REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

Survey of marine pollutants from industrial sources in the West and Central African Region

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PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities.

By Decision 88 (V). C of 25 May 1977, the Governing Council of UNEP requested the Executive Director to initiate the development of an action plan for the West and Central African Region.

After a preparatory process, which included a number of experts meetings, fact finding missions and in-depth studies on resources and environmental problems of the region, the Conference of Plenipotentiaries on Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan 16-23 March 1981) adopted:

- the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the West and Central African Region;

- the Convention for the Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region; and

- the Protocol Concerning Co-operation in Combating Pollution in Cases of Emergency.

The Governments of the region also established a trust fund to support the activities called for in the Action Plan. UNEP was designated as the secretariat of the Action Plan and the Convention.

This document was prepared as a contribution to the development of the Action Plan for the West and Central African Region. Its main objective is to provide the Governments of the Region with appropriate information on the type and quantity of industrial pollution from major land-based sources entering the marine environment through direct coastal discharges or indirectly through rivers, as well as on the present status of industrial waste management (treatment and disposal) practices.

Most of the data in this publication were collected by six UNIDO consultants who visited eighteen States of the West and Central African Region during the period January through August 1980. Industrial operations were visited, and information was collected from the various ministries concerned with industrial development and environmental protection. Estimates of the pollution discharges to the ocean were based on production rates in conjunction with actual measurements made by the industries located in the States visited, on studies reported in the literature, and on extrapolation from the United States Environmental Protection Agency Effluent Standards for various industrial sectors.

Consultants

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ABSTRACT

The objective of the project was to provide the West and Central African Region with appropriate information on the type and quantity of industrial pollution from major land-based sources entering the marine environment through direct coastal discharges or indirectly through rivers, as well as on the present status of industrial waste management (treatment and disposal) practices.

Most of the data utilized in this report were collected by six UNIDO experts who visited the 18 countries of the West and Central African Region during the period January through August 1980. Industrial operations were visited and information was collected from the various ministries involved with industrial development and environmental protection. Estimates of the mass of pollution discharged to the ocean were based upon production rates in conjunction with actual measurements made by the industries located in the countries visited, studies reported in the literature, and an extrapolation from the United States Environmental Protection Agency Effluent Standards for various industrial sectors.

The West and Central African Region was divided into five zones closely approximating the major currents of the Atlantic Ocean. The estimated pollution discharged by the industrial sector was calculated for each of the zones by adding the contribution from each country assigned to a zone.

In Zone I (from Cape Blanc to Cape Verga), most of the estimated mass of biochemical oxygen demand (BOD_5) discharged to the ocean is attributable to the edible oils (41%) and leather (44%) industries. The vast majority of suspended solids (SS), oil and grease, and chemical oxygen demand (COD) discharged to the ocean are also produced by the edible oils and leather industries.

In Zone II (from Cape Verga to Cape Palmas), over 50 per cent of the mass of BOD_5 discharged to the ocean comes from breweries. The estimated mass of SS emanating from breweries is only 30.5 per cent of the total SS discharged, but this contribution is over one and one-half times as large as the second largest contribution to SS, which is the fish and shrimp industry (19%). Oil and grease discharges to the ocean from Zone II result principally from the edible oils (47%), petroleum refining (33%), and fish and shrimp (18%) industries.

In Zone III (from Cape Palmas to Cotonou), the majority of the mass of BOD_5 discharged to the ocean is evenly distributed between the edible oils (19%), brewing (21%), cement (14%), and coffee (20%) industries. Textile industries contribute an additional 7 per cent of the mass of BOD_5 discharged. Phosphate mining contributes over 74 per cent of SS discharged to the ocean. The textile industry is the second largest (6%) contributor to SS discharged, but the mass is comparatively insignificant. The edible oils industries are principally responsible for oil and grease discharges (72%). The phosphate mining industry discharges large quantities of fluoride and total phosphorus.

In Zone IV (from Cotonou to Cape Lopez), petroleum refining and handling operations account for 7 per cent of BOD_5 and for 99 per cent of the oil and grease discharged to the ocean. The majority of the crude oil production and petroleum refining along the coast of the West and Central African Region is in Zone IV. The distribution of pollution discharges from other industrial sectors is similar to that observed in the other four zones except that activity in Zone IV is generally on a much larger scale.

In Zone V (from Cape Lopez to Cape Frio), the estimated discharges to the ocean are the lowest of any of the five zones. Of BOD_5 discharged to the ocean, beer production accounts for 45 per cent, and petroleum refining and handling over 17 per cent. The latter industry also contributes approximately 98 per cent of the oil and grease discharged. SS discharges come principally from petroleum (18%), beer (31%), and textiles (27%).

A comparison of the pollution loads for the five zones shows that Zone IV discharges far more pollution than any of the other four zones. Of the total pollution discharged to the ocean from the 18 countries

of the Region, it is estimated that 43 per cent of BOD_5, 36 per cent of SS, 83 per cent of oil and grease, and 60 per cent of COD are discharged from Zone IV. Zones I and III contribute almost equally to the majority of the remaining pollution load except that Zone III discharges 38 per cent of the total SS discharged in the Region. This large percentage of SS is principally attributable to phosphate mining operations. Zones II and V discharge only a minor proportion of the pollution to the ocean in the Region.

Industrial development in the West and Central African Region is limited and pollution discharges from the industries have little impact on the environment except in isolated cases. Waste treatment in the countries of the Region is virtually non-existent. Only an occasional sedimentation basin, grease trap or sand filter was observed by the consultants as they visited industries in the 18 countries of the Region. A significant change in the impact on the environment will likely occur because of the concerted efforts being made towards expanding industry in the Region (see projected development table, table 10); many large industries are being planned in the coastal area. Because of the extensive natural resources, it is very likely that rapid development will occur in most countries of the Region. The lack of a significant pollution problem in most of these countries at this time allows Governments and industry to begin a planning process that will avoid creating an environmental problem. The immediate needs in most areas are solutions to the pollution from sewage. It is strongly recommended that planning begin and a long-range plan be implemented to avoid the creation of industrial pollution problems. Where localized pollution problems exist, the problems will be compounded as new development occurs unless development is co-ordinated with an environmental protection plan.

Local universities and technical programmes should be encouraged to begin a long-range plan to produce the professionals and technicians required to protect the environment of the West and Central African Region. It is imperative that individuals become knowledgeable and begin to consider protection of the entire environment when expansion is considered. Adequate planning at this stage will ensure that the environment is not degraded beyond repair.

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INTRODUCTION

The West and Central African Region has been recognized by the Governing Council of UNEP (Decision 88.C(V) of 25 May 1977) as a "concentration area" in which UNEP, in close collaboration with the relevant components of the United Nations system, will attempt to fulfil a catalytic role in assisting the developing States of the West and Central African Region to formulate and implement, in a consistent manner, a commonly agreed upon action plan.

Recognizing the complexity of the problem and being aware of ongoing activities, UNEP has undertaken numerous preparatory activities to provide a sound basis for the adoption of the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the West and Central African Region.

At the IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas (Abidjan, 2-9 May 1978), industrial waste was identified as a major source of marine pollution in the region. It was noted in the Report of the Workshop, that:

> "Rapidly increasing industrial development of the region, particularly in the coastal zone and along the major rivers, is likely to lead to an increase in the volume and diversity of industrial wastes discharged without adequate treatment into the marine environment. Detrimental effects of these discharges have been observed in many places, and yet practically no records exist on the amount discharged, on the concentration of these pollutants in the marine environment or on their effects on marine life and human health .... . Considering that the living marine resources, which are easily damaged by these types of pollutants, constitute an important source of revenue and food for the population of the region, a pilot project to assess the magnitude of the problem caused by discharges of industrial and agricultural waste into the marine environment is recommended". (pp.8/9)

The Workshop recommended that a detailed survey of land-based sources of industrial and agricultural pollutants be carried out as a first step towards the objective of establishing regionally applicable standards for the management and control of industrial and agricultural pollutants.

Based on the recommendations of the Abidjan Workshop, the draft action plan for the West and Central African Region adopted by the Meeting of Experts to Review the Draft Action Plan for the West African Region calls for "a detailed survey of industrial and agricultural pollutants discharged directly or indirectly into the sea." (UNEP/WG.27/3, p.5, para.13.5).

The present survey is concerned with pollution from industrial sources. The objective of the project is to provide the West and Central African Region with appropriate information on the type and quantity of pollutants from major land-based sources entering the marine environment through direct coastal discharges or indirectly through rivers as well as on the present status of industrial waste management (treatment and disposal) practices. In particular, the results of the survey should assist Governments in identifying priority activities that could be incorporated in the regional action plan and should provide the basis on which related waste management activities may be initiated (see annex I).

The survey is based on information obtained on field missions to the States of the West and Central African Region.

The objectives of the field missions were to survey the industrial pollution in the Region and to produce:

(a) An inventory of industrial sources of pollution discharging into the marine environment of the West and Central African Region;

(b) An assessment of the nature and quantity of pollution entering the sea from industrial sources, including pollution from an indirect discharge;[1/]

(c) A review of present industrial waste treatment and disposal practices.

1/ An indirect discharge means a discharge into a river or stream not more than 20 km from the coast.

I. CONCLUSIONS

Information describing the contribution of industrial pollution to the marine environment from 18 West and Central African countries (all of the coastal countries from Senegal to Angola) was collected by six UNIDO experts who visited each country. Reports from earlier studies and information from the literature were used to integrate the data collected. An assessment of the information collected resulted in the following conclusions.

1. Data describing the industrial pollution discharges to the ocean in the West and Central African Region are limited.

2. Estimates of the pollution discharges from each of the countries, the zones and the Region are conservative, and actual discharges are probably higher. However, it is difficult to know how low the estimated discharges may be.

3. Projected industrial growth in the Region is great, but data on the expected capacity, completion data and types of industries are limited.

4. Pollution discharges to the Atlantic Ocean will likely increase significantly in the next 10 years, and industrial pollution discharges are likely to become a significant problem in West and Central African Region and many localized areas where industry is concentrated.

5. Discharge of industrial pollution to estuaries, rivers and the ocean in many of the countries is not currently creating a significant problem. If the planned increase in industrialization occurs, significant water pollution problems could develop in a short time.

6. The major sources of pollution in most of the countries of the West and Central African region are from human waste and not from industrial sources. Estimates indicate that approximately 80 per cent of the pollution currently discharged to the ocean is attributable to people.

7. Development of the tourist industry on the coast of the West and Central African Region is directly dependent upon the protection of the environment. Continuation and expansion of the uncontrolled discharges from the municipalities and industrial sites will eventually destroy the beautiful beaches that are a basis for the tourist industry.

II. RECOMMENDATIONS

It is recommended that the Governments of the Region undertake the following activities in order to help achieve the objectives of understanding and managing present and future environmental problems in the Region.

1. Each Government should undertake, at the national level:

(a) The development of a joint municipal industrial and governmental planning commission to evaluate the trends and needs for pollution control. One of the functions of the commission should be to carry out a systematic review of national industrial development plans and an assessment of their impact on the environment. Appropriate measures either to eliminate or to reduce damaging environmental effects should be adopted;

(b) The development and implementation of a long-range plan of action to provide municipal and industrial control programmes for waste water, air pollution, and solid waste;

(c) The development of regulations to control pollution discharges in order to provide guidance for industry so that future needs may be anticipated and incorporated in pollution control plans.

2. In order to assist Governments to implement effectively the above, regional co-operation should be developed under the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the West and Central African Region, as follows:

(a) As part of the regional marine pollution research and monitoring programme to be organized under the environmental assessment component of the Action Plan, a project should be established to identify and assess the magnitude of wastes from industrial sources and their effects on the marine and coastal environment (UNEP/IG.22/7, para.13.5 of the Action Plan);

(b) Principles and guidelines should be developed for industrial waste management on the basis of a series of workshops. An initial workshop may be convened to review the overall problems of industrial waste in the Region and to suggest appropriate environmental management practices. Subsequent workshops may deal with specific subsectors, such as industrial air pollution monitoring and control, industrial water pollution assessment and control, and industrial solid waste management (UNEP/IG.22/7, para.19.4 of the Action Plan);

(c) A workshop should be organized to review various methodologies to be used for the assessment of the impact of industrial development activities on the environment and to propose management policies to eliminate or reduce damaging environmental effects (UNEP/IG.22/7, para.18.4 of the Action Plan);

(d) An up-to-date compilation of national legislation of the West and Central African states should be maintained concerning the control of industrial pollution, and the provision, upon request, of technical assistance and advice on the drafting of appropriate national legislation (UNEP/IG.22/7, para.21 of the Action Plan).

III. SURVEY OF MARINE POLLUTANTS FROM INDUSTRIAL SOURCES

A. Survey methods

Data collection

Most of the data utilized in this report were collected by six UNIDO experts who visited the 18 countries of the West and Central African Region during the period January through August 1980.

Country reports were prepared by the experts. Each Government received a copy of the report on its country with a request for comments. Certain Governments indicated changes that should be made to their country report, and these have been taken into account in the preparation of the present survey. When no reaction was received from a government, it was assumed that the report was acceptable.

Data were collected from as many sources as possible before and during the visits. Reports from earlier studies were consulted, industrial operations were visited and information was collected from the various ministries involved with industrial development and environmental protection. Each of the industries visited was requested to complete one of the questionnaires shown in annex II. The shorter questionnaire was developed near the end of the project for use with small industries that were just beginning to develop pollution control data. The majority of the industries visited by the consultants were asked to complete the longer questionnaire.

Data on industrial activity in Nigeria were compiled differently than for the other countries of the Region. Industrial activity on the coast of Nigeria was estimated by using data presented in Africa: South of the Sahara (1), Mitteilungen der Bundesstelle für Aussenhandelsinformation (2), and Mounier (3). Production data for the sectors of crude petroleum, petroleum refining and pulp and paper (annex III, table 11) were collected by Mounier (3) during a visit to Nigeria in July 1980. Production data for the other segments of industry (annex III,

table 11) were taken from (1) and updated by using indices presented by (2). The proportion of the industrial activity situated on the coast of Nigeria was estimated to be 75 per cent of the total. Mounier (4) estimated that approximately one half of the industrial activity in Nigeria was concentrated in the Lagos area, and approximately one half of the remaining industry was located along the coast.

Production indices were based upon an index of 100 in 1972 and a value for 1979 was available (see (2)). Production data for industry in Nigeria were available for 1972 (see (1)), and the index was used to update the production data to 1979. Since the degree of concentration of industry on the coast was unknown and it was necessary to use judgement to estimate the activity on the coast, an attempt was not made to correct the 1979 projection to 1980. It was assumed that these projections were adequate to estimate 1980 conditions.

Certain sectors of industry were not included in the indices (2), and it was necessary to assume an index. In these cases an overall industrial index of 163.8 was used to correct the 1972 production rates. When the projected production for 1979 was less than the production that actually occurred in 1977, the projected value was discarded and a 1979 production rate estimated.

Zones

The countries of the West and Central African Region were divided into zones approximating the major currents in the Atlantic Ocean off the coast of the West and Central African Region (table 1). The zones closely parallel the five zones established by Williams (5); however, Williams's zones were modified by moving the zone boundaries to the nearest border. This modification resulted in relatively small changes in the original configuration proposed by Williams (5). Williams divided the West and Central African Region into five basic hydrographic zones, as follows:

North Transitional Zone (NTZ), extending from Cape Blanc in Mauritania to Cape Verga in Guinea

Western Tropical Zone (WTZ), extending from Cape Verga to Cape Palmas in Liberia

Central Upwelling Zone (CUZ), extending from Cape Palmas to Cotonou in Benin

Eastern Tropical Zone (ETZ), extending from Cotonou to Cape Lopez in Gabon

Southern Transitional Zone (STZ), extending from Cape Lopez to Cape Frio in Angola

Table 1. Zones and countries included in the survey of pollution discharged to the Atlantic Ocean from the West and Central African Region

Zone	Country
I	Senegal Gambia Guinea-Bissau
II	Guinea Sierra Leone Liberia
III	Ivory Coast Ghana Togo Benin
IV	Nigeria United Republic of Cameroon Equatorial Guinea Sao Tome and Principe Gabon
V	Congo Zaire Angola

The Tropical Surface Water of the West and Central African Region is warm (more than 24°C) and has a salinity of less than 35°/oo. Seasonal replacements of the Tropical Surface Water occur with cold, high-salinity water replacing the warm waters in the NTZ, CUZ and STZ zones. This replacement is caused in the NTZ zone by the southward-moving oceanographic front. The replacements in the NTZ and STZ occur about six months apart. Cold, high-salinity water upwells in the CUZ between late June and October. Off the Ivory Coast, a weaker, secondary upwelling also occurs in the period from January to March, but the other part of the CUZ is more stable. The temperature and salinity of the WTZ and ETZ fluctuate with rainfall and run-off from the land. Productivity tends to be much higher where upwelling occurs; whereas, the Tropical Surface Water has a relatively poor productivity.

