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RAPID ASSESSMENT OF SOURCES OF AIR, WATER, AND LAND POLLUTION

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PREFACE

This book outlines a procedure for making a rapid across-the-board assessment of the amount of air, water, and land pollution in a given region or country. Although most of the methods described in this publication are not new, they have been adapted especially for use in developing countries, where it is often difficult to obtain certain kinds of information. Also, the methods have been streamlined so that they are similar for air, water, and land pollution, thus facilitating the interpretation of the results obtained.

Although the procedure for rapid assessment studies described in this book has been simplified considerably, it is necessary for the technical staff carrying out the assessment study to have a certain knowledge and understanding of the principles and the procedures involved and of the data required to complete the study. It is recommended therefore that personnel without previous experience in making environmental assessment studies should undergo some training before starting a study.

Good environmental assessment studies require: (1) easy access to all sources of information, and (2) an ability to sift through large amounts of data. The information usually needs to be condensed, sometimes converted to other units, and, if possible, cross-checked with other information. Although this book gives guidance and examples in this area, success will ultimately depend on the skill and perseverance of the team carrying out the study. Once the necessary data have been assembled, they can be entered into the appropriate working tables in order to calculate amounts of pollution[1] and waste[2] from various sources.

In addition to guidance on calculating pollution and waste loads, this book presents information on the interpretation of the results obtained. It is recommended that such interpretation be done in cooperation with officials responsible for planning and public health in order to ensure that the results of the study are produced in a form suitable for the development of actions to prevent or reduce the impact of environmental pollution on human health and the environment in general.

Work on this book started in 1977 when a number of pilot projects were undertaken with a view to gaining practical experience in carrying out environmental assessment studies in developing countries. During the projects efforts were made to refine and adapt various methods of environmental assessment, and Mr W. Martin and Dr A. Economopoulos were particularly actively involved at this stage.

In December 1979, a group of consultants met in Geneva to prepare the first draft, which was subsequently reviewed by another group of experts. Finally, in December 1980 a second round of consultations was held in Geneva to complete the text and, where possible to incorporate the advice of the reviewers.

Throughout the preparation of this book, invaluable assistance was received from Dr Economopoulos. Also, Mr Timm's contribution during the completion of this book is gratefully acknowledged.

It should be pointed out that rapid environmental assessment studies are a relatively new subject and some aspects of the methods described here are still of a somewhat controversial nature. Hence, the views expressed herein are not necessarily shared by all the contributors and reviewers. It is hoped that the users of this book will draw attention to any difficulties they encounter in applying the proposed methods and address suggestions for improvement to: the Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

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[1] The term pollution refers to the introduction into the environment (air, water, or land) of contaminants, the quantities, characteristics, and duration of which are likely to be injurious to human, animal, or plant life.

[2] In this book waste refers to any refuse, including water-borne waste, sewage, and semisolid sludges, originating from domestic or commercial premises or processes, such as commercial or municipal garbage, sewage, or water-treatment plants.

1. INTRODUCTION

Rapid industrial development and the growth of cities throughout the world have led to the recognition and increasing understanding of the interrelationship between pollution, public health, and the environment. For example, we now know much, and are constantly learning more, about the many adverse effects of air pollution on the lungs, skin, and eyes of humans, on animals, and on vegetation; about diseases transmitted by water - either directly through consumption or indirectly through the food chain; and about the dangers of the improper disposal of solid wastes, which may lead to the breeding of rats and other vermin or the creation of sources of many toxic pollutants.

Essentially, public health programmes, as well as pollution prevention and control programmes, include: recognition of the problem; collection of information; definition of sources and causes; and the selection and implementation of appropriate solutions. Until recently, pollution prevention and control programmes were designed separately for air, water, and land pollution, and concentrated on the removal of pollutants from waste-receiving water bodies. This often resulted in the transfer of the problem from one part of the environment to another. For example: solid pollutants were removed from air and water, but then were improperly disposed of on land: sewage and industrial sludges were incinerated, adding to the air pollution problem; and solid wastes were exposed to leaching action or burned, increasing water or air pollution problems. Present practices recognize these environmental interactions and now focus simultaneously on the reduction of wastes at source and on comprehensive environmental planning.

However, while there exists a good understanding of the general principles and practices of environmental health and pollution control programmes, there are frequently no specific data on the types, numbers, and relative importance of pollution sources in many of the urban or industrial areas.

Wherever there are environmental problems, an inventory of the types of pollution and waste source, including their location and emission levels, is mandatory. Very detailed and precise inventories can be very resource-intensive and involve sophisticated monitoring and data-processing systems, and the budgetary and personnel requirements for such programmes are often beyond the scope of many agencies. However, by using the limited existing information it is possible to make reasonably accurate emission inventories at a relatively low cost. This book describes a procedure for making such inventories. By following the procedure described here one or two properly qualified professionals, with the help of a few technicians and auxiliary workers, should be able to produce in a period of one to three months, depending on the size and complexity of the study area, a rather complete and reasonably accurate inventory of all pollution and waste sources. It should be pointed out, however, that such inventories do not obviate the need for more detailed studies, but provide a first integrated view of the magnitude of the air, water, and land pollution in the area; they also mark the beginning of effective and comprehensive environmental pollution control planning.

This book is intended primarily for engineers or scientists involved in environmental planning and control. However, it also discusses how public health managers can use the results of rapid assessment studies in public health programmes aimed at pollution control. The rapid assessment procedure presented here has been selected from environmental assessment methodologies developed in the course of various UNEP, UNIDO, and WHO projects, and is especially adapted to conditions in developing countries.

The rapid assessment procedure is designed to utilize, wherever possible, data readily available in most countries, and usually there is no need for any extensive factory or source sampling surveys involving high levels of technical competence and large expenditures. The procedure is presented in a stepwise format (including discussions of basic assumptions) and comprises instructions from project initiation to the preparation of the final report. The discussions stress the need to use information available to cross-check and improve the accuracy of the estimates. Suggested formats for information gathering, analysing, and reporting and methods of presentation are also included.

The basic procedure for rapid assessment studies described here is equally applicable to all types of area in a country: urban, industrial, agricultural, mining, etc., and can be used in making integrated pollution inventories on a country-wide basis. However, the pollution factors and working tables in this document are designed primarily for use in urban areas and industrial zones.

Inventories of pollution and waste sources have varied applications in environmental protection programmes, depending on the governmental level at which they are applied in a given country. At the local or municipal level, they have been effectively used in formulating environmental monitoring programmes in the most economical way. In such programmes these inventories facilitate the selection of sampling sites and of frequencies of measurement of emissions and assessment of the environmental effects of emissions. Furthermore, they allow quick pollution control action to be taken against the most severe of the environment-related public health problems.

At the provincial or state level they can be used for the above-described purposes, but more often they are used for selecting priority areas for more intensive environmental monitoring surveys, which may be necessary for assessing the problems on a wider scale, and for setting priorities for pollution control programmes. Sometimes, the emission inventories are also used as the basis for formulating pollution control laws and regulations, and for the preparation of preliminary environmental impact assessments.

At the national level, emission inventories from various regions or states can be combined and used to determine the appropriate balance between industrial and economic development and pollution control. Also, they can be used in formulating policies with regard to environmental protection in the national development plan and in allocating resources and setting priorities for environmental health and pollution control programmes at the various national levels.

Other uses of such inventories include the identification of emission levels of hazardous compounds that can be quickly controlled. Furthermore, when such inventories are known to be reliable, it may be possible to establish links between various pollutants and diseases (e.g., water pollution can be linked to enteric diseases and air pollution to emphysema and chronic bronchitis), and to propose restrictions on specific pollutants in order to improve the environment and health of the population.

The rapid assessment procedure described here is designed to produce only a preliminary assessment. In places where extensive resources are available more detailed surveys may be undertaken, if needed. The making of emission inventories should be considered as a continuous exercise, producing better estimates as additional data are acquired and analysed. Therefore, even when not many data are immediately available, rapid assessment studies can be undertaken and later reviewed and modified with the gathering of more detailed information.

2. ORGANIZATIONAL OVERVIEW OF RAPID ASSESSMENT STUDIES

The fact that every study area is unique in many respects makes advance detailed step-by-step planning difficult. Hence, the survey team should have the flexibility to collect whatever data and information they feel are suitable for the study and plan visits to data sources and industries, if necessary, as they deem appropriate. It is also important that both the public health officials and survey team members understand the rapid assessment procedure, including its managerial and administrative support requirements. The following sections briefly describe the general points to be considered in making rapid assessment surveys.

2.1 Definition of the study area

The definition of a study area depends upon the selection of appropriate boundaries. The boundaries can be physical (such as drainage basins, ridges, or canyons), political (such as city limits or state/provincial limits or even international borders), or economic (such as industrial zones or economic development or planning areas). This question is further discussed in Section 3.

2.2 Team personnel and support

Rapid assessment studies can be carried out with as few as one or two properly qualified professionals (engineers or scientists with some prior experience in environmental planning and control and with previous training or knowledge of the rapid assessment procedure described here) plus two or three technicians to do the routine work. If larger groups are likely to be involved, a team leader should be designated and assigned overall responsibility. The need for close cooperation between the team members should be stressed.

Proper authorization for access to data and information should be obtained from all government departments and industries, from which data are to be collected. Such authorization could be obtained on the basis of existing government policy of allowing data collection for environmental studies. It is necessary to ensure that the authorization includes access to data sources falling under any administrative or legislative subdivisions within the study area.

Development of a spirit of cooperation between the rapid assessment team and those providing the data (government offices, industries, business groups, trade unions, etc.) should be encouraged. Such cooperation will facilitate data collection, improve the completeness and accuracy of the study, and lay the ground work for future development of pollution control activities at the national level.

Finally, some administrative support, including a typist, may be required. Other requirements include transport, office space, telephones, and a photocopying machine. These will be needed during both data collection and the preparation of the report.

2.3 Data collection

(1) The first step is to identify the types and sizes of the various pollution and waste sources in the area, using the list of industries in Table 1 as a guide. Other information, such as the location of pollution and waste sources in relation to major population centres, extension of the sewage system, and the location of sewage outfalls is also required at this stage. On the basis of this information it will be possible to subdivide the study area and to single out the potential principal sources of pollution and waste.

(2) Next, find out what are the data required by looking up pollution and waste factors[1] in the working tables in Annexes 1-5 for the pollution and waste sources, respectively, identified in the study area. The pollution and waste factors are used in calculating pollution and waste loads[2] respectively, and indicate the nature of the data required. Further details on pollution and waste factors and the types of datum required are given in Sections 4 and 5.

(3) Now determine which government departments or other sources have the data required to complete the working tables. Section 6 provides further information on possible data sources and on how to obtain the data. Visit the relevant governmental agencies and other sources and obtain the required data and information. If the study area has a few prominent pollution and waste sources, such as an integrated iron and steel plant or a refinery, it may be worthwhile to organize visits to such sources in order to obtain first-hand process and production data, validate source data, and gain effluent treatment and disposal information. These visits do not require much time, provided that emphasis is placed on collection of existing data rather than inspection. Such visits will substantially increase in the reliability of the overall assessment. It should be emphasized, however, that very few carefully selected site visits are within the scope of these studies.

(4) Cross-check the data collected from various sources and verify, to the extent possible, their accuracy. Point out data of questionable accuracy. If any assumptions are made to complete the data, these should be clearly indicated (see also Section 6).

(5) Convert, if necessary, the units of the data collected to those suitable for the working tables, and summarize all data and information in the working tables (see Section 9).

By following the above steps one can obtain a comprehensive summary of the important pollution sources in the study area and a measure of their activity in units that allow the calculation of pollution and waste loads. If the study area has been subdivided, there will most probably be separate summaries for each subdivision.

2.4 Calculation of pollution and waste loads and assessment of overall pollution and waste problem in the study area

Once the required data have been collected, the air, water and land pollution and waste loads can be calculated by following the steps given below.

---

[1] Pollution factor is the amount of a pollutant or a combination of pollutants released into the environment by an industry (directly, or indirectly through municipal sewers or through the municipal waste collection and treatment network) per unit of merchandise produced or per unit of raw material consumed, depending upon the type of industry or method of calculation of the pollution factor. In the case of domestic and municipal wastes, the term waste factor refers to the total amount of waste (solid or liquid) released into the environment (directly, or indirectly through municipal sewers or through the municipal waste collection and treatment network) by one person per year in a given area. For an example of the calculation method see page 23.

[2] The term pollution load refers to the total amount of a pollutant or a combination of pollutants released into the environment (directly, or indirectly through municipal sewers or through the municipal waste collection and treatment network) by an industry or a group or industries in a given area during a certain period of time. In the case of domestic and municipal wastes, the term waste load refers to the total amount of waste released into the environment (directly, or indirectly through municipal sewers or through the municipal waste collection and treatment network) by a community, city, or state, etc. during a certain period of time.

(1) Enter the collected industrial production and waste output data in the appropriate working tables.

(2) For each industrial process or waste source find the corresponding pollution or waste factors (as applicable) in the various subsequent columns.

(3) Multiply each production or waste output figure by the corresponding pollution or waste factor and record the pollution or waste load thus calculated in the space provided. (The working tables are designed so that for each pollutant or pollution indicator there are two columns - the first gives the pollution factor and the second is for recording the calculated pollution load.)

(4) Summarize the calculated pollution and waste loads in the summary tables at the end of each working table in order to obtain an overall picture of the total air, water and land pollution in the study area.

(5) For each of the pollutants or pollution indicators make separate lists of their major sources. These lists help in establishing priorities for pollution and waste monitoring and pollution abatement studies.

2.5 Reporting

Once the pollution and waste load calculations and summary tables have been completed, the team should start preparing the study report. In addition to the findings, the report should include the following:

- an interpretation of the environmental impact of the calculated pollution and waste loads in relation to the supplementary geographical, meteoroligical, hydrological, environmental quality, and monitoring data collected;
- a rough assessment of the impact of major emissions on the population and on valuable natural resources;
- a summary of possible areas where environmental control measures will be most effective;
- an assessment of the effectiveness of the existing pollution control programmes and recommendations for improvements as appropriate.

Section 9 provides a more detailed discussion on report writing.

3. DEFINITION OF THE STUDY AREA

3.1 General considerations

For countrywide or regional rapid environmental assessment studies the first step is to determine the number, types, and sizes of the study areas. Often the definition of study areas is influenced by the prevalent pollution or public health problems in the region or country. However, it is usually more advisable to consider the existing legal, institutional, or economic systems in the country in selecting boundaries. Usually the country or region is already divided into several districts and has predominant socioeconomic features; e.g., urban, industrial, rural, agricultural, mining, etc. These serve as a good basis for the definition of the study areas.

The major concern, however, is the selection of the appropriate boundaries. Sometimes there may be many possible choices of boundaries, but usually they fall into one or more of the following categories:

Physical boundaries - drainage basins (surface or sewered); ridgelines; rivers; coastlines; escarpments; expressways; railroads; canals; etc.

Political/legal boundaries - city limits, county, state or provincial lines; public health districts; census districts; air quality control regions; flood control/drainage districts; international borders; etc.

Economic boundaries - industrial zones; mining districts; economic development areas; water/sewerage/refuse collection districts; etc.

Each category has its merits. Natural features usually facilitate the evaluation of the pollution load impacts on air or water quality; political or legal boundaries facilitate data collection because the desired information as well as knowledgeable support staff are generally available in the corresponding governmental office in or near the study area; and economic boundaries facilitate the assessment of the environmental impact of future growth.

Thus, the person responsible for rapid assessment studies must consider each of these categories in relation to other factors, such as known pollution or public health problems and available staff, in making the final decision on the definition of the study areas. A metropolitan city area along with the adjacent industrial zones is a typical example of a suitable study area.

The study team should have the flexibility to modify the boundaries of the study area during the course of the study if the collected data indicate that this will enhance the completeness of the inventory, facilitate the assessment of emission impacts, or help in the formulation of better pollution and waste control studies.

Finally, all the study areas in a country or region should be ranked in order of priority; among other factors, the severity of the pollution problems and the existence of any previous inventory studies could serve as the basis for setting priorities.

3.2 Selection of possible substudy areas

During the first few days the survey team, using area maps and other information obtained from the planning department or from other sources, can form a general idea about the geography of the area, the current and projected land usage, the location of industries and population centres, the boundaries of existing or planned sewerage systems, the prevailing meteorological and hydrological conditions, the various liquid waste receivers, the solid waste collection and disposal system, as well as the major pollution or public health problems and the existing pollution control authorities and legislation.

On the basis of this general information the survey team may find it desirable to subdivide the study area into smaller zones.

It is useful to decide at an early stage whether or not the study area is to be subdivided, since this will affect the collection and organization of data. Generally, the complexity of the survey work increases with an increase in the number of subdivisions since separate pollution source activity data are required for each subregion. Experience so far indicates that the added difficulties are usually not so great as to advise against subdivision, but subdivisions should be made only when there are definite reasons for doing so.

Among the possible reasons for subdividing the study area can be the existence of several waste control authorities or waste control regulations in the study area. In such cases, it may be worth while to consider separate inventories for the areas covered by each of them.

With regard to liquid wastes, area subdivisions that allow separate assessments to be made of affluent discharges into different receiving water bodies are often desirable; such subdivisions facilitate the evaluation of the impact of discharges on receiving water bodies and help in the formulation of high-priority waste control measures. Also, subdivisions may

be made in order to determine the type and capacity of pollution control facilities for the waste volumes and pollution loads discharged into the existing, planned, or proposed sewerage systems.

As to air pollution, it may be desirable to make separate inventories for areas with point sources and those with mobile sources. Also, pollution sources within major population centres should be considered separately from those in sparsely populated areas, since the former can be generally expected to have a greater impact on human health than the latter. With regard to areas outside major population centres, further subdivision may be necessary taking into consideration meteorological and topographical factors, such as wind directions, distances between pollution sources and cities, or the existence of any canyons or valleys in the study area.

The study area often needs to be subdivided also with regard to solid waste collection and disposal. However, considering the different characteristics of municipal and industrial solid wastes and the usual organization of public and private solid waste disposal systems, any subdivision would usually be along economic boundaries.

Although separate reasons are given above for subdividing the study areas with regard to water, air, or land pollution problems, in practice it is often possible, and is certainly more useful, to subdivide areas in relation to all three together.

4. POLLUTION AND WASTE GENERATING ACTIVITIES AND POLLUTION AND WASTE LOAD FACTORS

4.1 Classification of pollution and waste generating activities

There are often many types of pollution-generating activity in a study area. However, the object of rapid assessment is to single out the very large sources (such as power plants, steel mills, and municipal waste water outfalls) suspected of having a major impact on the environment of the study area. Sometimes the major pollution sources may also include many groups of smaller sources such as metal-work shops, pottery works, textile factories, etc.

The rapid assessment procedure described in this book pertains to the air, water and land pollution sources in urban areas and industrial zones; other sources of pollution and waste such as agriculture, mining, fugitive dust, and storm run-offs are not covered. For further information on these categories the reader is referred to the bibliography.

4.2 Sources of industrial pollution and wastes

While almost all industrial activities cause some pollution and produce waste, relatively few industries (without pollution control and waste treatment facilities) are responsible for the bulk of the pollution and waste loads generated in a given area. Careful selection of the major pollution and waste-producing industries can greatly simplify the preparation of the assessment, while still covering most of the pollutants and wastes produced. On the basis of this premise, a list was made (Table 1) of the industrial sources and processes that account for much of the industrial pollution and waste loads in almost any study area. This classification facilitates the extraction of data from government sources, since most governments use this or similar classification systems to record data on industrial activity. The list in Table 1 should be used in the initial phases of the inventory work as a check-list to identify the existing major industrial operations in the study area.

4.3 Factors for air emissions from fuel combustion, industrial processes, and solid waste disposal

A good repertory of air emission sources and corresponding air emission load factors is the Compilation of air pollutant emission factors. Supplement No. 9. Washington, DC, US Environmental Protection Agency, 1979 (AP-42). The air emission load factors listed in Annex 1 for the common stationary combustion sources, mobile combustion sources (transport), industrial processes, and solid waste disposal operations have been taken from that publication.

