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Rapid Assessment

Water pollution in the catchment area of Lake Victoria, Tanzania

Peter A.G.M. Scheren
Jeroen C. Bosboom
Karoli N. Njau

Research Report

Eindhoven University of Technology
Faculty of Philosophy and Social Sciences
Rapid Assessment

Water pollution in the catchment area of Lake Victoria, Tanzania

August 1994

Peter A.G.M. Scheren
Jeroen C. Bosboom
Karoli N. Njau
PREFACE

In the last decade, environmental problems in developing countries have received increasing international attention. Recently the United Nations Conference on Environment and Development at Rio de Janeiro in June 1992 was an apogee. The Rio Summit stressed the necessity to take action as soon as possible, but also indicated that developing countries are determined to take responsibilities for the solution of their own problems and to analyse and solve the problem in the context of their local priorities. This means that developing countries will have to work on their own environmental monitoring and management systems.

For a country like Tanzania this is rather difficult, since the infrastructure necessary for such systems is still rather inadequate. The government and linked institutions have collected little of the necessary information. Quite a number of both local and foreign organisations have collected data in the past. Until now, little effort has been made to place the scattered data in an overall context. The purpose of this study is to do exactly that.

The results of the study will show whether such an exercise can lead to a foundation on which environmental monitoring and management can be based. In the mean time, Tanzania will have to set everything into place in order to develop the necessary capacity to further underpin the necessary action in this field. Because of constraints on time and resources it was decided to take the catchment area of Lake Victoria in Tanzania, commonly known as the Lake zone, as a case study. Lake Victoria region with its diversity of problems can serve as a good example and is essentially of influence on not only Tanzania, but an important part of the whole of East Africa.

The study gives an overall picture of the main contributors to the pollution of watercourses in the catchment area of Lake Victoria, in Tanzania. The study was carried out by J.C. Bosboom and P.A.G.M. Scheren, two post-graduate students of the Faculty of Chemical Engineering and Chemistry of Eindhoven University of Technology, the Netherlands(1), and K.N. Njau, lecturer at the Department of Chemical and Process Engineering of the University of Dar es Salaam, Tanzania(2). The field-study was coordinated by the Centre for International Cooperation Activities (CICA) of Eindhoven University of Technology. In the implementation of the field-study, the researchers collaborated with Dr. A.M.C. Lemmens, head of the Environmental Programme of the Centre for International Cooperation Activities.

Execution of this study was well received by both the government of Tanzania through the Ministry of Tourism, Natural Resources and Environment and institutions like the University of Dar es Salaam through the Chemical and Process Engineering Department. The Ministry and Centre for International Cooperation Activities provided logistical support in the field-study.
This study has been based on methodological guidelines presented in literature, using pollution/waste-load factors to estimate pollution and waste load respectively. It does not rely on point data, which would require much more consistent data collection.

The results will be presented to both central and district governmental and non-governmental organisations dealing with pollution prevention policies in the catchment area.

Peter Scheren  Karoli Njau  Jeroen Bosboom
SUMMARY

During the 1992 United Nations Conference on Environment and Development at Rio de Janeiro, it was indicated that the developing countries are determined to take responsibilities for the solution of their own environmental problems and to analyse and solve the problem in the context of their local priorities. This means that developing countries, like Tanzania, will have to develop their own environmental monitoring and management systems. For Tanzania this is rather difficult since the infrastructure necessary for such systems is still inadequate.

A Rapid Assessment of water pollution has been carried out. The catchment area of Lake Victoria in Tanzania, commonly known as the Lake zone, has been taken as a case study in order to produce an inventory of pollution sources of industrial, domestic, agricultural and mining origin. The study places the available, but scattered, data in Tanzania in an overall context. The results of the study will show whether such an exercise can lead to a foundation on which environmental monitoring and management can be based. To get a complete picture for the whole catchment area, similar studies ought to be done in Kenya, Uganda, Burundi and Rwanda (part of which is/has already been done). The study has been based on methodological guidelines, using conversion factors to estimate the pollution and waste loads.

It has been found that the industrial sector contributes significantly to pollution of watercourses in the catchment area, causing, however, mainly only local nuisances. The effluents from this sector are mostly discharged directly into watercourses, waste water treatment facilities being either completely absent or badly operated. The characteristics of the effluents from these industries exceed the Tanzanian Effluent Standards considerably. Industrial wastes are characterised by high values of Biological Oxygen Demand (BOD$_5$). Comparing the different industries, vegetable oil processing industries and soap manufacturing industries are the major sources of high BOD$_5$ waste, while Mwanza Tanneries is the only source of hazardous chemicals (chromium) worth mentioning. Transportation and machinery are the main sources of waste oils and greases. Industrial activities in the catchment area are still limited but are expected to increase considerably in the near future.

Domestic pollution, mainly from urban waste, has been identified as a major contributor in terms of Biological Oxygen Demand (BOD$_5$) and nutrients and is a rapidly growing source (2.7% population growth annually). Waste-water treatment is totally absent and urban waste water from the three major municipalities, Mwanza, Bukoba and Musoma, therefore largely ends up in Lake Victoria.

The agricultural sector has been found to be the main source of nutrients, posing a threat for eutrophication of watercourses. Organic manure has been identified as the major source, the contribution of artificial fertilizers being much less significant. Use of agrochemicals (organochlorine pesticides, other pesticides and copper) momentarily is very restricted due to prices that are unaffordable to the mostly small-scale farmers in the area. The concentrations of agrochemicals in the runoff of agricultural land exceed the Tanzanian Effluent Stan-
ards for indirect discharge into receiving waters, at the fields. Downstream concentrations are much lower, however.

The gold mining sector has been identified as a major source of mercury to watercourses (and the environment in general) in the area, activities being quite extensive and control absent.

Solid waste management is poor. Many private dumping sites for both industrial and solid waste exist and remain uncontrolled. Waste that is actually being collected is dumped without sufficient control, leakage of pollutants to watercourses therefore being expected.

The results and findings from this rapid assessment study have resulted in several recommendations for the future development of a system for management and control of the environment in Tanzania:

- Generally, environmental monitoring and management in the area under study is very poor. The limited data available on the environment is scattered and not easily accessible. As a result it is difficult to judge the extend of pollution in the catchment area, let alone be able to predict future developments on which to base environmental policy. It is therefore important to develop a system of monitoring on the basis of which problems can be identified in the earliest possible stage. It is also important to develop systematic data acquisition and an accessible database from which information can be derived to underpin policies.

- In order to obtain reliable data on waste water characteristics and, in general, water quality for environmental control purposes, it is necessary to strengthen laboratory capacities, formalise procedures and set up monitoring programs.

- Cultural, technological and economical situations differ considerably. However calculations of pollution and waste-loads made in this report can be assumed to give good order of magnitude estimations, it is necessary to develop a pollution index system specifically for the Tanzanian situation, in order to assess pollution and waste generation more accurately. In many cases such a system could limit the necessity of costly and time-consuming monitoring programs for environmental management and control purposes.

- Environmental education and awareness of the majority of the people in the catchment area is still very low and long-term environmental consequences seem to be too distant to perceive. Environmental policy making and implementation is not well organised yet, especially not on regional and district levels. It is therefore important to stimulate the environmental awareness particularly within industries and governmental organisations, as well as to coordinate environmental control activities.

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1. INTRODUCTION

1.1 Project aim

The aim of this project is to make an inventory of pollution sources of industrial, domestic, agricultural and mining origin in Tanzania, around Lake Victoria, in order to define priority study areas for pollution control measurements.

1.2 Project boundaries

- The total catchment area of Lake Victoria is defined in figure 1.1. The study area for this assessment study is further restricted by the international boundary between Tanzania and its neighbouring countries of Uganda, Kenya and Burundi.
- The catchment area of the study comprises Kagera, Mwanza and Mara regions, commonly known as the Lake zone, where pollution is generated that is expected to directly or indirectly end up in Lake Victoria and its surrounding watercourses.
- The study is restricted to an inventory of pollution sources. The fate and effect of pollutants in the environment is not investigated or described.
- The study is restricted to liquid and solid waste generation in the catchment area. As air pollution is not expected to add substantially to water pollution it is not regarded in this study.
- The study covers the yearly generation of waste load and pollution from sources in the catchment area.
- This study was carried out between July 1993 and June 1994, resulting in data on pollution and waste load up to 1993.

1.3 General background of the catchment area

With a surface area of 68,800 km² and an adjoining catchment area of 184,000 km², Lake Victoria is a source of life for tens of millions of people. As the second largest freshwater body in the world (by surface), the Lake and its ecosystem also harbour unique biological resources representing a global heritage.

The lake is shared between three countries - Tanzania, Kenya and Uganda - with Tanzania controlling 51% of the total area of the Lake (figure 1.1). The catchment area on Tanzanian side can be roughly defined as being the three regions of Mara, Mwanza and Kagera.

The natural resources within this sector and its catchment, are used to obtain food, shelter and energy, to secure residential and industrial water supply and transport needs, to irrigate land, and to dispose of human, agricultural and industrial waste. As the population around the Lake increased and foreign organisms were directly introduced into the Lake’s ecosystem, the uses of the Lake basin’s resources have increasingly come into sharper conflict with each other. This has contributed to significant, and considered by some to be alarming changes of the ecosystem over the last three decades.
1.4 Management and control of pollution

The Tanzanian cabinet, as the highest governmental body, is the principal policy-making and appraisal organ on matters related to strategies for the management and control of environmental pollution. Under the current structure the prime responsibilities for environmental policy-making in the government lie with the newly established Division of Environment of the Ministry of Tourism, Natural Resources and Environment, operative since a few years only. Before the establishment of this fully fledged Ministry for Environment, matters concerning the environment were dealt with by the
National Environmental Management Council (NEMC). This body was assigned to:
- Formulate proposals on environmental management and to recommend its implementation by the government, and to coordinate activities.
- Coordinate the activities of all bodies concerned with environmental matters and serve as a channel between these bodies and the government.
- Evaluate existing and proposed policies and activities of the government directed at pollution control and enhancement of the environment.

Under the current structure NEMC is affiliated with the ministry.

Responsibilities for the new ministerial division have not yet been fully defined. Water quality control, for example, is still largely coordinated by the Ministry of Water, Energy and Minerals, which, however, is mainly concerned with drinking water quality control only. Activities of regional water engineers and water quality laboratories (Maji's), therefore, mainly concern itself with this aspect. However, certain regional institutions are being involved in regional environmental policy-making on a more or less ad hoc basis. These include the Regional Development Director’s offices (RDD), Regional Water Engineer’s offices (RWE) and Municipal/Town Councils.

Due to the lack of funds, among other problems, systematic data collection and monitoring activities in the regions are not being undertaken. Rarely individual activities are undertaken by regional institutions or external research groups. In the latter case feedback of results of certain priority area studies towards both the division of environment of the government or the project areas themselves does not seem to take place.

1.5 Methodology

It is important to first define the terms "pollution", "water pollutants" and "waste" as used in this study. Pollution is the unfavourable alteration of our surroundings, wholly or largely as a by-product of man’s actions, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundances of organisms.

Water pollutants have been categorised by the Environmental Protection Agency (EPA) as follows:
- Oxygen-demanding waste
- Disease-causing agents
- Synthetic organic compounds
- Plant nutrients
- Inorganic chemicals and mineral substances
- Sediments
- Radioactive substances
- Thermal discharges

Waste is defined to be anything (material or characteristic) that is unwanted by or without value to
a system. Pollution is caused by waste from the system entering the environment or an unwanted release of non-waste materials or characteristics into the environment.

Based on the Regional programme for environmental management of Lake Victoria and the Rapid Assessment of Sources of Air, Water and Land pollution, the pollution sources of the waters of Lake Victoria have been divided in four main contributors:

- Industrial pollution.
- Domestic pollution.
- Agricultural pollution.
- Pollution by mining activities.

For estimation of industrial and domestic pollution the "Rapid Assessment" report by the World Health Organisation (WHO) has been used as a guideline. The report outlines a procedure for making rapid assessments of pollution sources in a certain region. It makes use of methods which have been especially adapted for use in developing countries, where it is often difficult to obtain certain kinds of information. The methods applies waste/pollution factors which are used to calculate the waste/pollution load.

Use of such a methodology has several limitations: Different states of technology for the industrial branches evaluated are not being regarded, although the overall technical, cultural, and economical differences between countries may imply differences in actual waste-load factors. Where available, therefore, typical ranges of waste load characteristics for industries as found in other literature are presented as a comparison for the characteristics and waste/pollution factors used. The characteristic waste load factors used will appear to be within range, however, pollution and waste-loads calculated should be seen as first estimations only. For accurate calculations, factors specific for the Tanzanian situation would have to be developed, and/or extensive pollution programs would have to be set up.

Methods to estimate the agricultural pollution and pollution by mining activities have either been selected from literature or have been developed, making use of pollution factors based on published data.

Basically, these methods have the same limitations as the WHO methods limitations.

Taking into account the limitations of the methodologies used, it should be kept in mind that pollution loads of the various sources of pollution mentioned in the report are meant to give as good an estimation of the actual case as possible. Especially for diffuse sources of pollution like rural domestic pollution and agricultural runoff, the values given should be regarded as no more than good order of magnitude estimations. The large extent of the catchment area makes it difficult to estimate contributions of these sources. Point sources of pollution such as urban domestic pollution and industrial pollution can be assumed to be less inaccurate, as actual runoff mostly occurs directly into the watercourses.
1.6 Literature and sources

2. INDUSTRIAL SOURCES OF POLLUTION

2.1 Methodology

Major polluting industrial establishments
A first index of major industrial establishments in the selected regions was extracted from the latest version of the "Directory of Industries" published by the Tanzanian Bureau of Statistics. The WHO rapid assessment methodology lists those industrial branches which can be expected to contribute significantly to environmental pollution. Combining these two lists an index of major polluting industrial establishments in the Lake Victoria catchment area in Tanzania has been established (appendix 1). Industrial establishments with less than 20 persons engaged have not been included in this index.

Characteristics of industries
An environmental assessment of industrial pollution sites in the Mwanza, Mara and Kagera regions was carried out in July 1993 and April 1994 by the authors of this report. Information on production figures and pollution loads from industries in these municipalities was gathered both on state level (ministries and governmental institutions) and on regional level (Regional Development Offices and regional institutions). An index of sources of information can be found at the end of this chapter. Most information on industries in the Mwanza region was gathered from a report by Höjlund et al. and from regional sources. Information on industries in the Mara region was available from a report by Höjlund et al. and regional sources. Information on industrial establishments in the Kagera region was gathered from regional sources only.

Pollution loads
The "rapid assessment" guidelines report by the World Health Organisation was used as a guideline for a rough estimation of pollution loads of the various industrial establishments. The methodology presents pollution loads and waste production per unit product and thus allows for the calculation of total pollution loads of the selected industrial establishments from their production figures. The production figures used mainly present figures for the periods 1990/1991 or 1991/1992 gathered from various sources. For all the vegetable oil mills average production figures was used, however. The values used seem to be fairly representative for the last years as they compare very well with figures given by Mpendazoe et al. for 1992/1993.

Three remarks on the "rapid assessment" methodology should be stated here:
- The methodology presents average pollution load and waste production figures for industrial establishments, not regarding the exact production process.
- Pollution/waste-load factors for most industries are based on the assumption that no waste water treatment facilities exist. Therefore, information on this was also gathered during the survey.
For certain industries, such as leather tanneries and textile mills, simplified (averaged) sets of pollution/waste-load factors were used, thus requiring less information on the actual production process.

The remarks above indicate that calculations of pollution loads of the selected industrial establishments are only rough estimations, being presumed however to be good enough to meet the aim of this "rapid assessment" survey.

Tanzanian effluent standards for industrial activities have been defined by the government(20). Standards for those pollution substances/characteristics calculated by pollution factors used for the selected industrial branches (table 2.2) in the "Rapid Assessment" methodology are displayed in table 2.1. Discharges by industries in the catchment area can in this way be compared with the respective standards for the various pollutants.

Table 2.1 Several Tanzanian Effluent Standards

<table>
<thead>
<tr>
<th>Substance/Characteristic</th>
<th>Unit</th>
<th>Direct discharge</th>
<th>Indirect discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>No limit</td>
</tr>
<tr>
<td>BOD₃, 20°C</td>
<td>g/m³</td>
<td>30</td>
<td>No limit</td>
</tr>
<tr>
<td>TDS</td>
<td>g/m³</td>
<td>3000</td>
<td>7500</td>
</tr>
<tr>
<td>SS</td>
<td>g/m³</td>
<td>Not to cause formation of sludge or scum in the receiving water</td>
<td>No limit</td>
</tr>
<tr>
<td>Chromium III</td>
<td>g/m³</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Nitrates</td>
<td>g/m³</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Sulphides (S²)</td>
<td>g/m³</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Grease and oils</td>
<td>g/m³</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

2.2 Pollution by industrial sources

A summary of the major industrial branches in the area, their corresponding International Standard Industrial Classification (ISIC) codes and the number of larger establishments of the branches present in the area are given in table 2.2.