Although the basic structure of the currents of the West and Central African Region and the adjacent regions are reasonably well established, Portmann (6) indicates that it is unlikely that enough detail exists to predict the movement and fate of waste waters discharged to most areas of the coast of the West and Central African Region. Eddy currents and seasonal changes are not understood well enough to predict the impact of discharges to specific areas of the ocean. Studies to determine the movement of discharges will be necessary at most sites selected for discharge.

Pollutional discharges were estimated for each of the zones by adding the estimated discharges from each of the countries assigned to a zone.

B. Data analysis

The various types of data were compiled, together with an individual country report, for each of the 18 countries of the Region and sent to the Governments concerned for comments (Margola (7 - 15); Middlebrooks (16, 17); Mounier (3, 18); Rozanov (19, 20); Schifini (21 - 23)).

The pollution discharge projected for each of the countries reported on may differ from the values given in the country reports because of the individual preferences of the various authors in selecting pollutional mass loading factors for each type of industry. To ensure continuity a common set of pollutional mass loading factors for each type of industry was selected and used for all of the countries. The values used in this report are not considered superior to those employed by the authors of the individual country reports. Wide variations in the mass of pollutants discharged per unit of production are reported in the literature and, depending upon the one selected, the estimated discharge for a country can vary considerably.

Estimates of the mass of industrial pollution discharged to the Atlantic Ocean were included in each country report, and were based upon production rates and the number of employees in conjunction with three sources of information. The first source consisted of actual measurements made by the industries located in the countries visited; the second was studies reported in the literature; and the third was an extrapolation of the United States Environmental Protection Agency Effluent Standards for various industrial sectors. It has been necessary to use all three sources of information with the production data collected in each of the countries to estimate pollution discharges because of the lack of detailed data in the country or in the literature for certain types of industries. A detailed description of the methods used to project pollutional loads is presented in the following section.

C. Pollution loadings

Because of the variability between industries and countries, it has been necessary to develop some technique for uniform projection of the pollution discharges from the West and Central African countries. The most desirable method of projecting pollutional discharges would be to have information on the quantities of waste water discharged and its characteristics measured by a competent laboratory. However, this type of information is not often available. The second method of making projections is based upon the daily

or yearly production of goods or the consumption of water and the number of employees working in a given plant. Because of the paucity of data in the West and Central African Region, it has been necessary to utilize the production, employee or water consumption data to project waste water discharges. It is very difficult to relate the number of employees to pollution discharges because of the effort to take advantage of the large labour force in many of the countries of the Region in order to make industries labour intensive. Although all industries do not attempt to take advantage of the large labour force, the majority do, and for this reason there is great disparity between the numbers of employees used at similar manufacturing plants.

The reliability of results varies from country to country and from industry to industry, but the use of the above-mentioned type of information will result in as accurate an estimate as any other technique that might be employed. Although numerous waste-loading parameters are available for various industries, it has been decided to use the same procedure employed by UNIDO in the Mediterranean Sea study (Carmichael and Nemerow (24)). They used the United States Environmental Protection Agency (EPA) Guidelines (25) in which information was available to convert production data to contaminant loads (see table 2, and annex IV for definitions). In all cases where EPA Guidelines have been used, 30-day average values have been selected to more accurately describe world-wide conditions. The EPA Guidelines describe pollution parameters for effluents from a treatment facility only. Where effluent guidelines are not available for a particular industry, the characteristics of raw waste waters for a given industry have been taken from books by Nemerow (26), Middlebrooks (27), EPA reports (28) (29), Carmichael and Nemerow (24) and from Bulk Standards for Water Consumption and Water Discharge in Various Branches of Industry (30). These data are also summarized in table 2.

Table 2. Raw waste loads based on production rates used to estimate pollution discharges from countries in the West and Central African Region

(Kilograms per ton)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus	Reference
Canned and preserved fruits & vegetables	5.13	6.33		12.8							(25)
Southern (non-breaded) shrimp		253.3	80.0								(25)
Alaskan bottom fish processing		11.3	0.60								(25)
Corn wet milling	9.02	8.93		22.6							(25)
Corn dry milling	0.71	0.63		1.78							(25)
Bulgar wheat flour mills	0.10	0.10		0.25							(25)
Parboiled rice	0.93	0.53		2.33							(25)
Ready-to-eat cereal	2.67	2.67		6.68							(25)
Wheat starch gluten	13.3	13.3		33.3							(25)
Simple slaughterhouse (kg/ton, live killed weight)	0.80	1.33	0.4	2.0							(25)
Dairy products	0.90	1.35		2.3							(25)
Crystalline cane sugar	5.73	1.20		14.3							(25)
Edible oils	22.3	19.5	14.0 *	55.8							(26)
Brewery	10.2	4.73		11.2							(26)
Soft drinks	3.15	4.33		7.9							(26)
Flavouring extracts (chocolate etc.)	-	-		-							(26)
Coffee	625	50		1 562							(27)
Petroleum refining (topping)	0.094	0.080	0.029	0.47	0.010	0.0006	0.0016				(25)
Petroleum refining (cracking)	0.126	0.080	0.048	0.35	0.026	0.0006	0.0016				(28)
Petroleum storage & washing			0.5								(24)
Petrochemicals	0.144	0.116	0.047	0.85	0.084	0.0009	0.0024				(25)
Manufacturing soap flakes & powders	0.067	0.067	0.067	0.33							(25)
Manufacturing bar soap	2.27	3.87	0.27	5.67							(25)

Table 2 (continued)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus	Reference
Tires & inner tubes		0.43	0.11								(25)
Emulsion crumb rubber	2.67	4.33		53.3							(25)
Solution crumb rubber	2.67	4.33	1.07	24.3							(25)
Latex rubber	2.27	3.67	0.93	45.7							(25)
Leather tanning & finishing (hair pulp with chrome tanning)	26.67	33.3	5.0	66.7			0.67				(25)
Pulp, paper & paperboard (unbleached kraft)	18.67	40.0		46.7							(25)
Cement manufacturing (leaching)	2.67			6.7							(25)
Explosives	1.46	29.3		3.87							(29)
Textiles printing & dyeing (assume cloth weighs 0.15 kg/m^2)	22.7	58.0		282.0		0.40	0.40				(25)
Paint & lacquer	0.13	0.20		0.33							(9)
											(30)
Plywood (kg/m^3 of plywood)	0.62			1.56		0.70					(27)
Veneer (hardwood, kg/m^3)	3.64			9.1							(25)
Iron & steel		0.24	0.073		0.61	0.01			0.15		(25)
Primary aluminium smelting by Hall-Heroult process		10.0						6.67			(25)
Phosphate manufacturing		3.33						0.33		1.00	(25)
Sulphuric acid		0.30	0.045								(30)
Ammonium sulphate					2.5						(25)
Plating & galvanizing		1.26					0.018	0.031		0.063	(25)
Fertilizers		3.33						0.33		1.00	(27)
Pharmaceuticals	21.3	47.3		53.3							(30)
Batteries[a/]	6.24	1 560		15.6							(30)

a/ 62.4 kg/t of lead and cadmium are also discharged.

It has been necessary to extrapolate effluent loading data to raw waste water information by considering what constituted the best practical treatment utilized to produce these effluent guideline levels. There are inherent weaknesses in estimating raw waste discharges from an industrial installation by using effluent standards; however, the standards are based upon 85 per cent removal of BOD_5 and SS. The estimates for BOD_5 and SS are more reliable than those for other parameters such as oil and grease, COD, and the heavy metals. It has been decided that a rough approximation and an indication of the types of materials being discharged to the ocean would be more valuable than ignoring those constituents and misleading the countries involved. Production data are reported most often by the industries surveyed; therefore, an example illustrating the method used to make projections utilizing the EPA Guidelines is presented in the following paragraph.

For a petroleum-refining operation the EPA Guidelines state that an effluent from a waste-water treatment facility at a petroleum refining operation (cracking subcategory) should contain, on a 30-day average, 5.5 lb of BOD_5/1,000 barrels of feed stock. To convert this quantity of discharge from a treatment facility to the amount of BOD_5 contained in the raw waste water effluent, it was assumed that 85 per cent removal of the BOD_5 was obtained with the treatment facility. The untreated waste water would, therefore, contain 5.5 : 0.15 or 36.7 lb of BOD_5/1,000 barrels of crude oil refined (16.68 kg/1,000 barrels). It was also assumed that 7.3 barrels of crude oil weighed 1 ton (specific gravity = 0.86), and the discharges in terms of pounds per 1,000 barrels were converted to kilograms per ton of crude oil processed (0.126 kg/ton). Assuming that an oil refinery was processing 4.5 million barrels per year of crude oil, or 616,440 tons per year, the quantity of BOD_5 expected in the raw waste water would be (4,500,000 : 7.3 barrels/ton) x 0.126 kg of BOD_5 per ton, or 77,670 kg BOD_5/year. The same procedure was followed to calculate the other types of pollution discharged from the oil refinery.

An American Petroleum Institute (API) separator was operating at all of the oil refineries visited; the separator is considered an integral part of a refinery operation. The Guidelines presented in table 2 are based upon the production of a treated effluent starting with the effluent from an API separator. Comparing the median BOD_5 effluent concentration measured at 135 refineries (17.25 kg per 1,000 barrels of crude oil) with the calculated discharge based on 85 per cent removal (16.68 kg per 1,000 barrels of crude oil) shows excellent agreement between the two values.

When an industry's pollution production is expressed in terms of thousand pounds of product, it is possible to make the following calculations that are more convenient than the one presented above. Since 1 lb of BOD_5 per 1,000 lb of product is equal to 1 kg per ton of product, the British units can easily be converted to the metric system. If the units are expressed in, for instance, barrels, as used above, it is first necessary to convert the quantity of material to a mass of product before these conversions can be made.

In cases where values for the COD are not available, an approximation can be calculated by converting the value of the BOD_5 with a selected conversion factor. What constitutes an acceptable factor is controversial, but for convenience the ratio of COD to BOD_5 will be assumed to be 2.5 in all of the calculations in this report where actual data are unavailable.

D. Estimated pollution discharges

Production rate method

Compilations of the production data and estimated mass of pollutants being discharged to the ocean for each of the countries on the coast of the West and Central African Region are presented in annex III, tables 1-18. In some countries a complete listing of industry along the coast is

unavailable, and in some cases when a complete listing is available, production rates are not. Production rates are frequently reported for periods other than the immediate past year (1979), and it is rare that estimates for 1980 are available. Through consultations with the local ministries associated with industrialization, estimates of the 1980 production have been made and used to estimate the pollution discharged to the Atlantic Ocean.

When production rates are not available for an existing industry, the fact is noted in the table containing the data for the country, but pollution discharge projections are omitted for that industry. Only installations with reported production rates have been used to estimate the pollution being discharged to the ocean. This approach has resulted in a low estimate of the discharges, but with the exception of three countries (Liberia, Nigeria and Sierra Leone), the number of industries in the coastal areas without production data is insignificant considering the uncertainty involved in the projection techniques.

Industries known to be discharging very little or no pollution to the ocean have been excluded from the estimates even though production data are available. Therefore, there are two classes of industry without pollution discharge projections (annex III): those with production rates but contributing little pollution, and those without production data.

Production rate data for most of the industries in Liberia and Sierra Leone are unavailable, and it is necessary to project the pollution discharged to the ocean by multiplying the estimated pollution discharges from the industries visited by a ratio of the number of local employees in the coastal areas to the number of employees working at the industries visited.

Industrial data method

Some of the industries visited in 7 of the 18 countries visited reported data on the characteristics of the waste water discharged, number of employees, and production rates. These data differ from the data presented in annex III in that the data represent laboratory measurements or an estimate of the pollution discharged by the industry based on the judgement of the consultant and the industry representative.

With such a methodology, the estimated total pollution discharges are calculated by multiplying the total pollution discharged by the industries visited by a ratio of the total number of employees in all industries in the coastal area to the number of employees working at the industries visited. In the case of an unusually large and specialized industry (for example, Blohorn in Ivory Coast), the pollution discharges are not included in the totals for the industries visited to calculate the projected total coastal discharge. These unusually large quantities are added to the projected total.

A comparison of the above estimates with the estimates based upon the Guidelines (table 2) is presented in table 3. There is very little agreement between the results of the two methods. This is not unexpected when the differences in the two methods are considered. In general, the projection method for the industries visited would be expected to yield the higher values, because the industries visited were known to be the largest users of water, and consequently the most likely dischargers of pollutants. When the total pollutant discharges are multiplied by an employee ratio that includes employees from all categories of industry, a high estimate will likely result. This is particularly true where only a few industries discharging large quantities of waste water are included in the number of industries visited.

The most logical method of making projections of pollution discharges is based upon actual data collected by a competent independent laboratory. This option was unavailable to this study and is unlikely to become available in the near future because of the expense involved, lack of equipment and trained personnel.

The data reported in annex V, tables 1-7 are not based only upon laboratory studies. Much of the data are approximations based upon the judgement of the industrial personnel and the consultant visiting the industry. The production data are thought to be the most accurate of all data collected, and estimates of pollution discharge rates based upon production rates and the Guidelines (table 2) are probably the most accurate.

Table 3. Comparison of methods to estimate mass of pollutants discharged to the ocean in seven countries of the West and Central African Region

(Tons per year)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Ivory Coast										
Guidelines	5 216	3 507	815	14 173.7	75.3	5.9	8.8	21.9		65.2
Industry visited	14 880	4 650	536	39 450						
Togo										
Guidelines	1 708	23 898	250	3 885	62.6	1.2	1.6	2 310	9.0	7 000
Industry visited	710	2 450 425	36	2 040						
Sao Tome and Principe										
Guidelines	38	18	27	43						
Industry visited	47	390								
United Republic of Cameroon										
Guidelines	2 187	4 800	259	5 139		2.2	2.1	334		
Industry visited	10 400	9 000	196	32 000						
Gabon										
Guidelines	897	381	5 601	1 840	54.8	54.0	3.8			
Industry visited	1 400	5 200	42	37 200		5.6				
Congo										
Guidelines	1 085	606	1 265	2 656	10.0	3.5	2.4			
Industry visited	402	330	48	800		0.2				
Angola										
Guidelines	449	497	3 766	2 076	41.8	2.7	4.2		0.5	
Industry visited	720	402	115	2 584			1.5			

Note: The difference of two orders of magnitude between the values obtained from the Guidelines and from the industry visited for SS in Togo is because United States phosphate mining operations are carried out utilizing a holding pond or some other preliminary treatment for waste waters before discharge of what is termed raw waste. Since nearly all SS in industrial waste come from phosphate mining operations in Togo, this is reflected in the substantial difference observed in the two figures in the table.

Pollution discharge by zone

As mentioned above, the West and Central African Region was divided into five zones closely approximating the major currents of the Atlantic Ocean. The estimated pollution discharged by industrial sector is calculated for each of the zones by adding the contribution from each country assigned to a zone. Estimated pollution discharges for the five zones are presented in tables 4-8. Although the results are reported to the first decimal point, the intent is not to imply that the results are significant to that level. The values in tables 4-8 are probably accurate to only two or three significant figures. On the map (see figure) are shown the boundaries of the five zones, the type of industries located near the coast, and the magnitude of industrial pollutants discharged to the ocean in each zone.