Table 1. List of important industries with United Nations classification codes[1]

AGRICULTURAL AND LIVESTOCK PRODUCTION

1110a Beef feedlot
1110b Swine feedlot
1110c Broiler feedlot
1110d Lamb feedlot
1110e Turkey feedlot
1110f Duck feedlot
1110g Dairy farms
1110h Layer houses

FOOD MANUFACTURING

3111a Slaughterhouses
3111b Packing-houses
3111c Poultry processing
3112 Dairy products, manufacture of
3113 Canning of fruits and vegetables
3114 Canning of fish
3115a Olive oil extraction
3115b Vegetable oil refining
3116 Grain mills
3118a Cane sugar factories
3118b Beet sugar manufacturing
3121a Starch and glucose manufacturing
3121b Yeast manufacturing

BEVERAGE INDUSTRY

3131a Alcohol distilleries
3133a Malt and malt liquor manufacture
3133b Beer fermenting
3133c Total for beer production
3133d Wine production
3134 Soft drinks and carbonated waters industries

MANUFACTURE OF TEXTILES

3211a Wool (scouring included)
3211b Wool (no scouring)
3211c Cotton
3211d Rayon
3211e Acetate
3211f Nylon
3211g Acrylic
3211h Polyester

MANUFACTURE OF LEATHER

3231a Leather tanneries (complete chrome)
3231b Leather tanneries (vegetable)
3231c Leather finishing only

MANUFACTURE OF WOOD AND WOOD AND CORK PRODUCTS, EXCEPT FURNITURE

3311a Plywood manufacturing
3311b Fibreboard manufacturing

MANUFACTURE OF PULP, PAPER AND PAPERBOARD

3411a Sulfate (kraft) pulp
3411b Sulfite pulp
3411c Semi-chemical pulp
3411d Paper mills
3411e Paper mills (with water recovery system)
3411f Paper mills (with improved water recovery system)

MANUFACTURE OF INDUSTRIAL CHEMICALS

3511 Manufacture of basic industrial chemicals, except fertilizers
Basic inorganic chemicals:
3511a Hydrochloric acid
3511b Sulfuric acid
3511c Nitric acid
3511d Phosphoric acid (without pond)
3511e Phosphoric acid (with pond)
3511f Phosphoric acid (thermal process)
3511g Ammonia
3511h Sodium hydroxide (mercury-cathode cell or Castner-Kellner process)
3511i Sodium hydroxide (diaphragm cell)
3511j Hydrofluoric acid
3511k Chrome pigments
Basic organic chemicals:
3511m (See Table 2.3, Annex 2, page 75)
3511n (See Table 2.3, Annex 2, page 75)
3511o (See Table 2.3, Annex 2, page 75)
3511p (See Table 2.3, Annex 2, page 75)
3512 Manufacture of fertilizers and pesticides
Fertilizers:
3512a Normal superphosphate (19% P_2O_5)
3512b Triple superphosphate (48% P_2O_5)
3512c Ammonium phosphate (20% P_2O_5)
3512d Diammonium phosphate (20% P_2O_5)
Pesticides:
3512e DDT
3512f Chlorinated hydrocarbon herbicides
3512g Carbamate
3512h Parathion
3513 Synthetic resins, plastics and fibres
3513a Rayon fibres
3513b Vulcanizable elastomers - synthetic rubber
3513c Polyolefins (polythelenes)
3513d Polystyrene resins and copolymers
3513e Vinyl resins (PVC)
3513f Polyester and alkyd resins
3513g Phenolic resins
3513h Acrylic resins (bulk polymer)
3513i Acrylic resins (emulsion)
3521 Manufacture of paint, varnishes, and laquers
3522 Manufacture of drugs and medicines
3522a Biological products
3522b Medical, chemical and botanical products
3523 Soap and cleaning preparations
3523a Soap by kettle boiling
3523b Soap by fatty acids
3523c Detergents
3523d Glycerine refining
3523e Liquid detergents
3529a Animal glue manufacturing (from fleshing, hides, and chrome stocks)
3530 Petroleum refining
3530a Topping refineries
3530b Low-cracking refineries
3530c High-cracking refineries
3530d Lubrication oil refineries
3530e Petrochemical refineries
3530f Integrated refineries
3530g Spent lubricating oil re-refining

MANUFACTURE OF MISCELLANEOUS PRODUCTS OF PETROLEUM AND COAL

3540 Asphalt product manufacturing
3540a Asphalt paving
3540b Asphalt roofing
3540c Builders felt and topping

MANUFACTURE OF RUBBER PRODUCTS

3551a Tyres and inner tube manufacturing
3551b Other rubber products

NON-METALLIC MINERAL INDUSTRY

3610 Pottery, china, and earthware manufacturing
3620 Glass and glass product manufacturing
3621 Structural clay product manufacturing
3692 Cement manufacturing
3697 Lime manufacturing

BASIC METAL INDUSTRY

3710 Iron and steel industry
3710a Metallurgical coke oven
3710b Blast furnace
3710c BOF steel furnace

[1] The industries have been listed according to the nomenclature used in: Statistical Office of the United Nations. Indexes to the Standard Industrial Classification of all Economic Activities, Statistical Papers, Series M, No. 4, Rev.2, Add.1, New York, Department of Economic and Social Affairs, 1971 (ST/STAT/M.4/Rev.2/Add.1).

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Table 1. List of important industries with United Nations classification codes[1] (continued)

3710d Open hearth steel furnace
3710e Electric arc steel furnace
3710f Steel and grey iron foundries
3720 Non-ferrous metal basic industry
3720a Manufacture of aluminium from bauxite
3720b Primary aluminium smelting
3720c Secondary aluminium smelting
3720d Copper smelting from sulfite ores
3720e Copper electrolytic refining
3720f Secondary copper smelting
3720g Brass and bronze foundries
3720h Lead smelting from ore
3720i Secondary lead smelting and refining
3720j Primary tin smelting and refining
3720k Primary zinc smelting
3720l Secondary zinc processing
3720m Primary antimony smelting
3720n Primary mercury smelting and refining
3720o Primary titanium smelting and refining

MANUFACTURE OF FABRICATED METAL PRODUCTS, MACHINERY AND EQUIPMENT

3840a Household appliances
3840b Electroplating
copper deposit
nickel deposit
chromium deposit
zinc deposit
3841 Shipbuilding
3843 Motor vehicles manufacturing

ELECTRICITY, GAS AND STEAM

4101a Power plants using lignite as fuel
4101b Power plants using bituminous coal as fuel
4102 Manufacture of gas from coke ovens

[1] The industries have been listed according to the nomenclature used in: Statistical Office of the United Nations. Indexes to the Standard Industrial Classification of all Economic Activities, Statistical Papers, Series M, No. 4, Rev.2, Add.1 New York, Department of Economic and Social Affairs, 1971 (ST/STAT/M.4/Rev.2/Add.1).

With regard to refineries, the above publication provides too detailed a list of individual sources for which data are difficult to collect in the course of a rapid assessment study. Hence, a simplified, though not as accurate, list of pollutants with pollution load factors, normalized per tonne of crude oil processed, is presented in Table 1.3 (Annex 1). Simplifications along these lines have also been made for certain other industrial processes.

Most industries emit pollutants from both fuel-burning and industrial production processes. Individual fuel-consumption data for industries, however, are not expected to be procurable during the course of a rapid assessment study, while overall fuel-consumption data for the entire study area are generally easily obtainable. Therefore, in this document the practice is followed whereby combustion emissions have to be calculated separately from the industrial production emissions. This necessitates the exclusion of the fuel-emission loads from industrial process emissions.

Factors listed in the above-mentioned US Environment Protection Agency publication occasionally account for both fuel-combustion and industrial process emissions, especially in cases where it is physically impossible to separate such emissions - as in glass, ceramic, or cement kilns. In order to be consistent, however, with the rapid assessment methodology, the factors listed in Table 1.3 (Annex 1) specifically refer to industrial production processes and exclude emissions from fuel burning. Exceptions to this rule are industries that use special fuels such as metallurgical coke (e.g., in iron blast furnaces), and consumption of such fuels does not interfere with other conventional fuel-consumption data.

4.4 Factors for industrial effluents

At present, there is no comprehensive single compilation of factors for liquid wastes from industrial processes. Numerous publications deal with effluents from individual industries or a number of industries, but they are often incomplete in the sense that they do not always contain pollution and waste factors or contain data from which they can be derived. Some publications include, for example, the concentration of pollutants in effluents from various industries, mainly from the viewpoint of treatment of effluents, but do not provide the corresponding normalized pollution and waste factors (i.e., total waste volumes or concentrations of pollutants per unit product or per unit of raw material consumed).

A thorough literature review was therefore conducted and suitable pollution and waste load factors for industrial effluents were identified for most of the industrial processes listed in Table 1. Annex 2 gives liquid waste and pollution factors for industrial processes. These factors are based on published data from various countries, mainly the USA. The suitability of these factors has been verified during pilot projects in several developing countries, and it is believed that they can be used to produce reasonable initial assessments. Some of the liquid waste and pollution factors have been calculated from data collected in the UNDP/WHO Environmental Pollution Control Project in Athens, Greece, in which a limited number of visits were made to certain industries to collect samples and production data. These factors have not been tested elsewhere and therefore may not be very reliable, but in the absence of any other data they may still prove valuable. All factors should be reviewed and verified, where possible, on the basis of any available information pertinent to the study area. The order in which industries appear in Table 2.3 (Annex 2) is the same as in Table 1. Annex 6 gives a summary of useful conversion factors for converting the units in which raw data may have been obtained into appropriate units for pollution and waste load calculations.

4.5 Factors for domestic effluents

Domestic effluents include all normal household wastes discharged into the sewer, as well as the wastes from the numerous small factories and shops that are difficult to identify and account for individually. Table 3.1 (Annex 3) gives factors for domestic wastes on a *per capita* basis.

Owing to differences in eating and washing habits as well as in the traditional types of small factory and shop throughout the world, the *per capita* waste volume and loads produced,

vary among countries. It has been seen, however, that despite the very large cultural and economic differences among the countries, the variation in waste loads is moderate. This enables the calculation of average waste load factors of reasonable accuracy in preliminary domestic waste load calculations in any area. In practice, the waste volume tends to vary the most, and is generally related to the average standard of living of the people in the study area. A better standard of living generally results in a higher water consumption and, consequently, more waste water.

The factor for domestic waste volume in Table 3.1 is 73 m^3 per person per year. It is recommended that if water consumption data are available for a study area the study team should derive its own factor for waste volume. This can be done by multiplying the average annual water consumption per person by 0.6. However, if the calculated factor differs from the recommended factor (73 m^3) by more than 50%, the smaller of the two should be used.

In calculating waste loads of domestic effluents special attention should be paid to the population using septic tanks and cesspools, particularly if the contents of these are discharged into the municipal sewers for further treatment or disposal. Although the use of septic tanks and cesspools reduces to some extent the waste volume, because some of the waste water often percolates into the ground and there is partial treatment of the sludge through anaerobic digestion, cesspools and septic tanks still contribute significantly to the waste load of an area. Table 3.1 also includes waste load factors for non-sewered areas. These factors are based on data from typical septic tanks in the Greater Athens area and have not been tested elsewhere. (Factors such as design of the septic tank, soil permeability, and specific loading may considerably affect the characteristics of septic tank sludges.) However, in the absence of any other data they may still prove useful. If in an area it is found that septic tank sludges are discharged directly into receiving water bodies, factors for sewered areas will apply.

Finally, all the factors provided in Table 3.1 relate to untreated waste water. If waste water treatment facilities are in operation, the pollution load should be reduced appropriately. Usually, after primary treatment there is a 30% reduction in the 5-day biological oxygen demand (BOD_5) and suspended solids (SS), and after secondary treatment 80% reduction occurs in BOD_5 and SS. However, the actual operating efficiency of the facilities should be verified by a visit to waste water treatment plants before such reductions are made in the data.

4.6 Factors for industrial solid wastes

For the purposes of this inventory three major source categories of industrial solid wastes can be considered:

- solid wastes from industrial processes;
- solid wastes from the treatment of liquid effluents; and
- solid wastes from the treatment of air emissions.

The wastes not included in these categories are solid wastes (non-toxic) from offices and from other minor sources which are difficult to identify and account for separately, since such wastes are normally picked up along with domestic refuse and are included in municipal solid waste load factors (see section 4.7). Mining, on the other hand, is the largest single source of industrial process wastes in many countries. Since this study does not cover mining operations, which are often more active in the rural areas, factors for such solid wastes are not included.

Among the industries listed in Table 1, those with major process solid wastes are listed in Table 4.1 (Annex 4) together with load factors; the wastes are characterized according to their nature.

It should be pointed out, however, that frequently solid wastes from one industry can be used as raw material in another industry. For example, wastes from the food and beverage industry (slaughterhouses, poultry processing plants, canneries, alcohol distilleries, etc.) can be used as raw materials for producing animal glue, animal food, etc. and, sometimes, even used as fertilizer. Clearly, in those situations there is no solid waste problem. Thus, whenever possible in the course of the inventory work, additional information should be obtained regarding the possible reuse or disposal methods of major wastes.

Industries treating their own effluents often generate solid wastes, mostly in the form of sludges. These sludges are often toxic in nature and their collection and disposal requires special attention, a task often neglected by pollution control authorities when planning liquid waste control measures.

In developing countries not many industries have liquid waste treatment facilities. However, a few large industries (such as alumina production plants or phosphoric acid (wet process) plants with heavy loads of solids in their liquid effluents, may be treating their liquid wastes and producing sludges that create considerable solid wastes disposal problems. Table 4.1 gives solid wastes factors for selected industries and includes factors for solid wastes produced from the treatment of effluents.

The list of solid waste factors included in Table 4.1 should be expanded as more data become available on industries producing solid wastes from effluent treatment operations, since in time this could assist the assessment of solid wastes disposal problems expected when liquid waste control measures are implemented.

Industries with air pollution control devices are also potential sources of solid wastes. Such devices are often installed and are properly operating in large industrial plants before other pollution control measures are implemented. Solid waste factors for industries with emission control devices are listed in Table 4.1 (Annex 4) allowing the assessment of the quantity of solid wastes as a function of the control devices used. The type of control device will ordinarily be documented as part of the air pollution inventory results.

There are two types of air pollution control device: (1) those that operate without water (dry cyclones, bag filters, electrostatic precipitators, etc.) and directly generate solid wastes in a dry form; and (2) those that use water (scrubbers, spray towers, etc.) and generate liquid wastes. In the latter case waste loads are calculated in terms of solid wastes (sludge) obtained from the further treatment of the effluent. In iron blast furnaces, for example, about 60% of the dust is collected in solid form from dry cyclones; and wet scrubbers may further collect another 30% in effluent-settling ponds. The waste loads factors given in Table 4.1 (Annex 4) are calculated on the assumption that whenever water is used in the air pollution control equipment, the resultant effluent is treated in order to remove suspended solids.

Sometimes solids recovered from air pollution control equipment can be a part of the final product, as in cement kilns. They can also be recycled into the process, occasionally after some treatment, as in the case of dust from dry cyclones of blast iron furnaces after sintering. In some other cases the wastes can be used for other purposes, such as the use of fly ash from thermal power plants in road paving. Clearly, such major reuses of solid wastes should be identified, since they effectively eliminate part of the solid waste problem.

Solid waste inventory studies are perhaps the area where interactions among the various forms of pollution show up most. As we have briefly discussed, in addition to solid wastes from production processes, more wastes, often hazardous, are generated in significant quantities, as a result of water and air pollution control measures.

4.7 Factors for municipal solid wastes

In this book municipal solid wastes are defined as (1) refuse from dwellings of all kinds, including hotels, offices, and public buildings, (2) minor non-toxic wastes from small

industrial operations which are collected along with other refuse and are difficult to account for separately, and (3) solid wastes collected from city streets and other public places.

The quantity of municipal solid wastes tends to vary from place to place and bears a rather consistent correlation with the average standard of living of the study area. Typical municipal solid waste loads normalized on a per capita per day basis are given in Table 5.1 (Annex 5). The Annex also provides calculated waste load factors in relation to living standards for different areas in the world.

The composition of municipal wastes also varies considerably from place to place. In developing countries wastes are normally high in biodegradable matter and low in paper, metal, and glass. In industrialized countries it is the other way round. Table 5.2 (Annex 5) gives typical composition and density values for municipal solid wastes in some developing and industrialized countries.

Another potentially significant source of municipal solid wastes can be sludges from waste water and water treatment plants. Table 5.4 (Annex 5) provides factors for estimating both the volume and weight of these sludges. Since it is still a fairly common practice to discharge these sludges into nearby water bodies or dispose of them on land, the survey team should calculate the pollution load, verify the method of disposal, and then include the sludge volumes and weights in the report as either water or land pollution.

5. RAPID ASSESSMENT OF THE SOURCES OF POLLUTION AND WASTES

5.1 Description of the method

Once the major sources of data and information have been identified and classified, the next step is to complete the working tables in Annexes 1-5. The following sections describe the working tables and discuss the data required to complete them.

The working tables provide a concise classification of all major pollution-causing and waste-producing activities and list the corresponding pollution and waste load factors. The tables include columns for filling in the required data and the calculated pollution and waste loads. It should be noted that for some complex industrial processes the factors had to be simplified in order to obtain average overall factors for which input data are almost always available. Also, for most industries the required data are in terms of tonnes of product produced; these data are usually the most easily available and most accurate.

While the factors given in the tables may not be very accurate at the individual industry level, they generally yield sufficiently accurate pollution and waste loads in regions where there are many similar industries and where production averages are statistically valid.

5.2 Working table for the calculation of air pollution loads from stationary combustion sources

The emission factors for stationary combustion of various types of fuel are listed in Table 1.1 in Annex 1. Combustion furnaces have been classified in three size categories: power plant furnaces (normally large in size); industrial and commercial furnaces (normally of medium size); and domestic furnaces of small size, in order to account for some differences in the normalized emission loads.

Usually, it is easy to find overall fuel consumption data for a study area, but it is often difficult to determine the proportions being burned in large, medium, and small furnaces. Data on fuel consumption in power plants are usually easy to obtain since such large units are few. It is, however, more difficult to estimate how the remaining fuel consumption is split between industrial and domestic use. To find this out one may be able to use supplementary information.

For example, if only distillate oil is allowed for space heating in the study area, one can assume that the residual oil is consumed by industrial and commercial furnaces. In any event, as Table 1.1 (Annex 1) shows, the differences in the calculated emission loads between medium and small furnaces are rather slight and inaccuracies have little effect on the overall emission load calculations.

Attention is drawn to the fact that most government agencies and fuel distribution companies often exclude from their overall fuel consumption data the quantities of fuel consumed by very big industries, if special supply lines outside of the normal market exist. Moreover, the amount of fuel consumed by refineries is often not included in data on total fuel consumption, since accounting tends to start from refinery output.

On the other hand, some industries may be using fuel in the production process rather than burning it. Petrochemical plants for example use considerable quantities of hydrocarbons as raw material; similarly, ammonia plants use natural gas.

The above points should be clarified before pollution load calculations are made and, whenever necessary, supplementary information should be sought.

Additional information, such as the location of major sources (e.g., power plants), stack heights, wind directions, and area topography will help to make a rough assessment of the impact of major emission sources on the population and to establish possible air monitoring requirements.

5.3 Working table for the calculation of air pollution loads from mobile combustion sources

Table 1.2 (Annex 1) lists average emission factors for: road transport vehicles, aeroplanes during take-off and landing, ships in berth, and stationary turbines.[1]

Road traffic pollution loads can be calculated in two different ways.

The first is based on factors calculated by the US Environmental Protection Agency, and is more appropriate for vehicles of US design. These factors allow pollution load calculations to be made for light- and heavy-duty gasoline and diesel-powered vehicles on the basis of total kilometres driven per year by each vehicle category; these data can be estimated from the registered number of vehicles and corresponding average driving distance figures. Since reliable data of this sort may be difficult to obtain, road traffic pollution loads are more often calculated on the basis of total gasoline and diesel fuel consumption per year; factors for this method are derived from European calculations. The factors are expressed in units that correspond to data easily available in government departments or fuel distribution companies.

Additional information on the location of major airports and major gas turbine stations (including their stack heights), wind directions, topography of the area, etc. will help to make a rough assessment of the impact of major emissions in this category on the population.

5.4 Working table for the calculation of air pollution loads from industrial sources

Table 1.3 (Annex 1) lists average air emission load factors for industrial processes most commonly found in urban areas or industrial zones.