A complete list of industrial establishments characterised by these branch descriptions, that were in 1989 in the catchment area(11), can be found in appendix 1. The majority of industrial establishments is located in or nearby the major urban centres Mwanza, Musoma and Bukoba. Exceptions are several smaller vegetable oil mills in the Mwanza region, Ushashi and Kimbara ginneries in Bunda and Biharamulo Cotton Co. located in Biharamulo.

Table 1 and 2 in appendix 3 display "rapid assessment" estimations of annual pollution loads to watercourses of the major industrial establishments in the Mwanza, Mara and Kagera region respectively. Table 1 and 2 in appendix 4 also give "rapid assessment" estimations of solid waste pollution.
loads, part of which may end up in watercourses. Production figures could be gathered for the largest industrial establishments only.

Table 2.2 Major industries in the catchment area

<table>
<thead>
<tr>
<th>ISIC Code</th>
<th>Industry</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>3115</td>
<td>Vegetable oil refining</td>
<td>5</td>
</tr>
<tr>
<td>3118</td>
<td>Cane sugar factories</td>
<td>1</td>
</tr>
<tr>
<td>3121</td>
<td>Manufacture of coffee</td>
<td>2</td>
</tr>
<tr>
<td>3134</td>
<td>Soft drinks industries</td>
<td>4</td>
</tr>
<tr>
<td>3211</td>
<td>Manufacture of cotton</td>
<td>6</td>
</tr>
<tr>
<td>3231</td>
<td>Leather tanneries (complete chrome)</td>
<td>1</td>
</tr>
<tr>
<td>3522</td>
<td>Manufacture of drugs and medicines</td>
<td>1</td>
</tr>
<tr>
<td>3523</td>
<td>Soap and cleaning preparations</td>
<td>2</td>
</tr>
<tr>
<td>4101</td>
<td>Electric light and power</td>
<td>3</td>
</tr>
</tbody>
</table>

2.2.1 Characteristics of selected industrial branches

Characteristics of the industrial branches listed in table 2.2 are shortly presented further on in this section. Information has been derived from Jørgenson\textsuperscript{16}, Codd \textit{et al.} (1975), reports from Höjlund \textit{et al.}\textsuperscript{1,2}, personal visits to some of the factories and from the WHO "rapid assessment\textsuperscript{13}" report. From the latter report waste-water characteristics could be calculated by dividing the pollution load per unit product by the waste-water generation per unit product, as given in the report.

As a comparison for most of the industrial establishments in Mwanza, waste-water characteristics are given that have been obtained from direct analysis of effluent streams of several establishments in 1992, as reported by Höjlund \textit{et al.}\textsuperscript{1}, Matowo\textsuperscript{3}, Maji Ubungo\textsuperscript{6} and Mpendazoe \textit{et al.}\textsuperscript{22}. In all cases sampling occurred just once, at one point in an effluent stream and at one moment of a particular day. The results from these measurements may therefore not be fully representative as large fluctuations in effluent stream constitution can be expected.

Table 1 in appendix 2 displays some of the other results of the analysis. Total annual pollution loads of the industrial establishments are given as well, that were obtained from these analyses together with the total waste-water generation as given in the above reports.

Fish processing

Fish processing is a growing industry around Lake Victoria. However at the time of the survey only 2 factories were operative, namely Vicfish Ltd in Mwanza and Fish Pack in Musoma, plans have been made for 7 new factories with similar capacities to be opened in 1993.

In the fish processing industries around Lake Victoria in Tanzania nearly 100% of the fish is being used. Fish remains after filetting end up as feed for cattle or are used for human consumption. During fish filetting, however, 5 to 10% of the product is lost into the waste water. Depending on the
kind of fish being processed 40 to 80% of this organic matter lost is protein and up to 60% is fish oil. Apart from this organic waste chlorine used for disinfecting the fish fillet after processing ends up in the waste water.

Typical waste-water characteristics for the fish-processing industry, as well as a waste-water generation figure for Vicfish, are displayed in table 2.3.

Table 2.3 Waste-water characteristics for fish-processing industries

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values&lt;sup&gt;13&lt;/sup&gt;</th>
<th>Analysis Vicfish&lt;sup&gt;11&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m³/t</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>BOD&lt;sub&gt;s&lt;/sub&gt;</td>
<td>g/m³</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>g/m³</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>g/m³</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>g/m³</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>g/m³</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Vegetable oil refining (ISIC 3115)

Vegetable Oil Industries Ltd (VOIL) is the largest establishment of this industrial branch in the area. Next to this several smaller factories can be found in the area, such as Farai and New-Era Oil Mills in Mwanza, Kimbara and Mugango Oil Mills in the Mara district and Biharamulo Cotton Co. in the Kagera district, the latter only producing a minor amount of seed oil next to other activities. Since 1989, when the "Directory of Industries<sup>11</sup>" was written, some changes seem to have occurred. Farai Oil Mill in Mwanza no longer exists, while in Musoma the Mara Oil Mill, a small factory, started operating in 1992. Production of the latter factory is still very low and it is therefore ignored in this survey. Next to all these establishments, several other small mills have been found to be operative in the three districts, especially in Mwanza. The largest ones, as reported in the "Directory of Industries<sup>11</sup>", have been surveyed.

Part of the fats and oils produced by VOIL and Biharamulo Cotton Co. are processed into soap. Surplus fat of VOIL is also sold to Lake Soap Ltd (see the section for Soap and cleaning preparations). Vegetable oil refining involves the production of vegetable oil from cotton or sunflower seeds. A screw-press expeller is used for extraction of oil from the seed. Besides the organic material, i.e. fats and oils from cotton seed, waste water also contains the remains of chemicals used in the refining process:

(i) Soap stock resulting from saponification of oils during caustic refining.
(ii) Bleaching agents used for decolorisation.
(iii) Antioxidants used for deodorisation.
(iv) Excess caustic soda.

Typical waste-water characteristics for the vegetable oil refinery industry, as well as analysis results for effluent characteristics of VOIL<sup>13,4</sup>, are displayed in table 2.4.

Solid waste is in the form of husks from cotton seeds, part of which is burnt in the steam boilers
(VOIL) and part of which is used for animal feed or pillow stuffing.

### Table 2.4 Waste-water characteristics for vegetable oil refining industries

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values(^{(13)})</th>
<th>Analysis VOIL(^{(13,4)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m(^3)/t</td>
<td>60</td>
<td>0.3</td>
</tr>
<tr>
<td>BOD(_3)</td>
<td>g/m(^3)</td>
<td>200</td>
<td>66</td>
</tr>
<tr>
<td>COD</td>
<td>g/m(^3)</td>
<td>400</td>
<td>5.9</td>
</tr>
<tr>
<td>SS</td>
<td>g/m(^3)</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>g/m(^3)</td>
<td>15000</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>g/m(^3)</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Cane sugar factories (ISIC 3118)

Only one sugar cane factory can be found in the area: Kagera Sugar Ltd in Bukoba rural area. Sugar cane processing firstly involves crushing the cane and squeezing out the sugar cane juice. The juice then undergoes several washing, skimming, heating, evaporation/crystallisation, centrifugation and refining steps in order to obtain refined sugar.

Wastes of cane sugar factories are generally divided into three categories:

(i) Cooking and condenser waste water, which is only slightly polluted.
(ii) Water containing solid impurities such as washing water and boiling blow-down water.
(iii) Highly polluted water, with a high organic matter content; pulp press water, molasses and filter-water.

Solid waste is mainly from the filtering process. Typical waste-water characteristics for cane sugar processing are displayed in table 2.5.

### Table 2.5 Waste-water characteristics for cane sugar factories

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values(^{(13)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m(^3)/t</td>
<td>30</td>
</tr>
<tr>
<td>BOD(_3)</td>
<td>g/m(^3)</td>
<td>100</td>
</tr>
<tr>
<td>SS</td>
<td>g/m(^3)</td>
<td>100</td>
</tr>
</tbody>
</table>
**Processing of coffee (ISIC 3121)**

Coffee beans from Kagera plantations are processed at Bukoba Coffee Curing Works (Bukob) Ltd. The processing involves the removal of the coffee husks to expose the bean. According to the general manager, hardly any waste water is produced as a dry processing technique is used. Only condensation water of the steam boiler is recirculated into the lake. Only a small part of the solid organic waste ends up in waste water, for example from cleaning practices. Solid waste is in the form of husks which are stored in the factories industrial area. Some leakage can occur.

Some of the coffee beans are processed by Tanganyika Instant Coffee Co. Ltd (Tanica), to obtain instant coffee. Its manufacturing process essentially follows the standard operations of roasting and grinding with large-scale percolation battery extraction, to provide a relatively high concentration of coffee extracts. These extracts are then spray dried to powders.

Waste water of the factory is mainly cooling water, while 4 tons of coffee residue per day is transported to a dump some 8 km away. The latter waste is very high in organics, reflected by high BOD and COD values, and a phosphorous and nitrogen compounds content. Substantial leakage to watercourses can occur.

Direct water pollution hardly occurs, as only cooling water low in pollutant content is recycled to Lake Victoria waters, and the coffee processing industries are not further regarded in this survey. However, as a result of leakage from solid and residual waste dumps, the establishments may still contribute to pollution of the lake.

**Soft drinks industries (ISIC 3134)**

Several bottling companies can be found in the area. Largest is Nyanza Bottling Ltd in Mwanza, next to slightly smaller ones, Mwanza Bottling Co. Ltd, Musoma Bottlers and West Lake Bottlers. Certain stages in the process involve the addition of chemicals such as chlorine and caustic soda used in the bottle-rinsing process, which can largely end up in waste water. BOD load and other waste load are expected to be very low and for this reason only two factories were surveyed as a case study: Nyanza Bottling Ltd, being the largest one, and West Lake Bottlers, representing one of the smaller ones.

Typical waste-water characteristics for bottling companies as well as some effluent analysis results for Nyanza Bottling Ltd are displayed in table 2.6.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values</th>
<th>Analysis Nyanza Bottling Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m³/t</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>BOD₅</td>
<td>g/m³</td>
<td>400</td>
<td>70</td>
</tr>
<tr>
<td>SS</td>
<td>g/m³</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

*Industrial sources of pollution*
Manufacture of cotton (ISIC 3211)

The first stage in cotton processing is the so-called "ginning" process, involving the removal of seeds from the cotton fibres. Larger cotton ginneries in the area are the Mugango, Ushashi and Kibara Ginneries in the Mara district and Biharamulo Cotton Ltd. in the Kagera district. The ginning process is a "dry" process and waste is mainly in the form of solid matter. The ginneries are therefore not further regarded in this report.

The second stage is textile processing. Textile mills process raw cotton and synthetic fibres into woven clothes. Further, the cloth may undergo dyeing and printing. Waste water is characterised by the remains of additives used in the different stages of the process:

(i) The slashing operation, or coating of yarn with sizing to give them tensile strength involves substances such as starch (or substitutes), polyvinyl alcohol, carboxy-methyl cellulose, gelation glue and gums. The waste volume is usually low but BOD can be quite high.

(ii) Desizing after weaving involves soaking of the fabric in a solution of sulphuric or acetic acid for several hours followed by washing out. Desizing contributes the largest BOD of all cotton finishing processes (about 45%).

(iii) Scouring involves the removal of cotton wax and other non-cellulose components using caustic soda and soda ash along with soaps and synthetic detergents. This process contributes the second largest BOD (about 30%).

(iv) Bleaching of the cotton fibres involves bleaching agents such as sodium hypochlorite and hydrogen peroxide.

(v) Mercerisation involves rinsing in acid wash, washing in water and drying. Waste water is alkaline and high in dissolved solids, but low in BOD.

(vi) Dying involves the addition of dyestuffs (pigments).

Waste effluents from textile mills are highly coloured, have high pH-values at times exceeding 12, high BOD and suspended solids. Effluents of Mwatex and Mutex show a lot of oil and grease floating on the water. Solid wastes are mainly the remains of fibre, yarn and cloth.

Typical waste-water characteristics for textile industry as well as effluent analysis results for Mwatex\textsuperscript{(1,3,4)} are displayed in table 2.7.

\textbf{Table 2.7 Waste-water characteristics for the cotton textile industry}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values\textsuperscript{(13)}</th>
<th>Typical range\textsuperscript{(16)}</th>
<th>Analysis Mwatex\textsuperscript{(13,4)}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m\textsuperscript{3}/t</td>
<td>300</td>
<td></td>
<td>825</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8-11</td>
<td>6-10</td>
<td>12.7/9.4</td>
</tr>
<tr>
<td>BOD\textsubscript{5}</td>
<td>g/m\textsuperscript{3}</td>
<td>500</td>
<td>300-1200</td>
<td>42</td>
</tr>
<tr>
<td>COD</td>
<td>g/m\textsuperscript{3}</td>
<td></td>
<td></td>
<td>9.8</td>
</tr>
<tr>
<td>SS</td>
<td>g/m\textsuperscript{3}</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>g/m\textsuperscript{3}</td>
<td>600</td>
<td>500-3000</td>
<td>4.6</td>
</tr>
</tbody>
</table>

\textit{Industrial sources of pollution}
Leather tanneries (ISIC 3231)

One leather tannery can be found in the area. The factory, Mwanza Tanneries Ltd., uses the chromium tanning method.

Most highly polluted waste-water comes from the liming and tanning operations. Waste water can be characterised according to the main stages in the process:

(i) Washing and preliminary soaking mainly involves organic waste; fat, blood, hair, salts and pieces of flesh.

(ii) Waste water from the liming step contains calcium compounds, sodium and potassium sulphides, albuminous substances, residual hair and pieces of fat and hair.

(iii) Pickling and chromium tanning involves remains of sodium chloride, mineral acids and trivalent chromium.

Typical waste-water characteristics for chromium tanneries \[^{13,16}\] , as well as result from the analysis of effluent from Mwanza Tanneries Ltd are given in table 2.8.

Solid wastes are mainly scrap products but there are also process wastes containing substantial concentrations of chromium.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical values(^{13})</th>
<th>Typical range(^{16})</th>
<th>Analysis Mwanza Tanneries Ltd(^{1,3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste volume</td>
<td>m(^3)/t</td>
<td>50</td>
<td>8-9</td>
<td>49</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>1-13</td>
<td>8-9</td>
<td>13</td>
</tr>
<tr>
<td>BOD(_5)</td>
<td>g/m(^3)</td>
<td>1700</td>
<td>500-1000</td>
<td>26.4</td>
</tr>
<tr>
<td>COD</td>
<td>g/m(^3)</td>
<td>5000</td>
<td>500-1200</td>
<td>15.5</td>
</tr>
<tr>
<td>SS</td>
<td>g/m(^3)</td>
<td>2700</td>
<td>1000-2000</td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>g/m(^3)</td>
<td>6800</td>
<td>3000-5000</td>
<td>9.9</td>
</tr>
<tr>
<td>Oil</td>
<td>g/m(^3)</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>g/m(^3)</td>
<td>300</td>
<td>100-200</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>g/m(^3)</td>
<td></td>
<td>10-40</td>
<td></td>
</tr>
<tr>
<td>S(^2)-</td>
<td>g/m(^3)</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>g/m(^3)</td>
<td>70</td>
<td>0.1-2</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Manufacture of drugs and medicines (ISIC 3522)

As far as the authors could tell the only company operative in the region, Mwanza Pharmaceutical Supplies Ltd, only deals with the importation and wholesale distribution of made-up pharmaceutical preparations, both medicines and cosmetics, and is therefore not engaged in the preparation of drugs and their fabrication into tablets, injections, etc. The company is therefore not regarded in this report any further.
Soap and cleaning preparations (ISIC 3523)
Lake Soap Industries Ltd in Mwanza is the only specialised factory of this kind in the area. However, VOIL and Biharamulo Cotton Co. also convert part of the fats and oils produced into soap.

The process mainly involves saponification; the conversion of fats and oil to soap by boiling with caustic soda. Apart from organic waste such as fats and oils and, chemicals used in the production process, waste water may be expected to contain; caustic soda, sodium, perfumes and colouring agents. Typical waste-water characteristics for this kind of industry as well as results from effluent analysis of Lake Soap Industries Ltd\(^{[13,4]}\) are displayed in table 2.9.

<table>
<thead>
<tr>
<th>Table 2.9 Waste-water characteristics for soap industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Waste volume</td>
</tr>
<tr>
<td>BOD&lt;(_5)</td>
</tr>
<tr>
<td>COD</td>
</tr>
<tr>
<td>SS</td>
</tr>
<tr>
<td>Oil</td>
</tr>
</tbody>
</table>

Electric light and power (ISIC 4101)
Power generation plants of TANESCO are found in all three of the largest municipalities, Mwanza, Musoma and Bukoba. Diesel engines are used for power generation. Pollution therefore is mainly air pollution, while water may be polluted by oil and grease used for the lubrication of the diesel engines. This type of industry was not further regarded in the rapid assessment analysis.

