e.g. Katunayake, Biyagame or Boosa). The final choice of the research area will take place after having made an inventory of the industrial activities in the Colombo District.

5.2. Effluent Tolerance Limits

A certain number of parameters continuously has to be monitored in order to manage and control the water quality in rivers, lakes, estuaries and reservoirs. Tolerance limits for effluents with different origins and destinies, valid for Sri Lanka and India respectively, are given in table 1, appendix 3. [ref 9, 1981; ref 20, 1989]. India, Sri Lanka's neighbour, is included in the list of tolerance limits to place the Sri Lankan situation in a wider context. To my opinion Sri Lanka and India allowed an honest comparison.

According to UNIDO the following pollutants may be found in industrial effluents in South Asia [ref 18, 1989]:

- Toxic and non-toxic metal ions: Fe, Cu, Zn, Ni, Be, Ti, As, Pb, Hg, Cd, associated anions such as sulphites, phosphates, fluorides, sulphides, cyanides, sulphocyanides, chlorides;
- Acids and bases: hydrochloric, nitric and sulfuric acids, potassium and sodium hydroxides;
- Solids in suspension: sands, oxides, hydroxides, clays, pigments, fibres;
- Organics: greases, aliphatic & aromatic hydrocarbons, tars, alcohols, phenols, sugars, proteins.

Comparison of the Sri Lankan tolerance limits with this UNIDO enumeration shows some polluting determinants (like Be, Ti, sulphites, sulphocyanides, acids, bases, tars, alcohols, sugars, proteins) not to be mentioned in the tolerance limits of Sri Lanka. On the other hand, however, in table 1 several determinants are included, which are not mentioned by UNIDO.

Further investigation by means of literature survey will supply lacking determinants and tolerance limits. Research will have to point out which determinants are relevant to the chosen research area and which to the chosen enterprise. The real values of these parameters will be determined by means of literature survey and/or laboratory research. Moreover the measured values of relevant determinants will be compared to the given tolerance limits.

5.3. Research design

Initial remarks
The research will take place at three levels:
1) the (international) level of the comparative analysis;
2) the regional level;
3) the micro-level of the individual enterprise.

Research at the third level may be obstructed by lack or unwillingness to collaborate. However, through contacts with UNIDO and DGIS hopefully these obstructions can be avoided.

Phased research design
The research is divided into 4 phases. The third phase is divided into three components. Place, research level and activities are outlined below.

PHASE 1
Place: Vienna, UNIDO
Level: regional

By means of literature research an inventory of available data will be drawn up, guided by the following questions. Based on the results one industrial sector and if possible both a Sri Lankan and a Dutch enterprise will be selected next.

- Which industrial activities take place in Sri Lanka and which in the selected area?
- Which data are available about the water pollution problems in that area?
- What kind of firms have a large share in the water pollution in the area under consideration?
- What kind of process technology do these firms use? Categories of types of technology will be made before.
- Which environmental policies does the Sri Lankan government use? Especially with respect to the water quality.
- Which institutions have what power, capacity, expertise with regard to these policies?

PHASE 2
Place: Netherlands
Level: micro-level

In the beginning of this phase the selected Dutch firm is contacted. The firm will be investigated by means of the following questions:

- What kind of process technology does the Dutch firm use? The firm must have a production process (with a certain kind of products) similar to the Sri Lankan firm.
- Is the wastewater of the firm treated within the firm and in what way?
- Which parameter values are known about the wastewater drainage by the Dutch firm? Size and composition of the pollution will be determined.
- What can be said about these values in relationship with the Dutch control standards?

PHASE 3
This phase is entirely conducted in Sri Lanka and is divided into three components, which not necessarily take place chronologically.