Since public reaction to nearby heavy industrial air pollution is much stronger than to other types of pollution, air emission control equipment is often installed in industries much earlier and is operated much better than water pollution control equipment - often, even before pollution control authorities reach the stage of effectively imposing pollution and waste control measures. Moreover, air pollution control measures are associated with considerably

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[1] Stationary turbines are included in this category because fuel consumption data for them are normally obtained along with data for mobile combustion sources.

higher production efficiencies for some important types of industry. A cement plant for example, without any pollution control equipment, emits the equivalent of 17% of its final product into the air. Similarly, the large quantities of CO emitted by a blast furnace without dust control equipment cannot be used for heating purposes (875 kg of CO are emitted per tonne of pig iron produced). For such large plants, therefore, an assessment of existing controls should be taken into consideration if meaningful results are to be obtained; Table 1.3 also includes factors for various air pollutants trapped by different types of pollution control equipment in different industries. Information about the types of control equipment in the major industrial plants in a given study area should be easy to obtain because there are usually very few such plants to consider.

Sometimes even smaller industries within cities and houses may be required to have some kind of dust collector or other air pollution control device; however, the factors provided in Table 1.1 (Annex 1) for such combustion sources are based on the assumption that such equipment is rarely functioning at optimum efficiency.

Additional information about the location of the major air-polluting industries, the stack heights, wind directions, and area topography are important in making rough assessments of the impact of such emissions on the population and in the identification of environmental monitoring requirements.

5.5 Working table for the calculation of air pollution loads from the disposal of solid wastes

Table 1.4 (Annex 1) summarizes air emission factors for common solid waste disposal processes.

The information required to complete this table includes: the quantities of solid wastes processed; the kind of combustion process used; and, for municipal or industrial incinerators, whether air pollution control measures are taken or not.

Supplementary information about the location of incinerators or burning sites is essential in order to evaluate the impact of these emissions on the study area.

5.6 Working table for the calculation of pollution loads from industrial effluents

Table 2.1 (Annex 2) presents a compilation of the important industrial processes producing effluents and lists their associated pollution load factors.

Experience gained from a number of pilot studies shows that in developing countries industrial pollution problems are recent and only few industries have effluent treatment facilities, except in cases where such equipment is in a way part of the industrial process - e.g., the American Petroleum Institute (API) separators in refineries. Also, where effluent treatment facilities exist, they are often not functioning at the optimum efficiency. Therefore, pollution and waste factors for most industries included in Annex 2 are based on the assumption that no effluent treatment facilities exist. However, it is recommended that the survey team verify this assumption for all major industrial pollution and waste sources.

Comparing Tables 2.1 and 2.3 (Annex 2), it may be noted that for certain industries, such as leather tanneries and textile mills, the former table includes only simplified (averaged) sets of factors requiring less information on the process used. This is in line with the basic objective of utilizing, to the extent possible, easily available data in order to minimize the effort required in data collection. However, even though the factors in Table 2.1 are based on average pollution from various processes in the same industry, one can still expect reliable results if several similar plants are in operation in the study area.

Additional information on the location of major industries or industrial areas and on the water bodies receiving industrial discharges is necessary for evaluating the possible health effects of water pollution from industrial effluents (e.g., improper discharge of toxic effluents into potable-water courses) and for assessing the environmental impact of the effluents on receiving water bodies.

5.7 Working table for the calculation of pollution and waste loads of domestic effluents

Pollution and waste load factors for domestic effluents from both sewered and unsewered areas are given in Table 3.1 (Annex 3). The data required are the number of people in the two types of area. Factors for the unsewered areas are based on the assumption that either cesspools or septic tanks are used by the population in those areas. These factors have not been tested before and therefore may not be very reliable; however, in the absence of any other data they may still prove useful.

Additional information required includes: (1) how are the septic tank and cesspool sludges disposed of; (2) how efficient are the wastewater treatment facilities; (3) how are the sludges produced as a result of wastewater treatment disposed of.

5.8 Working table for the calculation of industrial solid waste loads

Table 4.1 (Annex 4) is the working table for industrial solid wastes. It gives solid waste factors for various industrial processes along with the nature of wastes produced. It also includes factors for solid wastes produced by air pollution control devices or by the treatment of industrial effluents. The industrial production data collected to complete Tables 1.3 and 2.1 can also be used to complete Table 4.1. Moreover, the additional information required with regard to air and water pollution control devices is also common.

Here are two examples of how to calculate solid waste loads from factors given in Table 4.1. Assume that a study area has one high-cracking refinery and one packing-house. From Table 4.1 we know that the data required are: the volume (in 10^3 m^3) of total oil refined per year for the refinery, and the total amount (in tonnes) of the produce packed per year for the packing-house. Now, suppose that the refinery refines 500 000 barrels of oil per year and the packing-house produces 60 000 tonnes of meat products and foodstuffs. In the case of the former we first need to convert barrels per year into cubic metres per year. This can be done easily by looking up the appropriate conversion factor in Annex 6. Thus, the throughput of the refinery in m^3 per year is: 500 000 barrels/year x 0.159 m^3/barrel = 79.5 x 10^3 m^3/year. Now enter 79.5 in column 3 (production 10^3 units/year) of Table 4.1 across from high-cracking refineries (code 3530c) and multiply it by the corresponding solid waste factor given in the next column, which is 3303 kg/unit. Thus, the solid waste load is: 79.5 x 3303 = 262.58 t/year. Enter this figure in the next column. (Note that by entering the production data in 10^3 units in the column "production 10^3 units" and by multiplying the data entered in that column by the corresponding factors (in kg/unit), one can directly get the waste loads in tonnes per year.)

For the packing-house enter 60 in the column "production 10^3 units" and multiply it by the factor in the next column: 300 kg/unit. Hence, the waste load is equal to 60 x 300 = 18 000 t/year.

The additional information required in the case of solid industrial wastes (usually containing pollutants) is: (1) what proportion of major industrial wastes are recycled or used as raw material for other industrial processes; and (2) how are the wastes that are not used disposed of. On the basis of this information and of calculated waste loads an attempt should be made to evaluate the possible health effects of solid industrial wastes (e.g., possible exposure to toxic substances in the wastes). Solid industrial wastes can also cause air, water, and land pollution problems (e.g., when the wastes like oily sludges are burned, when sludges containing pollutants escape into potable water or leach into the ground water, or when wastes are improperly disposed of on land). These problems should be assessed in detail.

5.9 Working table for the calculation of municipal solid waste loads

Table 5.1 in Annex 5 is the working table for municipal solid wastes. It lists solid waste factors as normalized per capita per year for municipal waste quantities generated as a function of the average standard of living of the people in the study area. It also lists factors for water and wastewater treatment plant sludges.

The data required for the first part of this table (municipal solid wastes) are the number of people served by regular garbage collection, as well as the average living standard of the people in the study area. For the second part (sludges from water and wastewater treatment plants), the information needed is the number of people served by sewers and the type of water and wastewater treatment facilities in the study area. Note that if the potable water treatment process does not involve softening the sludge produced is small and can be neglected.

Here is an example of how to use Table 5.1. Assume that a study area in a developing country has a population of 200 000 with medium incomes and with a complete garbage collection service. The whole population is served by sewers and there is a secondary wastewater treatment plant. The municipal solid waste factor for such an area is 250 kg/person/year. Thus, the waste load is: 200 000 persons x 250 kg/person/year = 50 000 000 kg/year = 50 000 t/year. The waste factor for a secondary wastewater treatment plant is 180 kg/person/year. Thus, the waste load is:

200 000 persons x 180 kg/person/year = 86 000 000 kg/year = 86 000 t/year.

6. DATA ACQUISITION

6.1. General description of information

Most of the input data required for the study are normally available in various government departments. In fact, the study procedure was designed with a view to making maximum use of existing information.

In most cases, important information can also be found in government publications such as statistical yearbooks, industrial activity reports, or master plan. Useful data can also be obtained from publications of international organizations such as UNDP, UNEP, UNIDO, WHO, and from any studies being undertaken in the area by United Nations regional economic commissions or other regional intergovernmental organizations. Also, reports produced by local authorities or industrial associations, trade unions, social security agencies, etc. may contain valuable information.

A sizeable portion of the required information available with various government agencies is often unpublished. These data are usually kept in a raw form and are not classified. Therefore, some effort has to be made to have the useful information extracted, processed, and classified. Examples of unclassified data include annual questionnaires completed by industries for government production statistics or economic studies and individual census forms.

The major difficulties with unpublished information are determining which data are required, and then interpreting the selected data. Often there is a danger of leaving out important information if the screening is not done carefully, and, on the other hand, the complexity and the resource requirements increase considerably if relatively unimportant data are retrieved and processed. Previous experience in data collation will certainly be most helpful here in minimizing work, while ensuring the accuracy of the final results. If the study team has only limited experience of data handling, it may be advantageous to minimize the danger of major omissions by putting in additional work.

During the inventory process all the data collected have to be organized, critically assessed, and, wherever possible, cross-checked. This procedure will help identify areas for which data are lacking so that more emphasis can be placed on those areas. Clearly, not all the data required can be obtained from government departments. Therefore, additional information will have to be sought either through experienced government employees or through direct contacts with industry. Again, this process is time-consuming and a balance has to be made between the need for particular data and the effort required in obtaining them. Experience again helps to reduce the size of this work without sacrificing much accuracy. Typical examples of additional information that can be obtained through direct contacts include: the information on the types of air pollution control equipment in key industries such

as cement plants and blast furnaces; details of the processes involved in other key plants such as fertilizer industries; information on the efficiency of wastewater treatment plants; and information on where to find important missing data.

Cross-checking the data with information from other sources is often possible and highly desirable, since it is the best way of measuring the accuracy of the results. If important data from various sources of information are in significant disagreement, investigation of their original derivation often provides a good basis for the formulation of the most reasonable assumptions. In any event, the reliability of the data along with major data deficiencies and disagreements should be clearly indicated in the final report. This will allow an overall assessment to be made of the accuracy of the results and enable future study teams to fill in the gaps in the inventory.

As an example, the volume of municipal solid waste production can be cross-checked by determining the frequency of garbage collection, the number and size of garbage trucks involved, and the relative efficiency of on-truck compacting. These results can be correlated to the waste volumes estimated from the working table. Similarly, the team should look for any available data on pollution load measurements in the study area and then use these to confirm the waste factors provided in the working tables.

The sources of all the data collected should be fully documented in order to permit future verification and upgrading.

6.2 Authority for data access

In the course of its assignment the inventory team will clearly have to contact many government agencies, local authorities, industrial associations, and other institutions.

Written authorization to obtain access to both published and unpublished data is most desirable, as it will enable civil servants to disclose information without fearing any possible consequences. Industrial concerns also often demand such government authorization before they will disclose process and production data or even permit site visits. The authorization should include references to the appropriate statutes and regulations and be issued by the appropriate minister or an equivalent high-level governmental official.

However, authorization alone is not enough, since the most important element in this type of work is the establishment of a spirit of true cooperation between the inventory team and the agencies and industries involved. In places where competition exists among various government agencies for authority over pollution control work, it may be desirable to assign the inventory task to a team not directly associated with any one of them, or have all the competing agencies participate in it in order to ensure cooperation among all parties involved.

6.3 List of possible data sources

A major task of the study team is to locate all major government information sources and to extract the required data from them. In order to facilitate this task a list summarizing the most important types of information required and likely places from which that information can be obtained is provided below. Of course, the list is by no means exhaustive, since data sources will vary in different countries depending upon the structure of the government services.

Type of data	Possible sources
Population	Statistical yearbooks Census reports Master plan studies National planning or development agencies

Type of data	Possible sources
Sewage collection and disposal	Ministry of public works Ministry of health Sewerage organizations Municipalities
Water supply	Ministry of public works Ministry of health Water company Municipalities
Industrial activity	Ministry of industry or commerce National planning or economic development agencies Electric energy ministry, authority or company Internal revenue agencies Local governments Industry associations Ministry of animal production Air and water pollution control authorities
Fuel consumption data	Ministry of energy Ministry of industry Internal revenue agencies Refineries or oil distribution companies
Road traffic data	Ministry of transportation
Airport activity data	Airport authorities Ministry of transportation
Port activity data	Port authorities Ministry of transportation
Water quality data and effluent loading data	Oceanographic institute Ministry of health River authorities Water pollution control authorities Ministry of fisheries Area planning agencies Local health departments Universities
Air quality data and air emission data	Ministry of health or environment Air pollution control authorities Universities
Meteorological data	Meteorological services Airport authorities Universities
Solid wastes data	Local authorities Ministry of environment Private refuse disposal companies Area planning or development agencies

6.4 Data reliability

Background information on population, industrial establishments, and commercial facilities is most often available through national agencies dealing with population censuses, manufacturing, and commerce. The accuracy of these data may vary considerably and, where data are likely to be less reliable, efforts should be made to verify and cross-check them to the maximum extent possible with information from other sources. For example, the total amount of fuel consumed by road transport vehicles may be reliably estimated from tax records if the total amount of tax collected from fuel sale and tax per litre of fuel are known. This can be cross-checked with the number of vehicles registered and with any actual traffic counts, etc.

Inevitably, data deficiencies will exist and assumptions will have to be made in some cases in order to complete the calculations. This is quite acceptable in rapid assessment studies, as long as the data are substantiated later. However, all data deficiencies should be clearly indicated in order to help assess the overall accuracy of the estimates and to allow for future inventory improvements.

Although the pollution and waste load factors included in this book will give satisfactory results in most study areas, they can be improved and adapted to specific study areas as more experience is gained in their use. Also, new industries can be added to the tables to reflect local conditions more accurately. Such refinements, along with an increase in the number of experienced personnel, are expected to increase the reliability of the results and, consequently, improve environmental planning.

7. EVALUATION AND USE OF RAPID ASSESSMENT DATA

The rapid assessment report should discuss, at least in a qualitative sense, the environmental impact of the calculated pollution and waste loads, including possible health hazards and major water, land, and air pollution problems.

In areas with real or suspected pollution or waste problems, it is possible to use rapid assessment studies to set priorities at the national level with regard to financial, manpower, and laboratory resource distribution, and to review land-use plans. At the local level rapid assessment studies are expected to provide direct contribution or assistance in:

- defining high-priority environmental control actions;
- organizing most effective and detailed pollution and waste source surveys;
- organizing most appropriate environmental monitoring programmes;
- assessing the impact of proposed pollution control strategies, thus helping to establish proper control measures; and
- assessing the impact of proposed industrial development projects and selecting their proper location and the environmental control measures necessary for their safe operation.

By identifying the major sources of pollution and waste that have a significant impact on the wellbeing of people and on the quality of natural resources, one can plan high-priority follow-up pollution control studies in order to achieve effective pollution control. If in a rapid assessment study it is found that there is extensive environmental damage, and if skilled manpower and other resources are limited, follow-up studies should be dispensed with and the limited resources should be used for environmental control immediately; often, simple environmental control measures have a significant impact. Thus, it is possible to derive directly high-priority environmental control actions through rapid assessment studies.

When planning pollution and waste control measures, serious consideration should be given to the existing constraints relating to both implementation and enforcement. The most important of such constraints include:

- lack of financial resources, and often lack of foreign exchange, particularly in cases where both the equipment and technology have to be imported;

- lack of skilled manpower, including qualified designers, operators of control equipment, laboratory technicians, skilled planners, inspectors, and scientists.

By proper planning, however, many of the above constraints can be lessened to a certain extent and a number of relatively simple and highly effective measures can be identified. Such measures, if decided upon, should be clearly outlined in the report.

In organizing more detailed follow-up studies in complex areas with many kinds of pollution source, two important points such be considered:

(1) The highest priority should be given to the sources identified during the rapid assessment study as generating the largest pollution and waste loads. Surveys of pollution and waste sources of lesser importance and a large number of smaller industries can be deferred without seriously affecting the results of the study.

(2) The existence of considerable variations in the rates of discharge and compositions of effluents due to differences in effluent treatment processes and seasonal variations is the rule rather than the exception. Thus, reliable sampling and measurements of the effluents from each source require a significant effort over a long period (usually at least one year) in order to obtain meaningful results.

The rapid assessment study report should provide a list of the major liquid, solid, and air pollution sources in the study area. This automatically sets priorities for the more detailed source survey work to follow.

In organizing environmental monitoring programmes it is most helpful to identify in advance the locations where maximum pollution levels are expected and the pollutants to be monitored. With this kind of information, which can be deduced from rapid assessment study reports, environment monitoring programmes can be organized so that the best use is made of the existing laboratory facilities, while allowing rational planning of future laboratory requirements.

While rapid assessment studies concentrate on the description of existing pollution problems, the same basic methodology can be used in assessing the impact of planned industrial establishments in various locations, or in testing the impact of pollution control measures on existing or planned industries. Thus, these studies offer valuable assistance in land-use planning and pollution abatement studies even in advanced stages of the pollution abatement effort.

8. MANPOWER REQUIREMENTS AND TRAINING

Rapid assessment studies should be normally conducted by small teams of one to three full-time professionals (qualified scientists or engineers) working in very close cooperation. The professionals need to be supported by an equivalent number of technicians whose principal role is to organize and tabulate the data. Other personnel required include a typist and a draftsman.

A rapid assessment study should normally take about a month to complete in areas with no great complexity and not much more than three months in the most complex metropolitan city areas. If the time allotted is too short, it may not be possible to obtain all the required data and the accuracy of the study will suffer. On the other hand, if the study team spends

too long completing the job, the chances are that it may have gone beyond rapid assessment into more detailed survey studies. As discussed in section 7, detailed environmental studies should be deferred until after the rapid assessment study is completed.

The key element in such studies is the skill of the survey personnel. Because the study procedure is simple and straightforward, it relies heavily on the intuition, judgement, and experience of the study team for obtaining meaningful results. Hence, the professional staff should be either engineers or persons holding science degrees, and should have some prior experience in environmental planning and control. They should also have some knowledge of the basic production processes of the industries in the study area, the origin and character of the industrial effluents from those industries, and the methods of treatment of the effluents involved.

The survey personnel should be selected from the present national or local environmental health staff, since the purpose of the study, in addition to rapidly assessing the pollution and waste sources and related problems, is to develop national or local proficiency in environmental survey methodology. Also, since environmental protection programmes are an ongoing activity, it is essential that national or local staff should be involved from the start. Thus, outside experts should be engaged only to give on-the-job training to local survey personnel, who will later have the capability to take whatever follow-up action is necessary.

9. PRESENTATION OF A RAPID ASSESSMENT STUDY REPORT

The following is a recommended outline, with brief descriptions of the key elements for a report of a rapid assessment study.

Introduction. The introduction should include: the reasons for undertaking the study, its major objectives, a few words regarding its authorization, and a brief review of the methodology and the uses and limitations of the study results.

Conclusions and recommendations. Pollution and waste loads of air, water, and land should be summarized separately. The major sources of pollution and waste and any existing health problems in the area should also be stated. If any immediate control measures or other follow-up activities are required, the study group should present them in the form of recommendations in this section.

General background. A description of the study area should be presented. This should include the geographical limits of the study area, with a mention of prominent geographical and hydrological features. The area could be compared with the country as a whole in terms of population and population trends, industrial activity, economic development, etc. A brief review of uses of water and fuel, number of motor vehicles, sewage and refuse disposal facilities, climate, etc. will also be helpful. A map of the study area is essential.

Industrial activity. The data collection procedures should be presented with a tabulation of significant industrial facilities and production rates. Data sources should be referred to and their reliability assessed.

Air emissions from stationary combustion sources. Fuel consumption by power plants, industrial and commercial facilities, and domestic heating should be reviewed by fuel type, and a summary of estimated emissions of particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide, should be included.

Air emissions from mobile combustion engine sources. Fuel use (diesel and gasoline) data must be presented. Statistics on numbers and types of motor vehicle, mileage, etc. should be displayed and emission data calculated. If applicable, air pollution from airports and seaports should also be measured and presented.

Air emissions from industrial processes. As above, emission rates for each major process should be computed and displayed. It is important to summarize these data by source type, highlighting the more significant sources and any potential health hazards caused by toxic emissions.

Air emission from solid wastes disposal. Incineration or open-pit burning of domestic solid wastes or other industrial wastes and sludges should be considered and air emission loads calculated.

The air pollution problem. The meteorology of the study area should be reviewed with respect to prevailing wind directions and velocities, taking note of source locations and population centres. The calculated air pollution loads should be reviewed in relation to the meteorology of the area and to contributions by source type. Industries and areas requiring air emission controls should be indicated. Appropriate conclusions should be presented.

Effluents from industrial sources. A summary of the estimated industrial waste discharges should be presented by industry type. Comparisons should be made between waste discharges of each type. Any discharges of toxic or hazardous materials should be highlighted. The discharges should also be classified by receiving water bodies. If possible, a map showing the location of major sources should be included.