Machinery and transportation
Machinery and transportation (cars, trucks, boats) use substantial amounts of grease and lubrication oils. Figures on the amounts used\(^{[24]}\) in the Lake zone are shown in table 2.10. In the area there is no collection of waste oils for further treatment. It is to be expected that most of the waste oil will end up in watercourses.

<table>
<thead>
<tr>
<th>Table 2.10 Sale figures of oils in the Lake zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Lube oils</td>
</tr>
<tr>
<td>Grease</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Industrial sources of pollution
2.2.2 Waste treatment and disposal

In general it has been found that waste-water treatment systems are not available, insufficient or do not work properly as ponds are overloaded and lines are blocked. In Mwanza waste water of Mwatex, Nyanza Bottling Ltd. and TANESCO is treated in the same three successive aeration ponds. Residence time and efficiency of the treatment ponds are very low. Discharge occurs into the Nyashiri or Mirongo rivers, near the lake entrance. Mwanza Tanneries Ltd. has its own waste-water treatment plant (several sedimentation ponds) which have not been used for years. Waste water is expected to enter the lake directly or indirectly, by seepage processes through soil. Waste water from Lake Soap Ltd, VOIL, New-Era and Vicfish Ltd is discharged directly into the lake without any treatment.

In Musoma waste water from Mutex is treated in three successive sedimentation ponds which, however, do not seem to work properly as oil and grease simply flow from one pond into the other and on into the lake. The efficiency of the treatment has been found to be hardly 50% of BOD reduction and even less in COD. Part of the waste water of Mara Oil Mill, a new factory, is treated in three sedimentation ponds which are overloaded. Together with the remaining part waste-water flows directly into the lake. Other industries in the Mara region do not have any treatment facilities, but the ginneries and oil mills are located further from the lake. Fish Pack discharges directly into the lake.

In the Kagera district treatment system for waste water are not available and waste-water is discharged directly into the lake. Waste loads from the industries in the areas are very low, however.

Solid waste is often dumped on the industrial site itself. Runoff from private dumping sites near the lake, such as at Bukoba Coffee Curing Works Ltd, Tanica and the oil mills can be expected to be high. Centrally collected waste, such as waste from the fish processing industries, is dumped 5 to 10 km from the lake without any further control.

2.2.3 Pollution load of selected industrial establishments

From the characteristics of industrial branches that are found in the area and knowing that waste-water treatment facilities are inadequate or not available at all, the rapid assessment results indicate that in most cases the Tanzanian effluent standards are exceeded by far. However, the direct analysis results for some of the establishments would indicate much lower excesses. Comparing analysis results and the rapid assessment results, the results of the analysis are being questioned, however, as analysis values are mostly totally out of range with values found for similar industries in literature.

A summary of the "rapid assessment" results on BOD, is given in table 2.11. The availability of waste-water treatment facilities is also indicated.
Table 2.11  \( BOD_5 \) pollution load of selected industrial establishments around Lake Victoria, 1992

<table>
<thead>
<tr>
<th>Industrial establishment</th>
<th>( BOD_5 ) [t/year]</th>
<th>Waste-water treatment facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mwanza:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mwatex</td>
<td>100</td>
<td>Available but operating badly and too small</td>
</tr>
<tr>
<td>Mwanza Tanneries Ltd</td>
<td>20</td>
<td>Available but not operative</td>
</tr>
<tr>
<td>Lake Soap Industries Ltd</td>
<td>90</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>VOIL</td>
<td>200</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>New-Era</td>
<td>100</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Nyanza Bottling Co. Ltd</td>
<td>20</td>
<td>Available but operating badly and too small</td>
</tr>
<tr>
<td>Vicfish Ltd</td>
<td>10</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Mara:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mutex</td>
<td>100</td>
<td>Available but operating badly</td>
</tr>
<tr>
<td>Mugango Oil Mill</td>
<td>50</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Kimbara Oil Mill</td>
<td>20</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Fish Pack</td>
<td>40</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Kagera:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kagera Sugar Ltd</td>
<td>9</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>West Lake Bottlers Ltd</td>
<td>8</td>
<td>No treatment facilities</td>
</tr>
<tr>
<td>Total:</td>
<td>767</td>
<td></td>
</tr>
</tbody>
</table>

Comparing the calculated \( BOD_5 \) pollution load, vegetable oil refineries (VOIL and several smaller refineries), the cotton textile industry (Mwatex and Mutex), and the soap and cleaning preparations industries (Lake Soap Industries Ltd and VOIL) are the major contributing industries in the Lake zone.

Pollution from lube oil and grease used in machinery and transportation equipment (cars, trucks, boats) can be substantial as a result of the use of old and outdated equipment. Oil and grease spills and remains from machinery in the factories is generally disposed of together with waste water (and can be seen floating on top). In a few cases, as for Tanesco, oil filters have been installed. Oil from means of transportation in general is disposed of by dumping it into the environment, eventually polluting watercourses, as no central collection point exists.

The total amount of lubricant oil and grease sold in the area, 4198 and 409 tonnes respectively in 1992 (source: Matandula\(^{24}\)), gives an idea of this pollution load.
2.4 Conclusions

In general, technology and machinery used in industries in the catchment area date from 15 or more years ago (appendix 1) and are therefore obsolete. Environmental considerations such as waste control and good housekeeping are not given that much attention.

Waste water, in many cases untreated, is either being discharged directly into the lake or at a short distance from the entrance to the lake or one of its tributaries. The few waste-water treatment sites existing are not operating properly.

Due to lack of proper waste-water treatment facilities, effluents from industrial establishments in the Lake Victoria region are expected to exceed the Tanzanian pollution standards considerably. Because of weak sampling procedures and poor methods of analysis direct analysis results for effluent streams of industries in Mwanza(1,3,4), producing contradictory results, have to be questioned.

The major industrial discharges of waste in the catchment area are of an organic nature. The main polluting industries in this respect (expressed in high BOD$_5$ and COD values) are vegetable oil refineries (VOIL and several smaller refineries), the cotton textile industry (Mwatex and Mutex), and the soap and cleaning preparations industries (Lake Soap Industries Ltd and VOIL).

Pollution by toxic substances is mainly only from chromium used in the leather tanning process. The chromium levels in the effluent exceed the Tanzanian effluents standards significantly.

Machinery and transportation contribute a great deal to the pollution of watercourses by petroleum oils.

2.5 Data reliability

Official data on industrial establishments from the Directory of Industries(11) are regarded to be correct. Unfortunately, the most recent version of the directory contained data on 1989, which means that some newly-founded establishments could not be found in the directory.

General information on major industrial establishments within Mwanza town, obtained from reports of Höjlund et al.(1), Matowe(3) and Maji Ubungo(4) and from regional sources, showed little difference and seem to be reliable. The same applies to the information on major industries within Musoma town obtained from the reports by Höjlund et al.(2) and from regional sources. Data on the Kagera region, obtained from regional sources, are regarded to be reliable although limited.

Production figures used for the "rapid assessment" calculations in this report seem to be representative enough to serve the aim of this survey. Data from various sources, and different years of production, correspond quite well.

However, the reliability of data on the direct analysis of the effluent streams of several industrial establishments reported by Höjlund et al.(1), Matowo(5), Maji Ubungo(4) and Mpandazo et al.(22) is doubted for several reasons: First of all because of the sampling procedure, whereby samples were collected only once and at one point in an effluent stream, not taking into account the possibility of fluctuations in the streams. Secondly, the data obtained greatly differ from the "rapid assessment" calculations. Thirdly, the fact that results of analysis from different groups differ considerably.

Industrial sources of pollution
2.6 Literature and sources

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7. Mwisijo, Discussion with the Regional Trade Officer for Mwanza, RDD Block Mwanza, 6 July 1993.
12. NATEX, National Textile Institute, Dar es Salaam, Discussion with one of the officers of the institute, 26 July 1993.
15. Machajji, D., Discussion with the Regional Trade Officer for Kagera, RDD Block Bukoba, 18 April 1994.
22. Mpendazoee, M.T., Kibogoya, M., Rutagemwa, D.K., Kayombo, S., Rwegasira, M., Marwa, P., Evaluation of Point Source Discharge Treatment Options in the Lake Victoria Area in Tanzania,


3. DOMESTIC POLLUTION

3.1 Methodology

An estimation of the waste load from domestic sources has been made using population figures of the study area, together with information on sanitary facilities. Population figures of 1992 have been projected from the 1988 Population Census\(^2\). The division urban/rural and the population growth in the different regions could be gathered from the same Census. Information on sanitary facilities in the different regions was gathered locally, in the Mwanza\(^{(1)}\), Mara\(^{(3)}\) and Kagera\(^{(11)}\) regions. Using this information the "rapid assessment" methodology\(^{20}\) has been applied to estimate the total waste load of domestic sources. The methodology defines different conversion factors for parts of the population that are either connected or not connected to the sewage system and gives average waste loads per person for such situations. Waste load estimations are calculated by multiplying the number of people with a certain characteristic by the applicable conversion factor. As already discussed in the introduction, the methodology allows a rough estimation of waste loads only, which is assumed to be good enough to serve the aim of this survey.

3.2 Pollution by domestic sources

A description of domestic waste load requires a distinction between urban and rural or mixed populations. As the urban population in the Mwanza, Mara and Kagera regions is concentrated in and around the main municipalities of Mwanza, Musoma and Bukoba only, located directly at the lake shore, a high percentage of the urban waste produced eventually end up as pollution in Lake Victoria waters. For the rural and mixed urban/rural populations, the percentage of waste ending up in watercourses is presumed to be much lower, as the population is scattered over a vast area reaching up to 150 km from the lake shore. Most of the waste produced by the rural population has enough time to disintegrate and get into nutrient cycles before entering into watercourses. Only a small portion of the waste produced may leach into watercourses as pollution via the many seasonal and non-seasonal rivers.

3.2.1 Domestic characteristics in the regions

A summary of population statistics for the Mwanza, Mara and Kagera regions is given in table 3.1. The population figures in the table are projections for 1992 based on the 1988 Population Census\(^2\) figures. The latter report distinguishes between urban, rural and mixed urban/rural populations. Presumably the population growth figure for rural areas is higher than the average given here. In Mwanza it was stated that the population increase amounted to 7.2% annually between 1988 and 1992\(^{(12)}\).
Table 3.1  Summary of population statistics for the Mwanza, Mara and Kagera regions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mwanza</th>
<th>Mara</th>
<th>Bukoba</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population</td>
<td>2,081,362</td>
<td>1,088,566</td>
<td>1,475,317</td>
</tr>
<tr>
<td>Population growth</td>
<td>2.6%</td>
<td>2.9%</td>
<td>2.7%</td>
</tr>
<tr>
<td>% Urban</td>
<td>8.9%</td>
<td>6.6%</td>
<td>2.2%</td>
</tr>
<tr>
<td>% Rural</td>
<td>71.3%</td>
<td>86.2%</td>
<td>83.3%</td>
</tr>
<tr>
<td>% Mixed</td>
<td>19.8%</td>
<td>7.2%</td>
<td>14.5%</td>
</tr>
</tbody>
</table>

Accurate figures on sanitary facilities were found hard to obtain as no proper record was kept on this. However, estimations could be made from the limited data\(^{(11,13)}\) available.

A sewage system only appeared to be present in the Mwanza municipality, serving approximately 12% of the urban population of the municipality. A summary of the sanitary facilities of the urban population in Mwanza, Musoma and Bukoba is given in table 3.2.

Due to a lack of adequate master plans in the three municipalities, houses are very scattered, industrial areas are mixed with housing areas and hardly any control over sanitary facilities exists (or would be possible).

Table 3.2  Sanitary facilities for urban populations in Mwanza, Musoma and Bukoba.

<table>
<thead>
<tr>
<th>Sanitary facility</th>
<th>Mwanza</th>
<th>Musoma</th>
<th>Bukoba</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Sewered</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>% Septic tanks</td>
<td>20%</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>% Pit latrines</td>
<td>68%</td>
<td>67%</td>
<td>80%</td>
</tr>
<tr>
<td>% Other</td>
<td>0%</td>
<td>23%</td>
<td>0%</td>
</tr>
</tbody>
</table>

3.2.2 Waste treatment and disposal

There is a total lack of waste-water treatment plants in the catchment area. The Mwanza municipality is the only town where a waste-water treatment plant has been installed. However, the installation has been overloaded since its completion in 1972\(^{(13)}\). Due to a pump failure, the total amount of waste water (approximately 2900 m\(^3/\text{day}\)) is being passed directly as pollution into Lake Victoria.

Because of the total absence of waste-water treatment in the whole catchment area virtually all of the urban waste produced will end up in Lake Victoria.

In the Mwanza, Musoma and Bukoba municipalities solid waste is collected and dumped on selected waste sites out of town, 5 to 10 km from the lake shore. Leakage to open waters however is very possible as wastes are crudely thrown and there is no control over the waste dumping sites.

In rural areas people normally dig holes to dump waste until they are filled up. Part of the solid waste of both rural and urban people is also used for fertilization of agricultural grounds.
Collection of waste from septic tanks is badly organised and only part of the waste is collected: 40% of the total septic tanks waste for Bukoba town and only 17% for Musoma. The waste collected is dumped outside of town not far from the lake. For example in Mwanza it is only 0.5 km from the lake shore. Disposal of the remaining waste from septic tanks is totally uncontrolled. In all cases considerable leakages are expected.

3.2.3 Domestic waste load

Table 1 in appendix 5 displays the outcome of "rapid assessment" estimations of the waste load from domestic sources. For calculations, pollution loads from the mixed and rural population are taken together in the category of rural, and calculated as such. As discussed before, a large part of this urbanely produced waste can be assumed to end up as pollution in the lake waters, either directly via the sewerage, as in Mwanza, or via drainage systems in the three municipalities, which in many cases also function as a sewerage system.

The percentage of the total waste load from rural population that may end up as pollution in watercourses is very low and thus is not considered in this table. However, the waste production of the rural population can be found in table 1 in appendix 5.

It can be seen from the table that in the absence of any treatment, pollution from domestic sources is expected to be quite substantial, especially in terms of organic waste (expressed in high BOD$_5$ and COD values) and nutrients (expressed in high N and P values). Regarding the population growth figures (table 3.1) the growth of this pollution load from domestic sources is considerable and actually doubles approximately every 30 years. A summary of the results of the calculations on the urban load is given in table 3.3.

Table 3.3 Summary of domestic waste estimations for the Mwanza, Mara and Kagera regions

<table>
<thead>
<tr>
<th>Region</th>
<th>BOD$_5$</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mwanza</td>
<td>1600</td>
<td>600</td>
<td>80</td>
</tr>
<tr>
<td>Mara</td>
<td>500</td>
<td>200</td>
<td>30</td>
</tr>
<tr>
<td>Kagera</td>
<td>200</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2300</strong></td>
<td><strong>900</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

3.3 Conclusions

In the absence of any waste-water treatment facilities pollution by urban domestic sources is expected to be substantial and the total load is growing fast, especially in terms of organic waste (expressed in high BOD$_5$ and COD values) and nutrients (expressed in high N and P values). Domestic waste management and control in the area is very poor and waste-water treatment facilities are either not available or not operative.
3.4 Data reliability

Population figures gathered from the 1988 Population Census for Tanzania\(^{(0)}\) are regarded to be reliable. The extrapolations to 1992 probably introduce relatively small errors only. General information on sanitary facilities\(^{(1,11,13)}\) and waste disposal and treatment\(^{(13,4,11)}\) are not viewed as very accurate. However, it can be assumed that information and figures obtained present a rough, but realistic, picture of the situation in the towns and regions.

3.5 Literature and sources

3. Matowo, S., Baragwiha, Discussion with respectively the Head of Laboratory of Maji Mwanza and the Regional Water Engineer for Mwanza, Maji Mwanza, 8 July 1993.
5. Gunda, M.O., Discussion with the Town Director of Musoma, Musoma, 9 July 1993.
9. Matowo, S., Discussion with the Head of Laboratory of Maji Mwanza, Maji Mwanza, 13 April 1994.
11. Kwiluhya, Mrs., Roderick, Mr., Discussion with respectively the Acting Town Director and the Town Sanitary Engineer of Bukoba, Town Director Office Bukoba, 18 April 1994.
12. Salage, Mr., Discussion with the Municipal Planning Officer of Mwanza, Town Director Office Mwanza, 20 April 1994.

23 Domestic pollution
4. AGRICULTURAL SOURCES OF POLLUTION

4.1 Methodology

There are two potential sources of agricultural pollution which can have an impact on the aquatic environment:
- Fertilizers. Organic and artificial fertilizers used on land may cause eutrophication of lakes and reservoirs, through leaching of nutrients into watercourses.
- Agrochemicals. Pesticides, herbicides and fungicides are mostly used for crop protection and, in smaller amounts, as disinfectants for animals, which is especially important in hot, tropical climates. Their toxic breakdown products can reach the aquatic environment either directly via runoff water or bound to soil, sediment and air particles.