In tables 4-8, three dots (...) are used to indicate that production data are not available although the category of industry is known to exist in the coastal area of the zone. As explained above, if production data were not available, estimates of the pollution discharged were not attempted.

In Zone I, 41 and 44 per cent of the estimated mass of BOD_5 discharged to the ocean are attributable to the edible oils and leather industries, respectively (table 4). The vast majority of the SS, oil and grease and COD discharged to the ocean are also produced by the edible oils and leather industries. Processing of fish and shrimps makes a significant contribution to the SS and oil and grease discharged, but the contribution is less than 15 per cent of the total discharged.

The estimated mass of pollutants discharged to the ocean in Zone II is shown in table 5. Over 50 per cent of the mass of BOD_5 discharged to the ocean comes from breweries. The estimated mass of SS emanating from breweries comprises only 30.5 per cent of the total SS discharged, but this contribution is over one and one-half times as large as the second largest contribution to SS, which is the fish and shrimp industry (19%). Oil and grease discharges to the ocean from Zone II result principally from the edible oil (47%), petroleum refining (33%), and fish and shrimp (18%) industries.

MAJOR INDUSTRIAL POLLUTANTS IN THE WEST AND CENTRAL AFRICAN REGION

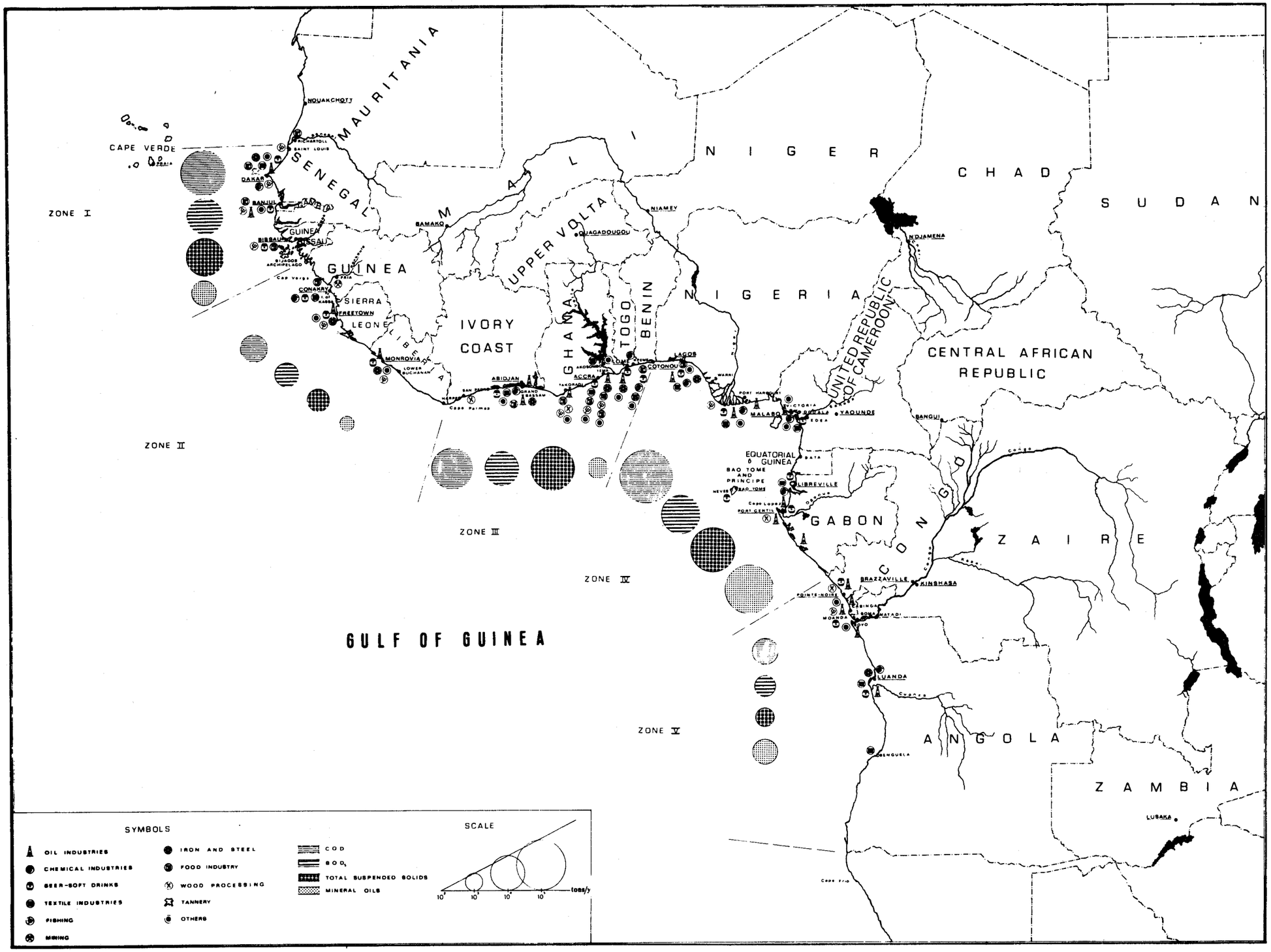

Table 4. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone I of the West and Central African Region

(Tons per year)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Petroleum refining & handling	116.1	74.2	44.1	331.1	25.0	0.6	1.5			
Edible oils	4 984.1	4 356.3	3 129.0	12 471.5						
Beer	418.2	193.9		459.2						
Soft drinks	154.4	212.2		387.1						
Soap & detergents	63.7	108.5	7.7	159.3						
Fish & shrimps		2 338.4	557.0							
Sugar	779.8	962.2		1 945.6						
Textiles	230.0	587.8		1 857.8		4.1	4.1			
Paint	0.5	0.8		1.3						
Rice	2.8	1.6		7.0						
Dairy products	20.0	30.0		51.2						
Fruits & vegetables	27.5	33.9		68.6						
Meat	0.6	1.0	0.3	1.5						
Leather	5 334.0	6 660.0	1 000.0	13 000.0			134.0			
Fertilizer		381.6						38.2		114.6
Asphalt	0.7	0.6	0.2	4.1	0.4	0.1	0.1			
Metal working & coating	0.3	1.7	0.1	0.8	0.1	0.1		0.7		
Total	12 132.7	15 944.7	4 738.3	31 746.1	25.5	4.7	139.6	38.9		114.6

Table 5. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone II of the West and Central African Region

(Tons per year)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Petroleum refining	598.3	379.9	227.9	1 662.0	123.5	2.8	7.6			
Edible oils	515.9	451.1	323.9	1 290.4						
Beer	1 704.5	792.3		1 876.0						
Soft drinks	192.2	264.3		480.6						
Alcohol & blending of spirits	0.4			1.0						
Soap & detergents	84.1	143.5	10.1	211.1						
Fish & shrimps		490.8	125.3							
Sugar	68.8	14.4		171.6						
Textiles	10.2	26.1		126.9						
Explosives	1.0	20.5		2.7		0.2	0.2			
Paint	0.3	0.5		0.8						
Flour	3.7	3.3		9.3						
Fruits & vegetables	7.4	9.1		18.4						
Total	3 186.8	2 595.8	687.2	5 850.8	123.5	3.0	7.8			

The estimated mass of pollutants discharged to the ocean in Zone III is shown in table 6. The majority of the mass of BOD_5 discharged to the ocean is distributed between the edible oils (19%), brewing (21%), cement (14%), and coffee (20%) industries. Textile industries contribute an additional 7 per cent of the mass of BOD_5 discharged. Phosphate mining contributes over 74 per cent of SS discharged to the ocean. The second largest contribution to SS discharged is the textile industry (5.5%), but comparatively the mass is insignificant. Oil and grease discharges principally result from the edible oils industries (72.4%). Large quantities of fluoride and total phosphorus are discharged by the phosphate mining industry.

The estimated mass of pollutants discharged to the ocean in Zone IV is shown in table 7. Petroleum refining and handling operations account for 6.8 per cent of the BOD_5 and for 99.0 per cent of the oil and grease discharged to the ocean. The majority of the crude oil production and petroleum refining along the West African coast occurs in Zone IV. The distribution of pollution discharges from other industrial sectors is similar to that observed in the other four zones except that activity in Zone IV is generally on a much larger scale. For example, pulp and paper manufacturing occurs in other zones, but on such a relatively small scale that pollution discharges are an insignificant part of the total; whereas, in Zone IV the estimated mass of pollution (SS) contributed by the pulp and paper industry is larger than the total mass of SS discharged from Zone V.

The estimated mass of pollutants discharged to the ocean in Zone V is shown in table 8. The estimated discharges to the ocean from Zone V are the lowest of any of the five zones. Beer production accounts for 45 per cent of BOD_5 discharged in the zone; petroleum refining and handling contribute over 17 per cent of the BOD_5 discharged; wood products (10%); edible oils (8%); and textiles (7%) are the other large contributors to the total mass of BOD_5 discharged. Approximately 98 per cent of the oil and grease discharged in the Zone results from petroleum refining and handling. SS discharges come principally from petroleum (18%), beer (31%), and textiles (27%).

Table 6. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone III of the West and Central African Region

(Tons per year)

Type of Industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Petroleum refining & handling	537.0	341.2	204.5	1 496.3	111.4	2.6	6.8			
Edible oils	1 828.6	1 599.0	1 148.0	4 575.6						
Beer	2 007.4	930.9		2 204.2						
Soft drinks	241.6	332.1		605.9						
Alcohol & wine bottling	187.2	257.4		469.6						
Soap & detergents	93.6	159.5	11.2	234.0						
Textiles	684.5	1 752.2		8 519.2		12.1	12.1			
Paint	0.5	0.9		1.5						
Flour	57.7	51.3		144.7						
Dairy products	189.0	283.5		483.0						
Fruits & vegetables	82.1	101.3		204.8						
Meat	1.4	2.2	0.7	3.4						
Fertilizer		23 525.9	0.9		6.3			2 330.8		7 063.0
Asphalt	27.8	22.4	9.1	164.1	16.2	0.2	0.5			
Steel		14.4	4.4		36.6	0.6			9.0	
Aluminium		1 874.4						1 250.2		
Metal plating & coating		44.6					0.6	1.1		2.2
Cement	1 355.0			3 400.3						
Coffee	1 875.0	150.0		4 686.0						
Cocoa products	329.7	288.3	207.0	824.9						
Wood products (plywood, veneers, lumber)	13.2			33.2		2.6				
Total	9 511.3	31 731.5	1 585.8	28 050.7	170.5	18.1	20.0	3 582.1	9.0	7 065.2

Table 7. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone IV of the West and Central African Region

(Tons per year)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Petroleum refining & handling	1 386.0	712.0	59 528.4	3 850.0	286.2	6.6	17.6			
Edible oils	698.0	610.4	438.2	1 745.6						
Beer	5 371.3	2 490.8		5 897.9						
Soft drinks	726.8	998.9		1 822.0						
Soap & detergents	276.8	471.9	33.0	691.9						
Textiles	5 428.6	16 426.1		79 864.7	0.1	113.2	113.2			
Paint	236.4	355.6		592.0						
Dairy products	0.2	0.3		0.6						
Wood products (plywood, veneers, lumber)	96.5	20.4		242.0		108.3				
Pulp & paper	1 179.0	2 526.0		2 949.0						
Alcohol & blending of spirits	0.1	0.1		0.2						
Tubes & tires		1.7	0.4							
Steel & fabrication		2.3					0.1	0.1		0.1
Matches	...	...								
Glass	...	...								
Fruits & vegetables	25.7	31.7		64.1						
Aluminium		500.0						333.5		
Blankets & linen	...	...								
Rubber	4.5	7.3	1.9	91.3						
Shoes	...	...								
Batteries[a/]	9.4	2 340.0		23.4						
Fishing		1 921.0	102.0							

Table 7 (continued)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Flour	60.0	60.0		150.0						
Sugar	158.1	33.1		394.7						
Canned meat	0.8	1.3	0.4	2.0						
Cement	3 791.4			9 514.0						
Total	20 449.6	29 510.9	60 104.3	107 895.4	286.3	228.1	130.8	333.6		0.1

a/ 93.6 t/a of lead and cadmium are also discharged.

Table 8. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone V of the West and Central African Region

(Tons per year)

Type of industry	BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Petroleum refining & handling	342.1	238.0	4 948.6	1 165.3	61.1	1.8	4.8			
Edible oils	164.1	143.5	103.0	410.6						
Beer	900.7	417.7		989.0						
Soft drinks	56.7	77.9		141.8						
Soap & detergents	5.9	10.1	0.7	14.7						
Fish & shrimps	...	...								
Sugar	77.4	16.2		193.4						
Textiles	144.7	369.8		1 797.8		2.6	2.6			
Explosives	...	...								
Paint	0.1	0.1		0.1						
Flour	96.6	85.7		242.1						
Dairy products	...	...								
Wood products (plywood, veneers, lumber)	198.4			496.1		2.1				
Pulp & paper	...	...								
Cement	...	...								
Tubes & tires		0.1	0.1							
Steel		1.0	0.3		2.4	0.1			0.5	
Total	1 986.6	1 359.9	5 052.6	5 450.8	63.5	6.5	7.4		0.5	

A comparison of the pollution loads for the five zones shows that Zone IV discharges far more pollution than any other zone. Of the total pollution discharged to the ocean from the 18 countries of the Region, it is estimated that 43 per cent of BOD_5, 36 per cent of SS, 83 per cent of oil and grease, and 60 per cent of COD are discharged from Zone IV. Zones I and III contribute almost equally the majority of the remaining pollution load except that Zone III discharges 38 per cent of the total SS discharged in the Region. This large percentage of SS is principally attributable to phosphate mining operations. Zones II and V discharge only a minor proportion of the pollution to the ocean in the Region.

E. Comparison of municipal and industrial waste discharges

Table 9 shows a comparison of the potential mass of BOD_5 and SS discharged to the ocean by the population of the major coastal cities and industries. The BOD_5 estimate is based upon a per capita discharge of 64 grams per day, and 91 grams per capita per day is used to estimate SS discharged by the population of the coastal cities. The estimated industrial pollution discharged to the ocean for each country is taken from table 18.

Only in Zones I and IV does the percentage of BOD_5 discharged by industry exceed 12 per cent of the municipal discharge. Both Zones I and IV are much more industrialized than the other zones. The percentage of SS discharged by industry is approximately the same as that observed for BOD_5, the exception being Zone III where large phosphate washing operations are located. The phosphate washing operations result in an exceptionally large discharge of SS.

In industrialized nations the discharge of BOD_5 and SS usually exceeds 50 per cent of the municipal waste water discharges and in many locations can exceed the municipal discharges. Only Zones I and IV are approaching full industrialization, and in these two zones most of the industrial activity is concentrated in Nigeria and Senegal. Of the five zones, Zone IV is in need of immediate planning and implementation of pollution control programmes. Other areas of concentrated activity on the coast also need immediate attention, but the greatest potential for a serious problem to develop on a large scale exists in Zone IV.

Table 9. Comparison of estimated pollution discharged to the ocean by the populations of the major coastal cities and industries in the West and Central African Region

Zone	Country and major coastal cities	Estimated population[a/] in 1980 (In thousands)	Estimated pollution discharged (t/a) By population BOD_5	By population SS	By industry BOD_5	By industry SS
I	Senegal	5 585			11 201	14 950
	Saint Louis	97	2 266	3 222		
	Dakar	879	20 533	29 200		
	Ziguinchor	80	1 869	2 658		
	Thiés	129	3 013	4 285		
	Gambia	591			310	438
	Banjul	45	1 051	1 495		
	Guinea Bissau	1 006			622	557
	Bissau	100	2 336	3 322		
	Zone total		31 068	44 182	12 133	15 945
	Industrial percentage				39	36
II	Guinea	4 983			427	370
	Boffa	134	3 130	4 451		
	Conakry	530	12 381	17 607		
	Forécariah	146	3 411	4 850		
	Sierra Leone	3 421			1 677	1 179
	Freetown	316	7 382	10 498		
	Liberia	1 766			1 083	1 048
	Monrovia	221	5 163	7 342		
	Zone total		31 467	44 748	3 187	2 597
	Industrial percentage				10	6
III	Ivory Coast	7 548			5 216	3 507
	Abidjan	1 573	36 745	52 255		
	Ghana	11 473			1 414	3 669
	Accra-Tema Area	965	22 542	32 057		
	Takoradi-Sekondi	210	4 906	6 976		
	Cape Coast	68	1 588	2 259		
	Togo	2 548			1 708	23 899
	Lomé	249	5 817	8 272		
	Benin	3 558			1 174	657
	Porto-Novo	119	2 780	3 953		
	Cotonou	203	4 742	6 744		
	Zone total		79 120	11 2516	9 512	31 732
	Industrial percentage				12	28

a/ See (1).