Effluents from domestic sources. Population and population trend data must be displayed in detail, and their sources should be included in the reference list. Existing sewage collection and disposal facilities should be characterized by sewered or unsewered areas, receiving waters bodies, etc. Calculated waste load should be shown and the distribution of these loads in the study area discussed.

The water pollution problem. Characteristics of water bodies receiving industrial and domestic discharges and the possible or actual effects of these discharges on the water bodies should be reviewed. Any available data on the quality of water in receiving water bodies should be summarized and significant points highlighted (e.g., lack of dissolved oxygen, and concentration of toxic substances). Current waste treatment practices and plans for additional treatment facilities should be reviewed. The water supply and distribution system of the area must also be described. Finally, overall conclusions as to the extent of the water pollution problem should be presented with special emphasis on any potential human health problems.

Solid wastes from industrial sources. A summary of the estimated quantities of solid wastes generated should be presented by industry type. The possibility of public health or environmental hazards associated with these wastes should be evaluated. Any industrial sources of solid waste not included in the working tables should be highlighted. The mechanism for disposal of these wastes should be discussed and the disposal sites should be indicated on the study area map.

Solid wastes from domestic sources. The calculated quantities of solid wastes should be summarized and an extrapolation of future quantities be made on the basis of population trends. The system of garbage collection, transport, and disposal of garbage should be described and disposal sites indicated on the study area map.

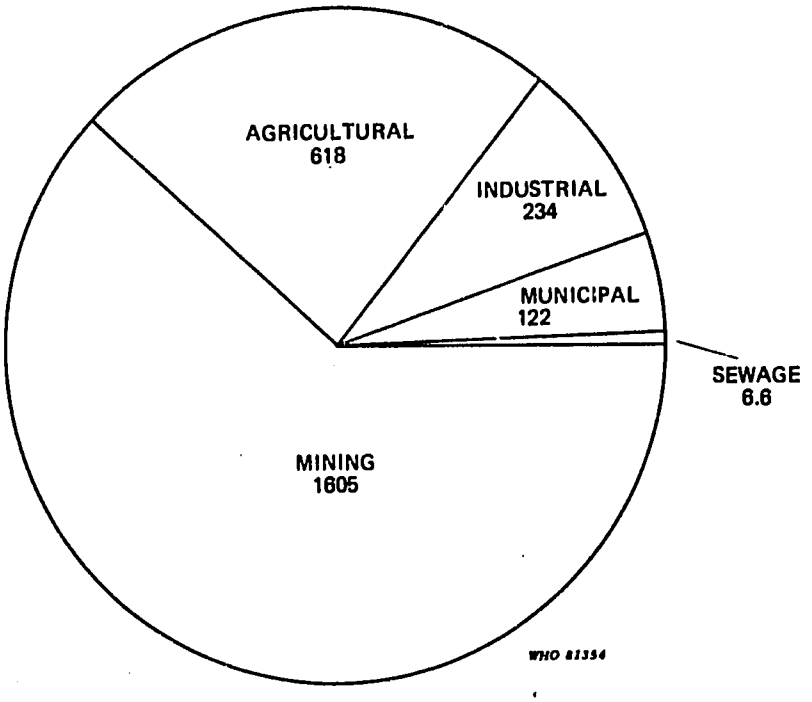
The solid waste problem. An evaluation of the present waste disposal practices and sites and any associated public health or environmental problems should be made. Problems such as inadequate or intermittent collection, uncontrolled dump sites, infestation of disposal sites by rats, vermin, or other disease vectors (scavengers, etc.) should be highlighted, and any possible measures for immediate improvements recommended. Ways of reducing the solid waste bulk by recycling, by segregation of hazardous wastes, or by conversion of domestic refuse into useful products (such as fertilizer or methane) should be included as appropriate.

Acknowledgements should be made where they are due and any additional information should be annexed.

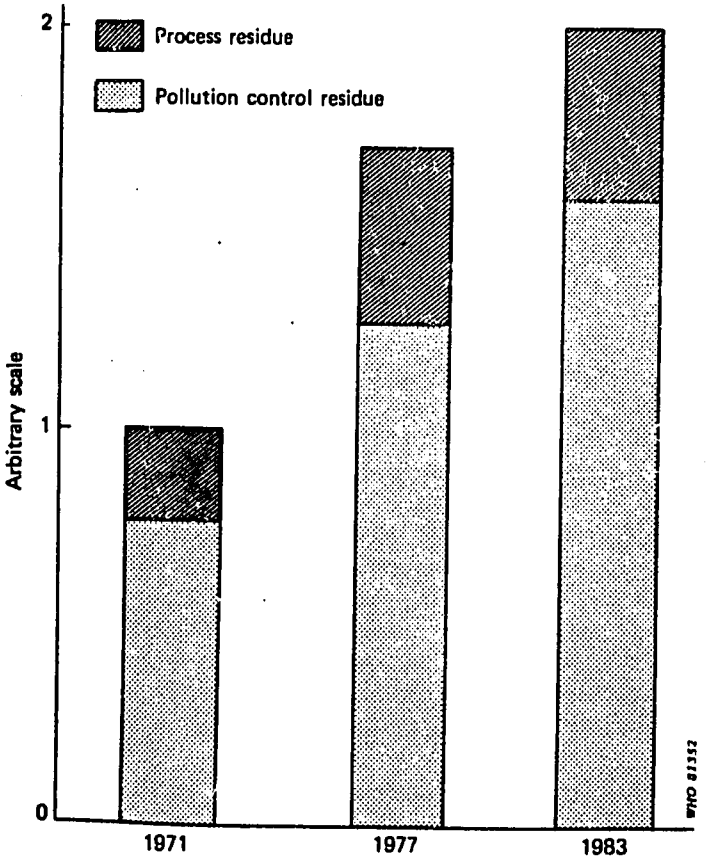
Finally, the report should make the maximum possible use of graphic displays to support the text. In addition to tables, diagrams such as shown in Fig. 1 and Fig. 2 can provide a quick and clear understanding of the distribution of the pollution loads, the magnitude of the problem, etc. This makes the report easier to understand.

Fig. 1 is an example of a pie chart and can be used to compare sources of pollution loads, as shown, or to display the relative impact of the different sources of pollution. Fig. 2 is an example of a bar chart, and is especially useful for showing the impact of growth and economic development or of pollution control measures.

EXAMPLE 1. ESTIMATED INDUSTRIAL VERSUS OTHER RESIDUALS (DRY WEIGHT IN MILLION TONNES PER YEAR)



EXAMPLE 2. PROJECTED GROWTH OF COMBINED WASTE QUANTITIES FOR FOUR REPRESENTATIVE INDUSTRIES (INORGANIC CHEMICALS, PAPER, STEEL, AND NON-FERROUS SMELTING)



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Annex 1. Air pollution loads from mobile and stationary combustion sources and industry

Table 1.1 Working table for the calculation of air pollution loads from stationary combustion sources

Table 1.2 Working table for the calculation of air pollution loads from mobile combustion sources

Table 1.3 Working table for the calculation of air pollution loads from industrial sources

Table 1.4 Working table for the calculation of pollution loads from the disposal of solid wastes

Table 1.5 Blank table for the calculation of pollution loads for industries not listed in Table 1.3

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Table 1.1 Working table for the calculation of pollution loads from stationary combustion sources

Area .....Year .....

Type of source	Fuel burned	Unit	Consumption 10^3 units per year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO	
				kg per unit	t/year	kg per unit	t/year	kg per unit	t/year	kg per unit	t/year	kg per unit	t/year
Power plants	Lignite	t		3.5(A)		15(S)		7		0.5		0.5	
	Anthracite	t		8.5(A)		19(S)		9		0.015		0.5	
	Bituminous coal	t		8 (A)		19(S)		9		0.15		0.5	
	Fuel oil	t		1.04		19.9(S)		13.2		0.13		0.66	
	Natural gas	10^3m^3		0.24		16.6(S)		9.6		0.016		0.27	
		t		0.29		19.9(S)		11.5		0.019		0.32	
Subtotal													
Industrial and commercial furnaces	Lignite	t		3.5(A)		15(S)		3		0.5		1	
	Anthracite	t		1 (A)		19(S)		5		0.1		3	
	Bituminous coal	t		6.5(A)		19(S)		7.5		0.5		1	
	Fuel oil, residual	t		2.87		19(S)		7.5		0.37		0.52	
	Oil, distillate	t		2.13		20.1(S)		7.5		0.41		0.59	
	Liquified petroleum gas	m^3		0.21		0.01(S)		1.43		0.036		0.19	
		t		0.38		0.02(S)		2.6		0.065		0.35	
	Natural gas	10^3m^3		0.29		6.6(S)		3		0.048		0.27	
		t		0.34		20 (S)		3.6		0.058		0.32	
Subtotal													
Domestic furnaces	Anthracite (hand-fired)	t		5		18(S)		1.5		1.25		45	
	Bituminous coal (hand-fired)	t		10		19(S)		1.5		10		45	
	Wood	t		13.7		0.5		5		1		1	
	Fuel oil, distillate	t		0.37		20.1(S)		2.72		0.14		0.75	
	Kerosene	t		3		17 (S)		2.3		0.4		0.25	
	Liquified petroleum gas	m^3		0.23		0.01(S)		1		0.094		0.24	
		t		0.42		0.02(S)		1.8		0.17		0.44	
	Natural gas	10^3m^3		0.302		16.6(S)		1.3		0.128		0.32	
		t		0.363		20 (S)		1.56		0.154		0.38	
Subtotal													
Total													

Notes: Assumed average specific densities:
- Fuel oil, distillate = 0.845
- Fuel oil, residual = 0.957
- Liquified petroleum gas = 0.55 (mixture of 80% butane and 20% propane)
- Natural gas = 0.832 kg/m^3 (at standard temperature and pressure)

A is the percentage ash content of combustible by weight
S is the percentage sulfur content of combustible by weight
Typical efficiency values for fly-ash control equipment

Electrostatic precipitators	65% to 99.5%
High-efficiency cyclone	30% to 90%
Low-resistance cyclone	20% to 80%
Settling chamber expanded chimney bases	10% to 30%

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Table 1.2 Working table for the calculation of pollution loads from mobile combustion sources

Area ..... Year .....

Type of vehicle	Unit	Consumption 10^3 units per year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO	
			kg per unit	t/year	kg per unit	t/year	kg per unit	t/year	kg per unit	t/year	kg per unit	t/year
Overall average for road transport vehicles	10^3km		0.36		0.12		3.3		7.2		48	
Light-duty, gasoline-powered (US)	10^3km		0.33		0.08		3.2		6		40	
Light-duty, diesel-powered (US)	10^3km		0.45		0.39		0.99		0.28		1.1	
Heavy-duty, gasoline-powered (US)	10^3km		0.52		0.16		5.7		9.9		81	
Heavy-duty, diesel-powered (US)	10^3km		0.75		1.5		21		2.1		12.7	
Motorcycles (US)	t		1.89		19(S)		52		5.2		32	
Gasoline-powered cars and trucks (EU)	10^3km; t of fuel consumed		0.2		0.02		0.07		10		17	
Diesel-powered cars and trucks (EU)	t of fuel consumed		2.0		0.54		10.3		14.5		377	
			2.4		19(S)		11		2.6		43.5	
Subtotal												
Wide-bodied jets	No. of landings and take-offs		2		3		50		19		74	
Other long-range jets			2		3		14		75		86	
Medium-range jets			0.5		1		11		5		18	
Turbo-prop aircraft			1.5		0.5		3		4		9	
Business jets			0.3		0.2		1.6		1.5		4.2	
General aviation piston			0.01		0.006		0.021		0.18		5.5	
Subtotal												
Steamships in berth	No. of ship-days in berth		6.8		136xS		90.7		4.1		0.036	
Motorships in berth			7.5		19.5		22.7		14.9		20.8	
Subtotal												
Stationary gas turbines: using distillate fuel oil	t		0.77		20.1(S)		9.7		0.8		2.2	
using natural gas	10^3m^3		0.274		15.5		6.6		0.67		1.84	
Subtotal												
Total												

Note: Particulate emission factors for vehicles also account for tyre-wear. US motor vehicle pollution factors are based on 1970 model cars. S is the percentage of sulfur content of the fuel by weight. Volume of natural gas is measured at standard temperature and pressure.

Table 1.3 Working table for the calculation of pollution loads from industrial sources[a]

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/ year)	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
FOOD MANUFACTURING														
3114 Canning of fish	t		0.05										H_2S-0.005	
3115 Manufacture of vegetable and animal oils and fats	t		-											
3116 Grain mill	t		8.8											
3118a Sugar cane factories	t		20											
3121a Starch factory	t		4											
BEVERAGE INDUSTRY														
3133c Total for beer production	m^3		4											
MANUFACTURE OF TEXTILES														
3211c Cotton ginning	t		14											
MANUFACTURE OF WOOD AND WOOD AND CORK PRODUCTS, EXCEPT FURNITURE														
3311a Plywood manufacturing	m^3								1.2					
MANUFACTURE OF PAPER AND PAPER PRODUCTS														
3411a Sulfate (kraft) pulp factory														
(i) With no air emission controls	t		123		2.5						35		H_2S-7.2 Phenols-77	
(ii) With scrubbers	t		27		2.5						35		H_2S-7.2 Phenols-77	
Subtotal A													H_2S	
													Phenols	

[a] For an explanation of the abbreviations used in this table, see Annex 7.

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/ year)	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3411b Sulfite pulp factory														
(i) Without air emission controls	t													
(ii) With controls	t													
3411c Semi-chemical pulp factory														
(i) Without air emission controls	t													
(ii) With controls	t													
MANUFACTURE OF INDUSTRIAL CHEMICALS														
3511 Basic inorganic chemicals:														
3511a Hydrochloric acid factory														
(i) Without air emission controls	t												HCl-3	
(ii) With controls	t												HCl-2	
3511b Sulfuric acid	t				20									
3511c Nitric acid														
(i) Without air emission controls	t						26.2							
(ii) With controls	t						2.5							
3511d/e Phosphoric acid factory (wet process)	t												Fluorides 20.1	
3511f Phosphoric acid factory (thermal process)	t		5.1											
Subtotal B													Fluorides	
													HCl	

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/year)	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3511g Ammonia factory	t				-				45				NH_3-101	
3511h Chlor-alkali factory (mercury cell)														
(i) Without air emission controls	t of Cl_2												Cl_2-306	
(ii) With water absorber	t of Cl_2												Cl_2-8.5	
3511i Sodium hydroxide (diaphragm cell)														
(i) Without air emission controls	t of Cl_2												Cl_2-60	
(ii) With water absorber	t of Cl_2												Cl_2-11	
3512 Fertilizer manufacturing:														
3512a Normal superphosphate	t		4.5										Fluorides 0.075	
3512b Triple superphosphate	t		-										Fluorides 0.015	
3512c/d Diammonium phosphate	t		41										Fluorides 0.02	
3512e Nitrate fertilizers (NH_3+HNO_3)	t		5				2						NH_3-1.5	
3512f Urea	t		10		0.7		2						NH_3-5	
3513 Synthetic resin, plastics, and fibres:														
3513a Rayon fibres	t												CS_2-27.5 H_2S-3	
Subtotal C													Cl_2, Fluorides NH_3, CS_2, H_2S	

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/year)	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3513b Vulcanizable elastomers, Butadiene	t								20					
1 others	t								5					
3513c Vinyl resin	t		17						3.5					
3521 Paints, varnishes and lacquers														
3521a Paint manufacturing,	t		1						15					
Surface coating	t								560					
3521b Varnish manufacturing,	t								40					
Surface coating	t								500					
3521c Lacquer surface coating	t								770					
3523 Soap and detergents:														
3523a Detergent manufacturing														
(i) With no air emissions controls	t		45											
(ii) With dry cyclone	t		4											
3530 Petroleum refineries:														
Product desulfurization units	kg of S removed from products				$2\left(\frac{100-E}{100}\right)^{a}$									
or	kg of S removed from products				$\left(\frac{200}{E} - 2\right)^{a}$									
Subtotal D														

[a] E is the percentage efficiency coefficient of the Claus sulfur recovery units (typical values of E are 90).

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/ year)	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
Miscellaneous process emissions of old refineries	m^3 of feed stock								2.5					
Miscellaneous process emissions of new refineries	m^3 of feed stock								1.54					
Storage tank emissions (floating roof)														
Petrol refining	m^3 capacity								12.1					
Jet fuel refining	"								4.4					
Kerosene refining	"								1.9					
Distillate fuel refining	"								1.9					
Crude oil refining	"								10.6					
3540 Asphalt products:														
3540a Asphalt paving	t		22											
3540b Asphalt roofing	t		2.3						0.8		0.5			
MANUFACTURE OF NON-METALLIC MINERAL PRODUCTS														
3610 Pottery, china and earthenware[a]	t		65											
3620 Glass, and glass products[a]	t		1										F_2-10	
3691 Structural clay products[a]	t		65											
Subtotal E													F_2	

[a] Emissions from fuel combustion have been excluded since they are calculated elsewhere (see Table 1.1, under industrial and commercial furnaces).

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
MANUFACTURE OF CEMENT, LIME AND PLASTER														
3692a Cement manufacturing plant[a]														
(i) Without any air emission controls	t		170											
(ii) With multicyclones	t		34											
(iii) With electrostatic precipitators	t		8.5											
(iv) With electrostatic precipitators and multicyclones	t		4.3											
3692b Lime manufacturing plant[a]														
(i) With rotary kilns, uncontrolled			170											
(ii) With rotary kilns with cyclones			100											
(iii) With vertical kilns, uncontrolled			4											
BASIC METAL INDUSTRY														
3710 Iron and steel industry:														
3710a Metallurgical coke oven	t of coal		1.75		2.01		0.02		2.1		0.63		NH_3-0.09	
	t of coke		2.5		2.9		0.03		3		0.9		NH_3-0.13	
3710b Blast furnace														
(i) Without air emission controls	t		75								875			
(ii) With dry cyclone	t		30								~50			
(iii) With wet scrubber	t		7.5								~10			
(iv) With venturi or electrostatic precipitators	t		0.75								~10			
Subtotal F													NH_3	

[a] Emissions from fuel combustion have been excluded, since they are calculated elsewhere (see Table 1.1, under industrial and commercial furnaces).

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area .... Year .....

Industry and process	Unit	Product (10^3 units/year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3710c BOF steel furnace														
(i) Without controls	t		25.5								69.5		CaF_2-0.1	
(ii) With spray chamber	t		7.65										CaF_2-0.03	
(iii) With venturi or electrostatic precipitators	t		0.255										CaF_2-0.001	
3710d Open hearth steel furnace														
(i) Without controls	t		8 7										CaF_2-0.015	
(ii) With electrostatic precipitators	t		0.175										CaF_2-0.0003	
(iii) With venturi	t		0.085										CaF_2-0.0008	
3710e Electric arc steel furnace														
(i) Without controls	t		5.5								9		CaF_2-0.119	
(ii) With electrostatic precipitators	t		0.3								9		CaF_2-0.0055	
(iii) With venturi	t		0.11								9		CaF_2-0.0055	
3710f Steel and grey iron foundries	t		8.5								72.5			
3720 Basic non-ferrous metal basic industries:														
3720a Manufacture of aluminium (from bauxite)														
(i) Without controls	t		295.0										HF-26.1 Fluorides-18	
(ii) With spray towers	t		83.3										HF-14.1 Fluorides-6.3	
Subtotal G													CaF_2	
													Fluorides	
													HF	

Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3720b Secondary aluminium smelting	t		2.15											
3720c Copper refining from sulfide ores	t		270											
3720d Brass and bronze foundries	t		30											
3720e Lead smelting from ore	t		300		297									
3720f Secondary lead smelting plant														
(i) With no controls	t		65		43									
(ii) With controls	t		1.6		43									
3720g Tin manufacturing														
3720h Zinc, smelting from ore	t		300		1 100									
3720' Zinc, secondary processing			50											
FABRICATED METAL PRODUCTS														
3840a Household appliances[a]	t of iron sheets								16.2					
3843b Motor vehicle industry	"								16.2					
Subtotal H														

[a] Evaporation losses from paints; the quantity of paint used is about 29 kg/t of iron sheet.

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Table 1.3 Working table for the calculation of pollution loads from industrial sources (continued)

Area ..... Year .....