A rapid assessment of agricultural pollution in the Mwanza, Mara and Kagera regions was carried out in July 1993 and April 1994 by the authors of this report. Information on the amount of fertilizers (organic and artificial) as well as the amount of pesticides, herbicides and fungicides used, was gathered both at state level (ministries and governmental institutions) and at regional level (Regional Agricultural Offices, Regional Development Offices and regional institutions). An index of sources of information can be found at the end of the chapter.

4.1.1 Fertilizers

The study has been restricted to the contribution of nitrogen (N) and phosphorous (P) nutrients. In order to discuss the total input of N and P from fertilizers, the complete nutrient balance for the whole area should be assessed. Some models to assess nutrient balances (e.g. Smaling\(^44\) and Vollenweider\(^45\)) do exist. However these models have not been applied in this study due to their shortcomings. Therefore, in this study an evaluation of the agricultural nutrients input from the use of fertilizers has been done through a comparison of the nutrient load from fertilizers in the catchment area with the expected total natural nutrient load in this area.

It should be noted that the method does not consider influences of the exact application method and soil factors to end results. However methodologies incorporating these effects do exists, limited data together with high uncertainties in the methodologies eliminate their usability for our purpose.

Natural nutrient load

The total natural load of N and P in the catchment area, for different land use, was calculated by multiplying the surface area of each type of land-usage with a characteristic loss of N and P to watercourses\(^35,36,37\). The figures presented on the natural nutrient load in table 4.1 are given by Thomann \textit{et al.}\(^38\). The large variation in the range, also reported by other literature \(^9,13,14,15,16,39\), indicates the difficulty of determining these non-point sources.
Table 4.1  Natural nutrient load for different types of land-usage

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Unit</th>
<th>Cultivated arable land</th>
<th>Forest and pasture land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>N</td>
<td>kg/ha year</td>
<td>5</td>
<td>0.5-50</td>
</tr>
<tr>
<td>P</td>
<td>kg/ha year</td>
<td>0.5</td>
<td>0.1-5</td>
</tr>
</tbody>
</table>

Artificial fertilizers

Figures concerning the amount of artificial fertilizer distributed to the regions within the catchment area by governmental organisations have been derived from the "Agricultural Statistics\(^\text{6}\)" published by the Tanzanian Bureau of Statistics. Data have also been obtained from the Planning and Marketing Division of the Ministry of Agriculture and Livestock Development\(^\text{1}\), the Ministry of Agriculture\(^\text{41}\) and on regional level in Mwanza\(^\text{3,4,42}\) and Musoma\(^\text{47}\). It is assumed, for the purpose of this study, that the total amount of artificial fertilizer distributed to the regions can be regarded as the amount used to fertilize the land.

A first assessment of the pollution load by artificial fertilizers in the Lake zone has been made using distribution figures of artificial fertilizer for 1990\(^\text{6}\). Although these data may differ from the exact situation during the survey they are presumed to be good enough for a first assessment.

Artificial fertilizers are applied during the growing season. This period coincides with the rainy seasons. Based on literature, a method has been selected to estimate the total load to watercourses of nutrients from artificial fertilizers. The method selected assumes an average loss to watercourses of 13% of P and 30% of N of the total amount of artificial fertilizers applied\(^\text{9,12,13}\). For each district in the Lake Victoria region, the total load to watercourses of P and N from artificial fertilizer has been calculated by multiplying the characteristic loss of the nutrient to watercourses (13% and 30% respectively) with the total nutrient contents of the amount of artificial fertilizer applied in the region.

Organic fertilizers (manure)

The catchment area is also a pastoral area. The animals graze across a large area. In the areas wherever mixed farming is practised farm manure is usually collected and spread over the land as fertilizer. This supplements artificial fertilizers which are expensive for most of the farmers. For the nutrients model applied, it does not matter whether waste produced by livestock is used as manure or spread over the land by the grazing animals.

Livestock figures for 1989 have been gathered at regional level in Mwanza\(^\text{36}\), Bukoba\(^\text{35}\) and Mara\(^\text{37}\). Although these data may differ from the current situation, they are presumed to be good enough for a first assessment.

Table 4.2 presents nutrient load factors for livestock manure in developed countries\(^\text{40}\). Although the quantity and quality of manure produced by animals will depend upon many factors, like type, weight, breed of animal, feeding, animal environment and the way in which manure is collected and stored\(^\text{40}\), these factors are assumed to be good enough (for our assessment purpose) for application to the Tanzanian situation. By multiplying the nutrient load factors with the livestock figures in the Lake zone, the total amount of N and P from manure produced by livestock can be calculated.
Production of manure in the region can be assumed to be constant throughout the year. However, leaching of nutrients to watercourses is only possible during the rainy seasons. To a large extent this covers the three months of long rains and two months of short rains. It is therefore assumed that animal waste produced in the seven months of the year is well scattered over a large area and has enough time to get into nutrient cycles.

Although several studies have pointed out that the kind of fertilizer used (artificial or organic) does influence the phosphate leaching to watercourses, the absence of reliable information on this forces us to assume there is no virtual difference in the average loss to watercourses of N or P from organic or artificial origin. By multiplying the total amount of nutrients in 5/12 of the manure produced by livestock with an average loss to watercourses of 13% of P and 30% of N, the total load to watercourses of these nutrients can be calculated.

Table 4.2 Nutrient loading factors for manure from livestock

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Cattle</th>
<th>Goats(a)</th>
<th>Sheep</th>
<th>Chicken</th>
</tr>
</thead>
<tbody>
<tr>
<td>P^{(39)}</td>
<td>kg/year</td>
<td>9.5</td>
<td>1.5</td>
<td>1.5</td>
<td>0.06</td>
</tr>
<tr>
<td>N^{(40)}</td>
<td>kg/year</td>
<td>60^{(b)}</td>
<td>3</td>
<td>3</td>
<td>0.7</td>
</tr>
</tbody>
</table>

a) Assuming that manure from goats has similar nutrient characteristics as manure from sheep; no specific information on goat manure was available.
b) Assuming 50% of the cattle can be regarded as calves and 50% as cows.

4.1.2 Pesticides, herbicides and fungicides

Two different kinds of approach can be followed to assess water pollution by agrochemicals; hazard assessments for pesticides, as proposed by Calamari et al., and predictive models for pesticides concentrations in water, as proposed by Wauchope et al. The assessment method proposed by Calamari et al. leads to a hazard classification of pesticides, based on their intrinsic properties (toxicity, bio-accumulation, persistence, leachability) and the amount used in the area. The predictive model proposed by Wauchope et al. leads to an estimation of pesticide concentrations in agricultural runoff. However, the model does not regard the fate and effects of pesticides after they have left the edge of the agricultural field, nor does it take into consideration the cumulative effects of the use of different pesticides on the same field.

In order to discuss the pollution load to watercourses of agrochemicals, a combination of both approaches as well as a prediction of downstream concentrations is preferred here. An accessible model although, dealing with all the aspects mentioned above was not available. A new approach taking into account most of the aspects mentioned, based on literature, is therefore introduced here. A distinction has been made between agrochemicals used for crop protection and agrochemicals used as disinfectants for livestock.
Agrochemicals used for crop protection

In the Musoma region 80% of the pesticides, herbicides and fungicides used for crop protection are applied on cotton fields, and 15% on coffee\(^{23}\), the two major crops in the area. It is assumed that agrochemicals in the regions are mainly used for the protection of these two crops. Subsequently, it is sufficient to know the amount of agrochemicals used for the protection of cotton and coffee crops only.

Figures concerning the amount of pesticides, herbicides and fungicides distributed for crop protection in the Lake zone have been collected from the Tanzania Cotton Marketing Board\(^{32,47}\), the Plant Protection Unit\(^{59}\) and, at regional level, from, the Regional Cooperative Union\(^{31}\), the Regional Agriculture and Livestock Development Offices\(^{3,28,29,30,33,34}\) and from Matowo\(^{3}\). Distribution figures for the 1992/1993 season have been used.

Similar to artificial fertilizers (section 4.1.1), it is assumed that the amount of agrochemicals distributed to the region and unions largely corresponds to the amount actually applied for crop protection. Up to 1991 this assumption would certainly have been valid, as distribution of agrochemicals up to then had been through governmental distributors. Nowadays, however, there is a free market of agrochemicals. As a large increase in prices for agrochemicals has accompanied the introduction of an open market, the sales and application of these chemicals has actually decreased considerably. The assumption made above would therefore, in the present situation, presumably be an upper limit.

As information on the amount of some pesticides, herbicides and fungicides used in the Lake zone is lacking, the amount used in the districts can only be estimated relative to the total amount of these agrochemicals applied in Tanzania. The contribution of coffee and cotton production\(^{1,6,36}\) in the three districts relative to the total Tanzanian production should provide a good estimate for the relative amount of agrochemicals used for crop protection of coffee and cotton in the region.

Information on application rates of agrochemicals (grams of active components per hectare) is given by Wauchope\(^{10}\), the Agrochemicals Handbook\(^{7}\) and the NCU\(^{31}\). Discussions with regional officers\(^{3,28,29,30}\), as well as extension workers and farmers themselves, have proved that, if actually used, the amounts of agrochemicals applied do indeed correspond to the prescriptions for the chemicals on the whole. The number of times that application can be afforded, however, is much less than is prescribed. The application rates given by the sources above therefore provide us with information per event of agrochemical application, which can be used for the calculation of average runoff concentrations.

The model proposed assumes an average loss to watercourses of 5% of the pesticides, herbicides and fungicides applied\(^{11,12,27}\). The total load of the active component (kg) to watercourses can be calculated by taking 5% of the amount of agrochemical used, multiplied by its typical active compound contents. Information on the active compound contents of various agrochemicals has been derived from the Agrochemicals Handbook\(^{7}\), the Pesticide Manual\(^{10}\) and the European Directory of Agrochemical Products\(^{48}\).

In order to calculate an average runoff concentration, it is necessary to define the event of runoff containing an agrochemical. This takes place during a certain time span after the application of an agrochemical. Here taken to be a week\(^{1,6,10}\). The procedure for estimation of the average concentration of agrochemicals per runoff event is as follows:
The average annual rainfall for the Lake zone is 1500 mm, being an average for the annual rainfall in Mwanza and Kagera\(^{(1,6)}\). This compares to an average weekly rainfall of 28.8 mm.

The average runoff concentration (mg/l) can be calculated by dividing the total load of active component by an estimated amount of runoff water, for which 2/3 of the average rainfall during a week has been used\(^{(9)}\).

**Disinfectants**

Agrochemicals used for livestock disinfection are either applied via the so-called "cattle dips" (pits filled with a water/chemical solution mixture) or by spraying. In the Kagera region 25% of the amount agrochemicals used as such is applied via cattle dips, which is quite characteristic for the Lake Victoria region\(^{(29,30)}\). Figures concerning the amount of disinfectants used were obtained from the Regional Agricultural and Livestock Offices\(^{(30,29)}\).

Agrochemicals applied via cattle dips are regarded to end up in watercourses completely, as cattle dips are most often located near rivers and lakes, in which case these watercourses are used as water resources and dumps for the dip's contents. Disinfectants applied by spraying are assumed to behave as agrochemicals used for crop protection. A 5% loss to watercourses is assumed.

The total load of the active component to watercourses can thus be calculated by adding up 25% of the total amount of disinfectants, as the amount used in dips, and 5% of the remaining 75% for the amount being sprayed. Multiplication with the active component content of the agrochemical eventually leads to an estimated leakage of chemicals to watercourses.

**Calculation of local and average concentrations in watercourses**

An accurate prediction of downstream concentrations requires a lot of information. To give an indication of downstream concentrations, considering the cumulative use of agrochemicals, a local and average concentration can be used.

The local concentration should be seen as the concentration of agrochemicals in watercourses near agricultural areas where agrochemicals are used. The average concentration should be seen as the concentration of agrochemicals in watercourses in the whole Lake Victoria region.

The total load to watercourses of each agrochemical has been divided into three groups for this purpose: agrochemicals containing chlorine (organochlorine pesticides (OCP)), agrochemicals containing copper (Cu), and other agrochemicals.

The local concentration is defined as the concentration of a specific kind of agrochemical (OCP, Cu and other), calculated from its cumulative load in the catchment area, and the total runoff from the agricultural areas on which it has been applied. Calculations of the concentrations are done by assuming that the total runoff is 2/3 of the annual rainfall in the area on which the agrochemical has been applied\(^{(9)}\).

Discussions with officers from the Regional Agricultural and Livestock Office in Mwanza\(^{(33)}\) have led to the conclusion that 30% of the farmers in Mwanza region use agrochemicals. It is being assumed here that these farmers also control 30% of the cultivated area and that the situation in the Mwanza region can be regarded as characteristic for the Lake zone. The total area on which agrochemicals are used can thus be defined as 30% of the total area used for cotton and coffee production.

Hence, the local concentration can be calculated by dividing the cumulative pollution loads of the
different kinds of agrochemicals by $\frac{2}{3}$ of the total annual rainfall, on 30% of the total area used for coffee or cotton production.

Similarly, the average concentration for all land areas can be calculated by dividing the cumulative pollution load of the different kinds of agrochemicals by $\frac{2}{3}$ of the annual rainfall for the total regional area.

**Methodological limitations**

It is important to consider the limitations of the proposed method, limiting the results of the calculations to good order of magnitude estimations:

(i) Research has pointed out that volatization of agrochemicals is a significant pathway leading to dissipation concerning their application. The axiom "what goes up must come down" has been confirmed in reports on pesticide concentration in dew and rainfall. The volatization of agrochemicals applied, however, has not been considered in the calculation of the pollution load to watercourses.

(ii) The calculated values for the runoff concentration represent average values, as an average weekly rainfall figure is used for the calculation. Occasional higher runoff concentrations could exist. The calculation of the runoff concentration does not consider the use of more than one agrochemical, nor the use of the same agrochemical several times on the same piece of land (cumulative use) during the time span of one week.

The runoff concentrations refer to edge of field concentrations and not to concentrations in streams, rivers or lakes. These are lower due to dilution. Wauchop stated that concentrations in the order of 10 mg/l are only observed right at the field edge and never in streams or lakes away from the application site.

(iii) Pesticide concentrations in rivers and streams are much higher during the three months immediately following major applications than they are during the remainder of the year. During these months of "high" concentrations, the pesticide concentrations reach peak values at periods of storm runoff events and drop in between runoff events. In general, the concentrations of individual pesticides in streams and rivers are proportional to the amount of use. Also, factors like persistence and mode of application strongly affect the peak and average concentrations. Lastly, it has been found that peak concentrations of individual pesticides often coincide. The methodology does not consider these aspects.

(iv) The calculation of local and average concentrations in watercourses considers the cumulative use of the agrochemicals, as it is based on the cumulative loads of the different types of agrochemicals applied in one year. The model proposed treats the local and average concentrations as if they were one event, in which the cumulative loads have been 'mixed' with the annual rainfall for a particular area. The concentrations calculated therefore represent an absolute concentration of loads to watercourses. As this situation never occurs the local and average concentrations have to be regarded as 'worst case' concentrations.

(v) The model proposed does not consider the half-life of the agrochemicals, nor does it consider influences of application methods and soil factors to end results. Instead, average runoff and leakage factors are being used.
4.2 Pollution by agricultural sources

4.2.1 Agricultural characteristics

In order to calculate the pollution load of agrochemicals to watercourses, some general figures concerning the three regions in the Lake Victoria region are needed. They are presented below.

Data on land-usage in the catchment area, as presented in table 4.3, have been derived from the Regional Agricultural Office in Bukoba(35) and the KILIMO/FAO fertilizer programme(36,37). Figures on the production area of cotton and coffee in the three regions have been gathered from the Ministry of Agriculture and Livestock Development(3) and the Tanzanian Bureau of Statistics(6).

Table 4.3 Surface area and land-usage per district

<table>
<thead>
<tr>
<th>District</th>
<th>Unit</th>
<th>Total area</th>
<th>Cultivated arable land</th>
<th>Forest</th>
<th>Pasture</th>
<th>Cotton</th>
<th>Coffee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kagera(35)</td>
<td>1000 ha</td>
<td>2851</td>
<td>405</td>
<td>2446</td>
<td>-</td>
<td>15.6</td>
<td>55.6</td>
</tr>
<tr>
<td>Mwanza(36)</td>
<td>1000 ha</td>
<td>2010</td>
<td>710</td>
<td>868</td>
<td>947</td>
<td>186.9</td>
<td>-</td>
</tr>
<tr>
<td>Mara(37)</td>
<td>1000 ha</td>
<td>2180</td>
<td>382</td>
<td>82</td>
<td>332</td>
<td>58.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>1000 ha</td>
<td>7041</td>
<td>1497</td>
<td>3396</td>
<td>1279</td>
<td>231.1</td>
<td>57.2</td>
</tr>
</tbody>
</table>

Figures concerning the livestock present in the three regions have been gathered from the Regional Agricultural Office in Bukoba(35) and the KILIMO/FAO Fertilizer Programme in Mwanza(36) and Musoma(37). These figures, representing the situation in 1988-1989, are presented in table 4.4.