Component 3A
Place: Sri Lanka, the selected research area
Level: regional

In the selected area in Sri Lanka an inventory will be made based on the following questions:

- Which data about the selected area are available with respect to:
  * industrial activities,
  * process technology used by firms relevant to the water pollution problem,
- What is known about the water pollution problem in the area:
  * do the results from Vienna (concerning the strongly polluting enterprises in Sri Lanka) correspond with the Sri Lankan reality?
  * Which parameter values can be found and what control standards have been put in writing?
  * Are these values reliable? The sources of the found data will be detected.
  * What are the main pollution sources in the selected area?
  * Is there any waste-water treated by firms themselves and are governmental treatment installations functioning?
  * which vacancies can be found?
- Have industrial effluents been found for which treatment is necessary?
- What environmental policy is in operation for Colombo, in the Free Trade Zones and the selected research area?

Are these policies realistic?
- Which policy institutions monitoring the water quality are functioning? Are those institutions effective, looking at coordination, capacity, realistic control standards and possibilities for laboratory research?
- What can be added to these results by means of own research? The possibilities of laboratory research will be gone into. Furthermore interviews with experts can be useful data sources.

Component 3B
Place: Sri Lanka, the selected firm
Level: micro-level

In this phase the firm(s) selected in Vienna will be contacted and if necessary final selection will take place based on the results of research component 3A). There must be a certain and determined similarity in the field of process technology, when the selected firm is compared to the Dutch firm. Then the Sri Lankan firm will be researched with the following questions in mind:

- What kind of process technology is used in the production process?
- What is the overall balance of inputs and outputs?
- What is known about the (chemical) composition of the effluent of the firm?
- Are there any data available on the values of the environmental parameters (par.5.2.)? If yes, which data?
- What methods does the firm use to treat the wastewater (if any wastewater treatment takes place)?
- Is wastewater treatment necessary when the pollution control standards are compared to the real values of the parameters?
- Is the firm acquainted with the governmental environmental policies? Are there indications, that these policies are not followed?

Component 3C
Place: Sri Lanka, Colombo
level: regional and micro-level

The results of the two previous research components are evaluated and if necessary (and possible) completed.

- Which vacancies do the results of component 3a and 3b show with regard to the investigated aspects?
- Which suggestions can be given with regard to these aspects?
- Are there possibilities to complete some of the identified vacancies by means of analysis, calculations, field research and laboratory research?
- Is the environmental policy stated by the Sri Lankan Government realistic for the investigated area? What discrepancies can be found between policy and reality?

PHASE 4
Place: the Netherlands, Eindhoven
level: level of the comparing analysis

In this last Phase the two investigated firms are compared with regard to water pollution aspects. Furthermore a final report will be made about the entire research.

- Given the results from the Dutch and the Sri Lankan firm, which are the main differences and similarities between both firms with regard to process technology as well as wastewater (-composition, -flow, -treatment)?
- Are there significant differences between the Dutch and Sri Lankan control standards resp. real parameters values?
- Can the wastewater treatment method used in the Dutch firm and possibly other methods be implemented in the Sri Lankan firm without high extra costs?
- Can the process technology relevant to avoid water pollution be implemented in the Sri Lankan firm without high extra costs?
- What conclusions can be drawn from the comparison of the two firms?

In the end an analysis of collected data will be made, resulting in several final reports with the following destinations:

- the Eindhoven University of Technology,
- the UNIDO,
- the Sri Lankan environmental policy institution,
- the Sri Lankan enterprise.