Industry and process	Unit	Product (10^3 units/ year	Particulates		SO_2		Nitrogen oxides		Hydrocarbons		CO		Other	
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
ELECTRICITY AND GAS														
4101 Power plants			(See Table 1.1)											
4102 Manufacture of gas from coke ovens	t of coal		1.75		2.01		0.02		2.1		0.63		$NH_3$0.09	
	t of coke		2.5		2.9		0.03		3		0.9		$NH_3$0.13	
	10^3m^3 of gas		3.75		4.31		0.04		4.5		1.35		$NH_3$0.19	
Subtotal I													NH_3	

Summary table for Table 1.3

Pollutant	Pollution load subtotals									Total pollution load (t/year)
	A	B	C	D	E	F	G	H	I	
Particulates										
SO_2										
Nitrogen oxides										
Hydrocarbons										
CO										
H_2S										
CS_2										
Phenols										
NH_3										
Cl_2										
HCl										
F_2										
Fluorides										
HF										

Table 1.4 Working table for the calculation of air pollution loads from the disposal of solid wastes

Area ..... Year .....

Disposal process	Unit	Solid wastes burned 10^3 units/year	Particulates		SO_2		Nitrogen oxides		Hydro-carbons		CO		Others			
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
Municipal incinerators:																
No controls	t		15		1.25		1.5		0.75		17.5					
With settling chamber or water spray system	t		7		1.25		1.5		0.75		17.5					
Industrial/commercial incinerators	t		7.5		1.25		1		7.5		10					
Open burning of municipal refuse	t		8		0.5		3		15		42					
Total																

Table 1.5 Blank table for the calculation of pollution loads for industries not listed in Table 1.3

Area ..... Year .....

Industry and process	Unit	Production 10^3 unit/year	Particulates		SO_2		Nitrogen oxides		Hydro-carbons		CO		Others			
			kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year

Annex 2. Pollution loads from industrial effluents

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents

Table 2.2 Blank table for the calculation of water pollution and waste loads for industries not listed in Table 2.1

Table 2.3 Liquid waste and pollution factors for industrial processes

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents[a]

Area ..... Year .....

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	$10^3 m^3$/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
CULTURAL AND STOCK PRODUCTION																							
a Beef feedlot	Heads			20.2		250				1 716						80.3							
b Swine feedlot	"			1.6		28.4				183						8.4							
c Broiler feedlot	"			0.04		1.4				14.6						0.51							
d Lamb feedlot	"			1.8		36.6				201						8.4							
e Turkey feedlot	"			0.04		15				14.6						0.51							
f Duck feedlot	"			0.04		1.4				14.6						0.51							
g Dairy farms	"					539																	
h Layer houses	"					4.6																	
MANUFACTURING																							
a Slaughterhouse,	t of LWK			5.3		6.4				5.2				2.8		1.58							
if blood is not recovered add	t of LWK					11																	
if paunch is not recovered add	t of LWK					4.7																	
b Packing-house	t of LWK			9.3		6.3				3				2.3		1.59							
c Poultry processing	10^3 Birds			37.5		11.9		22.4		12.7		15		5.6									
Dairy products	t of milk			2.4		5.3				2.2		3.3											
Canning of fruits and vegetables	t of prod.			11.3		12.5				4.3													
Canning of fish	"			23		7.9		16		9.2				4.5		0.64							
a Olive oil extraction	t		9-5	0.5		7.5		59		33													
b Vegetable oil refining	t			57.5		12.9		21		16.4		882		6.5									
Grain mill	t			0.6		1.1				1.6													
a Sugar cane factory	"			28.6		2.6				3.9													
b Beet sugar factory	"			23.4		20				75													
a Starch and glucose factory	"			33		13.4		21.8		9.7		42.3		1.2									
b Yeast products	"			150		1 125				18.7		2 250		127.5				SO_4^{-} 337					
Subtotal A																							

[a] For an explanation of the abbreviations used in this table see Annex 7.

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Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	$10^3 m^3$/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
BEVERAGE INDUSTRY																							
3131a Alcohol distilleries	t of prod.			63		220				257		385											
3133a Malt and malt liquor manufacturing	m^3 of Beer			4.5		1.1				0.2													
3133b Beer fermenting	"			10		7.5				14.5													
3133c Total for beer production	"			14.5		8.6				14.7													
3133d Wine production	m^3 of wine			4.8		0.26																	
3134 Soft drinks factory	t of prod.			7.1		2.5				1.3								alkalinity 3.7					
MANUFACTURE OF TEXTILES																							
3211a Wool (scouring included)	t of prod.		2-10	544		314		1 140		196		481		191				Cr 1.33		Phenols 0.22			
3211b Wool (no scouring)	"		2-10	537		87		347		43		365		-				Cr 1.33		Phenols 0.17			
3211c Cotton	"		8-11	317		155				70		205											
3211d Rayon	"			42		30		52		55		100											
3211e Acetate	"			75		45		78		40		100											
3211f Nylon	"			125		45		78		30		100											
3211g Acrylic	"			210		125		216		87		100											
3211h Polyester	"			100		185		320		95		150											
MANUFACTURE OF LEATHER																							
3231a Leather tanneries	t of hides		1-13	52		89		258		138		351		20		15		Cr 3.5				S^{2-} 7	
WOOD AND WOOD PRODUCTS																							
3511a Plywood manufacturing	$10^3 m^2$ prod.		10.5	4.1				7.3		1.1		5.1				0.24				Phenols 0.5			
3511b Fibreboard manufacturing	t of prod.			20		125				20													
Subtotal B																							

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

ıtry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	10^3m^3/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
ıRE OF PULP, PAPER ıBOARD																							
ıfate (kraft) pulp	t of prod.			61.3		31				18		166											
ıfite pulp	"			92.4		130				26		258											
ni-chemical pulp	"			47		27				12.5		134											
›er mills	"			54		8				23		37											
›er mills (with ıater recovery ıystem)	"			22		6.4				15.2		30											
›er mills (with ımproved water recovery system)	"			12.5		4				11.5		15											
ıRE OF INDUSTRIAL ı																							
ıic inorganic chemicals:																							
ırochloric acid	t of prod.			only cooling water		Negl.		Negl.		Negl.		Negl.		Negl.		Negl.							
ıfuric acid	"			1.62		Negl.		Negl.		Negl.		Negl.		Negl.		Negl.							
tric acid	"			C.W.		Negl.		Negl.		Negl.		Negl.		Negl.		Negl.							
›sphoric acid (without pond)	t P_2O_5			670						3 772						6		P_2O_5 32.3		F^- 22.2		Cu 0.74	
›sphoric acid (with pond)	"		1-1.6	2.8												0.15		P_2O_5 25.2		F^- 11.2		SO_4 82.2	
›sphoric acid (thermal process)	"			4.6														P_2O_5 1.0				SO_4 8.4	
monia	t of prod.			2.1		0.2		0.26						10		0.12							
dium hydroxide (mercury cell)	t of Cl_2																	NaOH 13.5		Hg 0.15		CH^{a} 0.7	
dium hydroxide (diaphragm cell)	"																	NaOH Negl.				NaOH Negl.	
drofluoric acid	t of prod.			11.0		Negl.		Negl.		2 711								F^- 45.4		Zn 0.4			
rome pigments	t of prod.									70.4								Cr^{+6} 30.5		Cr 21.5		Zn 8.6	
ıic organic chemicals:																							
e Table 2.3, page 75	t of prod.			8.3		0.11		2										TOC 0.467					
e Table 2.3, page 75	"			12.7		0.35		11										TOC 20					
e Table 2.3, page 75	"			12.6		63		193										TOC 76					
e Table 2.3, page 75	"			450		136		2 500										TOC 830					
Subtotal C																							

a = Chlorinated hydrocarbons.

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Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	$10^3 m^3$/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	
3512 Fertilizers:																							
3512a Normal superphosphate (19% P_2O_5)	t of prod.		(Major effluents are those from the production of phosphoric acid (3511d or e and sulfuric acid 3511b))																				
3512b Triple superphosphate (48% P_2O_5)								- ditto -															
3512c Ammonium phosphate (20% P_2O_5)								- ditto -															
3512d Diammonium phosphate (20% P_2O_5)								- ditto -															
3512 Pesticides:																							
3512e DDT	t of prod.			5.3														H_2SO_4 1 166		EHS[a] 38		CB[b] 38	
3512f Chlorinated hydrocarbon herbicides	"		0.5	3.6		22.7		30		9		365						CP[c] 4		CP[c] 0.85		Cl 187	
3512g Carbamate	"		7-10			0				0													
3512h Parathion	"		2			0				0													
3513 Synthetic resins, plastics and fibres:																							
3513a Rayon fibres	t of prod.			471		68.4		355		193		2 447											
3513b Vulcanizable elastomers (synthetic rubber)	"			19.6		2.6		20		12				1.2									
3513c Polyolefins (polythelenes)	"			0																			
3513d Polystyrene resins and copolymer				5.7		Negl.		Negl.		Negl.													
3513e Vinyl resins (PVC)	"			12.5		10				1.5													
3513f Polyester and alkyd resins	"																						
3513g Phenolic resins	"		6.4	4		47.3				1.6		0.5						Phenols 6.6					
3513h Acrylic resins (bulk polymer)	"			0																			
3513i Acrylic resins (emulsion polymer)	"			0.5		1.5																	
Subtotal D																							

[a] Ethyl hydrogen sulfate.

[b] Chlorobenzene.

[c] Chlorophenol.

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	10^3m^3/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
3521 Paints, varnishes and lacquers					Negligible pollution																		
3522 Manufacture of drugs and medicines:																							
3522a Erythromycin	t of prod.		7.2	4 000		13 800				5 600													
3522b Streptomycin	"		8.5	4 000		7 400																	
3522c Tetracyclin	"		9.4	4 000		5 200				1 776													
3522d Penicillin	"		4.5	4 000		12 800																	
3522e Aureomycin	"		8	4 000		14 280																	
3523 Soap and cleaning preparations:																							
3523a Soap by kettle boiling	t of prod.			4.5		6		10		4				0.9									
3523b Soap from fatty acids	"			3.1		13.5		29.5		23				3.5						ZnO 9			
3523c Detergents	"			2.8		0.4		1.2		0.7				0.4									
3523d Glycerine refining	"			10 (1 120)		20		40		4				2									
3523e Liquid detergents	"					5.3		7.9		0.6													
3529a Animal glue (from fleshing)	t of prod.			421		2 500		4 800		4 280													
3529b Animal glue (from hides)	"			457		580		1 420		1 920													
3529c Animal glue (from chrome stock)	"			426		280		650		400													
3530 Petroleum refining:																							
3530a Typical topping refineries	10^3m^3 feedstock			66		3.4		37		11.7				8.3		1.2		Phenols 0.034				TOC 8.0	
3530b Old topping refineries	"					190								115		24		Phenols 4.3		S^{2-} 5			
3530c Low-cracking refineries	"			79		71.5		200		27				27		10		Phenols 2.86				TOC 45.7	
3530d High-cracking refineries	"			93		72.9		217		18.2				31.4		28.3		Phenols 4.0		S^{2-} 0.9		TOC 41.5	
3530e Lubrication refineries	"			117		217		543		71.5				120		24.1		Phenols 8.3				TOC 108	
3530f Petrochemical refineries	"			108		171.6		463		48.6				52.9		34.3		Phenols 7.7		S^{2-} 0.86		TOC 148.9	
3530g Integrated refineries	"			234		197		328		58				75		20.5		Phenols 3.8		S^{2-} 2.9		TOC 139	
3540 Asphalt products:																							
3540a Asphalt paving					No significant pollution																		
3540b Asphalt roofing products	t of prod.			50		8				40													
Subtotal E																							

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

dustry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	10^3m^3/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
Tyres and inner tube factory	t of prod.			37				0.78		1		12		0.12									
TALLIC MINERAL INDUSTRY																							
Pottery, china and earthware manufacturing	t of prod.				No significant pollution																		
Glass and glass products	"		9	45.9				4.6		0.7		8.0											
Structural clay products	"				No significant pollution																		
Cement: wet process	"			5.1						0.9		6.6						alkalinity 1.4		$S^{=}$ 3.7		K 3.3	
dry process	"			5.1						negl.		0.3						0.1					
METAL INDUSTRY																							
Iron and steel industry:																							
Metallurgical coke oven[a]	t of prod.			0.42		0.58				0.44				0.075		0.95		CN 0.045		Phenols 0.197		S^{2-} 0.18	
Blast furnace	"			14.4		-				15.8						0.09		CN 0.011		Phenols 0.0065		S^{2-} 0.11	
BOF steel furnace	"			2.3						3.5						0.01						F^- 0.0018	
Open hearth steel furnace	"			2.41						4.93								Zn 1.01				F^- 0.0455	
Electric arc steel furnace	"			0.8						11.7								Zn 1.58				F^- 0.013	
Steel and grey iron foundries	"			1.6						0.3				0.25									
Non-ferrous metal basic industry:																							
Aluminium	t of prod.							2.9		4.47		2.2		0.46				Zn 0.016		SO_4 4.4		F^- 4.2	
Secondary aluminium smelting	"																						
Copper refining from sulfite ores	"																						
Brass and bronze foundries	"																						
Lead smelting from ore	"																						
Secondary lead smelting	"																						
Subtotal F																							

The waste factors for metallurgic coke ovens (3710a) are based on the assumption that the condensates and sludges produced (see Table 4.1) are disposed of as solid wastes. If, however, the wastes discharged quid, the liquid pollution and waste loads involved should also be considered.

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

[a] The waste factors for metallurgic coke ovens (3710a) are based on the assumption that the condensates and sludges produced (see Table 4.1) are disposed of as solid wastes. If, however, the wastes discha are liquid, the liquid pollution and waste loads involved should also be considered.

Table 2.1 Working table for the calculation of water pollution and waste loads from industrial effluents (continued)

Area ..... Year .....

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others				
				m^3/unit	10^3m^3/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit
3720j Tin smelting and refining	t of prod.																					
3720k Zinc smelting from ore	"																					
37201 Zinc secondary processing																						
3720n Primary mercury smelting	t			4.3																		
								Other waste factors are not available														
FABRICATED METAL PRODUCT																						
3840a Household appliances	t of iron sheet used			55		19.3		82		8.3		22.6		3.4				Zn 0.44		Cr 0.13		P 0.02
3840b Electroplating:	t of anodes:																					
	Cu			1 403														Cu 9.77		CN^{a} 20		
	Ni			1 519														Ni 3.98				
	Cr_2O_3			36 300														Cr^{6+} 297		Cr (total) 743		
	Zn			1 815														Zn 224		CN 32.5		
	Cd			883														Cd		CN 17.5		
	Sn			1 125														Sn				
Copper deposit	m^2 of metal electrodeposited			94														Cu 0.66				
Nickel deposit	"			103														Ni 0.27				
Chromium deposit	"			95														Cr^{6+} 0.92		Cr (total) 1946		
Zinc deposit	"			93														Zn 0.21				
3840c Acid pickling of iron sheets	t of sheets			1																		
3840d Pickling and bright dip of copper and brass	t of prod.			9																		
3843 Motor vehicles manufacturing	t of iron sheets painted			55		19.3		82		8.3		22.6		3,4				Cu 3.5		Zn^{b} 7.5		H_2SO_4 116
																		Zn 0.44		Cr 0.13		P 0.02
ELECTRICITY AND GAS																						
4101 Power plants	10^3MW H			129		2.2		17		286		110		0.15				Zn 0.01		Ni 0.047		Cr 0.006
4102 Manufacture of gas from coke ovens[c]	t of coke			0.42		0.58				0.44				0.075	0.95			CN 0.045		Phenols 0.197		S^{2-} 0.18
	10^3m^3 gas			0.63		0.87				0.66				0.11	1.4			CN 0.07		Phenols 0.3		S^{2-} 0.27
Subtotal G																						

[a] If cyanide bath is used.

[b] Only in cases of brass.

[c] Factors for manufacture of gas from coke ovens (code 4102) are based on the assumption that the condensates and sludges produced (see Table 4.1) are disposed of as solid wastes. If, however, the wastes discha are liquid, the liquid pollution and waste loads involved should also be considered.

Summary table for Table 2.1

Pollutant or pollution indicator	Subtotal A	Subtotal B	Subtotal C	Subtotal D	Subtotal E	Subtotal F	Subtotal G	Total
Waste volume								
BOD_5								
COD								
SS								
Oil								
N								
Phenols								
P_2O_5								
S^{2-}								
CN								
Hg								
Cu								
Ni								
Cr								
Zn								
Cd								
Sn								
Chlorinated hydrocarbons								
F^-								

NOTES: (1) Factors for chemical oxygen demand (COD) and total dissolved solids (TDS) are not always available. Therefore, blanks in the table in these columns mean no data available.

(2) Overall COD loads can be calculated from known loads of BOD_5; the ratio of COD to BOD_5 is 2 to 5 for most nontoxic effluents.

(3) TDS loads are not included in the summary table because TDS factors are available only for a few processes, and summing up TDS loads from these processes will not give a true picture of the overall situation with regard to TDS.

Table 2.2 Blank table for the calculation of water pollution and waste loads for industries not listed in Table 2.1

Table 2.2 Blank table for the calculation of water pollution and waste loads for industries not listed in Table 2.1

Industry and process	Unit	Production 10^3 units/year	pH	Waste volume		BOD_5		COD		SS		TDS		Oil		N		Others					
				m^3/unit	$10^3 m^3$/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year	kg/unit	t/year
Subtotal																							

Table 2.3 Liquid waste and pollution factors for industrial processes[1]

1110 AGRICULTURAL AND LIVESTOCK PRODUCTION

		Waste volume[2] m^3/head/year	BOD_5[3] kg/head/year	SS[2] kg/head/year	Total N[2] kg/head/year
1110a	Beef feedlots	20.2	250	1716	80.3
1110b	Swine feedlots	1.6	28.4	183	8.4
1110c	Broiler feedlots	0.04	1.4	14.6	0.51
1110d	Lamb feedlots	1.8	36.6	201	8.4
1110e	Turkey feedlots	0.04[4]	1.5[4]	14.6[4]	0.51[4]
1110f	Duck feedlots	0.04[4]	1.4[4]	14.6[4]	0.51[4]

Note: If the number of animals produced per year is given instead of the feedlot population, use equation:

Population in feedlot = (number of animals produced) x (average residence in feedlot).

		Raw waste[2]	BOD_5[5]
1110g	Dairy	17337 kg/cow/year	539 kg/cow/year
1110h	Layer house	66 kg/hen/year	4.6 kg/hen/year

Note: If the quantity of milk production is given instead of the number of cows, use equation:

$$\text{Number of cows on farms} = \frac{\text{total milk production in t/year}}{6.2}$$

If the number of eggs produced is given instead of the number of hens, use equation:

$$\text{Number of hens in layer houses} = \frac{\text{number of eggs per year}}{213}$$

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[1] For an explanation of the abbreviations used in this table see Annex 7.

[2] Koziorowski, B. & Kucharski, J. Industrial waste disposal. Oxford, Pergamon Press, 1972.

[3] Denit, J. D. Development document for effluent limitations guidelines and source performance standards for feedlots point source category. Washington, DC, US Environmental Protection Agency, January 1974 (EPA/440/1-74-004-A) (National Technical Information Service microfiche No. PB 238 651/4BA).

[4] Assumed values.

[5] Wadleigh, C. H. Wastes in relation to agriculture and forestry. Washington, DC, US Department of Agriculture, 1978 (Miscellaneous Publications No. 1065).

3111 SLAUGHTERING, PREPARING AND PRESERVING MEAT

3111a Slaughterhouse[1,2]

Waste volume	5.33	l/t of LWK
BOD_5	6.0	kg/t of LWK
SS	5.6	kg/t of LWK
Grease	2.1	kg/t of LWK
Kjeldahl nitrogen	0.68	kg/t of LWK
Chlorides	2.6	kg/t of LWK
Total phosphorus	0.05	kg/t of LWK

3111b Packing-house[1,2]

Waste volume	9.3	m^3/t of LW processed
BOD_5	6.28	kg/t of LW processed
SS	2.98	kg/t of LW processed
Kjeldahl nitrogen	1.59	kg/t of LW processed
Grease	2.32	kg/t of LW processed

Note:

1. Edible meat is about 60% of
2. Average cattle weight = 430 kg
3. Average calf weight = 97 kg
4. Average hog weight = 120 kg
5. Average sheep weight = 43 kg

3111c Poultry processing[2,3,4]

Waste volume	37.5	m^3/1000 birds processed
BOD_5	11.9	kg/1000 birds processed
COD	22.4	kg/1000 birds processed
TDS	15	kg/1000 birds processed
SS	12.7	kg/1000 birds processed
Grease	5.6	kg/1000 birds processed

(Typical technology is assumed)

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[1] Denit, J. D. Development document for effluent limitations guidelines and new source performance standard for the red meat processing segment of the meat product and rendering and processing point source category. Washington, DC, US Environmental Protection Agency, February 1974 (EPA/440/1-74-012-A) (National Technical Information Service microfiche No. PB 238 836/1BA).