Table 9 (continued)

Zone	Country and major coastal cities	Estimated population[a/] in 1980 (In thousands)	Estimated pollution discharged By population BOD5 (t/a)	By population SS (t/a)	By industry BOD5 (t/a)	By industry SS (t/a)
IV	Nigeria	82 800			17 328	24 311
	Lagos	4 100	95 776	136 202		
	Port Harcourt	276	6 447	9 169		
	United Republic of Cameroon	8 355			2 187	4 800
	Douala	532	12 427	17 673		
	Victoria	34	794	1 129		
	Equatorial Guinea	298				
	Malabo	37	864	1 229		
	Bata	27	630	897		
	Sao Tome and Principe	80	1 869	2 657	38	18
	Gabon	1 300			897	381
	Libreville	251	5 863	8 338		
	Port-Gentil	78	1 822	2 591		
	Zone total		126 492	179 885	20 450	29 511
	Industrial percentage				16	16
V	Congo	1 548			1 085	606
	Pointe-Noire	164	3 831	5 448		
	Zaire	28 188			452	257
	None					
	Angola	7 067			449	497
	Luanda	602	14 063	19 998		
	Lobito	74	1 729	2 458		
	Benguela	51	1 191	1 694		
	Zone total		20 814	29 598	1 986	1 360
	Industrial percentage				10	5
	Region total		288 961	410 929	47 269	81 145
	Total industrial percentage				16	20

a/ See (1).

F. Pollution problems

During the visits to the West and Central African Region, it was observed that industrial development was relatively limited and pollution discharges from the industries were creating little impact on the environment except in isolated cases. A significant change in the impact on the environment will likely occur because of the concerted efforts being made towards expanding industry in the Region. The lack of a significant pollution problem in most countries of the Region at this time allows Governments and industry to begin a planning process that will allow them to avoid creating environmental problems. Avoiding such problems is far less expensive than trying to correct them after they develop.

The major problem mentioned by the local citizens and observed by the consultants was the oil discharges that accumulate on the beaches. Boat owners also mentioned the coating of the sides of boats with oil. Two sources of oil were identified by the individuals interviewed and through observations: the first was credited to petroleum loading terminals, oil exploration activities and oil tankers cleaning bilges near the shore after unloading at oil refineries; tankers transporting petroleum from the Middle East were also thought to contribute. The second was the likely result from the discharge of used automobile crankcase oil into the drainage canals and sewers of the cities located along the coast. Many service stations apparently do not have oil-traps to capture the crankcase oil prior to discharging water to the ocean. This discharge has a significant impact on the streams, estuaries, and ocean near the cities of the Region. The problem could be solved inexpensively by requiring that the garages construct oil-traps.

Floating logs from lumber operations are a navigational hazard and accumulate on certain beaches. In certain areas of the Region, large quantities of oil, brewery, tannery, non-carbonated beverages, textile and food processing wastes are being discharged. These discharges have polluted the receiving waters, but the concentrations have not reached a level that causes obnoxious odours or unsightly solids accumulations. What impact these contaminants may be having on the health of the people remains unassessed, but in many areas of the Region drinking water is obtained from streams receiving industrial and human wastes. Clothes are also washed in these streams.

In most of the countries of the Region, visual observation of the rivers, estuaries, and streams indicated that the major types of materials discharged are the result of human activity and not industrial. However, there were exceptions and efforts should also be directed towards solving localized industrial problems.

The immediate needs in most areas were solutions to the human pollution problems. It is strongly recommended that planning begin, and a long-range management plan be implemented to avoid the creation of industrial pollution problems. It is essential that management planning be implemented immediately for the entire Region to avoid costly rehabilitation efforts.

G. Industrial waste treatment and disposal practices

Waste treatment in the countries of the West and Central African Region is virtually non-existent. Only an occasional sedimentation basin, grease trap or occasional sand filter was observed by the consultants as they visited industries in the Region. The role of waste-water treatment in pollution control is discussed in annex I.

API separators were observed at most of the petroleum handling and refining facilities, but this device is an integral part of most petroleum operations and is generally not considered to be waste-water treatment as such. The installation of an API separator makes a significant difference in the quantity of oil discharged to the environment, and also results in considerable financial savings because the recovered oil is recycled through the operation.

The majority of the industries in the West and Central African Region are producing waste products that are amenable to biological treatment. Planning of waste-water treatment facilities for the industries should be co-ordinated with the efforts made for the various municipal waste-water treatment systems. It is likely that a combined treatment facility would be far more economical for everyone involved. If new industries that produce wastes not amenable to biological treatment are attracted to the area, then some form of pretreatment could be required before the industry could discharge into the municipal system.

H. Educational needs

It was not obvious from the visits that the appropriate public officials are sensitive to potential environmental problems due to pollution. In addition, very few people receive an education in pollution control and environmental protection. In order to protect the healthy environment that currently exists in most areas of the Region, it is essential that people be trained in environmental engineering and science to develop programmes that will allow expansion of industry while protecting the environment.

The development of the tourist industry has a high priority with the Governments of many of the countries of the Region, and if this industry is to develop to its maximum potential, it is essential that the industrialization of the countries be co-ordinated with environmental protection activities. The survival of the tourist industry is indissolubly linked with the protection of the environment.

Local universities and technical programmes should be encouraged to begin a long-range plan to produce the professionals and technicians required to protect the environment of the West and Central African Region. Adequate planning at this stage will ensure that the environment is not degraded beyond repair. Ministry personnel knowledgeable in the control of pollutional discharges and the protection of the environment were not encountered in most of the countries visited. It is imperative that individuals become knowledgeable and begin to consider the protection of the environment when expansion is considered.

I. Projected industrial development

A summary of the projected industrial development for 13 of the 18 countries visited is presented in table 10. The production rates were frequently unknown or unavailable, and 5 of the countries did not report information on future development. All 18 countries were anticipating extensive industrial development within the next 10 years even though information on specific plans was not available.

As shown in table 10, many large industries are planned in the coastal area of the West and Central African Region. Because of extensive natural resources, it is very likely that rapid development will occur in most countries of the Region. Unfortunately, inadequate data are available to estimate the likely increase in the discharge of industrial pollution to the ocean, but the information provided shows that a significant increase in the discharge of industrial pollution is likely to occur within the next 5 to 10 years. Where localized pollution problems exist, they will be compounded as new development occurs unless development is co-ordinated with an environmental protection plan. Industrial developments will also accelerate the increase in population, thereby exacerbating the pollution problems caused by domestic sources that according to the survey are already the major sources of pollution loads discharged into the marine environment.

Table 10. Projected industrial establishments in the West and Central African Region

Country[a/]	Location	Company	Products	Estimated production rate	Estimated number of employees	Estimated year of completion
Senegal	Dakar	SIES	Phosphoric acid fertilizer	300 t/d 300 t/d	...	...
Senegal	Casamance		Oil extraction	...	...	...
Senegal		SAR	Petroleum refinery	...	...	...
Senegal	Kadac	SOTEXKA	Cotton textiles	2 000 t/a	...	...
Senegal			Starch & glucose from manioca	...	...	...
Senegal			Sugar & alcohol	...	...	...
Senegal	Cap Vert	ICOTAF	Textiles	...	127	by 1982
Senegal	Cap Vert	SIPL	Dairy products	...	55	by 1982
Senegal	Cap Vert	SONACOS	Edible oil	...	30	by 1982
Senegal	Casamance		Fruit juice	...	34	by 1982
Senegal	Casamance	AMERGER	Fish	...	126	by 1982
Senegal	Cap Vert	AGROCAP	Food	...	76	by 1982

Table 10 (continued)

Country[a]	Location	Company	Products	Estimated production rate	Estimated number of employees	Estimated year of completion
Senegal	Casamance		Dairy products	...	...	by 1982
Senegal	Cap Vert	SOSACHIM	Chemicals	...	21	by 1982
Senegal	Cap Vert	PINSER	Paints	...	10	by 1982
Gambia		FMC	Fish	...	...	...
Gambia			Sugar[b]	...	...	...
Gambia			Oil refinery[b]	...	...	...
Guinea-Bissau	Bissau	SEMEPESCA	Fish	twice the present production	...	...
Guinea-Bissau			Fish meal	...	...	...
Guinea-Bissau	Northern zone		Sugar refinery	10 000 t/a	...	...
Guinea-Bissau			Textiles[b]	...	...	...
Guinea-Bissau			Leather[b]	...	...	...
Guinea-Bissau	South-eastern zone		Bauxite[b] & aluminium oxide extraction	...	...	...
Guinea-Bissau			Pulp paper[b]	...	...	...
Guinea-Bissau			Petroleum[b] extraction & refinery	...	...	...
Guinea-Bissau			Phosphates[b] & fertilizers	...	...	...
Guinea	Conakry	SAPROCIMENT	Cement	250 000 t/a	...	...
Guinea	Conakry	Pilot centre	Electromechanical workshop	...	...	...
Guinea	Conakry		Footwear[b]	440 000 pieces/a	...	...
Guinea	Conakry		Fertilizers[b]	100 000 t/a	...	...
Guinea			Batteries[b]	...	...	...

Table 10 (continued)

Country[a/]	Location	Company	Products	Estimated production rate	Estimated number of employees	Estimated year of completion
Guinea			Paper pulp[b/]	...	...	...
Guinea			Fish canning[b/]	...	...	...
Guinea			Steel[b/]	18 000 t/a	...	...
			Shapes[b/]	3 000 t/a	...	...
Guinea			Milk[b/]	140 000 t/a	...	...
Guinea			Caustic soda[b/]	55 000 t/a	...	...
			Table salt[b/]	40 000 t/a	...	...
			Coarse salt[b/]	25 000 t/a	...	...
Guinea			Wheat flour[b/]	57 300 t/a	...	...
Guinea			Soap[b/]	15 t/d	...	...
Guinea			Petroleum refinery[b/]	20 000 bbl/d	...	1985-1990
Guinea			Lubricants[b/]	12 000 t/a	...	...
Sierra Leone	Freetown		Slaughterhouse	...	...	...
Sierra Leone	Makeni		Slaughterhouse	...	...	...
Sierra Leone		Integrated Fish Meal Ind. Ltd.	Fish meal	...	...	...
Sierra Leone		SLPMB	Edible oil refinery	...	...	...
Ivory Coast		SIR	Petroleum refinery	4 million t/a	...	...
Togo	Kpémé		Phosphoric acid	1 million t/a of phosphate mineral	...	...
Togo	Lama-Kara	TOGOTEX	Textiles	...	...	...

Table 10 (continued)

Country[a/]	Location	Company	Products	Estimated production rate	Estimated number of employees	Estimated year of completion
Togo	Lama-Kara	Brasserie du Benin	Beer	...	...	...
Benin	Seme		Petroleum refinery	600 000 t/a	...	...
Benin			Mixing & packaging of fertilizers	...	...	...
United Republic of Cameroon	Cap Limboh	SONARA	Petroleum refinery	2 million t/a	...	1981
United Republic of Cameroon	Edea	CELLUCAM	Paper pulp	130 000 t/a	...	end of 1980
Gabon	Kango	SOGACEL	Paper pulp	700 t/d	...	1982
Congo	Pointe-Noire		Paper pulp	...	...	1985
Zaire			Phosphate[b/]	...	...	...
Zaire			Aluminium[b/]	...	...	...
Zaire			Fertilizers[b/]	...	...	...
Zaire			Calcium carbide[b/]	...	...	...
Zaire			Specialized steel[b/]	...	...	...
Angola	Zaire region		Fertilizers[b/]	...	...	...
Angola	Luanda and Soyo		Ammonia[b/] Urea Methanol	...	...	...

a/ Given in geographical sequence from north to south.
b/ Feasibility study.

Annex I

WASTE-WATER TREATMENT IN POLLUTION CONTROL*/

Stream degradation

When many types of substances are discharged into a receiving body of water, the water quality is degraded to such an extent that beneficial uses are no longer possible. No one industry discharges all types of pollutants, but the discharge of only one substance in sufficient quantity can cause irreparable harm.

Components with pollution potential

Industrial waste discharges contain solids (floating, suspended, settleable, and dissolved), organic matter, nutrients, toxic substances, acids, and alkalies; frequently the discharged water is hot enough to cause temperature changes in the receiving stream.

Floating solids (grease and scum) are unsightly and can affect natural aquatic characteristics such as oxygen transfer and light penetration.

Settleable solids can form sludge blankets which decompose and produce odorous gases and floating mats on the surface of the water body. Blankets of solids also interfere with natural organisms which live attached to the stream bed. Fish hatching is also impeded by settleable solids. Suspended solids detract from the appearance of water and impede light penetration, probably retarding the growth of aquatic vegetation necessary for the survival of other life in the stream or lake. Water treatment for human consumption or other industrial processes is necessary when large concentrations of suspended solids are present.

Organic matter discharged to a water course depletes the dissolved oxygen supply in water. The depletion of the dissolved oxygen supply results in a change in the composition of organisms that inhabit a stream.

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*/ Extracted from E.J. Middlebrooks, Industrial Pollution Control - vol. I, Agro-Industries (New York, Wiley-Interscience, 1979) with permission from the publishers.

When the dissolved oxygen level drops below approximately 5 mg/l, the more desirable species of fish such as trout and bass leave the area and coarser types predominate. Below an oxygen level of approximately 2 mg/l fish disappear and the environment shifts toward anaerobic species. Only the elimination of the discharge of organic matter or mechanical mixing which increases gas transfer can help the stream to recover from the oxygen-depleted state.

The addition of nutrients such as phosphorus, nitrogen, and trace elements can result in excessive algal growth, and when this growth dies it can exert an oxygen demand which may cause fish kills, as well as unpleasant odors and tastes. Excessive algal growth also interferes with the recreational and domestic uses of a body of water.

Temperature changes in water can produce adverse effects on all aquatic organisms, and the reaeration rate slows with increases in temperature. Fish and other organisms function best within certain temperature limits, and when this optimum range is violated, the organisms move to another location or die. Rapid changes in temperature are extremely dangerous to aquatic life.

Toxic compounds are common constituents of some industrial processes and frequently find their way into streams. Where toxic substances are discharged, however, plant and animal life may be affected and the water becomes unsuitable for recreation or human consumption.

Acidity and alkalinity concentrations in wastewater can be critical factors in the quality of a receiving stream. Although not an exact measure of acidity and alkalinity, the pH value is frequently used to measure the effect that a discharge may produce. Effluents from wastewater treatment plants are usually controlled near neutrality, or a pH value of 7. Wide fluctuations or prolonged changes in the pH value of a receiving stream can be devastating to an aquatic environment.

Management philosophy

It is advantageous to consider excess materials as an additional resource to be utilized either in the form discarded or after further processing. This approach to waste processing is economically and environmentally important. If a government or ministry considers protection of the environment and maximum utilization of the base resource important, then the production management and the employees probably have an entirely different attitude toward performing this function and are more likely to take pride in producing high quality effluents and in recovering and utilizing as much of the material as possible. The importance of protecting the quality of the environment and the impact that improper handling of waste materials has on the employees' life styles and the nation as a whole must be emphasized.

Environmental protection must be stressed when management is expected to meet production quotas. Under such production systems management tends to concentrate its talent on product output, if not reminded continually of the value placed on environmental protection by the ministry and the nation. Environmental protection must be considered as a valuable natural resource in the same manner as the labor, materials, and the capital investment required to produce the basic product.