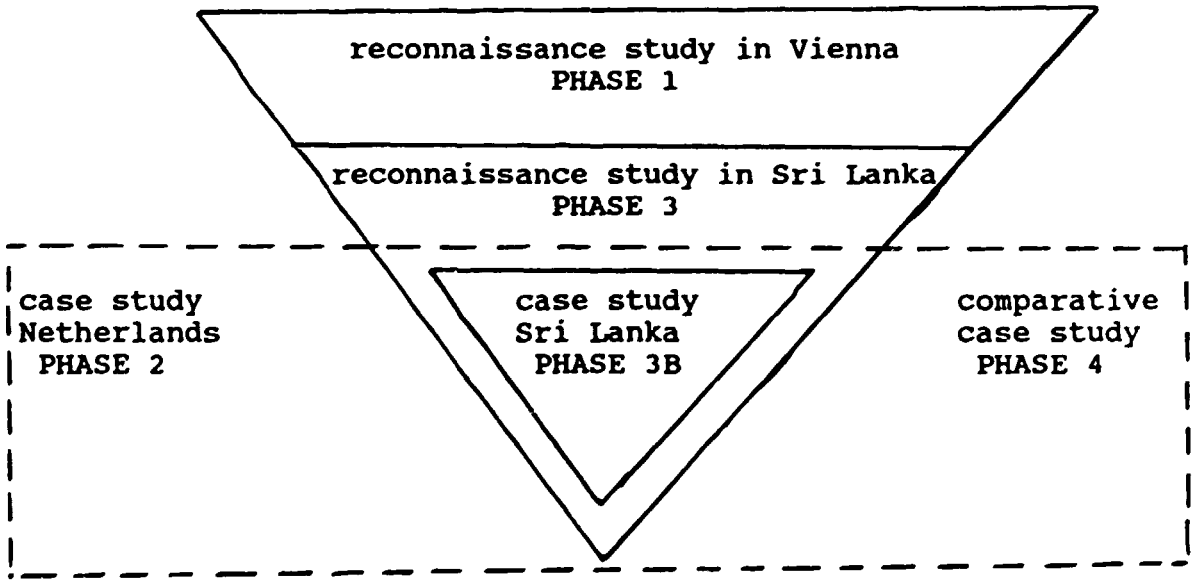
6. RESEARCH METHODS AND TECHNIQUES

6.1. Background

The research as a whole may be classified as a reconnaissance study in the field of water pollution. Namely, function of the research will be making an inventory of an unsatisfactorily known problem area. Based on this inventory specific vacancies will be formulated.

The main part of the survey may be characterized as a comparative case study. By means of a detailed analysis of a Dutch firm and a Sri Lankan firm respectively a part of the problem will be deepened, namely the field of wastewater, wastewater treatment and clean process technology in one specific sector. The environmental parameter values of the firms under consideration will be compared to the normative control standards. Used wastewater treatment methods and process technology will be evaluated. Based on the results of the reconnaissance study and the results of both case studies the Dutch and the Sri Lankan enterprise will be compared to each other.

Following the phases mentioned in the elaborated problem definition, the entire research can be presented schematically as shown in the figure below.



6.2. Methodology

This chapter treats the research activities in combination with the data collection methods. A general overview of the chapter is shown in Table 2, appendix 4.

Initial remarks
For all interviews detailed checklists have to be drafted carefully. Literature survey will take place with the help of libraries (of UN and EUT, e.a.), available data, data from the CEA and other statistic material (e.g. information from watersuppliers to the Sri Lankan firms). Laboratory research and other own observation methods have to be prepared initially (contacts to institutes with laboratory facilities have to be made).

Methodology
In phase 1 research will take place through making an inventory of available relevant literature at the UNIDO in Vienna (inventory of insights).

Phase 2 is a small case study of a firm in the Netherlands, that will be selected based on the found literature in the previous phase. The firm has to be characteristic for the relevant industrial sector which is an important water polluter in Sri Lanka. By means of literature survey, personal interview with company experts and environmental experts as well as observation the data will be obtained.

In phase 3A reconnoitring the problem area takes place by means of inventory of the available data in Sri Lanka through secundary sources and interview. Industrial activities, the water pollution problems as well as the environmental policies will get attention. Furthermore a Sri Lankan firm will be selected in the framework of the research component 3B. Available literature, interviews with policymaking experts and observation will be the main data sources. In case there are possibilities to conduct laboratory research, they will be used. These possibilities have to be explored before the research starts and appointments have to be made.

Phase 3B consists of a case study (see phase 2) of a firm in Sri Lanka. In this phase the UNEP research instrument called "Environmental Impact Assessment" (EIA) will be an important guideline. In short the EIA procedure contains the following five actions: 1) impact identification, 2) impact prediction and measurement, 3) impact interpretation and evaluation, 4) identification of monitoring requirements and mitigating measures, 5) communication of impact information to users such as decision makers and members of public [ref 6+10]. Like in Phase 2 the emphasis will be on the policy, the process technology, the wastewater treatment and the characteristics of the effluent (parameters). Data sources are personal interviews with company experts, literature, if possible laboratory research.