[2] Similar values have been obtained by the State Centre for Environmental and Sanitation Technology, São Paulo, Brazil.

[3] Carawan, J. Water and waste management in poultry processing. Washington, DC, US Environmental Protection Agency, 1974 (EPA-660/2-74-031) (US National Technical Information Service microfiche No. PB 235 650/9BA).

[4] Seas phase III - Reference data documentation - solid waste/recycling. Arlington, VA, International Research and Technology Corporation, 1975.

3112 Dairy products[1,2]

Effluent calculation based on production data:

Final product	WV	BOD_5	COD	SS
	m^3/t of product	kg/t of product		
Receiving station (cans)	0.83	0.46	0.84	0.03
Receiving station (bulk)	0.54	0.17	0.31	0.03
Fluid products	3.87	3.21	5.63	1.5
Cultured products	3.87	3.21	5.63	1.5
Butter	20.9	20.9	36.5	10.4
Cottage cheese (whey recovery)	79.4	137	239	3.4
Cottage cheese (no whey recovery)	80.3	609	953	3.4
Natural cheese (whey recovery)	14.8	10.3	16.8	5
Natural cheese (no whey recovery)	15.7	482	731	5
Ice cream	1.6	0.8	1.4	0.24
Condensed milk	7.2	3.9	6.8	1.5

Rough factors for milk processing when quantities of butter, cheese, etc. produced are not known.

Waste volume	2.42	m^3/t of milk
BOD_5	5.3*	kg/t of milk
SS	2.17	kg/t of milk
TDS	3.26	kg/t of milk

* Assumption: 40% of the milk is used for making cheese;

whey is recovered (if whey is not recovered add 21 kg of BOD_5 per t of milk processed).

Conversion factors for estimating the amount of whole milk required for making:

	Factor
1 litre of 40% cream	3.73
1 litre of 30% condensed milk	2.12
1 kg of non-fat dry milk	7.12
1 kg of sugar (lactose)	6.65

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[1] Gregg, R. Development document for effluent limitations guidelines and new source performance standards for the dairy product processing point source category. Washington, DC, US Environmental Protection Agency, May 1974 (EPA/440/1-74-021A) (US National Technical Information Service microfiche No. PB 238 835).

[2] Similar values have been obtained by the State Centre for Environmental and Sanitation Technology, São Paulo, Brazil.

3113 Canning of fruits and vegetables[1]

Waste volume	11.3 m^3/t of product
BOD_5	12.5 kg/t of product
SS	4.25 kg/t of product

[1] Seas phase III - reference data documentation - solid waste/recycling. Arlington, VA, International Research and Technology Corporation, 1975.

3114 Canning of fish[1]

Waste volume	23 m^3/t of product
BOD_5	7.9 kg/t of product
COD	16 kg/t of product
SS	9.2 kg/t of product
Oil and grease	4.5 kg/t of product
Organic nitrogen	0.62 kg/t of product
Ammonia nitrogen	0.022 kg/t of product

[1] Forsht, E. H. Development document for effluent limitations guidelines and standards of performance for catfish, crab, shrimp and tuna segments and preserved seafood processing industry point source category. Washington, DC, US Environmental Protection Agency, June 1974 (EPA/440/1-74-020A) (US National Technical Information Service microfiche No. PB 238 614/2BA).

3115 Manufacture of vegetable and animal oils and fats

3115a Olive oil expression[1]

Waste volume	0.5 m^3/t of product
BOD_5	7.5 kg/t of product
COD	55 kg/t of product
SS	33 kg/t of product
pH	3-5 kg/t of product

3115b Oil refining

Waste volume	57.5 m^3/t of oil refined
BOD_5	12.9 kg/t of oil refined
COD	21 kg/t of oil refined
SS	16.4 kg/t of oil refined
TDS	882 kg/t of oil refined
Oil and grease	6.5 kg/t of oil refined

[1] Economopoulos, A. P. Personal communication.

3116 Grain mill products[1]

Waste volume	0.65 m^3/t
BOD_5	1.14 kg/t
SS	1.62 kg/t

[1] Carton, R. J. Development document for effluent limitations guidelines and new source performance standards for the grain processing segment of the grain mills point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-028-A) (US National Technical Information Service microfiche No. PB 238 316/4BA).

3118 Sugar factories and refineries

	Cane sugar[1]	Beet sugar[2]
Waste volume	28.6 m^3/t	23.35 m^3/t
BOD_5	2.6 kg/t	20 kg/t
SS	3.9 kg/t	75 kg/t

[1] Dellinger, R. W. Development document for effluent limitations guidelines and new source performance standards for the sugar cane refining segment of the sugar processing point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-002-C) (US National Technical Information Service microfiche No. 238 147/3BA).

[2] Watkins, R. V. Development document for effluent limitations guidelines and new source performance standards for the beet sugar refining segment of the sugar processing point source category. Washington, DC, US Environmental Protection Agency, January 1974 (EPA/440/1-74-002-B) (US National Technical Information Service microfiche No. 238 462/6BA).

3121a Starch and glucose manufacturing[1]

Waste volume	33 m^3/t
BOD_5	13.4 kg/t
COD	21.8 kg/t
SS	9.7 kg/t
TDS	42.3 kg/t

[1] Carton, R. J. Development document for effluent limitations guidelines and new source performance standards for the grain processing segment of the grain mills point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-028-A) (US National Technical Information Service microfiche No. PB 238 316/4BA).

3121b Yeast manufacturing[1]

Waste volume	150	m^3/t of yeast
BOD_5	1125	kg/t
SS	18.7	kg/t
TDS	2250	kg/t
Total N	127.5	kg/t
Sulfate as SO_4	337	kg/t

[1] Carton, R. J. Development document for effluent limitations guidelines and new source performance standards for the grain processing segment of the grain mills point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-028-A) (US National Technical Information Service microfiche No. PB 238 316/4BA).

BEVERAGE INDUSTRY

3131 Alcohol distilleries[1,2]

		Grain[1,2] distilleries	Molasses[2] distilleries	Sugar-cane[2] distilleries
Waste volume	m^3/t of anhydrous alcohol	63	63	113
BOD_5	kg/t of anhydrous alcohol	216	220	426
SS	kg/t of anhydrous alcohol	257	300	-
TDS	kg/t of anhydrous alcohol	257	305	-

Useful conversion factors: 1 bushel of grain yields 17.8 l of alcohol and 2.4 l of molasses yields 1 litre of alcohol.

When feed is recovered the overall waste volume is 150 m^3/t of alcohol, while the BOD_5 is reduced by 94% to 98%.

[1] Rudolfs, W. Industrial wastes: their disposal and treatment. New York, NY, Reinhold Publication Co., 1953.

[2] Unpublished data from the State Centre for Environmental and Sanitation Technology, São Paulo, Brazil.

3132 Wine industries[1]

Waste volume (m^3/m^3 of wine)	BOD_5 (kg/m^3 of wine)
4.8	0.255

[1] New development in industrial wastewater treatment. Vienna, Wiener Mitteilungen Wasser - Abwasser Gewässer, 1979 (vol. 28).

3133e Total for beer production[1,2,3]

	Waste volume (m^3/m^3 of beer)	BOD_5 (kg/m^3 of beer)	SS (kg/m^3 of beer)
Malting		1.1	0.2
Fermenting	-	7.5	14.5
Total for beer brewing	14.5	8.6	14.7

[1] Perrin, C. Douzième Symposium sur les eaux residuaires des industries agricoles et alimentaires, Budapest, March 1970.

[2] Bhasharan, T. R. Unpublished WHO document No. WD/73.15.

[3] Nemerow, N. L. Liquid waste of industry, Reading, MS, Addison-Wesley, 1971, p. 330.

3134 Soft drinks and carbonated water industries[1]

	Average	No syrup preparation	With syrup preparation
Waste volume	7.1 m^3/t	4.3 m^3/t	12.8 m^3/t
BOD_5	2.5 kg/t	2.15 kg/t	4.33 kg/t
SS	1.9 kg/t	0.73 kg/t	4.33 kg/t
Total alkalinity	3.7 kg/t		

[1] Porges, R. & Struzenski, E. J. In: Proceedings of the 15th Industrial Waste Conference, p. 331, Purdue University, Purdue, 1960.

MANUFACTURE OF TEXTILES

3211a/b Processing of wool[1,2]

Wastes from individual processes:

		Scouring	Dyeing	Washing	Carbonizing	Bleaching
WV	(m^3/t)	17	25	362	138	12.5
BOD_5	(kg/t)	227	22	63	2	1.4
COD	(kg/t)	1093	-	-	347	-
SS	(kg/t)	153	-	-	44	-
TDS	(kg/t)	116	100	95	166	3.3
Oil	(kg/t)	191.4	-	-	-	-
Phenols	(kg/t)	0.0537	0.166	-	-	-
Cr	(kg/t)	-	1.33	-	-	-
pH		9-10.4	4.8-8	7.3-10	1.9-9	6

[1] The cost of clean water. Washington, DC, Federal Water Pollution Control Association, 1967 (Volume III, Industrial Waste Profiles No. 4 - Textile Mill Products) (US National Technical Information Service microfiche No. PB 218 185/BE).

[2] Seas Phase III - reference data documentation - solid waste/recycling. Arlington, VA, International Research and Technology Corporation, 1975.

Average compounded wastes:

		Unscoured stock	Scoured tops
Waste volume	(m^3/t)	544	537
BOD_5	(kg/t)	314	87
COD	(kg/t)	1440	347
SS	(kg/t)	196	43
TDS	(kg/t)	481	365
Phenol	(kg/t)	0.22	0.166
Oil and grease	(kg/t)	191	-
Chromium	(kg/t)	1.33	1.33
pH		2-10	2-10

Assumptions: 20% of the product is mercerized; and 10% of the product is bleached.

3211c Processing of cotton[1,2]

Wastes from individual processes:

		Yarn sizing	Desizing	Kiering	Bleaching	Mercerizing	Dyeing	Printing
WV	(m^3/t)	4.2	22	100	100	35	50	14
BOD_5	(kg/t)	2.8	58	53	8	8	60	54
SS	(kg/t)	-	30	22	5	2.5	25	12
TDS	(kg/t)	57	53	65	35	33	70	71
pH		7-25	7	10-13	8.5-9.6	5.5-9.5	5-10	-

Average compounded wastes:

Waste volume	317 m^3/t
BOD_5	155 kg/t
SS	70 kg/t
TDS	205 kg/t
pH	8-11

Assumptions made: 35% of the product is mercerized; 50% of the product dyed; and 14% of the product printed.

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[1] The cost of clean water. Washington, DC, Federal Water Pollution Control Association, 1967 (Volume III, Industrial Waste Profiles No. 4 - Textile Mill Products) (US National Technical Information Service microfiche No. PB 218 185/BE).

[2] Seas phase III - reference data documentation - solid waste/recycling. Arlington, VA, International Research and Technology Corporation, 1975.

Processing of synthetic textile[1,2]

	3211d Rayon	3211e Acetate	3211f Nylon	3211g Acrylic	3211h Polyester
Waste volume	42 m^3/t	75 m^3/t	125 m^3/t	210 m^3/t	100 m^3/t
BOD_5	30 kg/t	45 kg/t	45 kg/t	125 kg/t	185 kg/t
COD	52 kg/t	78 kg/t	78 kg/t	216 kg/t	320 kg/t
SS	55 kg/t	40 kg/t	30 kg/t	87 kg/t	95 kg/t
TDS	100 kg/t	100 kg/t	100 kg/t	100 kg/t	150 kg/t
pH			6.5-12.5		

[1] Masselli, J. W. et al. A simplification of textile waste survey and treatment, New England Interstate Water Pollution Control Commission, 1959.

[2] The cost of clean water. Washington, DC, Federal Water Pollution Control Association, 1967 (Volume III, Industrial Waste Profiles No. 4 - Textile Mill Products) (US National Technical Information Service microfiche No. PB 218 185/BE).

MANUFACTURE OF LEATHER AND PRODUCTS OF LEATHER, LEATHER SUBSTITUTES AND FUR, EXCEPT FOOTWEAR AND WEARING APPAREL

3231 Tanneries and leather finishing[1,2]

		Pulp hair/ chrome tanning/ finishing	Save hair/ chrome tanning/ finishing	Save hair/ vegetable tanning/ finishing
Waste volume	(m^3/t of hides)	53	63	50
BOD_5	(kg/t of hides)	95	69	67
COD	(kg/t of hides)	260	140	250
SS	(kg/t of hides)	140	145	135
TS	(kg/t of hides)	525	480	345
Total chromium	(kg/t of hides)	4.3	4.9	0.2
Sulfides	(kg/t of hides)	8.5	0.8	1.2
Oil and grease	(kg/t of hides)	19	43	33
Total N	(kg/t of hides)	17	13	9.2
pH		1-13	4-12.6	2-13

[1] Similar data have been obtained by the State Centre for Environmental and Sanitation Technology, São Paulo, Brazil.

[2] Gallup, J. D. Development document for effluent limitations guidelines and new source performance standards for the leather tanning and finishing point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-016A) (US National Technical Information Service microfiche No. PB 238 079/8BA).

		Finishing only	Chrome tanning and finishing	Pulp or save hair/ chrome or no tanning and no finishing
Waste volume	(m^3/t of hides)	20	63	28
BOD_5	(kg/t of hides)	37	67	110
COD	(kg/t of hides)	28	170	230
SS	(kg/t of hides)	47	88	110
TS	(kg/t of hides)	140	490	595
Total chromium	(kg/t of hides)	2.6	1.2	4.4
Sulfides	(kg/t of hides)	2.1	4.5	3.7
Oil and grease	(kg/t of hides)	7	24	6.6
Total N	(kg/t of hides)	3.7	6	16
pH		3.4-11.2	1.5-12.5	9.2-10.4

Useful conversion factors

Weight of a big hide (cattle or horse) = 25-26 kg.

Weight of a small hide (sheep or goat) = 3 kg.

Average waste volume and load factors from bulk production figures:

Waste volume	52 m^3/t of hides
BOD_5	89 kg/t of hides
COD	258 kg/t of hides
SS	138 kg/t of hides
TS	489 kg/t of hides
Total chromium	3.5 kg/t of hides
Sulfides	7 kg/t of hides
Oil and grease	20 kg/t of hides
Total alkalinity (as $CaCO_3$)	92 kg/t of hides
Total N	15 kg/t of hides
pH	1-13

Assumptions made: 80% of the hides are chrome-tanned; and 20% of the hides are vegetable-tanned.

MANUFACTURE OF WOOD AND WOOD AND CORK PRODUCTS, EXCEPT FURNITURE

3311a Plywood manufacturing[1]

Waste volume	4.1 $m^3/1000\ m^2$ of plywood
COD	7.3 $kg/1000\ m^2$ of plywood
SS	1.1 $kg/1000\ m^2$ of plywood
TS	6.2 $kg/1000\ m^2$ of plywood
Phenol	5.0 $kg/1000\ m^2$ of plywood
Total N	0.24 $kg/1000\ m^2$ of plywood
pH	10.5

[1] Bodien, D. G. Plywood glue waste disposal. Corvallis, OR, US Department of the Interior, Technical Project Branch, Northwest Region, Pacific Northwest Water Laboratory, February 1968 (Report No. PR-2).

3311b Fibreboard manufacturing[1]

Waste volume	20 m^3/t
BOD_5	12.5 kg/t
SS	20 kg/t

[1] Vogt, C. Development document for effluent limitations guidelines and new source performance standards for the unbleached kraft and semichemical pulp segment of the pulp, paper and paperboard mills point source category. Washington, DC, US Environmental Protection Agency, May 1974 (EPA/440/1-74-025A) (US National Technical Information Service microfiche No. 238 833/8BA).

MANUFACTURE OF PULP, PAPER AND PAPERBOARD

	3411a Sulfate (kraft) pulp[1]	3411b Sulfite pulp	3411c Semi-chemical pulp[1]
Waste volume	61.3 m^3/t	92.4 m^3/t	47 m^3/t
BOD_5	31 kg/t	130 kg/t	27 kg/t
SS	18 kg/t	26 kg/t	12.5 kg/t
TS	184 kg/t	284 kg/t	146 kg/t

Note: The processes considered are pulping, pulp screening, and pulp washing and thickening.

[1] The cost of clean water, Washington, DC, Federal Water Pollution Control Association, November 1967 (Volume III, Industrial waste profiles No. 3 - Paper mills) (US National Technical Information Service microfiche No. 217 994/1BA)

3411d Paper mills[1]

Waste volume	54 m^3/t
BOD	8 kg/t
SS	23 kg/t
TS	60 kg/t

	Waste reduction efficiency			
	Volume	TS	SS	BOD_5
3411e Paper mill with water recovery	60%	25%	34%	20%
3411f Paper mill with improved water recovery	77%	55%	50%	50%

[1] The cost of clean water, Washington, DC, Federal Water Pollution Control Association, November 1967 (Volume III, Industrial Waste Profiles No. 3 - Paper mills) (US National Technical Information Service microfiche No. 217 994/1BA).

MANUFACTURE OF INDUSTRIAL CHEMICALS

3511a Hydrochloric acid

Assuming that no effective air pollution control measures are implemented, there are mainly cooling water effluents.

3511b Sulfuric acid[1]

Normally only cooling water of effluents can be expected with the possible exception of tailing gas scrubbing waters in single absorption processes, and wastes from water treatment chemicals.

Typical waste volumes of a single absorption sulfur burning unit are:

Cooling	1.5 m^3/t	(95% recycling)
Process	0.125 m^3/t	
Total	1.625 m^3/t	

[1] Martin, E. E. Development document for effluent limitations guidelines and new source performance standards for the major inorganic product segment of the inorganic chemicals manufacturing point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-007-A) (US National Technical Information Service microfiche No. PB 238 611/8BA).

3511d Phosphoric acid[1]

	Wet process (Acid for fertilizers)	Thermal process (High-grade chemical and food)[2]
Waste volume	2.8 m^3/t of P_2O_5	4.6-92 m^3/t of P_2O_5
P_2O_5	25.2 kg/t of P_2O_5	1 kg/t of P_2O_5
Fluoride	11.2 kg/t of P_2O_5	None
Sulfate	8.4 kg/t of P_2O_5	None
Calcium	2.2 kg/t of P_2O_5	None
Ammonia	0.14 kg/t of P_2O_5	None
Nitrate	0.14 kg/t of P_2O_5	None
pH	1.0-1.5	

Solid waste produced: 4.75 t of gypsum/t of P_2O_5.

Note: The above factors for the wet process are for phosphoric acid plants with ponds where gypsum is deposited and the supernatant water is recycled. Factors for plants with no such pond and no water recycling are:

Waste volume	670	m^3/t of P_2O_5 (No cooling water recycling)
SS	3900	kg/t of P_2O_5
Fluoride (dissolved)	22.2	kg/t of P_2O_5
Ammonia	6.1	kg/t of P_2O_5
Copper	0.74	kg/t of P_2O_5
Sulfite	25.8	kg/t of P_2O_5
Sulfate	82.2	kg/t of P_2O_5

[1] Inorganic Chemicals Industry Profile (Updated). Washington, DC, US Environmental Protection Agency, July 1971 (EPA-12070-EJI-07/71) (US National Technical Information Service microfiche No. PB 206 308/9BA).

[2] Economopoulos, A. P. Personal communication.

3511g Ammonia[1]

Waste volume	2.1 m^3/t
BOD_5	0.2 kg/t
COD	0.26 kg/t
Oil	0.2-20 kg/t
Ammonia	0.12 kg/t

[1] Martin. E. E. Development document for effluent limitations guidelines and new source performance standards for the major inorganic product segment of the inorganic chemicals manufacturing point source category. Washington, DC, Environmental Protection Agency, March 1974 (EPA/440/1-74-007-A) (US National Technical Information Service microfiche No. PB-224 593/4BA).

3511h Manufacture of sodium hydroxide (mercury cell plants)[1]

NaOH	13.5 kg/t of Cl_2
NaCl	211 kg/t of Cl_2
H_2SO_4	16 kg/t of Cl_2
Chlorinated hydrocarbons	0.7 kg/t of Cl_2
Na_2SO_4	15.5 kg/t of Cl_2
Cl_2 (as $CaOCl_2$)	11 kg/t of Cl_2
Filter acids	0.85 kg/t of Cl_2
Mercury	0.15 kg/t of Cl_2
TSS (2)	2.2 kg/t of Cl_2

[1] Martin, E. E. Development document for effluent limitations guidelines and new source performance standards for the major inorganic product segment of the inorganic chemicals manufacturing point source category. Washington, DC, Environmental Protection Agency, March 1974 (EPA/440/1-74-007-A) (US National Technical Information Service microfiche No. PB-224 593/4BA).