The costs for environmental protection must be paid either now or in the future. The most effective method of handling excess products is to incorporate the facilities for protecting the environment and for further processing of the excess into useful products. It is much less expensive to install such equipment initially than to convert a production process and add pollution control equipment later; moreover, it has proved cheaper to spend today's money than an inflated one of a later date. However, it is still less expensive to add to existing systems the facilities for processing materials than to allow excess to be wasted as environmental pollutants; to clean these up at a future time is costly and difficult. Indeed, the damage to the environment before installing equipment to correct a situation may be impossible to rectify. It is burdensome to assess the economic losses incurred by people and industry because of delayed pollution control; however, these are real economic factors which must be considered and emphasized. The losses of health, happiness, and productivity of people owing to environmental pollution are the greatest costs of all.

Long-term economic effects of industrial pollution must not be neglected. If an industry is allowed to develop in an area without pollution control facilities, eventually the area may deteriorate to a level unacceptable to many of the residents, and they move away. Relocation of the population depletes the tax base for public services and results in a further deterioration of the local living conditions. With an added tax burden the community is forced to extract more support from the industry, resulting in higher product costs. Environmental pollution also influences maintenance costs for homes, public buildings, and thoroughfares, as well as the industrial buildings and equipment themselves.

Pollution control is a good business practice which a nation cannot afford to neglect. Maintenance of the environment is much the same as maintenance of machinery, automobiles, and other devices: if a nation does not routinely care for the environment, eventually it deteriorates. In this case, deterioration may occur to a level that is intolerable to flora and fauna and cost the people and the government more than the industry produces. A nation must not sacrifice its customs and desirable environment to short-term economic advantage.

Annex II

QUESTIONNAIRES[a/]

A. Survey Questionnaire on Industrial Wastes Discharged Directly or Indirectly[b/] into Coastal Waters (Long term)

UNIDO project carried out in co-operation

with the

UNEP Regional Seas Programme

SURVEY OF MARINE POLLUTANTS FROM INDUSTRIAL SOURCES IN THE WEST AND CENTRAL AFRICAN REGION

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a/ These questionnaires were sent out unedited and are reprinted as they were issued.

b/ An indirect discharge is understood to mean a discharge into a river or stream located not more than 20 km from the coast.

1. Industry identification

1.1 Country: .....

1.2 Province, district: .....

1.3 Place where industrial wastes are disposed of: .....

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1.4 Description of general setting where industry is located: .

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.....

1.5 Name of industry and address: .....

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2. Classification of industry (check appropriate classification or identify otherwise here): .....

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1110	Agriculture and livestock	( )
1110	Feedlot	( )
2110	Coal mining and preparation	( )
2200	Oil mining	( )
2302	Mineral mining	( )
2901	Store quarrying, clay and sand pits	( )
3111	Meat packing	( )
3112	Cannery	( )
3114	Fish	( )
3117	Bakery	( )
3118	Beet sugar	( )
3119	Cane sugar	( )
3121	Coffee	( )
3121	Pickle	( )
3121	Rice	( )

3131-3133	Brewery, distillery, pharmaceutical and winery	( )
3134	Soft drink	( )
3211	Textile	( )
3231	Tannery	( )
3311	Plywood glue plant	( )
3320	Wood furniture	( )
3411	Pulp and paper	(,)
3412	Building paper	( )
3420	Printing	( )
3511	Acid	( )
3511	Explosives	( )
3511	Formaldehyde	( )
3511	Naval stores	( )
3511	Other inorganic chemicals	( )
3511	Phosphates	( )
3511	Radioactive waste from fission and fusion products and laboratories	( )
3511	Wood preservation	( )
3512	Fertilizer	( )
3512	Pesticide	( )
3513	Plastic and resins	( )
3521	Paints	( )
5523	Animal glue	( )
3523	Soap and detergent	( )
5529	Candle making	( )
3529	Cornstarch	( )
3529	Photographic wastes	( )
3530	Oil refinery	( )
3540	Coke mill	( )

3540	Fuel oil	( )
3540	Petrochemicals	( )
3551	Rubber	( )
3620	Glass	( )
3692	Cement	( )
3699	Asbestos	( )
3710	Steel mill	( )
3720	Iron foundry	( )
3720	Other metal working	( )
3819	Metal plating	( )
3821	Motor industry	( )
4103	Steam power	( )
4200	Water treatment	( )
9520	Laundry	( )

3. Production of goods

3.1 Type of product

For each type of product, indicate production units/year[1/]

Type of product	Max.	Min.	Average	Year
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

1/ i.e.: tons/year, cases/year, square meters/year etc.

3.2 Raw materials

For each raw material, indicate the quantities/year

Name of raw material	Max.	Min.	Average	Year
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

3.3 Type of employees in plant

Description	Max.	Min.	Average	Year
Workers	.....	.....	.....	.....
Staff	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

3.4 Indicate the number of daily shifts of 8 hours duration

1 ( ) 2 ( ) 3 ( )

3.5 Percentage of local community employed at plant(s): .....

.....

4. Industrial uses of water

4.1 The water used in the plant is taken from:

Well(s) of the industry ..... ( )

Municipal supply ..... ( )

Surface waters ..... ( )

Other (specify) ..... ( )

4.2 The inlet water is used for:

Process	..... m^3/d	average
Cooling	..... m^3/d	"
Boiler	..... m^3/d	"
Sanitary sewage	..... m^3/d	"
Other (specify)	..... m^3/d	"
TOTAL daily consumption of water	..... m^3/d	average

4.3 Give a summary description of the main processes involving the use of water

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5. Industrial wastewater collection

5.1 Type of industrial wastewater collection

- Combined for all effluents ..... ( )
- Separate for process water, domestic water and rain run-off ..... ( )
- Other (specify) ..... ( )

5.2 Waste water outfalls

- One general outfall ..... ( )
- More than one outfall ..... ( )

In case of many outfalls specify, if possible, the nature of the process waters and the total daily quantity for each outfall.

- Outfall No. 1 .....

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- Outfall No. 2 .....

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- Outfall No. 3 .....

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- Outfall No. 4 .....

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.....;.....m^3/day

- Outfall No. 5 .....

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.....;..... m^3/day

6. Industrial wastewater treatment

	Treated		Untreated		Year
	m^3/year	%	m^3/year	%	
6.1 Total industrial wastewater m^3/year					
6.1.1 Estimated part discharged in a municipal system					
6.1.2 Estimated part discharged by industry directly into receiving waters					
6.1.3 Estimated part re-used or recirculated					

6.2 Industrial wastewater treatment

Type of wastewater	Total discharged quantity m^3/year	Quantity discharged in a community system				Quantity discharged directly into receiving waters				Type of treatment 2/	
		Treated		Untreated		Treated		Untreated		Treated wastewaters into municipal sewers	Treated wastewaters directly into receiving waters
		m^3/y	%	m^3/y	%	m^3/y	%	m^3/y	%		
Process											
Cooling											
Boiler											
Domestic sewage											
..... (other)											
TOTAL											

2/ Type of treatment abbreviations:

P : Process technical measure (re-use, recycling, separation of waters, evaporation, etc.)
G : Preliminary (screening, grit removal, flotation)
H : Primary sedimentation
C : Chemical treatment (chemical oxidation or reduction, acid-alkaline neutralization, precipitation, coagulation and sedimentation, etc.)
S : Secondary (sand filters, trickling filters, activated sludge, oxidation ponds, etc.)
T : Tertiary (absorption, electrodialysis, ionic exchange, etc.)
A : Any other (specify)

Use a combination of letters where more than one type of treatment is being applied.

6.3 Summary description of type of final treatment before discharge

Process technical measures (re-use, recycling, separation, etc.) ...

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Preliminary: .....

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..... Removal efficiency .....

Primary: .....

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.....Removal efficiency .....

Secondary: .....

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..... Removal efficiency .....

Tertiary: .....

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..... Removal efficiency .....

Chemical treatment: .....

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..... Removal efficiency .....

Any other: .....

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..... Removal efficiency .....

	OUTFALL No.	1				2				3				4				5			
		max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysis or est.
7.2.1	Volume (m^3/day)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
7.2.2	POLLUTANTS																				
7.2.2.1	General																				
	- Temperature ^oC	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- Colour	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- Odour	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.
	- pH	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.
7.2.2.2	Solids																				
	- Settleable solids(ml/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	..
	- Total suspended solids (TSS, mg/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	..
	- Volative suspended solids (VSS, mg/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
7.2.2.3	Organic matter																				
	- BOD_5 mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- COD mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- TOC mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- others (specify)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
		...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
		...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....

OUTFALL No.	1				2				3				4				5			
	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysi or est.
7.2.2.5 Specific organic pollutants																				
- Mineral oils (hexane soluble) mg/l																				
- Methylene blue active substances (MBAS) mg/l																				
- Phenols (mg/l)																				
- Chlorinated organic compounds (specify) mg/l																				
- Polychlorinated biphenyls (PCB) mg/l																				
- others (specify)																				

4. Industrial uses of water

4.1 The water used in the plant is taken from:

Well(s) of the industry ..... ( )

Municipal supply ..... ( )

Surface waters ..... ( )

Other (specify) ..... ( )

4.2 The inlet water is used for:

Process	..... m^3/d	average
Cooling	..... m^3/d	"
Boiler	..... m^3/d	"
Sanitary sewage	..... m^3/d	"
Other (specify)	..... m^3/d	"
TOTAL daily consumption of water	..... m^3/d	average

4.3 Give a summary description of the main processes involving the use of water

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5. Industrial wastewater collection

5.1 Type of industrial wastewater collection

- Combined for all effluents ..... ( )
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- One general outfall ..... ( )
- More than one outfall ..... ( )

In case of many outfalls specify, if possible, the nature of the process waters and the total daily quantity for each outfall.

- Outfall No. 1 .....

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.....;..... m^3/day

- Outfall No. 2 .....

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.....;..... m^3/day

- Outfall No. 3 .....

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.....;..... m^3/day

- Outfall No. 4 .....

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.....;.....m^3/day

- Outfall No. 5 .....

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.....;..... m^3/day

6. Industrial wastewater treatment

	Treated		Untreated		Year
	m^3/year	%	m^3/year	%	
6.1 Total industrial wastewater m^3/year					
6.1.1 Estimated part discharged in a municipal system					
6.1.2 Estimated part discharged by industry directly into receiving waters					
6.1.3 Estimated part re-used or recirculated					

6.2 Industrial wastewater treatment

Type of wastewater	Total discharged quantity m^3/year	Quantity discharged in a community system				Quantity discharged directly into receiving waters				Type of treatment 2/	
		Treated		Untreated		Treated		Untreated		Treated wastewaters into municipal sewers	Treated wastewaters directly into receiving waters
		m^3/y	%	m^3/y	%	m^3/y	%	m^3/y	%		
Process											
Cooling											
Boiler											
Domestic sewage											
..... (other)											
TOTAL											

2/ Type of treatment abbreviations:

P : Process technical measure (re-use, recycling, separation of waters, evaporation, etc.)
G : Preliminary (screening, grit removal, flotation)
H : Primary sedimentation
C : Chemical treatment (chemical oxidation or reduction, acid-alkaline neutralization, precipitation, coagulation and sedimentation, etc.)
S : Secondary (sand filters, trickling filters, activated sludge, oxidation ponds, etc.)
T : Tertiary (absorption, electrodialysis, ionic exchange, etc.)
A : Any other (specify)

Use a combination of letters where more than one type of treatment is being applied.

6.3 Summary description of type of final treatment before discharge

Process technical measures (re-use, recycling, separation, etc.) ...

.....

.....

Preliminary: .....

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.....

..... Removal efficiency .....

Primary: .....

.....

.....

.....Removal efficiency .....

Secondary: .....

.....

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..... Removal efficiency .....

Tertiary: .....

.....

.....

..... Removal efficiency .....

Chemical treatment: .....

.....

.....

..... Removal efficiency .....

Any other: .....

.....

.....

..... Removal efficiency .....

	OUTFALL No.	1				2				3				4				5			
		max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysis or est.
7.2.1	Volume (m^3/day)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
7.2.2	POLLUTANTS																				
7.2.2.1	General																				
	- Temperature ^oC	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- Colour	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- Odour	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.
	- pH	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.
7.2.2.2	Solids																				
	- Settleable solids(ml/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	..
	- Total suspended solids (TSS, mg/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	..
	- Volative suspended solids (VSS, mg/l)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
7.2.2.3	Organic matter																				
	- BOD_5 mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- COD mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- TOC mg/l	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
	- others (specify)	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
		...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....
		...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....	...	...	...	.....

OUTFALL No.	1				2				3				4				5			
	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysi or est.
7.2.2.4 Heavy metals																				
- Iron (Fe, mg/l)																				
- Manganese (Mn, mg/l)																				
- Arsenic (As, mg/l)																				
- Mercury (Hg, mg/l)																				
- Lead (Pb, mg/l)																				
- Cadmium (Cd, mg/l)																				
- Copper (Cu, mg/l)																				
- Chromium^{6+} (Cr, mg/l)																				
- Chromium^{3+} (Cr,mg/l)																				
- Nickel (Ni, mg/l)																				
- Zinc (Zn, mg/l)																				
- others (specify)																				

OUTFALL No.	1				2				3				4				5			
	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysi or est.
7.2.2.5 Specific organic pollutants																				
- Mineral oils (hexane soluble) mg/l																				
- Methylene blue active substances (MBAS) mg/l																				
- Phenols (mg/l)																				
- Chlorinated organic compounds (specify) mg/l																				
- Polychlorinated biphenyls (PCB) mg/l																				
- others (specify)																				

OUTFALL No.	1				2				3				4				5			
	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analysis or estimation	max	min	avg	analyis or estimation	max	min	avg	analysi or est.
7.2.2.6 Nutrients																				
- Total phosphorous (mg/l)																				
- Total Kjeldahl nitrogen (mg/l)																				
- Nitrates (NO_3, mg/l)																				
- Nitrites (NO_2, mg/l)																				
- Ammonia (NH_4, mg/l)																				
- others (specify)																				
7.2.2.7 Bacteria																				
- Total coliform bacteria (MPN/100 ml)																				
- 6thers (specify)																				

7.2.3 Sampling frequency

7.2.4 Method of analysis

- Standard methods ..... ( )
- Other methods (specify) ..... ( )

7.3 With the above data, evaluate the total pollution load for each main pollutant (year of survey .....)

Pollutant	Average Concentration	Volume m^3/day	Pollution load kg/day	TOTAL POLLUTION LOAD 3/ Tons/year
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

3/ The evaluation should be considered

accurate ( )

fairly good ( )

only general and indicative ( )

8. Location of discharges

in municipal system ..... ( )
in sea ..... ( )
in river ..... ( )
in lake ..... ( )
on land..... ( )
other (specify)..... ( )

Year of survey.....

9. Use(s) of receiving waters

Drinking ..... ( )
Irrigation ..... ( )
Fishing ..... ( )
Swimming ..... ( )
Other (specify) ..... ( )

9.1 General observations on quality of receiving waters:

.....
.....
.....
.....

10. Water Pollution Control Agency (if any) having jurisdiction at point of discharge (other than municipal system): .....
.....

11. Nearest municipal system (if discharge is not already made into the municipal sewer system)

Distance in metres: .....

11.1 Type of sewage treatment (if any) at nearest sewage treatment plant (if discharge is not already made into the municipal sewer system): .....
.....

12. Solid wastes

		tons/year
12.1	Total annual industrial solid wastes (year.....)	.....
12.1.1	Estimated annual disposal of industrial solid wastes to a municipal or centralized system (year.....)	.....
12.1.2	Estimated annual disposal by industry's own means (year.....)	.....

12.2	Description of disposal method:		% of total waste
	to municipal or centralized system	( )	.....
	in sea	( )	.....
	in lake	( )	.....
	in river	( )	.....
	on land	( )	.....
	other (specify)	( )	.....

12.3 General character of solid wastes

Organic ..... ( )

Inorganic ..... ( )

12.4 Treatment of solid wastes by industry:

Storage ..... ( )

Compression ..... ( )

Recovery ..... ( )

Incineration ..... ( )

Other (specify) ..... ( )

13. Gaseous wastes

13.1 List major air contaminants produced: .....

.....

.....

.....