In phase 3C the previous phases are combined and the findings are evaluated. The results of the water pollution research at

both the regional level and the micro level are ordered, evaluated and compared to the conducted policy with regard to the environmental parameters.

In phase 4 the two chosen companies (one in the Netherlands and one in Sri Lanka) are compared. Differences or important findings in technology which may influence the waste water stream directly, will be described for both firms. Furthermore the parameter control standards and other environmental regulations in Sri Lanka, relevant to the industrial water pollution, will be compared to the Dutch situaton. This phase mainly takes place in the Netherlands and uses the results from all previous phases. The results gathered in Sri Lanka are elaborated in different ways, dependent on the kind of information. This information can be divided into political/economical, industrial/technological, chemical, social/geographic information. Not only the kind of information but the kind of investigation (e.g. laboratory, interview) as well will determine the kind of elaboration. A good preparation of the research will ease the elaboration efforts.

At last all research data and results are evaluated and reported. Conclusions are drawn, suggestions will be made. This will lead to the final report, one for the Eindhoven University of Technology, one for the UNIDO, one for the Sri Lankan environmental policy institution and one for the Sri Lankan firm.

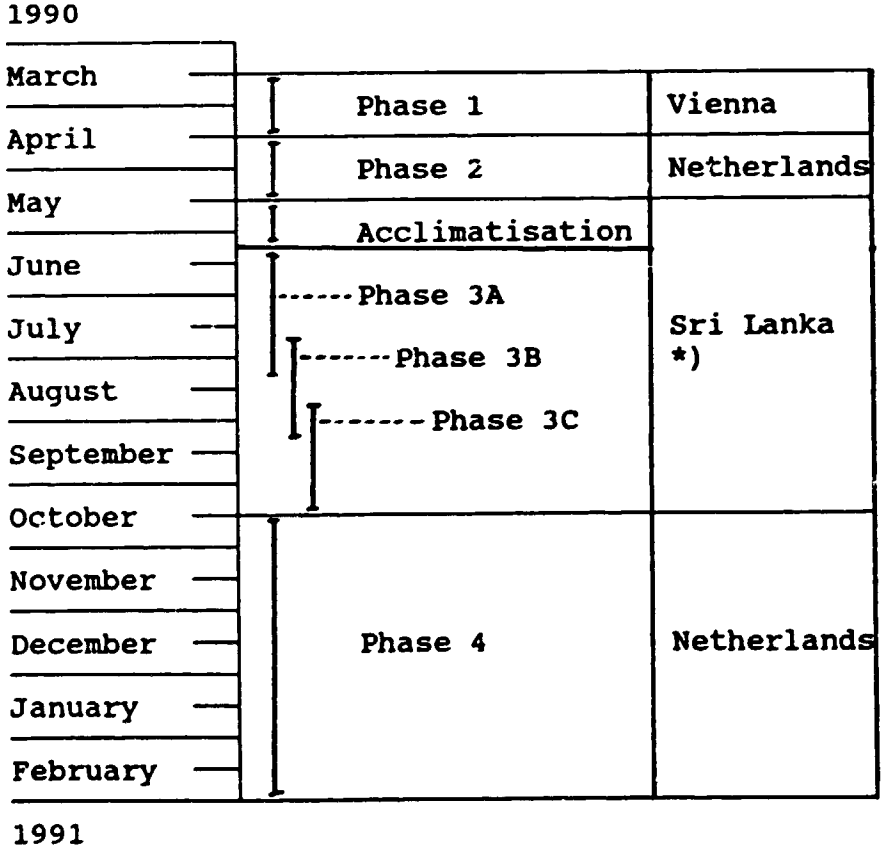
7. PROCESSING OF THE RESULTS

The elaboration of the results has already been described in phase 4 in chapter 6.2. A final report will be made for the EUT, because the research serves as my M.Sc. graduation at the Eindhoven University of Technology. The report will meet the requirements for graduation posed by the University.