3511m/n/o/p Basic organic chemicals[1]

Major product subcategories:

3551m	3511n	3511o	3511p
Cyclohexane	Ethylene	Acetaldehyde	Organic dyes
Ethyl benzene	Propylene	Acetic acid	Azoic dyes and components
Vinyl chloride*	Methanol	Acrylic acid	
BTX aromatics	Acetone	Aniline	
	Acetaldehyde	Bisphenol A	
	Vinyl acetate	Caprolactom	
	Butadiene	Coal tar	
	Acetylene	Ethylene glycol	
	Ethylene oxide	Dimethyl terephthalate	
	Formaldehyde	Oxo chemicals	
	Ethylene dichloride	Phenol	
	Vinyl chloride**	Terephthalic acid	
	Styrene	Acrylates	
	Methyl amines	p-Cresol	
		Methyl methacrylates	
		Tetraethyl lead	

* Produced by addition of HCl to acetylene.

** Produced by cracking ethylene dichloride.

	3511m Chemicals	3511n Chemicals	3511o Chemicals	3511p Chemicals
Waste volume	8.3 m^3/t	12.7 m^3/t	12.6 m^3/t	450 m^3/t
BOD_5	0.11 kg/t	0.35 kg/t	63 kg/t	136 kg/t
COD	2 kg/t	11 kg/t	193 kg/t	2500 kg/t
TOC	0.467 kg/t	20 kg/t	76 kg/t	830 kg/t

[1] Development document for effluent limitations guidelines and new source performance standards for the major organic products point source category. Washington, DC, US Environmental Protection Agency, April 1974 (EPA 440/1-74/009-a).

3512a/b/c/d Fertilizer manufacture

The major effluents of a fertilizer plant are those from the production of sulfuric acid (see 3511b) and phosphoric acid (see 3511d).

PESTICIDE MANUFACTURE

3512e DDT[1]

Waste volume	5.3 m^3/t
H_2SO_4	1166 kg/t
Ethyl hydrogen sulfate	38 kg/t
Chlorobenzene	38 kg/t

3512f Chlorinated hydrocarbon herbicides[2]

Waste volume	3.6 m^3/t
COD	30 kg/t
BOD_5	22.7 kg/t
SS	9 kg/t
TS	374.4 kg/t
pH	0.5 kg/t
Chlorides	187 kg/t
Chlorophenols	4 kg/t
Chlorophenoxy acids	0.85 kg/t

	3512g Carbamates[2]	3512h Parathion[2]
Waste volume	no data available	no data available
BOD_5	Nil	700 mg/l
COD	1000 mg/l	3000 mg/l

SS	Nil	no data available
TS	40000 mg/l	27000 mg/l
Sodium	8000 mg/l	6000 mg/l
Chlorides	100 mg/l	7000 mg/l
Phosphates	Nil	250 mg/l
Organic nitrogen	500 mg/l	no data available
Sulfates	20000 mg/l	3000 mg/l
Nitrates	no data available	20 mg/l
Parathion	no data available	20 mg/l
pH	7-10	2.0

[1] Nemerow, N. L. Liquid waste of industry. Reading, MA, Addison-Wesley, 1971, p. 491.

[2] The pollution potential in pesticide manufacturing. Washington, DC, US Environmental Protection Agency, June 1972 (Pesticide Study Series 5, Technical Studies Report EPA-OWP-TS-00-72-04).

3513 MANUFACTURE OF SYNTHETIC RESINS; PLASTIC MATERIALS AND FIBRES

3513a Rayon fibres

Data not available

3513b Vulcanizable elastomers (synthetic rubber)[1]

Waste volume	19.6 m^3/t
BOD_5	2.6 kg/t
COD	20 kg/t
SS	12 kg/t
Oil	1.2 kg/t

3513c Polyolefins (polyethylenes)

No significant liquid wastes are produced for low and high density polyethylene

3513d Polystyrene resins and copolymers[2]

Process waste volume 5.7 m^3/t

Slightly polluting character, can be directly discharged into sewer

3513 Vinyl resins[2]

Waste volume	12.5 m^3/t
BOD_5	10 kg/t
SS	1.5 kg/t

3513f Polyester and alkyd resins[2]

Quantitative data for liquid effluents are not available

3513g Phenolic resins

Waste volume	4.1 m^3/t (with 93% cooling water recycling)
Phenol	6.6 kg/t
BOD_5	47.3 kg/t
SS	1.6 kg/t
TS	2.1 kg/t
pH	6.4

[1] Riley, J. E. Development document for effluent limitations guidelines and new source performance standards for the tyre and synthetic segment of the rubber processing point source category. Washington, DC, US Environmental Protection Agency, February 1974 (US National Technical Information Service microfiche No. PB 238 609/2BA).

[2] Nemerow, N. L. Liquid waste of industry. Reading, MA, Addison-Wesley, 1971, pp. 493-500.

3513h Acrylic resins[1]

Bulk and solution polymerization methods produce little waste.

Emulsion polymerization yields:

Waste volume	0.5 m^3/t
BOD_5	1.5 kg/t

[1] Nemerow, N. L. Liquid waste of industry. Reading, MA, Addison-Wesley, 1971, pp. 493-500.

MANUFACTURE OF OTHER CHEMICAL PRODUCTS

3521 Manufacture of paints, varnishes and lacquers

Little pollution originates in the form of liquid effluents from these plants.

3522 Manufacture of drugs and medicines

3522a Biological products: no data available

3522b Medical, chemical and botanical products[2]

[1] Nemerow, N. L. Liquid waste of industry. Reading, MA, Addison-Wesley, 1971, p. 331.

[2] Koziorowski, B. & Kucharski, J. Industrial waste disposal, Oxford, Pergamon Press, 1972.

	pH	Waste volume m^3/t	BOD_5 kg/t	DD kg/t
Erythromycin	7.2	4000	13800	5600
Streptomycin	8.5	4000	7400	
Tetracyclin	9.4	4000	5200	1776
Penicillin	4.5	4000	12800	
Aureomycin	8	4000	14280	

3523 Manufacture of soap and cleaning preparations[1]

	3523a Soap by kettle boiling	3523b Soap from fatty acids	3523c Detergents (hard or soft)	3523d Glycerine refining	3523e Liquid detergents
Waste volume	4.5 m^3/t	3.1 m^3/t	2.8 m^3/t	10* (1120**) m^3/t	-
BOD_5	6 kg/t	13.5 kg/t	0.4 kg/t	20 kg/t	5.3 kg/t
COD	10 kg/t	24.5 kg/t	1.2 kg/t	40 kg/t	7.9 kg/t
SS	4 kg/t	23 kg/t	0.7 kg/t	4 kg/t	0.6 kg/t
Oil and grease	0.9 kg/t	3.5 kg/t	0.4 kg/t	2 kg/t	No data available

* With cooling water recycling.
** Without cooling water recycling.

[1] Gregg, R. T. Development document for effluent limitations guidelines and new source performance standards for soaps and detergent manufacturing category. Washington, DC, US Environmental Protection Agency, April 1974 (EPA/440/1-74-018-A) (US National Technical Information Service microfiche No. PB 238 613/4BA).

3529 Manufacture of animal glue[1]

	From fleshings	From hides	From chrome stock
Waste volume	421 m^3/t	457 m^3/t	426 m^3/t
BOD_5	2500 kg/t	580 kg/t	280 kg/t
COD	4800 kg/t	1420 kg/t	650 kg/t
SS	4250 kg/t	1920 kg/t	400 kg/t

[1] Nemerow, N. L. Liquid waste of industry. Reading, MA, Addison-Wesley, 1971, p. 463.

3530 Petroleum refining[1]

	3530a Topping refinery		3530b Low-cracking refinery	
Waste volume	66	$m^3/1000\ m^3$ of feedstock	79	$m^3/1000\ m^3$ feedstock
BOD_5	3.4	$kg/1000\ m^3$ of feedstock	71.5	$kg/1000\ m^3$ feedstock
COD	37	$kg/1000\ m^3$ of feedstock	200	$kg/1000\ m^3$ feedstock
TOC	8.0	$kg/1000\ m^3$ of feedstock	45.7	$kg/1000\ m^3$ feedstock
SS	11.7	$kg/1000\ m^3$ of feedstock	27	$kg/1000\ m^3$ feedstock
Oil	8.3	$kg/1000\ m^3$ of feedstock	27	$kg/1000\ m^3$ feedstock
Phenols	0.034	$kg/1000\ m^3$ of feedstock	2.86	$kg/1000\ m^3$ feedstock
Ammonia	1.20	$kg/1000\ m^3$ of feedstock	10	$kg/1000\ m^3$ feedstock
Sulfides	0	$kg/1000\ m^3$ of feedstock	1	$kg/1000\ m^3$ feedstock

[1] Hapler, M. Development document for effluent limitations guidelines and new source performance standards for the petroleum refining point source category. Washington, DC, US Environmental Protection Agency, April 1974 (EPA/440/1-74-014-A) (US National Technical Information Service microfiche No. PB 238 612/6BA).

	3530c High-cracking refinery		3530d Lubrication refinery	
Waste volume	93	$m^3/1000\ m^3$ feedstock	117	$m^3/1000\ m^3$ feedstock
BOD_5	72.9	$kg/1000\ m^3$ feedstock	217	$kg/1000\ m^3$ feedstock
COD	217	$kg/1000\ m^3$ feedstock	543	$kg/1000\ m^3$ feedstock
TOC	41.5	$kg/1000\ m^3$ feedstock	108	$kg/1000\ m^3$ feedstock
SS	18.2	$kg/1000\ m^3$ feedstock	715	$kg/1000\ m^3$ feedstock
Oil	31.4	$kg/1000\ m^3$ feedstock	120	$kg/1000\ m^3$ feedstock
Phenols	4.0	$kg/1000\ m^3$ feedstock	8.3	$kg/1000\ m^3$ feedstock
Ammonia	28.3	$kg/1000\ m^3$ feedstock	24.1	$kg/1000\ m^3$ feedstock
Sulfides	0.9	$kg/1000\ m^3$ feedstock	-	

	3530e Petrochemical refineries		3530f Integrated refineries	
Waste volume	108 x $10^3 m^3/1000\ m^3$	feedstock	234 x $10^3 m^3/1000\ m^3$	feedstock
BOD_5	171.6	$kg/1000\ m^3$ feedstock	197	$kg/1000\ m^3$ feedstock
COD	463	$kg/1000\ m^3$ feedstock	328	$kg/1000\ m^3$ feedstock
TOC	148.7	$kg/1000\ m^3$ feedstock	139	$kg/1000\ m^3$ feedstock
SS	48.6	$kg/1000\ m^3$ feedstock	50	$kg/1000\ m^3$ feedstock
Oil	52.9	$kg/1000\ m^3$ feedstock	75	$kg/1000\ m^3$ feedstock
Phenols	7.7	$kg/1000\ m^3$ feedstock	3.8	$kg/1000\ m^3$ feedstock
Ammonia	34.3	$kg/1000\ m^3$ feedstock	20.5	$kg/1000\ m^3$ feedstock
Sulfides	0.9	$kg/1000\ m^3$ feedstock	2.0	$kg/1000\ m^3$ feedstock

Note: The above effluent loads are valid only for refineries with American Petroleum Institute (API) separators.

MANUFACTURE OF MISCELLANEOUS PRODUCTS OF PETROLEUM AND COAL

3540 Asphalt products - building felt and tar paper[1]

Waste volume	50 000 l/t
BOD_5	8 kg/t
SS	40 kg/t

[1] Development document for effluent limitations guidelines and new source performance standards for the builder's paper and roofing felt segment of the builder's paper and board mills point source category. Washington, DC, US Environmental Protection Agency, May 1974 (USEPA-440/1-74-026 a).

MANUFACTURE OF RUBBER PRODUCTS

3551 Manufacture of tyres and inner tubes[1]

	Old factories
Waste volume	37 m^3/t
COD	0.78 kg/t
SS	1 kg/t
TS	13 kg/t
Oil	0.12 kg/t

[1] Riley, J. E. Development document for effluent limitations guidelines and new source performance standards for the tyre and synthetic segment of the rubber processing point source category. Washington, DC, US Environmental Protection Agency, February 1974 (US National Technical Information Service microfiche No. PB 238 609).

MANUFACTURE OF NON-METALLIC MINERAL PRODUCTS, EXCEPT PRODUCTS OF PETROLEUM AND COAL

3610 Pottery, china and earthenware

There is no significant water pollution problem.

3620 Glass and glass products

Waste volume	45.9 m^3/t of glass produced
COD	4.6 kg/t of glass produced
SS	0.7 kg/t of glass produced
TS	8.7 kg/t of glass produced
pH	9 kg/t of glass produced

3691 Structural clay products

There is no significant water pollution problem.

3692[1] Cement, lime and plaster

	3692a Wet process (leaching)	3692b Dry process (no leaching)
Waste volume	5100 l/t of product	5100 l/t
Alkalinity	1.4 kg/t of product	0.1 kg/t
TDS	6.6 kg/t of product	0.3 kg/t
SS	0.9 kg/t of product	0 kg/t
Sulfate	3.7 kg/t of product	0 kg/t
Potassium	3.3 kg/t of product	0.1 kg/t

[1] Riley, J. E. Development document for effluent limitations guidelines and new source performance standards for the cement manufacturing point source category. Washington, DC, US Environmental Protection Agency, January 1974 (EPA/440/1-74.00) (US National Technical Information Service microfiche No. PB 238 610).

BASIC METAL INDUSTRIES

3710 Iron and steel industries

	3710a Metallurgical coke[1]	3710b Blast furnace[1]
Waste volume	0.42 m^3/t	14.4 m^3/t
Ammonia	0.99 kg/t	0.09 kg/t
BOD_5	0.58 kg/t	No data available
Cyanide	0.045 kg/t	0.011 kg/t
Oil and grease	0.075 kg/t	No data available
Phenol	0.197 kg/t	0.0065 kg/t
Sulfide	0.18 kg/t	0.11 kg/t
SS	0.04 kg/t	15.89 kg/t
Fluoride	-	0.019 kg/t

	3710c BOF steel furnace[1]	3710d Open-hearth steel furnace[1]	3710e Electric steel furnace[1]
Waste volume	2.3 m^3/t	2.41 m^3/t	0.8 m^3/t
SS	3.5 kg/t	4.93 kg/t	11.7 kg/t
Fluoride	0.0018 kg/t	0.0455 kg/t	0.013 kg/t
Nitrate	No data available	0.0635 kg/t	No data available
Zinc	No data available	1.01 kg/t	1.58 kg/t

3710g Continuous casting foundries[1]

Waste volume	11.6 m^3/t
SS	0.3 kg/t
Oil and grease	0.25 kg/t

[1] Dunlaney, E. L. Development document for effluent limitations guidelines and new source performance standards for the steel making segment of the iron and steel manufacturing point source category. Washington, DC, US Environmental Protection Agency, June 1974 (EPA/440/1-74-024A) (US National Technical Information Service microfiche No. PB 238 837/9BA).

3720 Non-ferrous metal basic industries

3720a Manufacture of aluminium[1]

Alkalinity	0.555 kg/t
COD	2.9 kg/t
TS	6.7 kg/t
SS	4.47 kg/t
Sulfate	4.4 kg/t
Fluoride	4.2 kg/t
Oil and grease	0.46 kg/t
Zinc	0.016 kg/t
Copper	0.003 kg/t

For copper (3720c), lead (3720e), and zinc (3720h/i) smelter and refineries no data are available.[2]

3720g Brass and bronze foundries

There is mainly a cooling water effluent problem.

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[1] Thompson, G. S., jr. Development document for effluent limitations guidelines and new source performance standards for the primary aluminium smelting subcategory of the aluminium segment of the non-ferrous metal manufacturing point source category. Washington, DC, US Environmental Protection Agency, April 1974 (EPA/440/1-74-019-D) (US National Technical Information Service microfiche No. PB 240 859/9BA).

[2] US Environmental Protection Agency. Water pollution control in the primary non-ferrous metals industry: Vol. I, copper, zinc and lead industries. Washington, DC, September 1973 (EPA-R2-73-247a) (US National Technical Information Service microfiche No. PB 229 466/8BA).

MANUFACTURE OF FABRICATED METAL PRODUCTS, MACHINERY AND EQUIPMENT

3840b Electroplating

Raw waste calculation from quantity of anode used:

	WV (m^3/t) of metal deposited	kg/t of metal deposited
Cu	1 403	9.77 Cu+20 CN (if cyanide bath is used)
Ni	1 519	3.98 Ni
Cr_2O_3	36 300	743 Cr (total) and 297 Cr^{6+}
Zn	1 815	224 Zn + 32.5 CN
Cd	883	Unknown amount of Cd + 12.7 CN
Sn	1 125	Unknown amount of Sn

Raw waste calculations based on amperes of electricity consumed per hour or on electro-deposited area produced:

	WV (m^3/ampere/h)	Dry waste (mg/ampere/h)	WV (m^3/m^2)	Dry waste (mg/m^2)
Copper bath	1.67	11.6	94	658
Nickel bath	1.66	4.35	103	270
Chrome bath	1.66	13.6 Cr^{6+} 34 Cr (total)	95	918 Cr^{6+}, 1 946 Cr (total
Zinc bath	1.52	205	93	12 448
Cyanide bath of any kind		23.8		1 333

[1] Krickenberger, K. R. Development document for effluent limitations guidelines and new source performance standards for the copper, nickel, chromium and zinc segment of the electroplating point source category. Washington, DC, US Environmental Protection Agency, March 1974 (EPA/440/1-74-003-A) (US National Technical Information Service microfiche No. PB 238 834/6BA).

[2] Canning handbook on electroplating, Birmingham, W. Canning and Co. Ltd., 1970 (21st Edition).

3819a Manufacturing of household appliances (stoves, refrigerators, etc.)[1]

Waste volume	55	m^3/t of iron sheet
BOD_5	19.3	kg/t of iron sheet
COD	82	kg/t of iron sheet
SS	8.3	kg/t of iron sheet
TDS	22.6	kg/t of iron sheet
Oil and grease	3.4	kg/t of iron sheet
Phosphorus	0.02	kg/t of iron sheet
Zn	0.44	kg/t of iron sheet
Cr	0.13	kg/t of iron sheet

[1] Economopoulos, A. P. Personal communication.

tro-

e (mg/m^2

658

270

46 Cr (total)

448

333

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ELECTRICITY, GAS AND STEAM

4101 Steam power plant[1]

Waste volume	0.129	m^3/MW.h
BOD_5	2.2	g/MW.h
COD	17	g/MW.h
Cr	0.006	g/MW.h
Cu	0.005	g/MW.h
Fe	0.55	g/MW.h
Ni	0.047	g/MW.h
Oil	0.15	g/MW.h
Phosphate	1.32	g/MW.h
TDS	110	g/MW.h
SS	286	g/MW.h
Zn	0.0118	g/MW.h

[1] Nichols, C. R. Development document for effluent limitations guidelines and new source performance standards for the steam electric power generating point source category. Washington, DC, US Environmental Protection Agency, October 1974 (EPA/440/1-74-029-A) (US National Technical Information Service microfiche No. PB 240 853/2BE).

4102 Manufacture of gas by coke ovens

See 3710a Metallurgical coke.

Annex 3. Pollution loads from domestic effluents

Table 3.1 Working table for the calculation of pollution and waste loads from domestic effluents

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Table 3.1 Working table for the calculation of pollution and waste loads from domestic effluents[1,2]

Area ..... Year .....

	Population (10^3 people)	Waste volume		BOD_5		COD		SS		TDS		N		P	
		m^3/person/year	10^3 m^3/year	kg/person/year	t/year	kg/person/year	t/year	kg/person/year	t/year	kg/person/year	t/year	kg/person/year	t/year	kg/person/year	t/year
ıle connected to sewer[3]		73		19.7		44		20		36.5		3.3		0.4	
ıle not connected to sewer[4]		7.3		6.9		16		16							
Total															

[1] The per capita waste volume varies widely from place to place, and, whenever available, water consumption figures can be used for better accuracy.

[2] For an explanation of abbreviations used in this table see Annex 7.