13.2 Treatments used (if any)

Filter ..... ( )

Electrostatic precipitation ....( )

Scrubbers ..... ( )

Others (specify) ..... ( )

13.3

Contaminants discharged	Unit/unit of time	year
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

13.4 Stack height above ground level: .....

B. Industrial wastes questionnaire

1. Industry identification

   1.1 Name and address

   1.2 Geographical location where industrial wastes are disposed

2. Identify type of industry

3. Production of goods (list various types) | Amounts and Units of Production | Year

4. Number of employees (average)

5. Source of water:

6. Industrial uses of water (average values, m^3/d)

   Process ————————
   Cooling ————————
   Boiler ————————
   Sanitary Sewage ————————
   Total ————————————

7. Industrial wastewater collection

   Combined ( )
   Separate for process water, sewage, rain run off ( )
   Number of wastewater outfalls ————————

8. Total industrial wastewater, m^3/year ————————
   Amount receiving treatment ————————

9. Describe treatment processes before effluent discharge

10. Are data available on characteristics of the wastewater ?
    Summarize available data below

Pollutant	Ave. Conc.	Vol, m^3/day	Total Pollution Load, tons/year
BOD_5			
COD			
Temperature			
pH			
Suspended solids			
Metals (specify!)			
Specific organic pollutants			

11. To what body of water or sewer system are wastes discharged?

12. Uses of body of water receiving wastes

13. Distance in metres to sewer system

14. Amounts of solid waste, tons/ year

15. Disposal practice for solid wastes

	% total
Municipal system	_____
body of water	_____
land fill	_____
incineration	_____

Annex III

DATA FROM THE 18 COUNTRIES VISITED IN THE WEST AND CENTRAL AFRICAN REGION*

Table 1. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Senegal

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	CDS	Tuna-fish canning	8 534 t	...	96 434	5 120							
Dakar	ADRIPECHE	Fish & shrimps	11 993 t	...	425 769	102 424							
Dakar	SAPAL	Tuna-fish canning	6 994 t	...	79 030	4 196							
Dakar	SURGEL	Fish & shrimps	3 162 t	...	112 251	27 003							
Ziguinchor	AMERGER	Shrimps	1 190 t	...	301 427	95 200							
Dakar	PROCOS	Fish & shrimps	2 618 t	...	92 939	22 357							
Dakar	SPAC	Fish & shrimps	2 125 t	...	75 437	18 147							
Ziguinchor	CRUSTAVIF	Shrimps	408 t	...	103 366	32 640							
Dakar	SOSECHAL	Shrimps	1 020 t	...	258 366	81 600							
Dakar	SOPESEA	Fish & shrimps	8 330 t	...	293 715	71 138							
Dakar	SENEPESCA	Fish & shrimps	2 040 t	...	72 420	17 421							
Dakar	SAFCOP	Fish	2 040 t	...	23 052	1 224							
Dakar	SAPOA	Fish & shrimps	1 181 t	...	41 943	10 090							
Dakar	SARDINAFRIC	Fish	1 836 t	...	20 747	1 102							
Ziguinchor	PROPECSEN	Shrimps	170 t	...	43 061	13 600							
Dakar	AFRICAZOTE	Fish meal	3 400 t	...	38 420	2 040							
Dakar	COMAPECHE	Fish & fish meal	...	...									
Dakar	CDS	Fish meal	5 100 t	...	57 630	3 060							
Dakar	LESIEUR	Raw edible oil Cake Refined edible oil	100 000 t 125 000 t 20 000 t	2 230 000	1 950 000	1 400 000	5 580 000						

*/ Given by country in geographical sequence from north to south.

Table 1 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	PETERSEN	Raw edible oil Cake	50 000 t 65 000 t	1 115 000	973 000	700 000	2 790 000						
Ziguinchor	SEIC	Raw edible oil Palm kernels	36 000 t 1 920 t	802 800	702 000	504 000	2 008 800						
Dakar	SAPROLAIT	Yoghurt, milk, cheese, cream	...	...	...	...	...						
Dakar	SIPL	Condensed milk (with & without sugar)	16 000 t	14 400	21 600		36 800						
Dakar	CODIPRAL	Condensed milk	...	...	...		...						
Dakar	SOBOA	Beer Carbonated beverages	30 000 t 30 000 t	306 000 94 500	141 900 129 900		336 000 237 000						
Dakar	SIBRAS	Beer Carbonated beverages	3 500 t 16 500 t	35 700 51 975	16 555 71 445		39 200 130 350						
Dakar	SEVEN UP	Soft drinks	...	...	...		...						
Dakar	SOCAS	Tomato paste Canned dry vegetables	5 040 t 320 t	25 855 1 642	31 903 2 026		64 512 4 096						
Dakar	SIDCA	Green beans	...	...	...		...						
Dakar	BATA	Leather	200 000 m^2	5 334 000	6 660 000	1 000 000	13 000 000			134 000			
Dakar	SERAS	Leather & furs	...	...	...	...	...			...			
Richartou	CSS	Sugar cane Refined sugar	40 000 t 112 000 t	205 200 574 560	253 200 708 960		512 000 1 433 600						
Dakar	CCV	Cotton thread	1 072 t	24 334	62 176		302 304		428	428			

Table 1 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	SOSEFIL	Sewing thread	352 t	7 990	20 416		99 264		140	140			
Dakar	ICOTAF	Textiles	14 million m^2	48 351	123 540		600 660		852	852			
		Bedspreads	100 000 pieces	2 270	5 800		28 200		40	40			
Dakar	SOTIBA-SIMPAFRIC	Textiles	40 million m^2	136 200	348 000		1 692 000		2 400	2 400			
		Thread	480 t	10 896	27 840		135 360		192	192			
Dakar	SAR	Petroleum refinery	900 000 t	113 400	72 000	43 200	315 000	23 400	540	1 440			
Dakar	CSL	Lubricants	18 900 t	2 722	2 192	888	16 065	1 587	17	45			
Dakar	SIES	Fertilizers	114 600 t		381 618						38 162		114 600
		Aluminium sulphate	2 000 t										
Dakar	SSEPC	Animal feed	5 000 t	...	...	...	...						
		Pesticides	1 690 t										
		Propellants	84 650 t										
Dakar	NSOA	Toilet soap	27 000 t	61 290	104 490	7 290	153 090						
Dakar	SAF	Soap	...	...	...	...	...						
		Candles											
Dakar	SAD	Soap powder	1 373 t	92	92	92	453						
		Liquid detergents	343 t	23	23	23	113						
Dakar	SPS	Soap	...	...	...	...	...						
Dakar	VALDAFRIQUE	Tablets	5 541 000 boxes										
		Liniments, salves	477 000 tubes										
		Alcohol	268 000 flasks										
		Pesticides	800 000 spray cans										

Table 1 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	SIPOA	Tablets Bottles	130 million										
Dakar	SAEC	Lacquers	56 t	7	11		18						
		Solvents	164 t	21	33		54						
		Putty	61 t	8	12		20						
		Coating materials	103 t	13	21		34						
		Water-based paints	1 048 t	136	210		345						
		Other paints	959 t	125	191		316						
Dakar	La Seigneurie Afrique	Lacquers, paints & solvents	1 593 t	207	319		526						
Dakar	COLAS	Asphalt emulsion	4 800 t	691	557	226	4 080	403	4	8			
Dakar	NEMAS	Enamelled items	2 484 t	323	497		820						
Dakar	SENEPLAST	Plastic items	...										
Dakar	SIAP	Plastic shoes	...										
Dakar	PES	Polyurethane foam	553 t										
Dakar	SIMPA	Plastic shoes	1.6 million pairs										
		Plastic bags	1 760 t										
		Plastic pipes	128 t										
		Extruded items	288 t										
Dakar	CCIS	Granuled PVC pipes	800 t										
Dakar	ENSEME	Plastic foam items	136 t										

Table 1 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	VILBOIS	Cast iron Bronze Aluminium Zinc	190 t 6 t		46 2	14		116 4	2			30 1	
Dakar	AFD	Cast iron, bronze alloys	...										
Dakar	SAFAL	Aluminium foundry	112 t		1 120						747		
Dakar	TREFILERIE DE DAKAR	Wire Iron rods Trellis work Nails & nail products Springs Rods	1 600 t 80 t 720 t 800 t 80 t 160 000 t										
Dakar	FUMCA	Metallic rods Kegs Cans	96 000 pieces 152 000 pieces 1 360 000 pieces										
Dakar	ELMAF	Cans, metal packages	...										
Dakar	SACOME	Metal shapes	1 056 t										
Dakar	SODACOM	Metallic constructions	...										
Dakar	VIRMAUD	Metallic constructions	...										
Dakar	SAPONIGRO	Polishing & galvanizing of metals	...										

Table 1 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Dakar	LEGAVRE	Metal windows	283 t										
Total				11 200 731	14 949 722	4 164 095	29 520 480	25 510	4 615	139 545	38 909	31	114 600

Table 2. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Gambia

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Banjul	Gambia Produce Marketing Board	Ground-nut oil Cake	13 000 t 15 000 t	289 900	253 500	182 000	725 400						
Banjul	Seagull Coldstores	Frozen fish	4 800 t	...	170 400	40 992	...						
Banjul	Gambia Port Authority Dockyard	Boat building Ship repairing	...										
Banjul	Gambia Port Authority Sea Port	Ship loading & unloading operations	...										
Banjul	Jul Brew	Beer Soft drinks	1.5 million litres 1.5 million litres	15 300 4 725	7 095 6 495		16 800 11 850						
Total				309 925	437 490	222 992	754 050						

Table 3. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Guinea-Bissau

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Bissau	CICER, Compahnia Industrial de Cervejas e Refrigerantes	Beer	6 million litres/a	61 200	28 380		67 200						
		Soft drinks	1 million litres/a	3 150	4 330		7 900						
Port de Bissau	SEMAPESCA	Fish	810 t/a	...	9 153	486	...						
		Shrimps	90 t/a	...	22 797	7 200	...						
	BLUFO	Dairy products	24 000 litres/d	5 616	8 424		14 352						
Cumeré	Complexo Agro-Industrial de Cumeré	Peanut oil	24 500 t/d	546 350	477 750	343 000	1 367 100						
		Peanuts roasted	45 500 t/d										
		Rice	3 000 t/a	2 790	1 590		6 990						
		Soap	1 000 t/a	2 270	3 870	270	5 670						
	Slaughterhouse	Meat	2 t/d	582	968	291	1 456						
Total				621 958	557 262	351 247	1 470 668						

Table 4. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Guinea

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Conakry	ENTA, Enterprise Nationale de Tabacs et Allumettes	Cigarettes	72 000 cartons/a										
		Matches	120 000 cartons/a										
Boffa	SUCRERIE KOBA	Sugar	12 000 t/a	68 760	14 400		171 600						
		Alcohol	82 500 litres/a	400			1 000						
Conakry	SOBRAGUI Société de Brasserie de Guineé	Beer	60 000 litres/a	612	2 129		5 040						
		Soft drinks	20 000 litres/a	63	87		158						
	FRUITAGUINEE	Fruit juices	396 m^3/a	2 031	2 507		5 069						
		Syrup	500 litres/h	5 335	6 583		13 312						
	SIPA, Société Industrielle de Pâtes Alimentaires	Flour	20 t/d	3 692	3 276		9 256						
Ile de Kassa	Huilerie de Kassa	Edible oil	15 000 t/d	334 500	292 500	210 000	837 000						
Conakry	IGAT, Industrie Guineénne d'Articles de Toilette	Toilet items	16 000 litres/a	...									
	SIPECO, Société Industrielle de Peintures de Conakry	Paint	100 t/month	312	480		792						
	SOFAB, Société de Fabrication de Bougies	Candles	200 cartons/d	...									
		Shoe wax	2 000 units/d	...									
		Wax	30 t/a	...									
	SOGUIPLAST Fabrication de Plastiques	Plastic products	30 000 units/a	...									

Table 4 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Conakry	SOGUIREP, Rechapage de Pneus	Recapping tires	20 000 units/a (200 t/a)	...	86	22							
Conakry	Complexe Textile de Sanoyah	Bleaching & printing textiles	3 million m/a (450 t/a)	10 215	26 100		126 900						
Conakry	Briqueterie de Kebaya	Bricks	50 000 bricks/d										
Conakry	Ceramique de Matoto												
Conakry	Meubles Sonfonia	Furniture	45 000 units/a		...								
Conakry	C Metallique	Metal products	4 800 t/a	...	1 150	350			50				
Conakry	SOGUIFAB, Société Guineénne de Fabrications	Aluminium sheets	10 000 t/a		...								
Conakry	SOMOVA	Assembling vehicles			...								
Conakry	SOGEX	Explosives	700 t/a	1 022	20 510		2 709		180	180			
Total				426 942	369 808	210 372	1 172 836		230	180			

Table 5. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Sierra Leone

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Freetown	Sierra Leone Petroleum Refining Co.Ltd.	Petroleum refining	237 270 t	29 900	18 980	11 390	83 050	6 170	140	380			
Freetown	Palm Kernel Oil Mill	Palm oil	880 t	19 620	17 160	12 320	49 050						
Freetown	Sierra Leone Brewery Ltd.	Beer	10 million litres	102 000	47 300		112 000						
Freetown	Sierra Leone Enterprises	Soft drinks	3.6 million litres	11 340	15 590		28 350						
Freetown	Freetown Cold Storage	Soft drinks	3.0 million litres	9 450	12 990		23 625						
Freetown	Wellington Distilleries Ltd.	Blending of spirits	137 000 litres										
Freetown	Soap Factory	Soap	4 000 t	9 070	15 500	1 070	22 700						
Freetown	Sierra Fishing Co., Ltd.	Fish & shrimps	...	...	...	...	...						
Freetown	Red Lion Bakery	Bread	...	...	...								
Freetown	National Confectionery Ltd.	Cookies & candy	...	...	...								
Freetown	Seabread Flour Mill	Flour	...	...	...								
Freetown	Foam Manufacturing Co.	Pillows & mattresses	...		...								
Total				181 380	127 520	24 780	318 775	6 170	140	380			
Projected discharge to ocean a/				1 676 655	1 178 780	229 063	2 946 719	57 035	1 294	3 513			

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of Sierra Leone: (11 333/1 226) (BOD_5) = 9.244 (181 380) = 1 676 655.

Table 6. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Liberia

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Monrovia	Liberia Petroleum Refining Co.	Petroleum refining	616 438 t	77 671	49 315	29 589	215 753	16 027	370	986			
Monrovia	Monrovia Breweries Inc.	Beer	18 million litres	183 600	85 140		201 600						
Monrovia	Mesurado Fish Company	Fish	2 400 t	...	27 200	1 440	...						
		Shrimps	360 t	...	91 200	28 800	...						
Monrovia	Mesurado Detergent Ind. Inc.	Detergent	900 t	60	60	60	300						
Monrovia	Liberia Bleach and Chemicals	Sodium hypochlorite	117 000 litres		...								
		Candles	35 000 kg		...								
		Insectide	800 kg		...								
Monrovia	Liberia Distilling Corporation	Blending of spirits	301 000 litres	...			...						
Total				261 331	252 915	59 889	417 653	16 027	370	986			
Projected discharge to the ocean a/				1 083 110	1 048 230	248 215	1 731 000	66 425	1 533	4 086			

a/ Based on ratio of total number of employees working in all industries to number of employees in the industries visited on the coast of Liberia: $(4\ 099/989)(BOD_5) = (4.145)(77\ 671) = 1\ 083\ 110$.