A second final report will be made for the UNIDO, because the UNIDO will pose other requirements than the EUT. (e.g. the data will be more important for UNIDO, while the methodology will be emphasized by the EUT).

Of course the results of the survey also will be reported to the Sri Lankan firm and to the Sri Lankan environmental policy institution.

8. TIME SCHEDULE



*) The three components of phase 3 do not necessarily take place chronologically.

9. LANGUAGE

As a consequence of long British domination English is a commonly spoken and written language in Sri Lanka. To my opinion I master this language sufficiently in order to communicate at a scientific level. I don't speak the local languages like Singhalese and Tamil at all, but in case of necessity an interpreter can be used. No contacts have been made yet.

10. SUPERVISION

The research will take place within the framework of the UNIDO project. In the Netherlands my direct supervisor will be drs. P. van Tilburg (EUT). In Vienna the supervision will be done by (UNIDO). In Colombo the UN organisation will be contacted and hopefully I can make use of their infrastructure and expertise.
Technical supervisor and responsible in the technical field will be prof. ir. S.P. Ottengraf. However, also in Colombo a direct technical supervisor has to be contacted. The overall responsibility of the supervision of my M.Sc. research lays in hands of drs. P. van Tilburg of the Faculty Philosophy and Social sciences at the Eindhoven University of Technology.

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APPENDIX 1 : PERSONAL MOTIVATION

Why a developing country?
I have chosen for a course, that is a direct consequence of the development thinking of the industrialized West, namely: the Science of Technological Development. My technical specialisation is Chemical Engineering related to the Environment. My attention goes to developing countries, because it makes me feel more useful to devote my energies to very urgent problem situations.

Furthermore the unscrupulous ever increasing industrial growth is having some difficulties in the West due to the green political organisations and due to the rising costs. For both reasons many resource processing industries are moving to developing countries, because these countries have less stringent policies. This is why I think that environmental issues in the future will need equal or more attention in developing countries than in Western Europe.

Why Sri Lanka?
I have been studying literature about Sri Lanka and I have contacted some Sri Lanka experts (from the Ministry of Foreign Affairs and from the Institute for Social Studies). In these ways I discovered that the water quality is a very important issue in Sri Lanka, where health of man, flora and fauna are strongly dependent on the inland water resources. The water quality in Sri Lanka is, in times of industrialization and urbanisation, a hot item at the moment. This motivates me in doing my research.

Since 1977 Sri Lanka has been promoting liberalisation to attract foreign investment. Sri Lanka succeeded in attracting this investment, but the country's credits from foreign enterprises is one of unfulfilled expectations due to repatriation of profits and export of products. Another consequence of this investment promotion has been an increasing pollution. However, about this pollution little can be found in literature. My research will try to fill some of the existing gaps.

According to the data a coordinating environmental policy is necessary. Governmental agencies and commissions spring up like mushrooms. Since 1981 the so called Central Environmental Authority has been founded. This Authority has important coordinating tasks. Furthermore the Sri Lankan government is actively working on the environmental policies which are a part of the National Development Plan. These policies are called the National Environmental Act.

UNIDO came with the proposal to send me to Sri Lanka to conduct a preliminary survey in the field of water pollution. After short consideration I decided to accept the assignment for the following reasons:

- the subject interests me very much and is conform to my ideas concerning international cooperation.
- the subject is a very important one, which makes the research useful and relevant.

- the subject fits the direction I have chosen in my Eindhoven University of Technology - course. This motivates me to put in practice the things I have been tought.
- Sri Lanka appears to be a very interesting and beautiful (but unfortunately dangerous) country.
- I'm kind of attracted by the Hinduistic-Buddhistic world, especially since I have travelled through India during 6 weeks.
- The language, the English, will not cause insurmountable problems.