[3] These factors have been derived from values given in two publications: Okun, D. A. & Ponghis, G. Community wastewater collection and disposal. Geneva, l Health Organization, 1975; Hamza, Consolidated Gulf report. Nairobi, United Nations Environment Programme, 1980.

[4] These factors are based on data from the UNDP/WHO Environmental Pollution Control Project, Athens, Greece.

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Annex 4. Industrial solid waste loads

Table 4.1 Working table for the calculation of industrial solid waste loads

Table 4.2 Blank table for the calculation of industrial solid waste loads for industries not listed in Table 4.1

Table 4.1 Working table for the calculation of industrial solid waste loads

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3111a Slaughterhouse	t LWK		35		Blood, paunch, hooves, etc.	1
	t LWK		3		Infected animals and organs	2
3111b Packing-house	t		300		Bones, inedible meat parts, etc.	3
3111c Poultry processing	10^3 birds		35		Feathers, hooves, inedible parts	1
3113 Canning of fruits and vegetables	t		50		Peels, cores, seeds, etc.	4
3114 Canning of fish	t		100		Inedible fish parts	3
3115b Vegetable oil refining	t		4.7*		Purification muds soaked in oil	2
3118 Sugar refineries	t		N/A		Spent beets and canes	-
3121a Starch and glucose	t		N/A		Corn residues, etc.	
3131a Alcohol distilleries	t		N/A		Spent resins, figs, canes, etc.	-
3133 Beer brewing	m^3		20		Spent hop, grain residues, yeast, etc.	3
3211a Wool scouring	t		95		Dirt, wool, fly, and sweeps	5
	t		570*		Sludge from waste water treatment	
	t		5 700			

Note. Factors with asterisk yield solid waste loads on a dry basis.
No rendering attached to slaughterhouse, packing-house, and poultry processing is assumed.
N/A - No information available.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

No rendering attached to slaughterhouse, packing-house, and poultry processing is assumed.
N/A - No information available.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3211b Wool dyeing and finishing	t		38		Flock, dye and chemical containers etc.	5
	t		25*		Pretreatment screening-fibres	
	t		100			
3211c Cotton (yarn preparation)	t		32		Fibre and yarn	5
Weaving	t		11		Fibre and yarn and cloth	
Dyeing and finishing	t		7		Cloth and flock	
	t		0.8*		Pretreatment screening fibres	
	t		2.8			
	t		20*		Wastewater treatment sludge	
	t		2 300			
3231a Complete chrome tanneries-cattle[a]	1000 hides		450*		Process wastes (scrap products, etc.)	6
	1000 hides		550			
	1000 hides		910*		Process wastes containing Cr, Pb, Zn	
	1000 hides		1 770			
	1000 hides		90*		Wastewater screenings containing Cr, Pb, Zn	

Note. Factors with asterisk yield the solid waste loads on a dry basis.

[a] For sheep-skin tanneries similar wastes are normalized per tonne of product. One cowhide weighs 25 kg, and one sheep/goat skin weighs 3 kg.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
	1000 hides		390		Wastewater screenings containing Cr, Pb, Zn	
	1000 hides		300*		Wastewater sludge containing Cr, Pb, phenols	
	1000 hides		2 700			
3231b Complete vegetable tanning - cattle[a]	1000 hides		230*		Process wastes (scrap products, etc.)	6
	1000 hides		250			
	1000 hides		910*		Process wastes containing Cr, Pb, Zn	
	1000 hides		1 770			
	1000 hides		10*		Wastewater screening containing Cr, Pb, Zn	
	1000 hides		40			
3231c Leather finishing only - cattle[a]	1000 hides		75*		Process wastes (scrap products, dust, etc.)	6
	1000 hides		84			
	1000 hides		55*		Process wastes containing Cr, Pb	
	1000 hides		161			
3411 Pulp mills	t		50		Cellulose, lignins, reducing sugars, etc.	1

Note. Factors with asterisk yield the solid waste loads on a dry basis.

[a] For sheep-skin tanneries similar wastes are normalized per t of product. One cow hide weighs 25 kg, and one sheep/goat skin weighs 3 kg.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Factors with asterisk yield the solid waste loads on a dry basis.

For sheep-skin tanneries similar wastes are normalized per t of product. One cow hide weighs 25 kg, and one sheep/goat weighs 3 kg.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3511b Sulfuric acid	t		N/A		Spent catalyst in contact process (V_2O_5)	-
					Spent sulfide ore (when used as raw material)	
3511e Phosphoric acid (Wet process)	t of P_2O_5		4 750*		Gypsum when removed from the effluents	2
3511g Ammonia	t		N/A		Oily condensates from feedstock	-
3511h Sodium hydroxide (mercury-cathode cell process)	t of Cl_2		40*		Graphite and purification muds ($CaCO_3$ + Mg $(OH)_2$, perhaps with Hg)	7
3511 Basic organic chemicals	-		N/A			
3512 Pesticide production	t active ingredient		200*		Containers, bags, 1.5% active toxic/material etc.	8
					Broken emulsion products/ potentially toxic material	
3513 Manufacture of synthetic resins, plastics & fibres	t active ingredient		N/A			-
3521 Latex paints	t of paint		5.8		Paint sludge, waste solvents etc./ Hg 125 g/l	8
3521 Solvent paint	t of paint		8.3		Paint sludge, waste solvents etc./ Heavy metals 4.5%	8
3522 Synthetic organic pharmaceutical chemicals	t		800		Waste solvents	9

Note. Factors with asterisk yield the solid waste loads on a dry basis.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
	t		600		Dry solid wastes	
3522 Fermentation products (antibiotics)	t		1 200		Solvent waste concentrate	9
	t		600		Solvent (butyl acetate)	
	t		600		Dissolved fats, protein, etc.	
	t		80 000		Sludge from waste water treatment	
3523a Soap by kettle boiling	t		N/A			
3529 Animal glue	t		N/A			
3530a Topping petroleum refinery	$10^3 m^3$ feedstock		1 311		Oily and toxic sludges from gasoline storage tanks	10
3530b Low-cracking refinery	$10^3 m^3$ feedstock		1 675		Oily and toxic sludges	10
3530c High-cracking refinery	$10^3 m^3$ feedstock		3 303		Oily and toxic sludges	10
3530d Lubrication refinery	$10^3 m^3$ feedstock		6 140		Oily and toxic sludges	10
3530g Spent lubrication oil re-refining	m^3 of oil refined		150		Oily resins with sulfuric acid	11
	m^3 of oil refined		59		Other sludges	11
	m^3 of oil refined		77		Purification muds with oil	11

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

	m^3 of oil refined		77		Purification muds with oil	11

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3551a Rubber tyres	t		55		Rubber waste, fillers, etc.	12
3551b Other rubber products	t		175			12
3710a Metallurgic coke oven	t of coke		5.5		Condensates and sludge with Cr 10 g/m^3, Cu 4 g/m^3, Mn 102 g/m^3, Ni 5.5 g/m^3, Pb 30.5 g/m^3, Zn 90.5 g/m^3, oil 20.3%	13
3710b Blast furnace	t of pig iron		348		Slag (Cr, Cu, Mn, Ni, Pb, Zn present)	13
			16.2		Dust (Cr, Cu, Mn, Ni, Pb, Zn present)	
			24.4		Sludge (Cr, Cu, Mn, Ni, Pb, Zn present)	
3710c BOF steel furnace	t of steel		145		Slag (Cr, Cu, Mn, Ni, Pb, Zn present)	13
	t of steel		16.0		Dirt (Cr, Cu, Mn, Ni, Pb, Zn present)	
	t of steel		17.3		Sludge (Cr, Cu, Mn, Ni, Pb, Zn present)	
3710d Open-hearth furnace	t of steel		243		Slag (Cr, Cu, Mn, Ni, Pb, Zn present)	13
	t of steel		13.7		Dust (Cr, Cu, Mn, Ni, Pb, Zn present)	

Note. (a) Approximately 0.66 kg of coke is required per kg of pig iron.
(b) Approximately 0.72 kg of pig iron yield 1 kg of steel.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3710e Electric arc steel furnace	t of steel		120		Slag (Cr, Cu, Mn, Ni, Pb, Zn present)	13
	t of steel		12.8		Dust (Cr, Cu, Mn, Ni, Pb, Zn present)	
	t of steel		8.7		Sludge (Cr, Cu, Mn, Ni, Pb, Zn present)	
3710f Iron foundries	t of castings		142		Slag, dust, refractories with heavy metals	13
			600		Casting sand with heavy metals and phenols	
			32.8		Sludge with heavy metals	
3710f Steel foundries	t of castings		361		Slag, dust, refractories (heavy metals)	13
	t of castings		780		Sand (heavy metals and phenols)	
	t of castings		36.4		Sludge (heavy metals)	
3720a Alumina from bauxite	t of alumina		2 000*		Red muds from waste water treatment	2
3720b Primary aluminium smelting	t of aluminium		117		Sludge - from potline scrubbers (14% fluorine)	14
	t of aluminium		7.5		Cast house and roding room dust (F, Cu, Pb)	14

Note. Factors with asterisk yield the solid waste loads on a dry basis.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

	t of aluminium				dust (F, Cu, Pb)	

ote. Factors with asterisk yield the solid waste loads on a dry basis.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
	t of aluminium		59		Spent potliners and skim from cells (F, CN)	14
3720c Secondary aluminium smelting						
(i) Scrap smelting	t		75		Scrubber sludge (Cr, Cu, Pb, Zn)	14
(ii) Dross smelting	t		1 400		High salt slag (Cr, Cu, Mn, Ni, Pb, Zn)	14
3720d Copper smelting	t		3 000		Slag (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Se, Zn)	14
	t		17		Dusts (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Se, Zn)	14
	t		155		Sludges (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Se, Zn)	14
3720e Copper electrolytic refining	t		2.4		Sludge (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Se, Zn)	14
3720f Secondary copper smelting	t		350		Blast furnace slag (Cd, Cr, Cu, Mn, Ni, Pb, Sb, Sn, Zn)	14
3720h Primary lead smelting and refining	t		410		Slag (Cd, Cr, Cu, Mn, Pb, Sb, Zn)	14
	t		89		Sludge (Cd, Cr, Cu, Mn, Pb, Sb, Zn, Hg)	14

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
3270i Secondary lead smelting and refining						
(i) Soft lead/blast furnace	t		472		Slag and scrubber sludge (Cd, Cr, Cu, Mn, Ni, Pb, Sb, Sn, Zn)	14
(ii) Hard lead/cupola furnace	t		225		Slag (Cu, Mn, Ni, Pb, Sb, Sn, Zn)	14
(iii) White metal/ reverberatory	t		166		Slag (Cd, Cr, Cu, Mn, Ni, Pb, Sb, Sn, Zn)	14
3720j Primary tin smelting and refining	t		915		Slag (Sn, Pb, possibly Sb, As, Zn)	14
3720k Primary zinc smelting						
(i) Electrolytic refining	t		26.1		Sludges (Cd, Cr, Cu, Hg, Mn, Pb, Se, Zn)	14
(ii) Smelting and refining (pyrometallurgical)	t		1 050		Retort residue (Cd, Cr, Cu, Pb, Se, Zn)	14
	t		122		Sludges (Cd, Cr, Cu, Pb, Se, Zn, Hg)	14
3720m Primary antimony smelting and refining						
(i) Blast or reverber furnace (pyrometallurgical process)	t		2 800		Slag (Pb, Cu, Zn, Sb)	14
(ii) Electrolytic process	t		210		Spent anolyte (As 16 g/m^3, Pb 5 g/m^3, Cu 50 g/m^3, Zn 2 g/m^3, Ni 5 g/m^3, Sb 27 000 g/m^3, Cr 32 g/m^3, Cd 1 g/m^3	14

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

					Cu 50 g/m^3, Zn 2 g/m^3, Ni 5 g/m^3, Sb 27 000 g/m^3, Cr 32 g/m^3, Cd 1 g/m^3	

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process		Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
				kg/unit	t/year		
3720n	Primary mercury and refining	t		207 000		Calcine residue (As, Pb, Cu, Zn, Ni, Hg, Mn, Sb, Cd, Cr)	14
3720o	Primary titanium refining	t		330		Chlorinator and condenser sludges (V, Cr, Zr, Ti, Cl)	14
3840	Electroplating of Cu	t of Cu anodes		9*		Cu in the effluent treatment sludge (cyanide may be also present)	3, 15
	Electroplating of Ni	t of Ni anodes		4*		Ni in the effluent treatment sludge	3, 15
	Electroplating of Cr	t of Cr_2O_3		250*		Cr in the effluent treatment sludge	3, 15
	Electroplating of Zn	t of Zn anodes		220*		Zn in the effluent treatment sludge (cyanides may be also present)	3, 15
3840	Dry docks	-		N/A		Oily sludge from cleaning tanker ships. Toxic sludge from cleaning tanker ships	
4101a	Lignite powered power plants[b]	Mwh		10(A)[a]		Ash from chimneys and air pollution control equipment	3
4101b	Bituminous coal powered power plants[b]	Mwh		4.3(A)[a]		Ash from bottom and air pollution control equipment	3
		Mwh				Polychlorinated biphenyls from transformers	

ote. Factors with asterisk yield the solid waste [illegible] s on a dry basis.

[a] A is the percentage ash content in the fuel.

[b] If no air emission controls are employed only 70% of the ash quantities calculated above are obtained.

Table 4.1 Working table for the calculation of industrial solid waste loads (continued)

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste	Reference
			kg/unit	t/year		
4102 Manufacture of gas by coke oven	t of coke		5.5		Condensates and sludge with Cr 10 g/m^3, Cu 4 g/m^3, Mn 102 g/m^3, Ni 5.5 g/m^3, Pb 30.5 g/m^3, Zn 96.5 g/m^3, Oil 20.3%	13
	$10^3 m^3$ of gas		8.25		Condensates and sludge with Cr 10 g/m^3, Cu 4 g/m^3, Mn 102 g/m^3, Ni 5.5 g/m^3, Pb 30.5 g/m^3, Zn 96.5 g/m^3, Oil 20.3%	13

FOOTNOTES AND REFERENCES TO TABLE 4.1

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15. Suspended solid and toxic emission calculations are based on factors given in Table 2.3 for electroplating of different metals.

Table 4.2 Blank table for the calculation of industrial solid waste loads for industries not listed in Table 4.1

Industry and process	Production unit	Production 10^3 units/year	Solid waste		Nature of waste
			kg/unit	t/year	

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Annex 5. Municipal solid waste loads

Table 5.1 Working table for the calculation of municipal solid waste loads

Table 5.2 Factors for municipal solid wastes

Table 5.3 Composition and density of municipal wastes in various countries

Table 5.4 Quantities of wastewater and water treatment plant sludges

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Table 5.1 Working table for the calculation of municipal solid waste loads

Characteristics of study area	10^3 people with regular garbage collection	Municipal wastes	
		Factor (kg/person/year)	Load (t/year)
(1) Municipal refuse			
Very low income area		150	
Typical area in a developing nation		250	
Typical area in an industrialized nation		400	
Typical area in a wealthy region		900	

Characteristics of study area	10^3 people served by sewers	Dry weight of sludges	
		Factor (kg/person/year)	Load (t/year)
(2) Sludges			
Primary wastewater plant (undigested)		12	
Secondary wastewater treatment plant (digested)		5.4	
Lime soda softening water treatment		20	

Table 5.2 Municipal solid waste factors for different regions of the world[a]

	Municipal wastes
Lowest income areas in South East Asia	0.4 kg per person per day
Typical cities in Asia, North Africa, and South America	0.7 kg per person per day
Typical cities in industrialized nations	1.1 kg per person per day
Typical cities in wealthy regions (USA and Gulf countries)	2.5 kg per person per day

[a] Based on field work, unpublished data.

Table 5.3 Composition and density of municipal wastes in different countries[a]

	Britain	India	Mexico	Tunisia	Ecuador
Vegetable-putrescible (%)	28	75.2	55	80.8	65.5
Paper (%)	37	1.5	15	9.6	17.9
Metals (%)	9	0.1	6	2.1	1.4
Glass (%)	9	0.2	4	1.1	1.7
Textiles (%)	3	3.1	6	2.9	3.1
Plastic and rubber (%)	3	0.9	4	1.2	2.7
Miscellaneous combustible	1	0.2	2	0.5	3.0
Miscellaneous incombustible (%)	1	6.9	6	0.1	0.9
Inert below 10 mm (%)	9	12	0	1.8	3.8 (30 mm)
Density, kg/m^3	150	570		321	292

[a] Flintoff, F. Personal communication.

Table 5.4. Quantities of wastewater and water treatment plant sludges

A. Wastewater treatment[1,2]

Treatment process	Quantity of sludge			
	Wet		Dry	
	kg/m^3 of sewage	m^3/1000 persons/day	kg/1000 m^3 of sewage	kg/1000 persons/day
Primary sedimentation:				
Undigested	3.0	0.6	150	30
Digested in separate tanks	1.5	0.3	90	16
Digested and dewatered on sand beds	0.2	0.1	90	16
Trickling filters	0.8	0.2	57	12
Chemical precipitation	5.3	1.1	396	79
Dewatered on sand beds	1.4	0.3	396	79
Primary sedimentation and activated sludge:				
Undigested	7.0	1.4	280	56
Digested in separate tanks	2.0	0.4	168	33
Digested and dewatered on sand beds	0.4	0.1	168	33
Activated sludge:				
Wet sludge	19.5	3.9	270	46
Septic tank sludge, digested	-	0.2	97	20
Imhoff tank sludge, digested	-	0.1	83	17

B. Water treatment - lime-soda softening[3]

Sediment per 1000 m^3 of water treated = 0.2 t (dry weight) or 2000 litres (sludge).

[1] Based on a sewage flow of 200 litres/person/day or 0.06 kg/person/day of suspended solids in sewage.

[2] Adapted from: Metcalf & Eddy, Inc. Waste Water Engineering, New York, NY, McGraw Hill 1972.

[3] From: American Waterworks Association. Water treatment plant design, New York, NY, 1969.

Annex 6. Conversion factors

From	To	Factor
Length		
millimetre (mm)	inch (in)	0.0394
centimetre (cm)	inch (in)	0.3937
metre (m)	foot (ft)	3.2808
kilometre (km)	mile	0.6214
inch (in)	millimetre (mm)	2.54
foot (ft)	metre (m)	0.3048
mile	kilometre (km)	1.6093
Area		
square centimetre (cm^2)	square inch (in^2)	0.1550
square metre (m^2)	square foot (ft^2)	10.7639
hectare (ha)	acre	2.471
1000 m^2	acre	0.2471
square kilometre (km^2)	square mile	0.3861
square inch (in^2)	square centimetre (cm^2)	6.4516
square foot (ft^2)	square metre (m^2)	0.0929
acre	hectare (ha)	0.405
acre	square metre (m^2)	4046.8
square mile	square kilometre (km^2)	2.5900
Volume		
litre	cubic foot (ft^3)	0.03531
cubic centimetre (cm^3)	cubic inch (in^3)	0.06102
cubic metre (m^3)	cubic foot (ft^3)	35.31
cubic foot (ft^3)	litre (l)	28.317
cubic foot (ft^3)	cubic metre (m^3)	0.0283
Liquid capacity		
litre (l)	quart (US)	1.0567
litre (l)	gallon (US) (US gal)	0.2642
litre (l)	quart (UK)	0.8799
litre (l)	gallon (UK) (UK gal)[1]	0.2200
quart (US)	litre (l)	0.9464
gallon (US)	litre (l)	3.7854
quart (UK)	litre (l)	1.1365
gallon (UK)[1]	litre (l)	4.5461
barrel	litre (l)	158.984
barrel	gallon (UK)	34.9726
barrel	gallon (US)	42.00
Weight		
gram (g)	grain	15.4323
kilogram (kg)	pound (lb)	2.2046
metric ton (1000 kg)	ton (US) (2000 lb)	1.1023
grain	gram (g)	0.0648
pound (lb)	kilogram (kg)	0.4536
ton (US)	kilogram (kg)	907.2

[1] Known also as "imperial" gallon (Imp. gal).

Annex 7. List of abbreviations

AH	Ampere-hour
BOD_5 or BOD	5-day biological oxygen demand
COD	Chemical oxygen demand
LWK	Live weight killed
MW.h	Megawatt hour
Negl.	Negligible
Prod.	Produce
TDS	Total dissolved solids
TOC	Total organic carbon
TS	Total solids
SS	Suspended solids
WV	Waste volume
	Presumed to be zero or near zero

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