Table 7. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Ivory Coast

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Abidjan	Société Ivorienne de Raffinage (SIR)	Petroleum refinery	2 million t	252 000	160 000	96 000	700 000	52 000	1 200	3 200			
Abidjan	Lubtex	Lubricants	12 000 m^3	1 486	1 197	485	8 772	867	9	25			
Abidjan	Société Multi-nationale de Bitumes (SMB)	Asphalt	193 000 t	27 790	22 390	9 070	164 050	16 212	174	463			
Abidjan	SOTEXI	Printed textiles	24 million m^2	81 720	208 800		1 015 200		1 440	1 440			
Abidjan	ICODI	Printed textiles	27 million m^2	91 935	234 900		1 142 100		1 620	1 620			
Abidjan	UNIWAX	Printed textiles	20 million m^2	68 100	174 000		846 000		1 200	1 200			
Abidjan	SOFITEX	Printed textiles	4 million m^2	13 620	34 800		169 200		240	240			
Abidjan	BLOHORN	Palm oil refinery	50 000 t	1 115 000	975 000	700 000	2 790 000						
		Soap	33 000 t	74 910	127 710	8 910	187 110						
Abidjan	Palmindustrie	Palm oil											
Abidjan	BATA	Plastic shoes	1.2 million pairs	...	...		...						
		Leather shoes	1.4 million pairs	...	...		...						
Abidjan	SOLIBRA	Beer	60 million litres	612 000	283 800		672 000						
		Non-alcoholic	12 million litres	37 800	51 960		94 800						
Abidjan	BRACODI	Beer	50 million litres	510 000	236 500		560 000						
		Soft drinks	27 million litres	85 050	116 910		213 300						
		Ice	380 000 t										

Table 7 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Abidjan	SOBOCI	Soft drinks	6.8 million litres	21 420	29 444		53 720						
Abidjan	IRAN	Soft drinks Ice	6.8 million litres 10 000 t	21 420	29 444		53 720						
Abidjan	SICODIS	Bottling wine	33 million litres	103 950	142 890		260 700						
Abidjan	SOVINCI	Bottling wine	25 million litres	78 750	108 250		197 500						
Abidjan	AGR	Bottling wine	1 million litres	3 150	4 330		7 900						
		Bottling alcohol	220 000 litres	693	953		1 738						
Abidjan	GANAMET	Bottling wine	220 000 litres	693	953		1 738						
Abidjan	SACO	Cocoa seed	35 000 t	...	...		...						
Abidjan	API	Cocoa seed	18 000 t	...	...		...						
Abidjan	PROCAI	Cocoa seed	18 000 t	...	...		...						
Abidjan	CHOCODI	Cocoa seed	7 000 t	...	...		...						
Abidjan	Grand moulins d'Abdijan (GMA)	Grain mills	80 000 t	56 800	50 400		142 400						
Abidjan	CAPRAL	Coffee & instant coffee	3 000 t	1 875 000	150 000		4 686 000						
Abidjan	PFCI	Canned vegetables	8 000 t	41 040	50 640		102 400						
Abidjan	SCODI	Canned vegetables	8 000 t	41 040	50 640		102 400						

Table 7 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Abidjan	SIVENG	Sulphuric acid	20 000 t		6 000	900							
		Fertilizer: superphosphate	8 000 t		26 640						2 640		8 000
		Fertilizer: superphosphate gran.	55 000 t		183 150						18 150		55 000
		Fertilizer: ammonium sulphate	2 500 t		...			6 250					
Abidjan	Shell-Chimie	Chloro-organic & organophosphates - packaging	1 500 m^3	...	...		...						
		Pyrethine-packaging	700 m^3	...	...		...						
		Herbicides-packaging	100 m^3	...	...		...						
Abidjan	IPL	Paint & lacquer	3 000 t	390	600		990						
Abidjan	Toles Ivoire	Galvanizing metals	33 000 t		41 580					594	1 023		2 079
Abidjan	Zintec Ivoire	Zinc plating	2 400 t		3 024					43	74		151
Abidjan	IMCI	Concrete reinforcing bars	25 000 t		...								
Total				5 215 757	3 506 905	815 365	14 173 738	75 329	5 883	8 825	21 887		65 230

Table 8. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Ghana

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Tema	Food Specialities	Condensed milk	14 million cases	189 000	283 500		483 000						
		Milo (cocoa beverage)	300 000 cases										
		Cerelac (baby food)	100 000 cases	...	...		...						
		Nescafe	180 000 cases	...	...		...						
		Ketchup	17 000 cases	...	...		...						
Accra	Accra Brewery	Beer Soft drinks	19 300 t	196 860	91 289		216 610						
Accra	Tata Brewery	Beer	15 000 t	153 000	70 950		168 000						
Tokoradi	Pioneer Tobacco	Cigarettes & tobacco	200 t										
Tokoradi	Cocoa Products	Cocoa butter	5 208 t	116 138	101 556	72 912	290 606						
		Cocoa liquor	4 200 t	93 660	81 900	58 800	234 360						
		Cocoa cake	5 376 t	119 885	104 832	75 264	299 980						
		Cocoa powder											
Accra	Ghana Pharmaceutical	Antibiotics & pharmaceuticals	...	...	...		...						
Accra	Freedom Textiles	Grey cotton yarn	1 600 t	36 320	92 800		451 200		640	640			
		Printed textiles	6 million m^2	23 608	60 320		293 280		416	416			
Tema	Tema Textiles	Printed textiles	22 million m^2	89 892	229 680		1 116 720		1 584	1 584			
Tema	Ghana Textiles Manufacturing	Textiles	36 million m^2	147 096	375 840		1 827 360		2 592	2 592			
Tema	Ghana Textiles Printing	Printed textiles	18 million m^2	72 252	187 920		913 680		1 296	1 296			

Table 8 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Tema	West Coast Dyeing	Dyed cotton & rayon yarns	240 t	5 448	13 920		67 680		96	96			
Tema	Volta Aluminum	Aluminium	187 440 t		1 874 400						1 250 225		
Tema	GHAIP	Petroleum refinery	1 250 000 t	157 500	100 000	60 000	437 500	32 500	750	2 000			
Tema	Lever Brothers	Soap & detergents		...	...		...						
Takoradi	The Takoradi Veneer and Lumber	Plywood Lumber Doors	3 750 m^3 3 000 m^3 50 000 pieces	2 325 10 920			5 850 27 300		2 625				
Takoradi	L'Air Liquide	Oxygene Acetylene	70 000 m^3 26 000 m^3										
Tema	Tema Development Co.	House construction											
Total				1 413 904	3 668 907	266 976	6 832 676	32 500	9 999	8 624	1 250 225		

Table 9. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Togo

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Kpémé	Office Togolaise des Phosphates (O.P.T.)	Washing of phosphate mineral	7 million t		23 310 000						2 310 000		7 000 000
Lomé	Sciété Togolaise d'Hydrocarbures (S.T.H.)	Petroleum refinery	1 million t	126 000	80 000	48 000	350 000	26 000	600	1 600			
Lomé	Brasserie du Benin (B.B.)	Beer	30 million litres	306 000	141 900		336 000						
		Carbonated beverages	7 million litres	22 050	30 310		55 300						
Lomé	Société Togolaise de Boisson (S.T.B.)	Soft drinks	8 million litres	25 200	34 640		63 200						
Lomé	Société de Detergentes du Togo (SODETO)	Detergents	1 200 t	80	80	80	396						
Lomé	Société Nationale de Siderurgie (S.N.S.)	Steel	20 000 t		4 800	1 460		12 200	200			3 000	
		Steel rolling	40 000 t		9 600	2 920		24 400	400			6 000	
Lomé	CIMTOGO	Cement	340 000 t	907 800	...		2 278 000						
Lomé	SOTOMA	Marble working											
Lomé	Office National des Abbattoirs et Frigorifie (O.N.A.F.)	Bovine slaughtering	1 200 t	960	1 595	480	2 400						
		Swine slaughtering	140 t	112	186	56	280						
		Ruminants slaughtering	350 t	280	465	140	750						
Lomé	Luxolin	Paints	1 500 t	195	300		495						
Lomé	Huilerie du Benin	Peanut oil	14 000 t	312 200	273 000	196 000	781 200						

Table 9 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Lomé	SAVONNERIE	Soap	3 000 t	6 810	11 610	810	17 010						
Lomé	Société Generale des Moulins du Togo (S.G.M.T.)	Flour mill	...	...	...		...						
Total				1 707 687	23 898 486	249 946	3 885 031	62 600	1 200	1 600	2 310 000	9 000	7 000 000

Table 10. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Benin

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Cotonou	SONICOG	Palm oil	15 000 t	334 500	292 500	210 000	837 000						
		Peanut oil	1 000 t	22 300	19 500	14 000	55 800						
		Vegetable butter	2 000 t	44 600	39 000	28 000	111 600						
Porto Novo	SONICOG	Bar soap	5 200 t	11 804	20 104	1 404	29 484						
Cotonou	SOBETEX	Printed textiles	16 million m^2	54 480	139 200		676 800		960	960			
Cotonou	LA BENINOISE	Beer	22 500 000 litres	229 500	106 425		252 000						
		Carbonated beverages	9 100 000 litres	28 665	39 403		71 890						
		Ice	10 950 t										
Cotonou	SCB	Cement	167 500 t	447 225			1 122 250						
Cotonou	GMB	Wheat flour	9 380 t	938	938		2 345						
Cotonou	MABECY	Bicycles	13 400		...								
		Motorcycles	9 500		...								
		Bicycles	...		...								
		inner tubes	...	...	...								
Cotonou	BATA BENINOISE	Shoes	321 600 pairs	...	...		...						
Total				1 174 012	657 070	253 404	3 159 169		960	960			

Table 11. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Nigeria

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Eastern part of Atlantic Coast	NNOC	Crude petroleum	107 million t		...	53 500 000							
		Fishing	170 000 t (live weight)	...	1 921 000	102 000							
		Tinned meat	986 t	790	1 310	394	1 972						
		Margarine	6 000 t	133 800	117 000	84 000	334 800						
		Groundnut oil	7 300 t	162 790	142 350	102 200	407 340						
		Wheat flour	600 000 t	60 000	60 000		150 000						
		Raw sugar	27 600 t	158 148	33 120		394 680						
		Beer	357 million litres	3 641 400	1 688 610		3 998 400						
		Soft drinks	181 million litres	570 150	783 730		1 429 900						
		Textiles	276 608 t	6 279 000	16 043 264		78 [illegible] 456		110 643	110 643			
		Plywood	80 000 m^3	49 600			124 800		56 000				
		Paints	26 500 t	3 445	5 300		8 745						
		Soap and detergents	103 800 t	235 626	401 706	28 026	588 546						
		Petroleum refining	8.9 million t	1 121 400	712 000	427 200	3 115 000	231 400	5 340	14 240			
		Bicycle & motor-cycle tires	1 914 t		823	210							
		Other tires	2 050 t		881	226							
		Cement	1.42 million t	3 791 400	...		9 514 000						
		Pulp & paper	60 000 t	1 120 200	2 400 000		2 802 000						
Total				17 327 749	24 311 094	54 244 256	100 873 639	231 400	171 983	124 883			

Table 12. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of the United Republic of Cameroon

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Douala	Complexe chimique camerounais (CCC)	Soap Detergents	18 000 t 2 000 t	40 860 134	69 660 134	4 860 134	102 060 660						
Douala	Cotonnière industrielle du Cameroun (CICAM)	Bleaching and printing Textiles	35 million m^2	119 018	304 500		1 480 500		2 100	2 100			
Douala	Societé Guiness-Cameroun	Beer	50 million liters	510 000	236 500		560 000						
Douala	Emaillerie Nouvelle Afrique	Fabrication of steel containers & enamel plating	1 800 t		2 268					32	56		113
Douala	Brasseries du Cameroun (SA)	Beer Non-alcoholic carbonated beverages	65 million litres 25 million litres	663 000 78 750	307 450 108 250		728 000 197 500						
Douala	ALUBASSA	Aluminium products	...		...								
Douala	CTMC	Concrete re-inforcing bars	...		...								
Douala	CEP	Paint	...	...	...		...						
Douala	UNALOR	Matches	...		...								
Douala	CHOCOCAM	Chocolate refining Candy	7 000 t 4 500 t	... ...	... ...		... ...						
Douala	SOPARCA	Perfumes & creams	2 000 t	...	...		...						
Douala	SAPCAM	Paint, varnish & bleach	1.75 million t	232 750	350 000		582 750						

Table 12 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Douala	UCB	Non-alcoholic carbonated beverages	12 million litres	37 800	51 960		94 500						
Douala	PILCAM	Batteries	1.5 million	9 360	2 340 000		23 400						
Douala	SOCADEM	Fabrication of metal containers	...		...								
Douala	PLASTICAM	Assorted plastic articles	...		...								
Douala	Milliat Frères	Food pastes	...	...	...		...						
Douala	BATA	Shoes	...	...	...		...						
Douala	Societé camerounaise de produits laitiers	Dairy products	250 000 litres	225	338		563						
Douala	SOLADO	Concrete re-inforcing bars	...		...								
Douala	SYNTHECAM	Synthetic fabrics	1.5 million m^2	5 100	13 050		63 450	90	90				
Doula	SOCAVER	Glass	...		...								
Douala	CIAC	Tires	...		...								
Douala	SYNCATEX	Blankets & bed spreads	...										
Douala	CICAF	Blankets	...										
Douala	MCD	Blankets	...										

Table 12 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Douala	REGIC	Toilet paper	300 000 rolls (assume 1 roll weighs 0.5 kg)	2 790	6 000		6 975						
Douala	SOCAFRUITS	Canning vegetables & fruits	5 000 t	25 650	31 650		64 125						
Bonaberi	SOCAME (not presently operating)	Fertilizer	...		...								
Bonaberi	CAMOA	Oxygen & acetylene	...										
Bonaberi	DRATEX	Linen	...										
Bonaberi	ALPICAM	Small metal articles	...										
Victoria	Victoria Paper Mills	Paper pulp	3 000 t	56 010	120 000		140 025						
Victoria	Plantation Pomol	Palm oil	13 000 t	289 900	253 500	182 000	724 750						
		Palm kernel oil	5 000 t	111 500	97 500	70 000	278 750						
		Raw rubber	2 000 t	4 540	7 340	1 866	91 340						
Edea	ALUCAM	Aluminium	50 000 t		500 000						333 500		
Total				2 187 387	4 800 100	258 860	5 139 348	90	2 190[a/]	2 132[a/]	333 556		113

a/ 93.6 t/a of lead and cadmium are also discharged.

Table 13. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Equatorial Guinea

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Rio Muni		Cocoa	...	...	...		...						
Rio Muni		Coffee	...	...	...		...						
Rio Muni		Forest products	...	...	...		...						
Rio Muni		Palm oil	...	...	...		...						
Rio Muni		Soap	...	...	...		...						
Rio Muni		Beer	...	...	...		...						