APPENDIX 2

TABLE 1 - TOLERANCE LIMITS OF IMPORTANT DETERMINANTS FOR EFFLUENTS IN SRI LANKA AND INDIA

MEANING OF COLUMN NUMBERS IN TABLE 1

1 Tolerance limits for industrial effluents discharged on land for Irrigation Purpose, SRI LANKA. [ref 20, 1989]

2 Tolerance limits for industrial and domestic effluents discharged into Marine Coastal Areas, SRI LANKA. [ref 20, 1989]

3 Tolerance limits for effluents from Rubber Factories, SRI LANKA.
There are two types of factories: Latex Concentrate and [Standard Lanka Rubber, Crepe Rubber, Ribbed Smoke Sheets]. If no brackets are shown in the table, the value is valid for both types. [ref 20, 1989]

4 Tolerance limits for effluents from Tanning Industry, SRI LANKA.
Values are given for effluents discharged into Inland Surface Waters and into [Marine Coastal Areas]. If no brackets are shown, the value is valid for both destinations of the effluent. [ref 20, 1989]

5 Tolerance limits for effluents from Textile Industry, SRI LANKA. [ref 20, 1989]

6 General standards for discharge of effluents into Inland Surface Waters, SRI LANKA. [ref 20, 1989]

7 Tolerance limits for discharge of industrial effluents into Inland Surface Waters and into [Public Sewers], INDIA. [ref 9, 1981]
If no brackets are shown, the value is valid for both destinations of the effluent.

8 General standards for discharge of effluents into Inland Surface Water, INDIA. [ref 9, 1981]

NOTES

" - " means, that no tolerance limits are given.
(*) saturation value or 3 mg/l, whichever is higher.

APPENDIX 2 - TABLE 1: TOLERANCE LIMITS

DETERMINANTS	1	2	3	4	5	6	7	8
1. a) Total suspended solids [mg/l]								
I) process waste-waters	-	150	100	100 [150]	50	50	100.0 [600]	-
II) cooling water effl.		infl.+ 10%	-	-	-	-	-	-
b) Total dissolved solids [mg/l]	2100	-	1500 [1000]	-	-	-	-	-
2. pH - range	5.5 - 9.0	6.0 - 8.5	6.5 - 8.5	5.5 - 9.0	6.5 - 8.5	6.0 - 8.5	5.5 - 9.0	6.0 -9.0
3. Biological Oxygen Demand (5 days, 20°C) [mg/l]	250	100	60 [50]	60 [100]	60	30	30.0 [500]	3.0
4. Chemical Oxygen Demand [mg/l]	-	250	400	250 [300]	250	250	250.0 [-]	-
5. Temperature, max.	-	45°C	-	-	40°C	40°C	40°C [45°C]	-
6. Oils & grease [mg/l]	10.0	20	-	10 [20]	10.0	10.0	10.0 [100]	0.1
7. Residual chlorine [mg/l]	-	1.0	-	-	-	1.0	1.0 [-]	-
8. Ammonical nitrogen [mg/l]	-	50.0	300 [40]	-	60	50.0	50.0	-
9. Total nitrogen [mg/l]	-	-	300 [60]	-	-	-	-	-
9. Phenolic compounds (as phen. OH) [mg/l]	-	5.0	-	1.0 [5.0]	1.0	1.0	1.0 [5.0]	0.005
10. Cyanides (as CN) [mg/l]	-	0.2	-	-	-	0.2	0.2 [2.0]	0.01
11. Sulfate (as SO) [mg/l]	1000	-	-	-	-	-	-	1000.0
12. Nitrates (as NO) [mg/l]	-	-	-	-	-	-	-	50.0
13. Sulfides (as S) [mg/l]	-	5.0	2.0	2.0 [5.0]	2.0	2.0	-	-
14. Chloride (as Cl) [mg/l]	600	-	-	1000	70	-	- [600.0]	600.0
15. Fluorides (as F) [mg/l]	-	15	-	-	-	2.0	2.0 [-]	1.5
16. Boron (as B) [mg/l]	2.0	-	-	-	-	-	-	-
17. Arsenic (as As) [mg/l]	0.2	0.2	-	-	-	0.2	0.2 [-]	0.2
18. Cadmium (as Cd) [total mg/l]	2.0	2.0	-	-	-	0.1	-	-
19. Chromium (as Cr) [total mg/l]	1.0	1.0	-	2.0	2.0	0.1	-	-
20. Hexavalent Chromium [mg/l]	-	-	-	0.5	0.5	-	-	-
21. Copper (as Cu) [total mg/l]	-	3.0	-	-	3.0	3.0	-	-
22. Lead (as Pb) [total mg/l]	1.0	1.0	-	-	-	0.1	-	-
23. Mercury (as Hg) [total mg/l]	0.01	0.01	-	-	-	0.0005	-	-
24. Nickel (as Ni) [total mg/l]	-	5.0	-	-	-	3.0	-	-
25. Selenium (as Se) [total mg/l]	-	0.05	-	-	-	0.05	-	-
26. Zinc (as Zn) [total mg/l]	-	5.0	-	-	5.0	5.0	5.0 [15.0]	-
27. Particle size of								
a) Floatable solids [mm]	-	3	-	-	-	-	-	-
b) settlable solids [µm]	-	850	-	-	-	850	-	-
28. Radio-active material:								
a) α-emitters [µc/ml]	10^{-9}	10^{-8}	-	-	-	10^{-7}	-	-
b) β-emitters [µc/ml]	10^{-8}	10^{-7}	-	-	-	10^{-8}	-	-
29. Organo-phosphorus compounds [mg/l]	-	1.0	-	-	-	-	-	-
30. Chlorinated hydro-carbons (as Cl) [mg/l]	-	0.02	-	-	-	-	-	-
31. Sodium Adsorption Ratio (SAR)	10 to 15	-	-	-	-	-	-	-
32. Residual Sodium Carbonate [mol/l]	2.5	-	-	-	-	-	-	-
33. Alkalinity (as $CaCO_3$) [mg/l]	-	-	-	750 [-]	-	-	-	-
34. Pesticides/ Insecticides	-	-	-	-	-	undetect.	zero [-]	zero
35. Dissolved oxygen [mg/l]	-	-	-	-	-	-	-	3.0(*)
36. Coliform organism [most probable number per 100ml]	-	-	-	-	-	-	-	5.0