Table 4.4 Livestock figures per district for 1988-1989

<table>
<thead>
<tr>
<th>District</th>
<th>Unit</th>
<th>Cattle</th>
<th>Goats</th>
<th>Sheep</th>
<th>Chicken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kagera(34)</td>
<td>1000 hd</td>
<td>364</td>
<td>342</td>
<td>55</td>
<td>-</td>
</tr>
<tr>
<td>Mwanza(30)</td>
<td>1000 hd</td>
<td>1341</td>
<td>561</td>
<td>259</td>
<td>1270</td>
</tr>
<tr>
<td>Mara(28)</td>
<td>1000 hd</td>
<td>1103</td>
<td>440</td>
<td>235</td>
<td>-</td>
</tr>
</tbody>
</table>

Effluent Standards and receiving Water Standards for drinking water have been defined by the Tanzanian government(25). Some of the standards applicable to agricultural pollution are presented in table 4.5.
### Table 4.5  Several Effluent and receiving Water Standards for drinking water for Tanzania

<table>
<thead>
<tr>
<th>Substance</th>
<th>Unit</th>
<th>Drinking Water</th>
<th>Direct discharge</th>
<th>Indirect discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organochlorine pesticides</td>
<td>mg/l</td>
<td>0.0005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Other pesticides</td>
<td>mg/l</td>
<td>0.001</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/l</td>
<td>3.0</td>
<td>0.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

#### 4.2.2 Fertilizers

The results of the estimations for the total load of nutrients to watercourses per district for artificial fertilizers and manure are given in table 1 and table 2 of appendix 7 respectively. A resume of these results, together with the results of the calculation of the natural nutrient load per district, are given in table 4.6.

### Table 4.6  Total nutrient load to watercourses

<table>
<thead>
<tr>
<th>District</th>
<th>Unit</th>
<th>Total area</th>
<th>Manure</th>
<th>Artificial Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Kagera</td>
<td>9400</td>
<td>1200</td>
<td>2900</td>
<td>200</td>
</tr>
<tr>
<td>Mwanza</td>
<td>9000</td>
<td>1100</td>
<td>10000</td>
<td>800</td>
</tr>
<tr>
<td>Mara</td>
<td>3200</td>
<td>400</td>
<td>8500</td>
<td>600</td>
</tr>
<tr>
<td>Total</td>
<td>21600</td>
<td>2700</td>
<td>21400</td>
<td>1600</td>
</tr>
</tbody>
</table>

Although figures for the amounts of artificial fertilizer distributed are rough (see also section 4.4.), one can state that the estimations of total N and P loads to watercourses by artificial fertilizer clearly form a minor contribution to the natural nutrient load of the total area. The estimation of total load of N and P to watercourses from manure, though, indicate high contributions to the total nutrient load, exceeding the natural contribution in the Mwanza and Mara region. Estimates of the nutrient load from manure can, however, easily be out of range by a factor of 2, as the nutrient load factors used (table 4.2) have been taken from information on livestock in developed countries. So, the proposed method only indicates a significant contribution of the nutrients in manure to the nutrient loading to watercourses.
4.2.3 Pesticides, herbicides and fungicides

The estimations of the total pollution load to watercourses for each agrochemical, used for crop protection or as disinfectant, as well as their average runoff concentration, are given in table 1 of appendix 6. A summary is given in table 4.7. The local and average concentrations for the three groups of agrochemicals are presented as defined in the methodology (organochlorine pesticides, agrochemicals containing copper and other agrochemicals), together with their cumulative total pollution load and a range for the average concentrations of the different agrochemicals in direct runoff from the agricultural fields. For the local concentration and the cumulative pollution load in kg of active compound (a.c.) per year, a distinction is made between coffee and cotton growing areas.

Table 4.7 Total load of agrochemicals to watercourses and concentrations in watercourses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Organochlorine pesticides</th>
<th>Agrochemicals containing copper</th>
<th>Other agrochemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coffee</td>
<td>Cotton</td>
<td>Coffee</td>
</tr>
<tr>
<td>Cumulative pollution load(^{(a)})</td>
<td>kg a.c./year</td>
<td>4500</td>
<td>3600</td>
<td>14000</td>
</tr>
<tr>
<td>Range of average runoff concentrations(^{(a)})</td>
<td>mg/l</td>
<td>0.0007-0.2</td>
<td>700</td>
<td>0.002-0.3</td>
</tr>
<tr>
<td>Local concentrations(^{(a)})</td>
<td>mg/l</td>
<td>0.03</td>
<td>0.005</td>
<td>0.08</td>
</tr>
<tr>
<td>Average concentration(^{(b)})</td>
<td>mg/l</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.000006</td>
</tr>
</tbody>
</table>

a) Results of the calculation of the pollution load of agrochemicals used as disinfectants as presented in table 1, appendix 6 have been left out, because the runoff and the pollution load caused by these agrochemicals does not occur on the same cropland presented in the table.
b) Results of the calculation of the pollution load of agrochemicals used in which disinfectants are included.

The results shown in table 4.7 on the calculated runoff concentration are compared to the indirect effluent standards presented in table 4.5. The results on the local and average concentration are compared to the receiving water standards for drinking water as presented in table 4.5.

Organochlorine pesticides

The range of the average runoff concentrations calculated near land used for cultivation of coffee and cotton exceeds the indirect Effluent Standard up to 40 times. The local concentration calculated in watercourses for organochlorine pesticides near land used for cultivation of coffee exceeds the receiving water standard for drinking water by a factor of 6. The local concentration calculated in watercourses for organochlorine pesticides near land used for cultivation of cotton approximately matches the receiving water standard for drinking water. The average concentration calculated in
watercourses, however, is a factor of 5 below the receiving water standard for drinking water. Discussion\(^\text{34}\) has led us to believe that the amount of agrochemicals used for the crop protection of coffee could be lower than estimated here, as mainly the "hard robusta" type is being cultivated in the area, one that needs much smaller amounts of agrochemicals in comparison to others. Taking this into consideration standards can be expected to be exceeded only locally, where agrochemicals are applied. A note has to be made on the agrochemicals containing chlorine that are used as disinfectants for livestock and are distributed by 'cattle dips', which are considered to pollute the local environment severely. Part of the agrochemicals used for livestock disinfection, being all organochlorine pesticides, is applied via cattle dips, which are most of the times located near rivers and lakes. These watercourses are being used as water resources and dumps for the dip's contents. The organochlorine pesticides applied via cattle dips are considered to end up in the aquatic environment completely. As the largest part of the pollution load by these disinfectants (presented in table 1, appendix 6) ends up in the watercourses near cattle dips, high concentrations of these agrochemicals can be expected. Taking the application rate of the agrochemicals applied as an upper limit, they exceed the indirect effluent standard up to 140,000 times.

**Agrochemicals containing copper**
The range of the average runoff concentration of copper calculated near land used for cultivation of coffee exceeds the indirect effluent standard by a factor of 700. The local concentration calculated for copper in watercourses is 38 times lower than the receiving water standard for drinking water. The average concentration calculated in watercourses is 15,000 times lower than the receiving water standard for drinking water. Taking into account the discussion\(^\text{34}\) mentioned earlier, from which it appeared that agrochemical use for coffee protection in the Lake zone could be less, and the fact that agrochemicals containing copper are only used for coffee, presumably standards would only be exceeded locally, where agrochemicals are applied.

**Other agrochemicals**
The indirect effluent standard is exceeded up to 30 times regarding the range of the calculated average runoff concentration near land used for the cultivation of coffee and cotton. The local concentration calculated in watercourses near land used for cultivation of coffee is 5 times lower than the receiving water standard for drinking water. The local concentration near land used for cultivation of cotton does, however, exceed the standard by a factor of 5. The average concentration in watercourses calculated is, however, 250 times lower than the receiving water standard for drinking water. Bearing in mind the limitations of the model, it is not expected that standards are exceeded other than locally where agrochemicals are applied.
General
According to table 1 of appendix 6, about 700,000 litres and 700 tons of agrochemicals were distributed to the lake zone. Some of the pesticides (thiodan, dieldrin etc.) used in Tanzania have been on the market for quite some years and their usage has already been banned in developed countries. Most of these pesticides have high half-lives and are therefore potential hazards to the environment.

Discussion led to the conclusion that agrochemicals are frequently used for fishing in Lake Victoria, which means that fish are being paralysed by throwing considerable amounts of pesticides in the water, in order to have an easy catch. Apart from the pollution, it could be most hazardous to eat fish caught in this way.

Information and exact figures on the amount of seed-dressing chemicals have been found difficult to obtain. They have therefore not been regarded in this assessment, although estimations (240 tons in the Lake zone) indicate a considerable contribution.

4.3 Conclusions

The results of estimations of the total load to watercourses of N and P by artificial fertilizer clearly show a minor contribution to the natural nutrient load of the total area. The results of the estimation of the total load of N and P to watercourses by manure, however, show high nutrient loadings, exceeding the natural nutrient loading.

Although the estimates of the nutrient load from manure can easily be out of range by a factor of 2, the method clearly indicates a significant contribution to the nutrient loading to watercourses.

It cannot be assumed that runoff concentrations in the lake zone exceed the Tanzanian Effluent Standards other than locally, where agrochemicals are applied. These excesses can be severe, especially in watercourses near cattle dips. Downstream concentrations, however, do not even exceed the Tanzanian receiving Water Standards for drinking water.

Some of the pesticides used (thiodan, dieldrin etc.) have been forbidden in developed countries, which indicates their potential hazard.

Presumably, agrochemicals are frequently being used for fishing in Lake Victoria. Apart from the pollution of the aquatic environment caused, consumption of fish caught in this way could prove most hazardous to human health.
4.4 Data reliability

4.4.1 General

All data collected has been cross-checked and show large discrepancies. Two reasons why it was difficult to obtain reliable and correct data are:
- Poor record keeping.
- Tanzania is privatising cooperative unions and tolerates privately owned companies to distribute agrochemicals. There is no reliable overview on how the distribution of agrochemicals is proceeding (who is supplying who, when and how much).

Overall, it is thought, however, that the reliability of all data obtained is sufficient for a first assessment.

Figures on the land use\(^{(16,35,36,37)}\) are regarded to be correct. It has to be stated though, that production of cotton has declined considerably in recent years, as a result of the fact that farmers have not been paid by their unions for several years.

4.4.2 Fertilizers

Figures from the Bureau of Statistics\(^{(6)}\) on the amount of fertilizers distributed have been used to produce the first assessment as they were the most complete figures and gave a good overview.

Data from the Ministry of Agriculture\(^{(1)}\) disagree up to 50% with the figures from the Bureau of Statistics. Figures on the amount of fertilizers used collected by Matowo\(^{(5)}\), disagree up to 700%. The reliability of the data obtained from the Regional Agricultural Office\(^{(4)}\), although detailed, is highly doubtful as they differ from other values up to 4000%. Figures obtained from the FAO office in Mwanza\(^{(42)}\) differ up to 600%.

Figures from the Ministry of Agriculture\(^{(41)}\) on the amount distributed to the Mwanza and Mara region agree with figures from the Bureau of Statistics. For Kagera, however, they are found to differ up to 1000%. Figures derived from TCMB Musoma\(^{(47)}\) differ up to 50%.

4.4.3 Pesticides, herbicides and fungicides

Data from the Tanzania Cotton Marketing Board\(^{(2,22)}\), Nyanza Cooperative Union\(^{(31)}\), the Regional Agriculture and Livestock Development Office\(^{(33)}\) and the Plant Protection Unit\(^{(5)}\) on the amount of agrochemicals distributed are regarded to be quite reliable as they do not differ much from each other.

Data on the amount of pesticides, herbicides and fungicides used, collected by Matowe\(^{(5)}\), differ up to 100% from this data. Data collected from the Regional Agriculture Office\(^{(9)}\) are doubted very much as they differ from other values up to 2000%. Figures on the amount of disinfectants\(^{(29,30)}\) could, regrettably, not be cross-checked. Figures on the annual rainfall\(^{(1,6)}\) are regarded to be reliable.
4.5 Literature and sources


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28. Sassi, S.O.Y., Discussion with a Regional Agricultural Officer for Mara region, Musoma,
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1994.

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31. Hewa, Discussion with an officer of the Nyanza Cooperative Union (NCU), Mwanza, April
1994.

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April 1994.

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Agriculture Livestock Development Office (RALDO), Mwanza, April 1994.

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region, Bukoba, April 1994.

35. Annual report on the review of 1987/1988 season, Regional Agricultural Office Bukoba,

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39. Vighi, M. Eutrophication in Europe: the role of agricultural activities, Hodgson, E., Reviews

42. Lupeja, P.M., Discussion with an officer of the FAO fertilizer project, Mwanza, April 1994.
5. MINING ACTIVITIES

5.1 Methodology

A first indication of the major mining activities in the catchment area is given by Jones et al.\textsuperscript{(4)}. Gold mining, which is the only type of mining involving chemicals, is the main mining activity in the area. It is concentrated in two mining fields:

- Geita (South-West Mwanza Goldfield)
- Musoma Goldfield

The "Directory of Industries\textsuperscript{(3)}" lists the gold mines in the districts as registered in 1989. Table 2 in appendix 1 lists the largest registered establishments. The "Directory of Industries\textsuperscript{(3)}" lists mines in the Geita district only, excluding the Musoma Goldfield. This can be ascribed to the fact that either small scale-mines only exist in the area or mines in the area have not been registered at all. According to the regional mining officer\textsuperscript{(1)}, there is extensive small-scale mining in both of the districts. Information on mining activities in the Lake zone (Kagera, Mwanza and Mara districts) is being kept by the regional mining officer in Mwanza\textsuperscript{(1)}. Data on the production of the gold mines and the use of chemicals, however, were not available at this office.

Mercury, which is regarded to be extensively used in gold mining in the area, is officially being merchandised by the "Gold Unit" of the Bank of Tanzania\textsuperscript{(2)}, who keep figures on this. However, a rough estimate of about 50\% is being merchandised by the Bank and 50\% via other, unknown, sources.

A rough estimation on the amount of mercury lost to the environment can be made, assuming a steady-state situation in which 100\% of the mercury purchased yearly is used to make up the mercury loss to the environment during processing. This means the method does not consider any expansion of activities during the year.

The possibility that other chemicals were being used in mining was not apparent.

5.2 Pollution by mining activities

According to the Bank of Tanzania\textsuperscript{(2)} 21 boxes containing 25 bottles of 250 grams of mercury had been sold in the regions in one year (June 1992-June 1993), for usage in all districts around Lake Victoria, an amount typical for the yearly consumption of mercury for gold mining purposes in the region. Estimating their share in the supply of mercury at 50\% implies that approximately $2 \times 21 \times 25 \times 0.25 \text{ kg} = 300 \text{ kg}$ of mercury have been used in one year's time.

Mercury will either be lost by spillage, loss during extraction or in the final stage of the process when the mercury is being separated from the gold-amalgam by heating. The method proposed estimates the amount of mercury purchased yearly to cover this loss. The amount lost to the environment would thus be 300 kg of mercury per year.
5.3 Conclusion

In both the mining fields (South-West Mwanza Goldfield and Musoma Goldfield) extensive small scale mining takes place. It is difficult to estimate the amount of mercury lost in the process from these mining sites. It is also difficult to currently deduce the rate of expansion on mining activities in the regions. Pollution by chemicals used in this branch can be substantial. It is estimated that 300 kg of mercury will end up in the environment each year. Use of chemicals other than mercury in mining activities was not considered.

5.4 Data reliability

Figures on the amount of mercury sold by the Bank of Tanzania for mining purposes are regarded as reliable. Unfortunately, the Bank of Tanzania is not the only merchandising source for mercury and information on the other merchandising sources is difficult to obtain. No proof exists for the validity of the estimation concerning the total amount of mercury used in reality.

5.5 Literature and sources

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2. Bank of Tanzania, Discussion with an Officer of the Gold Unit, Mwanza, 6 July 1993.
6. CONCLUSIONS

6.1 Estimated pollution load of various sources

The aim of this study was to make an inventory of water pollution sources on the Tanzanian side of the catchment area of Lake Victoria. Although the methodologies applied in this study have some limitations, a comparative inventory of pollution sources can be presented. A summary of the inventory is given in table 6.1 (a list of abbreviations is given in appendix 8, in the back of this report).

Table 6.1 Major water pollution contribution from various sources.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>Industries</th>
<th>Domestic</th>
<th>Agriculture</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD₃</td>
<td>t/year</td>
<td>767</td>
<td>2300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>t/year</td>
<td>7</td>
<td>900</td>
<td>21510</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>t/year</td>
<td>120</td>
<td>1609</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy metals</td>
<td>t/year</td>
<td>0.8</td>
<td>-</td>
<td>14</td>
<td>0.3</td>
</tr>
<tr>
<td>Agrochemicals</td>
<td>t a.c./year</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Oils</td>
<td>t/year</td>
<td>4607</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>t/year</td>
<td>29000</td>
<td>11000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>t/year</td>
<td>800</td>
<td>4700</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Industrial pollution
As most of the industries are located near the lake shore, industrial waste load mostly ends up either directly in Lake Victoria waters or in watercourses near the lake. The outdated technologies used result in high pollution loads. As environmental considerations, such as good housekeeping and controlled waste disposal, are not given much attention, and the few waste-water treatment facilities that are existing within some of the industries are not operated properly, Tanzanian Effluent Standards will be exceeded severely. Waste is mostly characterised by high BOD₃ and COD values, through the general nature of the industrial processes; processing of agricultural products. Comparing BOD₃ pollution loads, vegetable oil processing industries and soap manufacturing industries are the major contributors. Hazardous waste production is limited, and mainly restricted to approximately 0.8 tons per year of chromium disposed of by Mwanza tanneries.