Table 14. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Sao Tome and Principe

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Neves	CETO	Beer	3.6 million litres	36 720	17 028		40 320						
Neves	FLEBE	Carbonated soft drinks	0.2 million litres	630	866		1 580						
Neves	Stockage Shell	Storage of petroleum products	...										
Neves		Boats	...										
Neves	SIPLANE	Alcoholic beverages	30 000 litres	95	130		237						
Sao Tome		Soap	100 t	227	387	27	567						
Total				37 672	18 411	27	42 704						

Table 15. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Gabon

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Libreville	Societé des brasseries du Gabon (SOBRAGA)	Beer Non-alcoholic carbonated beverages	36 million litres 10 million litres	376 200 31 500	170 280 43 300		403 200 78 750						
Libreville	Societé industrielle des textiles du Gabon (SOTEGA)	Printed textiles	7.5 million m^2	25 500	65 250		317 250		450	450			
Libreville	Gabonaise de peintures et laques (GPL)	Paint & lacquer	1 500 t	200	300		500						
Libreville	SOGAPIL	Batteries	...	...	...		...						
Libreville	GABOA	Oxygen, acetylene & nitrogen	...		...								
Libreville	ABA	Paint & glue	...	...	...		...						
Port Gentil	Terminal petrolier d'Elf-Gabon	Washing & storage of crude oil	8 million t			4 000 000							
Port Gentil	Societé gabonaise de raffinage (SOGARA)	Petroleum refining	900 000 t	113 400		43 380	315 000	23 490	540	1 440			
Port Gentil	COGER	Petroleum refining	1.2 million t	151 200		57 840	420 000	31 320	720	1 920			
Port Gentil	Societé des brasseries de l'Ogoue maritime (SBOM)	Beer Non-alcoholic carbonated beverages	15 million litres 2.5 million litres	153 000 7 875	70 950 10 825		168 000 19 750						
Port Gentil	Compagnie forestiére du Gabon (CFG)	Plywood Lumber Lumber	75 000 m^3 9 000 m^3 4 000 m^3	46 892	20 440		117 230		52 280				

Table 15 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Port Gentil	SAGA	Soaps & plastic products	...	...	...		...						
Port Gentil	GABOA	Oxygen, acetylene & nitrogen	...		...								
Port Gentil	Placages gabonais	Wood veneers	...		...								
Port Gentil	SADER	Wood veneers	...		...								
Port Gentil	Terminal Shell-Gabon	Washing (salt removal) & storage of crude oil	3 million t			1 500 000							
Total				896 767	381 345	5 601 220	1 839 680	54 810	53 990	3 810			

Table 16. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Congo

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Brazzaville	Brasseries africaines de Brazzaville (BAB)	Non-alcoholic carbonated beverages	6 million litres	18 900	25 980		47 250						
Brazzaville	Brasseries de Brazzaville (PRIMUS)	Beer	25 million litres	255 000	118 250		280 000						
Brazzaville	SCBK-Brazzaville	Beer Non-alcoholic carbonated beverages	6 million litres 6 million litres	61 200 18 900	28 380 25 980		67 200 47 250						
Brazzaville	Yaourt Biso	Yoghurt	...	...	...		...						
Brazzaville	Yaourt Yogo Santé	Yoghurt	...	...	...		...						
Brazzaville	SIAT	Cigarettes	...										
Brazzaville	SIAP-CONGO	Paper	...										
Brazzaville	SOTEXCO	Printed textiles	14 million m^2	47 670	121 800		592 200		840	840			
Brazzaville	IMPRECO	Printed textiles	...										
Pointe-Noire	Société congolaise de brasseries Kronenbourg (SCBK)	Beer Non-alcoholic carbonated beverages	22.5 million litres 6 million litres	229 500 18 900	106 425 25 980		252 000 47 250						
Pointe-Noire	SIDETRA Société industrielle de deroulage et tranchage	Lumber Wood veneer Plywood	10 800 m^3 24 000 m^3 3 000 m^3	87 360 1 872			218 400 4 680		2 100				

Table 16 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Pointe-Noire	PLACONGO	Wood veneer	30 000 m^3	109 200			273 000						
Pointe-Noire	Terminal Elf de Djeno (ELF)	Washing & storage of crude oil	2.4 million t			1 200 000							
Pointe-Noire	Raffinerie nationale de petrole (not operating)	Petroleum refining	1.0 million t	94 000	80 000	29 000	471 000	10 000	600	1 600			
Pointe-Noire	BATA	Shoes	790 000 pairs										
Pointe-Noire	SOVERGO	Glass	...		...								
Pointe-Noire	PLASCO	Plastic bottles	...		...								
Pointe-Noire	MACC	Munitions	...	...	...		...						
Pointe-Noire	CFA	Transporting & selling wood	...										
N-Kayi	SUCO	Sugar	13 500 t	77 355	16 200		193 388						
N-Kayi	HUILKA	Palm oil	2 600 t	57 980	50 700	36 400	144 950						
N-Kayi	MAG	Flour	10 000 t	7 100	6 300		17 800						
Total				1 084 937	605 995	1 265 400	2 656 368	10 000	3 540	2 440			

Table 17. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Zaire

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Moanda/ Banana	Société zairo-italienne de raffinage (SOZIR)	Petroleum refinery	450 000 t[a/]	56 700	36 000	21 600	157 500	11 700	270	720			
Moanda/ Banana	Zaire-Gulf	Off-shore crude oil	[b/]										
Moanda/ Banana	Zairep (FINA)	Off-shore crude oil											
Matadi	Minoterie de Matadi (MIDEMA)	Flour mill	126 000 t	89 460	79 380		224 280						
Matadi	Service entreprises pétroliéres (SEP ZAIRE) Matadi, Ango-Ango	Storage of petroleum products	...										
Matadi	PEMARZA	Fish	...	...	...		...						
Boma	BRALIMA	Beer	30 million litres	306 000	141 900		336 000						
Boma	ONATRA	Dry dock	...										
Total				452 160	257 280	21 600	717 780	11 700	270	720			

a/ Capacity is 750,000 t/a.
b/ Production began in 1980.

Table 18. Principal industrial establishments and estimated mass of pollutants discharged in the coastal area of Angola

Location	Company	Products	Annual production	Pollutants discharged (kg/a)								
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Luanda (Area of Cacuaco, Viana, Cazenga)	PETRANGOL	Petroleum refinery	1.5 million t	189 000	120 000	72 300	525 000	39 150	900	2 400			
Luanda	SONANGOL	Storage & loading of crude oil	250 000 t			125 000							
Luanda	Companhia Uniao de Cerreja Angola (CUCA)	Beer	1.8 million litres[a/]	18 360	8 514		20 160						
Luanda	NOCAL	Beer	3 million litres [b/]	30 600	14 190		33 600						
Luanda	TEXTANG	Printed textiles	5.5 million m^2	18 727	47 850		232 650		330	330			
Luanda	Ex Fabrica Imperial de Borracha (FIB)	Printed textiles	2 million m^2	6 810	17 400		84 600		120	120			
Luanda	CURBOL	Bicycle inner tubes	10 000 pieces		3	1							
		Tires	20 000 pieces		43	11							
Luanda	Tintas Dyrup	Paint	100 t	13	20		33						
Luanda	Siderurgia Nacional	Steel	4 000 t[c/]		960	292		2 440	40			500	

Table 18 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Luanda (Area of Cacuaco, Viana, Cazenga)	Cementeria National	Cement	...		...								
Luanda	Industria Angolana de Oleas Vegetales (INDUVE)	Vegetable oil	2 200 m^3	39 248	34 320	24 640	98 208						
		Soap	2 600 t	5 902	10 062	702	14 742						
		Plastic bottles	6 million pieces										
Luanda	FABIMOR	Bicycles	24 000										
		Motorcycles	2 500										
Cabinda	Gulf-Oil Terminal Cabinda	Washing & storage of crude oil	5 million t			2 500 000							
Cabinda	Gulf-Oil Refinery Cabinda	Oil refinery (topping only)	25 000 t	2 350	2 000	725	11 775	250	15	40			
Soyo	Oil Terminal Soyo (PETRANGOL/ TEXACO)	Washing & storage of crude oil	2 million t			1 000 000							
Benguela	Africa Textil	Printed textiles	11 million m^2	37 455	95 700		465 300		660	660			
Huambo	Unidade Textil do Huambo	Printed textiles	...										
Huambo	UNTEX (not operating)	Printed textiles	...										

Table 18 (continued)

Location	Company	Products	Annual production	Pollutants discharged (kg/a)									
				BOD_5	SS	Oil and grease	COD	Ammonia nitrogen	Phenols	Total chromium	Fluoride	Cyanide	Total phosphorus
Huambo	Fabrica Ulisses	Motocycle assembling	5 000 pieces		...								
Lubango	NGOLA	Beer	...	...	...		...						
Alto Catumbela	Companhia de cellulose et Papel de Angola	Paper pulp	...	...	...		...						
Alto Catumbela	Algodoura Agricola do Alto Catumbela (AAA)	Vegetable oils	3 000 t	66 900	58 500	42 000	167 400						
Dongo	EKA	Beer	...	...	...		...						
Dongo	SATEC	Printed textiles	10 million m2	34 050	87 000		423 000		600	600			
Total				449 415	496 562	3 765 671	2 076 468	41 840	2 665	4 150		500	

a/ Maximum capacity 2 million litres per year.
b/ Maximum capacity 31.5 million litres per year.
c/ Maximum capacity 30 000 t/a.

Annex IV

DEFINITIONS

Biochemical oxygen demand (BOD_5)

The 5-day, 20°C, BOD_5 test is widely used to determine the pollutional strength of waste water in terms of the oxygen required to oxidize or convert the organic matter to a nonputrescible end product. The BOD_5 test is a bioassay procedure that measures the oxygen consumed by living organisms while utilizing the organic matter present in the waste water under conditions as similar as possible to those that occur in nature. To make results comparable, the test has been standardized. The BOD_5 test is one of the most important in stream pollution control.

Suspended solids (SS)

Suspended solids are the suspended material that can be removed from waste waters by laboratory filtration excluding coarse or floating solids that can be screened or settled out readily. Suspended solids are a vital and easily determined measure of pollution and also a measure of the material that may settle out in slow-moving streams. Both organic and inorganic materials are measured by the SS test.

Oils and greases

Oils and greases are determined by multiple solvent extractions of the filterable portion of a sample of waste water; therefore, floating oils and greases are not included in the analysis. Several solvents are commonly used and each gives a different result with the same sample. Standardized tests are recommended, but there is much disagreement as to what constitutes the best method. Solvents such as hexane, ether, Freon, and carbon tetrachloride are used, and it is important that the solvent be specified. Oil and grease exert an oxygen demand, cause unsightly conditions, and can interfere with anaerobic biological treatment systems.

pH

Acidity, alkalinity, and pH are terms used to express the corrosive or caustic properties of a waste water. None of the tests related to these properties measures a specific component in waste water, but they serve a useful purpose by indicating a relative toxicity to aquatic life (see annex I).

Chemical oxygen demand (COD)

The COD test is an alternative to the BOD_5 test. It is widely used and measures the quantity of oxygen required to oxidize the materials in waste water under severe chemical and physical conditions. The major advantage of the COD test is that only a short period (3 hours) is required to conduct the test. The major disadvantage is that the test does not indicate how rapidly the biologically active material would be stabilized in natural conditions.

Annex V

WASTE-WATER CHARACTERISTICS AND THE NUMBER OF EMPLOYEES REPORTED BY THE INDUSTRIES VISITED, FOR SELECTED COUNTRIES

Table 1. Waste-water characteristics and number of employees, Angola

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Chromium (3+)	Iron
PETRANGOL												
Petroleum Refinery	550	...			...	30.20	54.75	22.3				
SONANGOL												
Hydrocarbons storage	32	...				0.25	0.50	0.1				
TEXTANG												
Printed textiles	1 290	500			50	125	500	0.5		60	0.25	
CURBOL												
Copper and Tyres	347	50			4	5	12.50				0.25	
INDUVE Vegetable oils, soap, Plastic bottles	620	...			80	40	160			50		
SIDERURGICA NACIONAL												
Steel	400	25			...			1				0.25
CABINDA GULF-INST												
Washing and Storage	20	...			...	73	146	14.6				
Total	3 259	575			134	273.45	861.25	38.5		110	0.50	0.25
Projected discharge to ocean[a/]	10 000	1 725			402	720	2 584	115		330	1.5	0.75

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of Angola: (10 000/3 259) (settleable solids) = (3)(575) = 1 725.

Table 2. Waste-water characteristics and number of employees, United Republic of Cameroon

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Sodium carbonate
CICAM	550	...			...	282	1 128	1.2		500	120
CCC	520	...			12.5	12.5	50			375	
Nouvelle émaillerie Afrique	375	...			1.5	0.25	0.6	0.1			
Guiness	1 200	2 000			500	250	500				
ALUCAM	1 100	...			...			10			
CELLUCAM	1 100	4 896			571	652	1 958				
SONARA	230	...			...	75	302	12.6			
Total	5 075	6 896			1 085	1 271.5	3 138.6	23.9		875	120
Projected discharge to ocean[a/]	41 252	51 200			9 000	10 400	32 000	196		7 200	980

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of the United Republic of Cameroon: (41 252/5 075)(settleable solids) = (8.2)(6 896) = 51 200.

Table 3. Waste-water characteristics and number of employees, Congo

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Grease	Waste water discharged (m^3/a)
SCBK												
Beer and carbonated beverages	343	700			165	83	165			60		
Terminal Elf-Djeno												
Washing and storage of crude oil	33	...			...	110	220	21.9				
SIDETRA												
Lumber, veneer and plywood	772	...	0.1	0.4	...	...	...					
Raffinerie nationale												
Petroleum refining	350	...			...	8	15	2				
Total	1 498	700	0.1	0.4	165	201	400	23.9		60		
Projected discharge to ocean[a/]	3 000	1 400	0.2	0.8	330	402	800	48		120		

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of the Congo: (3 000/1 498)(settleable solids) = (2.0)(700) = 1 400.

Table 4. Waste-water characteristics and number of employees, Gabon

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Grease	Waste water discharged (m^3/a)
SOBRAGA												
Beer and carbonated beverages	280	43			9	36	90					
SOTEGA												
Printed Textiles	120	350			35	87.5	350		1.75			
GPL												
Paint and lacquer	43	3.5			0.3	0.2	0.5		0.1			
SBOM												
Beer and carbonated beverages	146	70			17.5	21	56			3.6		
CFG												
Plywood and lumber	1 764	...	2.5	2.5	2 260	420	1 050					
Terminal Elf-Gabon												
Crude oil storage	100	...			...	50	100	12.5				
SOGARA and COGER												
Petroleum refining	330	...			...	10.5	20	6				
Total	2 783	466.5	2.5	2.5	2 315.8	625.2	1 656.5	18.5	1.85	3.6		
Projected discharge to ocean[a/]	6 320	1 050	5.6	5.6	5 200	1 400	37 200	42	4.2	8		

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited in Gabon: (6 320/2 783)(settleable solids) = (2.25)(466.5) = 1 050.

Table 5. Waste-water characteristics and number of employees, Ivory Coast

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Grease	Waste water discharged (m^3/a)
ICODI	450	90			45	180	450					900 000
SOTEXI	460	77			38.5	154	385					770 000
SIR	800	27.5			8.2	27.5	66	15.5				275 000
SOLIBRA	800	2 400			180	300	900			150		600 000
BRACODI	800	2 000			150	250	750			125		500 000
SOBOCI	250	75			15	24	60			80		150 000
PFCI	250	11.2			3.4	112	280				2.2	112 000
API	173	6			6	12	30					60 000
IBL	75	...			24							10 000
TOLES IVORIE	150	0.15			0.9							30 000
Total	4 209	4 686.85			471.0	1 059.5	2 921	15.5		355	2.2	3 407 000
BLOHORN[a/]	831	...			...	4 380	10 950			1 500	365	730 000
Projected discharge to ocean[b/]	41 169	46 000			4 650	14 880	39 450	150				

a/ Not included in totals used to make projections because of the unusual character of the waste water. Contributions of pollutants by BLOHORN were added after the projections were made.

b/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of the Ivory Coast: (41 169/4 209)(settleable solids) = (9.8)(4 686.85) = 46 000.

Table 6. Waste-water characteristics and number of employees, Sao Tome and Principe

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Grease	Waste water discharged (m^3/a)
CETO												
Beer	80	...			150	18	54			18		36 000
FLEBE												
Soft drinks	15	...			0.2	0.3	0.8			1		2 000
Total	95				150.2	18.3	54.8			19		38 000
Projected dischage to ocean[a/]	250				390	47	140			50		100 000

a/ Based on ratio of total number of employees in all industries to number of employees in the industries visited on the coast of Sao Tome and Principe: (250/95)(suspended solids) = (2.63)(150.2) = 390.

Table 7. Waste-water characteristics and number of employees, Togo

Name of industry and product	Number of employees	Settleable solids (m^3/a)	Phenol	Urea and formalin	Suspended solids	BOD_5 (t/a)	COD	Oil, mineral	Solvents	Caustic soda	Grease	Waste water discharged (m^3/a)
S.T.H.												
Petroleum refinery	230	...			6	20	48	10		-		
S.T.B.												
Soft drinks	130				7	11.2	28			55		
B.B.												
Beer and carbonated beverages	420				105	175	525			100		
Total	780				118	206.2	601			155		
O.T.P.[a]												
Washing of phosphate mineral	1 150	...			2 450 000		-			-		
Projected discharge to ocean[b]	4 000				2 450 425	710	2 040	36		560		

a/ Because of its atypical pollutant charges, this industry has not been considered in the further projection for the country.

b/ Based on ratio of total number of employees in all industries (except O.T.P.) to number of employees in the industries visited (except O.T.P.) on the coast of Togo, plus the figure for O.T.P.: /(4 000 - 1 150)/780/(suspended solids) = (3.6)(118) + 2 450 425.

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