APPENDIX 3 - TABLE 2: ACTIVITY SCHEDULE

PHASE	PERIOD	PLACE	RESEARCH SUBJECTS	RESEARCH ACTIVITIES	DATA COLLECTION METHOD
1	20/3-20/4	Vienna	- Industrial activities: a) Sri Lanka; b) one region - Water pollution - Environmental policy (water)	- Inventory of available data - Selection of Sri Lankan firm - Selection of Dutch firm	- literature - documentation
2	21/4-20/5	Eindhoven	*Dutch firm, specific: - process technology - waste-water treatment - water pollution	- Contacting & visiting of Dutch firm - Investigation of firm's characteristics - Application of E.I.A.	- personal interview (1) - check-list - observation - documentation
3A	7/6 - 7/8	Colombo	*Within one region: - industrial activities - process technology - waste-water treatment - water pollution(+policy)	- Inventory of available data - Laboratory research (if possible) - Contacting & visiting of Sri Lankan firm	- literature - documentation - personal interview (2) - laboratory research - observation
3B	21/7- 7/9	Colombo	*Sri Lankan firm, specific: - processtechnology - waste-water treatment - water pollution	- Investigation of Sri Lankan firm's characteristics - Applicaton of E.I.A. - Laboratory research (if possible)	- personal interview (1) - check-list - observation - documentation - laboratory research
3C	21/8-15/10	Colombo	*Region (see 3A) *Sri Lankan firm (see 3B)	- Analysis/evaluation ofresults - Elaboration of comparison of both case studies - Reporting to Sri Lankan firm & Policy institution	- calculation - additional interview
4	15/10-1/3	Eindhoven	*Sri Lanka (see 1a) *Region (see 3A) *Sri Lankan firm (see 3B) *Dutch firm (see 2)	- Elaboration of all results - Reporting to UNIDO and to EUT	- calculation

(1) personal interview with manager, production workers, pollution experts

(2) personal interview with governmental experts on industry and on water pollution