Machinery and mechanised means of transportation (cars, boats and trucks) contribute significantly to the pollution of watercourses, because much the lubricants used presumably will end up in the environment. At present, there is no collection of waste petroleum oils for either re-use or disposal. Industrial activities in the Lake zone are expected to increase rapidly, as new industries, for example
fish-processing industries, become operative. This will definitely affect the pollution load contribution by industries.

**Domestic pollution**
Urban waste is the main contributor of domestic pollution to watercourses, either directly via the sewerage, as in Mwanza, via drainage systems in the three towns (Bukoba, Mwanza, Musoma), which also functioning as alternative sewerage system in many cases, or generally via runoff of stormwater. Waste-water treatment of domestic pollution is completely absent. The treatment facility in Mwanza municipality, apart from being inadequate, has not been operative for years. With the increasing population (2.7% population growth annually), especially in urban areas, domestic pollution of watercourses will increase rapidly.

**Agricultural pollution**
Use of pesticides, other agrochemicals and artificial fertilizers is very restricted in the area, due to the high price of these products, unaffordable for the mostly small-scale farmers in this area. The total load of N and P to watercourses by artificial fertilizers forms a minor contribution relative to the natural nutrient load of the catchment area, in contrary to the total load to watercourses of N and P by manure which is very significant. The Tanzanian Effluent Standards for organochlorine pesticides, other pesticides and copper are exceeded wherever the agrochemicals are applied. These excesses can be severe, especially in watercourses near cattle dips. Downstream concentrations, however, do not exceed the Tanzanian receiving Water Standards for drinking water. Compared to developed countries, the total amount used is small. However, it should be stated that some of the agrochemicals used are forbidden in developed countries.

**Mining**
Mining activities in the area are mainly restricted to small-scale gold mining. Approximately 0.3 tons of mercury per year are estimated to end up in the environment in the catchment area, partly directly or indirectly in watercourses.

**General**
The largest contributor of nutrients (N and P) to watercourses is agriculture, domestic pollution being a good second one. The population increase and subsequent increase in domestic and agricultural activities in the project area pose a growing threat for eutrophication of watercourses. Industrial pollution and waste loads are yet limited, however, expected to rise with increasing industrial activities due to both population growth and improving technological knowledge and economical situations. Solid waste management, in general, is poor. Many private dumping sites for both industrial and domestic solid waste exist and remain uncontrolled. Most of the waste that is actually being collected is being dumped at several dumping sites without any further control. Leakage of pollutants to watercourses therefore occurs, the extend to which not being known.

*Discussion*
6.2 Pollution management and control

Environmental education and awareness of the majority of people in the catchment area is still very low, however, in some cases growing. Environmental problems seem to be related only to direct obvious consequences. Long-term consequences are too distant to perceive. Environmental policy making and implementation is not yet well organised, especially at regional and district levels. Most actions are a result of some sporadic reflexes rather than a well-planned line of action. This may be seen from examples such as in Musoma, where Mutex has been forced to build waste-water facilities because of the many complaints from the population living near the plant.

Due to this ad hoc nature of action, there is no real budget set for pollution monitoring and control and for legislative enforcement of environmental standards. A big task therefore exists for the young department of Environment of the Ministry of Tourism, Natural Resources and Environment.
7. RECOMMENDATIONS

Following the findings of this study on water pollution in the Lake Victoria catchment area several recommendations have been set up, in cooperation with the Department of Environment, Ministry of Tourism, Natural Resources and Environment of Tanzania.

This study has given an overall picture of the main pollutants and their sources of the watercourses in the Tanzanian part of the catchment area of Lake Victoria. To get a complete picture of the whole catchment area of the lake similar studies in Kenya, Uganda, Burundi and Rwanda are needed, part of which has already been done or is in process by other project teams in Kenya and Uganda.

Generally, environmental monitoring and management in the area under study is very poor. The limited data available on the environment is scattered and not easily accessible. As a result it is difficult to judge the extend of pollution in the catchment area, let alone be able to model the future predictions or develop a thorough environmental policy.

It is therefore important to develop a system of monitoring on the basis of which problems can be identified in the earliest possible stage. It is also important to develop a systematic data acquisition system and an accessible database from which information can be derived to underpin policies.

Results of this assessment on industrial pollution have given values which are within typical ranges obtained from different sources (table 2.7 and table 2.8). However, when these results are compared to results of direct analyses data available in some cases, the discrepancy is very large. This discrepancy can possibly be attributed to poor sampling procedures, methods of analysis and/or execution. It is therefore important to strengthen the laboratory capabilities and formalise procedures in order to gain reliable results. In order to produce actual waste generation figures sampling programs would have to be set up in order to evaluate pollution sources more thoroughly.

The conversion factors for pollution and waste load, as applied in the methodology, are derived from models developed in more developed countries, implying constant and easily predictable operations. Actual situations differ considerably, however. In order to assess pollution generation more accurately, a pollution index system, specifically for the Tanzania situation, should be developed, in which environmental pollution is linked to specific household, agricultural and industrial activities. In many cases such a system could strongly limit the need for costly and time consuming analytical monitoring activities for management and control of the environment.

Environmental education and awareness for the majority of the people in the catchment area is still very low. Long-term environmental consequences seem to be too distant to perceive. Environmental policy making and implementation is not well organised, especially on regional and district levels, where most actions are the result of sporadic reflexes rather than well planned actions. It is therefore important to stimulate the environmental awareness of people, particularly within industries and governmental organisations.
8. APPENDICES

List of appendices

APPENDIX 1
*Table 1* Index of major industrial establishments to the International Standard Industrial Classification (ISIC), in the Lake Victoria Catchment area in Tanzania, 1992
*Table 2* Index of major mining establishments to the International Standard Industrial Classification (ISIC), in the Lake Victoria Catchment area in Tanzania, 1992

APPENDIX 2
*Table 1* Pollution load in effluent streams of some industries in the Mwanza region.

APPENDIX 3
*Table 1* Rapid Assessment working table of pollution loads to watercourses of major industries in the Mwanza region.
*Table 2* Rapid Assessment working table of pollution loads to watercourses of major industries in the Mara and Kagera regions.

APPENDIX 4
*Table 1* Rapid Assessment working table for solid waste loads of major industries in the Mwanza region.
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APPENDIX 5
*Table 1* Rapid Assessment working table of waste loads from domestic effluents and municipal solid waste.

APPENDIX 6
*Table 1* Pollution load to watercourses for agrochemicals used in the Kagera, Mwanza and Mara regions in Tanzania.

APPENDIX 7
*Table 1* Pollution load of nutrients to watercourses for artificial fertilizers used in the Kagera, Mwanza and Mara regions in Tanzania.
*Table 2* Pollution load of nutrients to watercourses for manure produced in the Kagera, Mwanza and Mara regions in Tanzania.

APPENDIX 8
List of abbreviations and symbols.
APPENDIX 1

Tables:

1. Index of major industrial establishments to the International Standard Industrial Classification (ISIC), in the Lake Victoria Catchment area in Tanzania, 1992
2. Index of major mining establishments to the International Standard Industrial Classification (ISIC), in the Lake Victoria Catchment area in Tanzania, 1992

Notes to the tables:

Size

4 - Establishment with 20 to 49 persons engaged
5 - Establishment with 50 to 99 persons engaged
6 - Establishment with 100 to 499 persons engaged
7 - Establishment with 500 or more persons engaged

Ownership

1 - Governmentally owned
2 - Privately owned
3 - Establishments in which the government has 50 percent or more share capital
4 - Establishments in which the government has less than 50 percent share capital
5 - Establishments under Regional or District Cooperative Unions
6 - Establishments under other Cooperative Societies
7 - Other
Table 1  Index of major industrial establishments to the International Standard Industrial Classification (ISIC), in the Lake Victoria Catchment area in Tanzania, 1992

<table>
<thead>
<tr>
<th>ISIC Code</th>
<th>Name of Establishment</th>
<th>Region</th>
<th>District</th>
<th>Location</th>
<th>Postal Address</th>
<th>Telephone</th>
<th>Year production started</th>
<th>Size</th>
<th>Ownership</th>
<th>Principal products</th>
</tr>
</thead>
<tbody>
<tr>
<td>3115</td>
<td>Vegetable Oil Industries Ltd (VOIL)</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Kenyatta Rd.</td>
<td>Box 1211 Mwanza</td>
<td>1967</td>
<td>6</td>
<td>2</td>
<td>Cooking oil, hydrogenated fats</td>
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<tr>
<td>3115</td>
<td>Farai Oil Mill</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Nyakato Rd. Industrial Area</td>
<td>Box 1632 Mwanza</td>
<td>42138</td>
<td>-</td>
<td>4</td>
<td>Cooking oil</td>
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<tr>
<td>3115</td>
<td>New-Era</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Kenyatta Rd.</td>
<td>Box 9 Mwanza</td>
<td>1984</td>
<td>4</td>
<td>5</td>
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<tr>
<td>3115</td>
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<td>Bunda</td>
<td>Busambara Village Kibara Ward</td>
<td>Box 55 Musoma</td>
<td>1952</td>
<td>5</td>
<td>5</td>
<td>Cotton seed oil, seed cakes</td>
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<tr>
<td>3115</td>
<td>Mugango Oil Mill</td>
<td>Mara</td>
<td>Musoma</td>
<td>Nyangoma Village Kibiba Ward</td>
<td>Box 379 Musoma</td>
<td>1936</td>
<td>4</td>
<td>5</td>
<td>Cooking oil</td>
<td></td>
</tr>
<tr>
<td>3118</td>
<td>Kagera Sugar Ltd</td>
<td>Kagera</td>
<td>Rural</td>
<td>Nsunga Ward</td>
<td>Box 815 Bukoba</td>
<td>1982</td>
<td>7</td>
<td>3</td>
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<tr>
<td>3121</td>
<td>Bukoba Coffee Curing Works (Bukop) Ltd</td>
<td>Kagera</td>
<td>Bukoba</td>
<td>Custom Str.</td>
<td>Box 34 Bukoba</td>
<td>1950</td>
<td>6</td>
<td>5</td>
<td>Coffee beans</td>
<td></td>
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<td>3121</td>
<td>Tanganyika Instant Coffee Co. Ltd</td>
<td>Kagera</td>
<td>Bukoba</td>
<td>Custom Str.</td>
<td>Box 410 Bukoba</td>
<td>352</td>
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<td>6</td>
<td>6</td>
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<tr>
<td>3134</td>
<td>Mwanza Bottling Co. Ltd</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Plt. 30 A.R.C. Kenyatta Rd.</td>
<td>Box 897 Mwanza</td>
<td>3397/8</td>
<td>1982</td>
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<td>2</td>
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<tr>
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<td>Nyanza Bottling Ltd</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Plt. 73 Musoma Rd.</td>
<td>Box 2086 Mwanza</td>
<td>42562</td>
<td>1988</td>
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<td>3134</td>
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<td>Mara</td>
<td>Musoma</td>
<td>Urban</td>
<td>Nyerere Rd.</td>
<td>Box 325 Musoma</td>
<td>42420</td>
<td>1959</td>
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<td>West Lake Bottlers Ltd</td>
<td>Kagera</td>
<td>Bukoba</td>
<td>Sokoine Rd.</td>
<td>Box 124 Bukoba</td>
<td>660</td>
<td>1984</td>
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<td>4</td>
<td>Soft drinks</td>
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<td>3211</td>
<td>Mwanza Textiles Ltd (Mwatex)</td>
<td>Mwanza</td>
<td>Urban</td>
<td>Nyakato Ind. Area Musoma Rd.</td>
<td>Box 1344 Mwanza</td>
<td>42211-3</td>
<td>1968</td>
<td>6</td>
<td>3</td>
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<tr>
<td>ISIC Code</td>
<td>Name of Establishment</td>
<td>Region</td>
<td>District</td>
<td>Location</td>
<td>Postal Adress</td>
<td>Telephone</td>
<td>Year production started</td>
<td>Size</td>
<td>Ownership</td>
<td>Principal products</td>
</tr>
<tr>
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<tr>
<td>3211</td>
<td>Bed Cover Factory</td>
<td>Mara</td>
<td>Musoma Urban</td>
<td>Nyerere Rd.</td>
<td>Box 379 Musoma</td>
<td></td>
<td>1981</td>
<td>4</td>
<td>5</td>
<td>Cotton yarn, grey sheeting</td>
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<tr>
<td>3211</td>
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<td>Mara</td>
<td>Musoma Rural</td>
<td>Nyang'oma-Kiriba</td>
<td>Box 379 Musoma</td>
<td></td>
<td>1975</td>
<td>6</td>
<td>5</td>
<td>Cotton lint, seeds</td>
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<td>Ushashi Ginnery</td>
<td>Mara</td>
<td>Bunda</td>
<td>Misi Village Muchomo Ward</td>
<td>Box 17 Bunda</td>
<td></td>
<td>1952</td>
<td>6</td>
<td>5</td>
<td>Cotton lint, seeds</td>
</tr>
<tr>
<td>3211</td>
<td>Kibara Ginnery</td>
<td>Mara</td>
<td>Bunda</td>
<td>Busambara-Kibara</td>
<td>Box 55 Bunda</td>
<td></td>
<td>1975</td>
<td>6</td>
<td>5</td>
<td>Cotton lint, seeds</td>
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<tr>
<td>3231</td>
<td>Mwanza Tanneries Ltd</td>
<td>Mwanza</td>
<td>Mwanza Urban</td>
<td>Makongoro Rd.</td>
<td>Box 2200 Mwanza</td>
<td>40293</td>
<td>1978</td>
<td>6</td>
<td>2</td>
<td>Tanned leather</td>
</tr>
<tr>
<td>3522</td>
<td>Mwanza Pharmaceutical Supplies Ltd</td>
<td>Mwanza</td>
<td>Mwanza Urban</td>
<td>Plt. 17 Nyakato Rd.</td>
<td>Box 446 Mwanza</td>
<td>40307</td>
<td>1979</td>
<td>4</td>
<td>2</td>
<td>Medicines, cosmetics</td>
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<tr>
<td>3523</td>
<td>Lake Soap Industries Ltd</td>
<td>Mwanza</td>
<td>Mwanza Urban</td>
<td>Plt. 1,2,3,9,10 Mwanza South Rd.</td>
<td>Box 1420 Mwanza</td>
<td>40518</td>
<td>1967</td>
<td>6</td>
<td>2</td>
<td>Laundry/toilet soap, detergents</td>
</tr>
<tr>
<td>3523</td>
<td>Biharamulo Cotton Co.</td>
<td>Kagera</td>
<td>Biharamulo</td>
<td>Suzilayombo Village Nyakato Ward</td>
<td>Box 101 Biharamulo</td>
<td>1076</td>
<td></td>
<td>4</td>
<td>2</td>
<td>Soap</td>
</tr>
<tr>
<td>4101</td>
<td>Tanzania Electrical Supply Company (TANESCO)</td>
<td>Kagera</td>
<td>Bukoba Urban</td>
<td>Bukoba Town</td>
<td>Box 30 Bukoba</td>
<td>20061</td>
<td></td>
<td>5</td>
<td>1</td>
<td>Electricity</td>
</tr>
<tr>
<td>4101</td>
<td>Tanzania Electrical Supply Company (TANESCO)</td>
<td>Mwanza</td>
<td>Mwanza Urban</td>
<td>Mwanza Town</td>
<td>Box 8 Mwanza</td>
<td>40554</td>
<td></td>
<td>6</td>
<td>1</td>
<td>Electricity</td>
</tr>
<tr>
<td>4101</td>
<td>Tanzania Electrical Supply Company (TANESCO)</td>
<td>Mara</td>
<td>Musoma Urban</td>
<td>Musoma Town</td>
<td>Box 200 Musoma</td>
<td>122</td>
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<td>5</td>
<td>1</td>
<td>Electricity</td>
</tr>
<tr>
<td>ISIC Code</td>
<td>Name of Establishment</td>
<td>Region</td>
<td>District</td>
<td>Location</td>
<td>Postal Address</td>
<td>Telephone</td>
<td>Year production started</td>
<td>Size</td>
<td>Ownership</td>
<td>Principal products</td>
</tr>
<tr>
<td>-----------</td>
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<td>--------</td>
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</tr>
<tr>
<td>2302</td>
<td>Mathias Odeki</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Mwenekezi Village</td>
<td>Box 54</td>
<td></td>
<td>1987</td>
<td>5</td>
<td>2</td>
<td>Gold</td>
</tr>
<tr>
<td>2302</td>
<td>Majiku Lukanda</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Kaseme Village</td>
<td>Box 54</td>
<td></td>
<td>1986</td>
<td>5</td>
<td>2</td>
<td>Gold</td>
</tr>
<tr>
<td>2302</td>
<td>Francis Mandirisha</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Kaseme Village</td>
<td>Box 109</td>
<td></td>
<td>1986</td>
<td>5</td>
<td>2</td>
<td>Gold</td>
</tr>
<tr>
<td>2302</td>
<td>James Msoga</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Nyarugusu Village Bukori</td>
<td>Box 26</td>
<td></td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>Gold</td>
</tr>
<tr>
<td>2302</td>
<td>Buck Reef Gold Mine</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Nyarugusu Village Bukori</td>
<td>Box 71</td>
<td></td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>Gold</td>
</tr>
<tr>
<td>2302</td>
<td>Kijiji cha Kaseme (K)</td>
<td>Mwanza</td>
<td>Geita</td>
<td>Kaseme (K) Village</td>
<td>Box 30</td>
<td></td>
<td>1989</td>
<td>6</td>
<td>7</td>
<td>Gold</td>
</tr>
</tbody>
</table>
Table 1 Pollution load in effluents streams of some industries in the Mwanza region.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Mwatex</th>
<th>Mwanza Tanneries Ltd</th>
<th>Lake Soap Industries Ltd</th>
<th>VOIL</th>
<th>Nyanza Bottling Ltd</th>
<th>Vicfish Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste water generation</td>
<td>10^3 m^3/year</td>
<td>550(1)</td>
<td>11(4)</td>
<td>5(4)</td>
<td>3.75(4)</td>
<td>187.5(4)</td>
<td>1.5(4)</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>12.7(1)/9.4(4)</td>
<td>13.0(1)</td>
<td>6.4(3)/10.2(4)</td>
<td>5.9(1)/7.2(4)</td>
<td>8.3(4)</td>
<td>7.9(4)</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>g/m^3</td>
<td>4.3(1)/0.0(4)</td>
<td>7.7(1)</td>
<td>7.3(1)/1.8(4)</td>
<td>3.1(1)/1.2(4)</td>
<td>0.0(4)</td>
<td>1.5(4)</td>
</tr>
<tr>
<td>TDS</td>
<td>g/m^3</td>
<td>4.6(1)</td>
<td>9.9(1)</td>
<td>64.6(1)</td>
<td>890(1)</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>BOD₅</td>
<td>g/m^3</td>
<td>42(3)/41(22)</td>
<td>26.4(3)</td>
<td>8.6(3)</td>
<td>66(3)</td>
<td>70(3)</td>
<td>13.1</td>
</tr>
<tr>
<td>COD</td>
<td>g/m³</td>
<td>5.4/275</td>
<td>5.4/275</td>
<td>5.4/275</td>
<td>5.9(1)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>g/m³</td>
<td>0.03(1)</td>
<td>0.0003</td>
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</tr>
</tbody>
</table>

(a) Calculated from the daily waste-water generation figure (Mwanza Tanneries Ltd: 45 m³; Lake Soap Industries Ltd: 21 m³; VOIL: 15 m³; Nyanza Bottling Company: 750 m³)(3) multiplied by 250 operating days per year.
(b) Calculated from the daily waste-water generation figure (6 m³)(1) multiplied by 250 operating days per year.
Table 1  Rapid Assessment working table of pollution loads of major industries in the Mwanza region.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Mwatex</th>
<th>Mwanza Tanneries Ltd</th>
<th>Lake Soap Industries Ltd</th>
<th>VOIL</th>
<th>New-Era</th>
<th>Nyanza Bottling Co. Ltd</th>
<th>Vicfish Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>t/ year</td>
<td>667(^{(a)})</td>
<td>223(^{(b)})</td>
<td>15000(^{(1)})</td>
<td>18000(^{(2)})</td>
<td>9000(^{(23)})</td>
<td>8100(^{(6)})</td>
<td>1625(^{(40)})</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8-11</td>
<td>1-13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste volume factor</td>
<td>m³/t</td>
<td>317</td>
<td>52</td>
<td>4.5</td>
<td>57.5</td>
<td>57.5</td>
<td>7.1</td>
<td>23</td>
</tr>
<tr>
<td>Load</td>
<td>10³ m³/year</td>
<td>211</td>
<td>12</td>
<td>68</td>
<td>1035</td>
<td>518</td>
<td>12.9</td>
<td>7.9</td>
</tr>
<tr>
<td>BOD₅</td>
<td>kg/t</td>
<td>155</td>
<td>89</td>
<td>6</td>
<td>12.9</td>
<td>12.9</td>
<td>2.5</td>
<td>5.9</td>
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<tr>
<td>Load</td>
<td>t/year</td>
<td>47</td>
<td>138</td>
<td>4</td>
<td>16.4</td>
<td>16.4</td>
<td>1.3</td>
<td>9.2</td>
</tr>
<tr>
<td>COD</td>
<td>kg/t</td>
<td>70</td>
<td>10</td>
<td>150</td>
<td>103</td>
<td>189</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>t/year</td>
<td>47</td>
<td>31</td>
<td>60</td>
<td>378</td>
<td>189</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>kg/t</td>
<td>205</td>
<td>351</td>
<td>60</td>
<td>882</td>
<td>882</td>
<td>1.3</td>
<td>9.2</td>
</tr>
<tr>
<td>Load</td>
<td>t/year</td>
<td>78</td>
<td>78</td>
<td>60</td>
<td>15876</td>
<td>7938</td>
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<td></td>
</tr>
<tr>
<td>TDS</td>
<td>kg/t</td>
<td>20</td>
<td>1.9</td>
<td>6</td>
<td>6.5</td>
<td>6.5</td>
<td>4.5</td>
<td>7</td>
</tr>
<tr>
<td>Load</td>
<td>t/year</td>
<td>7</td>
<td>4.5</td>
<td>13.5</td>
<td>117</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>kg/t</td>
<td>15 (7)</td>
<td>3 (1.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Load</td>
<td>t/year</td>
<td>3.5</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N(\text{\textasciitilde}) S²</td>
<td>kg/t</td>
<td>15 (\text{7})</td>
<td>3 (\text{1.6})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Load</td>
<td>t/year</td>
<td>3.5</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkalinity</td>
<td>kg/t</td>
<td>3.7</td>
<td>30</td>
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</table>

(a) Calculated from the yearly production figure in metres \((4\cdot10^6 \text{ m})^{(1)}\) divided by the average length per kg cotton \((6 \text{ m})^{(12)}\).
(b) Calculated from the yearly production figure in m² \((45.5\cdot10^3 \text{ m}^2)^{(6)}\) multiplied by an estimated weight per m² of 5 kg. This estimation has been made, knowing that the weight of a hide of large cattle is 25-26 kg, and of goats 3 kg on average\(^{(13)}\).
(c) Calculated from the yearly production figure in crates for 1990/1991 \((1,352,350)^{(6)}\) multiplied by 24 * 0.25 kg (24 bottles of 0.25 l per bottle).
(d) Calculated from the daily production figure \((6.5\cdot10^3 \text{ kg})^{(10)}\) multiplied by 250 operating days per year.
(e) To calculate the waste load, the factor is multiplied by the annual production.
Table 2 Rapid Assessment working table of pollution loads of major industries in the Mara and Kagera regions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Mutex</th>
<th>Mugango Oil Mill</th>
<th>Kibara Oil Mill</th>
<th>Fish Pack</th>
<th>Kagera Sugar Ltd</th>
<th>West Lake Bottlers Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>t/year</td>
<td>650(a)</td>
<td>3600(b)</td>
<td>1800(b)</td>
<td>5000(b)</td>
<td>3500(17)</td>
<td>3000(18)</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste volume factor load</td>
<td>m³/t</td>
<td>317</td>
<td>57.5</td>
<td>57.5</td>
<td>23</td>
<td>28.6</td>
<td>7.1</td>
</tr>
<tr>
<td>BOD₃ factor load</td>
<td>kg/t t/year</td>
<td>155</td>
<td>12.9</td>
<td>12.9</td>
<td>7.9</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>COD factor load</td>
<td>kg/t t/year</td>
<td>70</td>
<td>16.4</td>
<td>16.4</td>
<td>9.2</td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
<td>SS factor load</td>
<td>kg/t t/year</td>
<td>70</td>
<td>16.4</td>
<td>16.4</td>
<td>9.2</td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
<td>TDS factor load</td>
<td>kg/t t/year</td>
<td>205</td>
<td>882</td>
<td>882</td>
<td>46</td>
<td>14</td>
<td>3.9</td>
</tr>
<tr>
<td>Oil factor load</td>
<td>kg/t t/year</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>4.5</td>
<td>3</td>
<td>3.7</td>
</tr>
<tr>
<td>N factor load</td>
<td>kg/t t/year</td>
<td>23</td>
<td>12</td>
<td>12</td>
<td>0.64</td>
<td>3</td>
<td>3.7</td>
</tr>
<tr>
<td>Alkalinity factor load</td>
<td>kg/t t/year</td>
<td>3.7</td>
<td>3</td>
<td>3</td>
<td>3.7</td>
<td>3.7</td>
<td>3.7</td>
</tr>
</tbody>
</table>

(a) Calculated from the average production figure in metres (3.9·10⁶ m)² divided by the average length per kg cotton (6 m), according to NATEX.
(b) Calculated from the daily production figure (20·10⁴ kg)² multiplied by 250 operating days per year.
(c) Calculated from the yearly production figure in crates (510,000)² multiplied by 24·0.25 kg (24 bottles of 0.25 l per bottle).
Table 1 Rapid Assessment working table for solid waste loads of major industries in the Mwanza region.

<table>
<thead>
<tr>
<th>Establishment</th>
<th>Unit</th>
<th>Production units/year</th>
<th>Solid waste kg/unit</th>
<th>Nature of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mwatex</td>
<td>t of products</td>
<td>667&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>32</td>
<td>Fibre and yarn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>7</td>
<td>Fibre and yarn and cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td>Cloth and flock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.8</td>
<td>2</td>
<td>Pretreatment screening fibres</td>
</tr>
<tr>
<td>Mwanza Tanneries Ltd</td>
<td>1000 hides</td>
<td>9&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>550</td>
<td>Process wastes (scrap products, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1770</td>
<td>16</td>
<td>Process wastes containing Cr, Pb, Zn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>390</td>
<td>4</td>
<td>Waste-water screenings containing Cr, Pb, Zn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2700</td>
<td>24</td>
<td>Waste-water sludge containing Cr, Pb, phenols</td>
</tr>
<tr>
<td>Lake Soap Industries Ltd</td>
<td>t of products</td>
<td>15000&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>No info</td>
<td></td>
</tr>
<tr>
<td>VOIL</td>
<td>t of products</td>
<td>18000&lt;sup&gt;(23)&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>Purification muds soaked in oil</td>
</tr>
<tr>
<td>New-Era</td>
<td>t of products</td>
<td>9000&lt;sup&gt;(23)&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>Purification muds soaked in oil</td>
</tr>
<tr>
<td>Nyanza Bottling Company</td>
<td>t of products</td>
<td>8100&lt;sup&gt;(e)&lt;/sup&gt;</td>
<td>No info</td>
<td></td>
</tr>
<tr>
<td>Vick Fish Ltd</td>
<td>t of products</td>
<td>1625&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td>100</td>
<td>Inedible fish parts</td>
</tr>
</tbody>
</table>

(a) Calculated from the yearly production figure in metres (<sup>4·10<sup>6</sup> m</sup>)<sup>(1)</sup> divided by the average length per kg cotton (6 m)<sup>(12)</sup>.
(b) Calculated from the yearly production figure in m<sup>2</sup> (<sup>45.5·10<sup>3</sup> m<sup>2</sup></sup>)<sup>(6)</sup> divided by an estimated surface of 5000 m<sup>2</sup>/1000 hydes. This estimation has been made, knowing that the weight of a hide of large cattle is 25-26 kg, and of goats 3 kg on average<sup>(13)</sup>.
(c) Calculated from the yearly production figure in crates for 1990/1991 (1,352,350)<sup>(6)</sup> multiplied by 24 * 0.25 kg (24 bottles of 0.25 l per bottle).
(d) Calculated from the daily production figure (<sup>6.5·10<sup>3</sup> kg</sup>)<sup>(11)</sup> multiplied by 250 operating days per year.
(e) Waste load on a dry basis.
Table 2 Rapid Assessment working table for solid waste loads of major industries in the Mara and Kagera regions.

<table>
<thead>
<tr>
<th>Establishment</th>
<th>Unit</th>
<th>Production units/year</th>
<th>Solid waste kg/unit</th>
<th>T/year</th>
<th>Nature of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutex</td>
<td>t of products</td>
<td>650&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>32</td>
<td>21</td>
<td>Fibre and yarn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>7</td>
<td></td>
<td>Fibre and yarn and cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td></td>
<td>Cloth and flock</td>
</tr>
<tr>
<td>Mugango Oil Mill</td>
<td>t</td>
<td>3600&lt;sup&gt;(23)&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>17&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>Purification muds soaked in oil</td>
</tr>
<tr>
<td>Kibara Oil Mill</td>
<td>t</td>
<td>1800&lt;sup&gt;(23)&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>8&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Fish Pack</td>
<td>t of products</td>
<td>5000&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>100</td>
<td>500</td>
<td>Inedible fish parts</td>
</tr>
<tr>
<td>Kagera Sugar Ltd</td>
<td>t</td>
<td>3500&lt;sup&gt;(17)&lt;/sup&gt;</td>
<td>No info</td>
<td></td>
<td>Spent canes</td>
</tr>
<tr>
<td>West Lake Bottlers Ltd</td>
<td></td>
<td>3000&lt;sup&gt;(17)&lt;/sup&gt;</td>
<td>No info</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Calculated from the average production figure in metres (3.9·10<sup>6</sup> m)<sup>(23)</sup> divided by the average length per kg cotton (6 m), according to NATEX.
(b) Calculated from the daily production figure (20·10<sup>3</sup> kg)<sup>(23)</sup> multiplied by 250 operating days per year.
(c) Waste load on a dry basis.
(d) Calculated from the yearly production figure in crates (510,000)<sup>(15)</sup> multiplied by 24 * 0.25 kg (24 bottles of 0.25 l per bottle).
### Table 1: Rapid Assessment working table of waste loads from domestic effluents and municipal solid waste, 1991

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Mwanza Urban</th>
<th>Mwanza Rural</th>
<th>Mara Urban</th>
<th>Mara Rural</th>
<th>Kagera Urban</th>
<th>Kagera Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sewered</td>
<td>Unsewered</td>
<td>Total</td>
<td>Unsewered</td>
<td>Unsewered</td>
<td>Unsewered</td>
</tr>
<tr>
<td>Population(2)</td>
<td>$10^3$ people</td>
<td>22</td>
<td>163</td>
<td>185</td>
<td>1896</td>
<td>72</td>
<td>1016</td>
</tr>
<tr>
<td>Waste volume</td>
<td>m$^3$/person/year</td>
<td>73</td>
<td>1606</td>
<td>1190</td>
<td>2796</td>
<td>7.3</td>
<td>13841</td>
</tr>
<tr>
<td></td>
<td>$10^3$ m$^3$/year</td>
<td>16</td>
<td>11</td>
<td>7.3</td>
<td>13841</td>
<td>7.3</td>
<td>7417</td>
</tr>
<tr>
<td>BOD$_3$</td>
<td>kg/person/year</td>
<td>19.7</td>
<td>433</td>
<td>6.9</td>
<td>1125</td>
<td>6.9</td>
<td>13082</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>44.7</td>
<td>2608</td>
<td>16</td>
<td>3576</td>
<td>16</td>
<td>30336</td>
</tr>
<tr>
<td>COD</td>
<td>kg/person/year</td>
<td>44</td>
<td>968</td>
<td>16</td>
<td>3576</td>
<td>16</td>
<td>30336</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>968</td>
<td>2608</td>
<td>16</td>
<td>3576</td>
<td>16</td>
<td>30336</td>
</tr>
<tr>
<td>SS</td>
<td>kg/person/year</td>
<td>20</td>
<td>440</td>
<td>16</td>
<td>3048</td>
<td>16</td>
<td>30336</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>440</td>
<td>2608</td>
<td>16</td>
<td>3048</td>
<td>16</td>
<td>30336</td>
</tr>
<tr>
<td>TDS(3)</td>
<td>kg/person/year</td>
<td>36.5</td>
<td>803</td>
<td>36.5</td>
<td>5950</td>
<td>36.5</td>
<td>6753</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>36.5</td>
<td>5950</td>
<td>36.5</td>
<td>6753</td>
<td>36.5</td>
<td>2628</td>
</tr>
<tr>
<td>N(4)</td>
<td>kg/person/year</td>
<td>3.3</td>
<td>73</td>
<td>3.3</td>
<td>538</td>
<td>3.3</td>
<td>611</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>3.3</td>
<td>73</td>
<td>3.3</td>
<td>538</td>
<td>3.3</td>
<td>611</td>
</tr>
<tr>
<td>P(4)</td>
<td>kg/person/year</td>
<td>0.4</td>
<td>9</td>
<td>0.4</td>
<td>66</td>
<td>0.4</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>0.4</td>
<td>9</td>
<td>0.4</td>
<td>66</td>
<td>0.4</td>
<td>75</td>
</tr>
<tr>
<td>Solid waste(4)</td>
<td>kg/person/year</td>
<td>0.7</td>
<td>15</td>
<td>0.7</td>
<td>114</td>
<td>0.7</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>t/week</td>
<td>0.7</td>
<td>15</td>
<td>0.7</td>
<td>114</td>
<td>0.7</td>
<td>129</td>
</tr>
</tbody>
</table>

**Note:** Calculation occurs using the two conversion factors for people connected to and not connected to the sewage system.

Example: BOD$_3$ load for urban Mwanza = (19.7 * 8/100 + 6.9 * 92/100) * 406.10$^5$ = 3217.

Mixed urban and rural population are taken together with the rural population in one category: rural.

(a) Pollution indexes for TDS, N, P and solid waste loads from non-sewered population are not given in the "rapid assessment" methodology handbook, nor could reliable data be found in other literature. The factors used therefore should be seen as maximum pollution loads.
Table 1  Pollution load to watercourses for agrochemicals used in the Kagera, Mwanza and Mara regions in Tanzania.

<table>
<thead>
<tr>
<th>Pesticide/Herbicide/Fungicide</th>
<th>Amount used (l,3,5,29,30,31,3233)</th>
<th>Active component (a.c.) (7,8,32,33,48)</th>
<th>Amount active component (7,8,48)</th>
<th>Application rate (7,8,33)</th>
<th>Half-life in water (days)</th>
<th>Average runoff concentration (mg a.c./L)</th>
<th>Total load to watercourses (kg a.c./year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>1000 litres</td>
<td>g/l</td>
<td>g a.c./ha</td>
<td>days</td>
<td>10^-3 mg a.c./l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiodan 25% ULV 35% EC (a)</td>
<td>160</td>
<td>endosulfan(a)</td>
<td>250</td>
<td>625</td>
<td>60-800(d)</td>
<td>161</td>
<td>2000</td>
</tr>
<tr>
<td>Samicidin 3% ULV</td>
<td>50</td>
<td>fenvalerate(a)</td>
<td>30</td>
<td>75</td>
<td>75-80</td>
<td>19.5</td>
<td>75</td>
</tr>
<tr>
<td>Karate 2% ED</td>
<td>10</td>
<td>cyhalothrin(a)</td>
<td>20</td>
<td>7</td>
<td>28-84</td>
<td>1.82</td>
<td>10</td>
</tr>
<tr>
<td>Karate 0.6% ULV</td>
<td>30</td>
<td>cyhalothrin(a)</td>
<td>6</td>
<td>15</td>
<td>28-84</td>
<td>3.9</td>
<td>9</td>
</tr>
<tr>
<td>Fenom C 1% ULV/ 6% ULV</td>
<td>30</td>
<td>cypermethrin(b)/profenofos(b)</td>
<td>10/160</td>
<td>25/400</td>
<td>5/93</td>
<td>6.5/52</td>
<td>15/240</td>
</tr>
<tr>
<td>Polythrin 1.8% ULV</td>
<td>20</td>
<td>cypermethrin(b)</td>
<td>18</td>
<td>45</td>
<td>5</td>
<td>11.7</td>
<td>18</td>
</tr>
<tr>
<td>Decis D. 0.3% ULV/ 12% ULV</td>
<td>20</td>
<td>deltamethrin/dimethoate</td>
<td>3/120</td>
<td>7.5/300</td>
<td>7-14(d)</td>
<td>1.97/78</td>
<td>3/120</td>
</tr>
<tr>
<td>Cotoran 500 FW</td>
<td>10</td>
<td>fluometuron</td>
<td>500</td>
<td>1000</td>
<td>60(a)</td>
<td>260</td>
<td>250</td>
</tr>
<tr>
<td>Cybolct 1.7% ULV</td>
<td>23</td>
<td>cypermethrin(b)</td>
<td>17</td>
<td>42.5</td>
<td>5</td>
<td>11.1</td>
<td>20</td>
</tr>
<tr>
<td>Ripcord 1.8% ULV</td>
<td>16</td>
<td>cypermethrin(b)</td>
<td>18</td>
<td>45</td>
<td>5(a)</td>
<td>11.7</td>
<td>14</td>
</tr>
<tr>
<td>Selecron 500 EC (a)</td>
<td>20(a)</td>
<td>profenofos(b)</td>
<td>500</td>
<td>500</td>
<td>93</td>
<td>130</td>
<td>488</td>
</tr>
<tr>
<td>Dursban 480(c)</td>
<td>71(a)</td>
<td>chlorpyrifos(b)</td>
<td>480</td>
<td>n.k.(c)</td>
<td>60-120(d)</td>
<td>125</td>
<td>1696</td>
</tr>
<tr>
<td>Cymbush 10% EC</td>
<td>46(b)</td>
<td>cypermethrin(b)</td>
<td>18</td>
<td>45</td>
<td>5(c)</td>
<td>11.7</td>
<td>41</td>
</tr>
<tr>
<td>Dieldrin 18% ULV(c)</td>
<td>22(a)</td>
<td>dieldrin(b)</td>
<td>180</td>
<td>180</td>
<td>13-120</td>
<td>46.8</td>
<td>200</td>
</tr>
<tr>
<td>Bayfian(c)</td>
<td>9(a)</td>
<td>triadimenol(b)</td>
<td>250</td>
<td>n.k.(c)</td>
<td>110-375(d)</td>
<td>65</td>
<td>109</td>
</tr>
<tr>
<td>Round up(c)</td>
<td>2</td>
<td>glyphosate</td>
<td>360</td>
<td>340</td>
<td>60(a)</td>
<td>88.4</td>
<td>36</td>
</tr>
<tr>
<td>Bravo 500</td>
<td>44</td>
<td>chlorothalonil(b)</td>
<td>500</td>
<td>630</td>
<td>45-90(d)</td>
<td>164</td>
<td>1100</td>
</tr>
<tr>
<td>Bayleton(c)</td>
<td>14 tons(a)</td>
<td>triadimefon(b)</td>
<td>250 g/kg</td>
<td>2.5</td>
<td>18(d)</td>
<td>0.65</td>
<td>177</td>
</tr>
<tr>
<td>Pesticide/Herbicide/Fungicide</td>
<td>Amount used (g, l, kg, ha, days)</td>
<td>Active component (a.c.)</td>
<td>Amount active component (g a.c./ha)</td>
<td>Application rate (g a.c./ha)</td>
<td>Half-life in water (days)</td>
<td>Average runoff concentration (mg a.c./l)</td>
<td>Total load to watercourses (kg a.c./year)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------</td>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
<td>----------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td><strong>Unit</strong></td>
<td>1000 litres</td>
<td>-</td>
<td>g/l</td>
<td>g a.c./ha</td>
<td>days</td>
<td>10^3 mg a.c./l</td>
<td>kg a.c./year</td>
</tr>
<tr>
<td><strong>Bulldock 0.5% ULV</strong></td>
<td>80</td>
<td>Betacyfluthrin</td>
<td>5</td>
<td>12.5</td>
<td>75-80</td>
<td>3.25</td>
<td>20</td>
</tr>
<tr>
<td><strong>Sumithion 50% EC</strong></td>
<td>61</td>
<td>fenvalerate</td>
<td>500</td>
<td>250</td>
<td>75-80</td>
<td>65</td>
<td>1531</td>
</tr>
<tr>
<td><strong>Blue Copper</strong></td>
<td>259 tons</td>
<td>Cu in CuSO₄*(5H₂O/Ca(OH)₂)</td>
<td>200 g Cu /kg</td>
<td>2500</td>
<td>n.r.</td>
<td>650</td>
<td>2591</td>
</tr>
<tr>
<td><strong>Kocide 101 50% WP</strong></td>
<td>45 tons</td>
<td>Cu in Cu(OH)₂</td>
<td>500</td>
<td>2500</td>
<td>n.r.</td>
<td>650</td>
<td>1127</td>
</tr>
<tr>
<td><strong>Red Copper</strong></td>
<td>397 tons</td>
<td>Cu in Cu₂O</td>
<td>500</td>
<td>2500</td>
<td>n.r.</td>
<td>650</td>
<td>9923</td>
</tr>
<tr>
<td><strong>Steladone</strong></td>
<td>10</td>
<td>Chlorfenvinphos</td>
<td>300</td>
<td>0.3-0.7 g/l</td>
<td>n.r.</td>
<td>n.r.</td>
<td>863</td>
</tr>
<tr>
<td><strong>Supadip</strong></td>
<td>5.6</td>
<td>Chlorfenvinphos</td>
<td>900</td>
<td>0.3-0.7 g/l</td>
<td>n.r.</td>
<td>n.r.</td>
<td>1449</td>
</tr>
</tbody>
</table>

(a) This is 35% of the total amount of the pesticide/herbicide/fungicide used for coffee production in Tanzania, based on the fact that 35% of the production of coffee in Tanzania has been grown in the area around Lake Victoria³".³ ACCOUNT FOR REFERENCE WITH NUMBER ³".³
(b) This is 46% of the total amount of the pesticide/herbicide/fungicide used for cotton production in Tanzania, based on the fact that 46% of the production of cotton in Tanzania has been grown in the area around Lake Victoria³".³ ACCOUNT FOR REFERENCE WITH NUMBER ³".³
(c) Agrochemicals used for coffee.
(d) Half-life for agrochemical in soil.
(e) Calculated concentration of active component in runoff, being (0.05 * application rate) / (2/3 * weekly rainfall).
(f) Calculated total load of active component to watercourses being (0.05 * amount applied * amount of active component).
(g) Chemicals used as disinfectant.
(h) Agrochemicals containing chlorine (Cl).
(i) As the application rate for this agrochemical could not be found, this is an assumed value based on application rates for similar agrochemicals given by literature³".³ ACCOUNT FOR REFERENCE WITH NUMBER ³".³
(j) In order to calculate the average runoff concentration the application rate (g/ha) is defined to be equal to the amount of active component (g/l).
Table 1 Pollution load of nutrients to watercourses for artificial fertilizers used in the Kagera, Mwanza and Mara regions in Tanzania.

<table>
<thead>
<tr>
<th>District</th>
<th>TSP</th>
<th>CAN</th>
<th>SA</th>
<th>UREA</th>
<th>P&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>N&lt;sup&gt;(b)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
</tr>
<tr>
<td>Kagera</td>
<td>-</td>
<td>81</td>
<td>159</td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>Mwanza</td>
<td>189</td>
<td>27</td>
<td>771</td>
<td>281</td>
<td>6</td>
<td>81</td>
</tr>
<tr>
<td>Mara</td>
<td>90</td>
<td>28</td>
<td>84</td>
<td>123</td>
<td>3</td>
<td>23</td>
</tr>
</tbody>
</table>

(a) Assuming an average loss to watercourses of 13% of the total amount of P in the fertilizers used<sup>(13)</sup>. TSP (Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>*H<sub>2</sub>O) contains 26% P.
(b) Assuming an average loss to watercourses of 30% of the total amount of N in the fertilizers used<sup>(9,12,13)</sup>. CAN (NH<sub>4</sub>NO<sub>3</sub>-CaCO<sub>3</sub>), SA ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>) and UREA (CO(NH)<sub>2</sub>) contain respectively 17, 18 and 45% N.
(c) Calculated total load to watercourses, being the characteristic loss to watercourses of the nutrient in the fertilizer multiplied with the amount of the nutrient present in the total amount of fertilizer used.

Table 2 Pollution load of nutrients to watercourses for manure produced in the Kagera, Mwanza and Mara regions in Tanzania.

<table>
<thead>
<tr>
<th>District</th>
<th>Cattle&lt;sup&gt;(c)&lt;/sup&gt;</th>
<th>Goats&lt;sup&gt;(c)&lt;/sup&gt;</th>
<th>Sheep&lt;sup&gt;(c)&lt;/sup&gt;</th>
<th>Chicken&lt;sup&gt;(c)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>P&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>N&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>P&lt;sup&gt;(a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unit</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
<td>r/year</td>
</tr>
<tr>
<td>Kagera</td>
<td>2730</td>
<td>188</td>
<td>128</td>
<td>28</td>
</tr>
<tr>
<td>Mwanza</td>
<td>10058</td>
<td>690</td>
<td>210</td>
<td>45</td>
</tr>
<tr>
<td>Mara</td>
<td>8273</td>
<td>568</td>
<td>165</td>
<td>36</td>
</tr>
</tbody>
</table>

(a) Assuming an average loss to watercourses of 13% of the total amount of P in manure, assuming there is no virtual difference from artificial fertilizers<sup>(13)</sup>.
(b) Assuming an average loss to watercourses of 30% of the total amount of N in manure, assuming there is no virtual difference from artificial fertilizers<sup>(9,12,13)</sup>.
(c) Calculated total load to watercourses, being the characteristic loss to watercourses of the nutrient in the manure multiplied with the amount of the nutrient present in 5/12 of the total amount of manure produced.
### List of abbreviations and symbols

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.c.</td>
<td>Active component</td>
</tr>
<tr>
<td>BOD$_5$</td>
<td>5-day biological oxygen demand</td>
</tr>
<tr>
<td>CAN</td>
<td>$\text{NH}_4\text{NO}_3-\text{CaCO}_3$</td>
</tr>
<tr>
<td>CICA</td>
<td>Centre for International Cooperation Activities</td>
</tr>
<tr>
<td>Cl</td>
<td>Chlorine</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical oxygen demand</td>
</tr>
<tr>
<td>Cr</td>
<td>Chromium</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
</tr>
<tr>
<td>EC</td>
<td>Emulsifiable concentrate</td>
</tr>
<tr>
<td>ED</td>
<td>Electrodin concentrate</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation</td>
</tr>
<tr>
<td>g</td>
<td>Grams</td>
</tr>
<tr>
<td>ha</td>
<td>Hectare</td>
</tr>
<tr>
<td>hd</td>
<td>Heads</td>
</tr>
<tr>
<td>ISIC</td>
<td>International Standard Industrial Classification</td>
</tr>
<tr>
<td>kg</td>
<td>Kilograms</td>
</tr>
<tr>
<td>l</td>
<td>Litres</td>
</tr>
<tr>
<td>m$^3$</td>
<td>Cubic metres</td>
</tr>
<tr>
<td>mg</td>
<td>Milligrams</td>
</tr>
<tr>
<td>N</td>
<td>Nitrogen compounds</td>
</tr>
<tr>
<td>NCU</td>
<td>Nyanza Cooperative Union</td>
</tr>
<tr>
<td>NEMC</td>
<td>National Environmental Management Council</td>
</tr>
<tr>
<td>n.k.</td>
<td>Not known</td>
</tr>
<tr>
<td>n.r.</td>
<td>Not relevant</td>
</tr>
<tr>
<td>OCP</td>
<td>Organochlorine pesticides</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorous compounds</td>
</tr>
<tr>
<td>Pb</td>
<td>Lead</td>
</tr>
<tr>
<td>RALDO</td>
<td>Regional Agriculture and Livestock Development Office</td>
</tr>
<tr>
<td>RDD</td>
<td>Regional Development Director's office</td>
</tr>
<tr>
<td>RWE</td>
<td>Regional Water Engineer's office</td>
</tr>
<tr>
<td>S$^2$</td>
<td>Sulfide</td>
</tr>
<tr>
<td>SA</td>
<td>(NH$_4$)$_2$SO$_4$</td>
</tr>
<tr>
<td>SS</td>
<td>Suspended solids</td>
</tr>
<tr>
<td>t</td>
<td>Ton</td>
</tr>
<tr>
<td>TCMB</td>
<td>Tanzanian Cotton Marketing Board</td>
</tr>
<tr>
<td>TDS</td>
<td>Total dissolved solids</td>
</tr>
<tr>
<td>TPDC</td>
<td>Tanzanian Petroleum Development Cooperation</td>
</tr>
<tr>
<td>TSP</td>
<td>$\text{Ca(H}_2\text{PO}_4)_2\text{*H}_2\text{O}$</td>
</tr>
<tr>
<td>UNEP</td>
<td>United Nations Environmental Programme</td>
</tr>
<tr>
<td>ULV</td>
<td>Ultra low volume</td>
</tr>
<tr>
<td>UREA</td>
<td>CO(NH)$_2$</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
<tr>
<td>WP</td>
<td>Wettable powder</td>
</tr>
<tr>
<td>Zn</td>
<td>Zinc</td>
</tr>
<tr>
<td>-</td>
<td>zero, nothing</td>
</tr>
</tbody>
</table>