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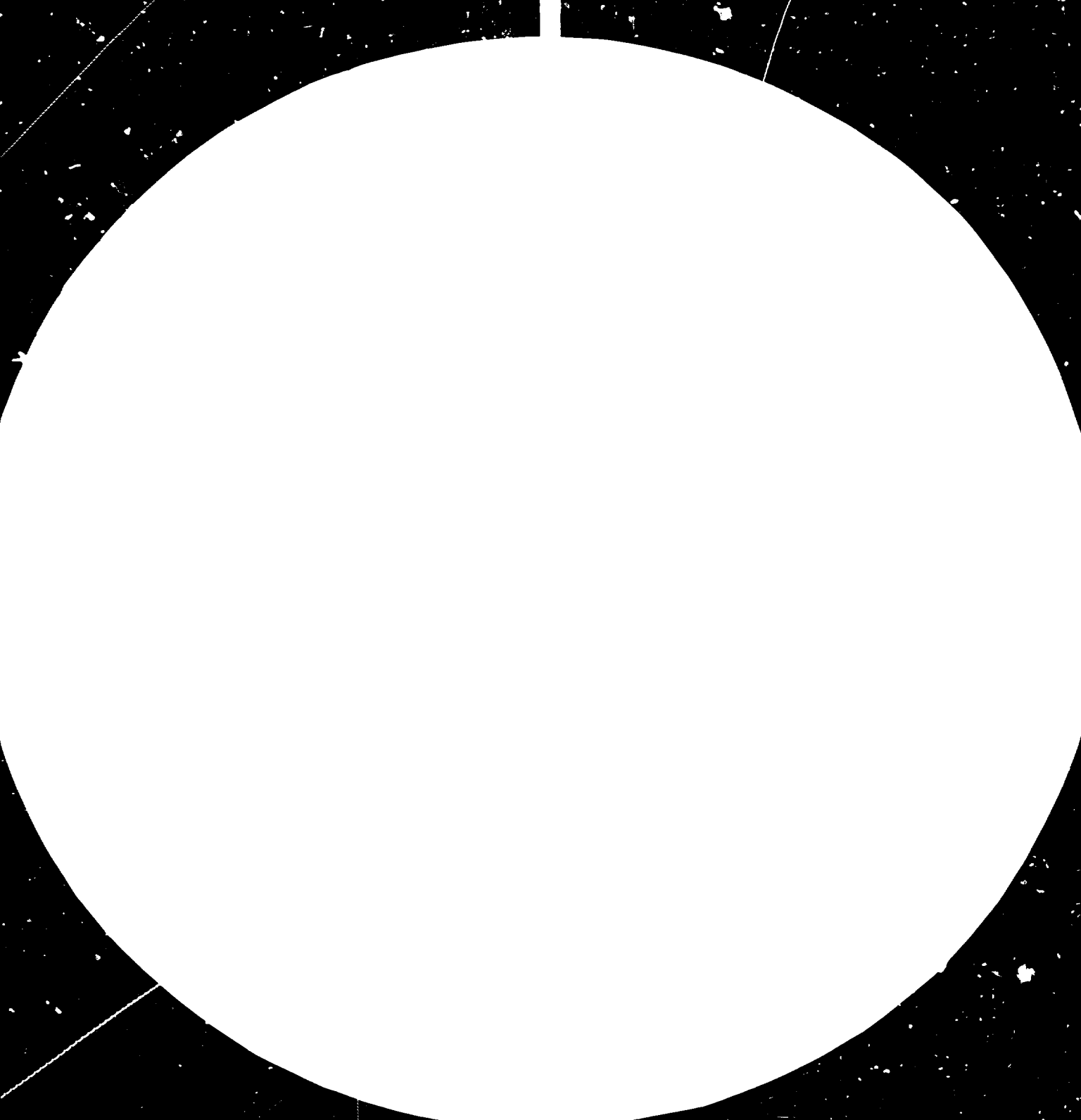

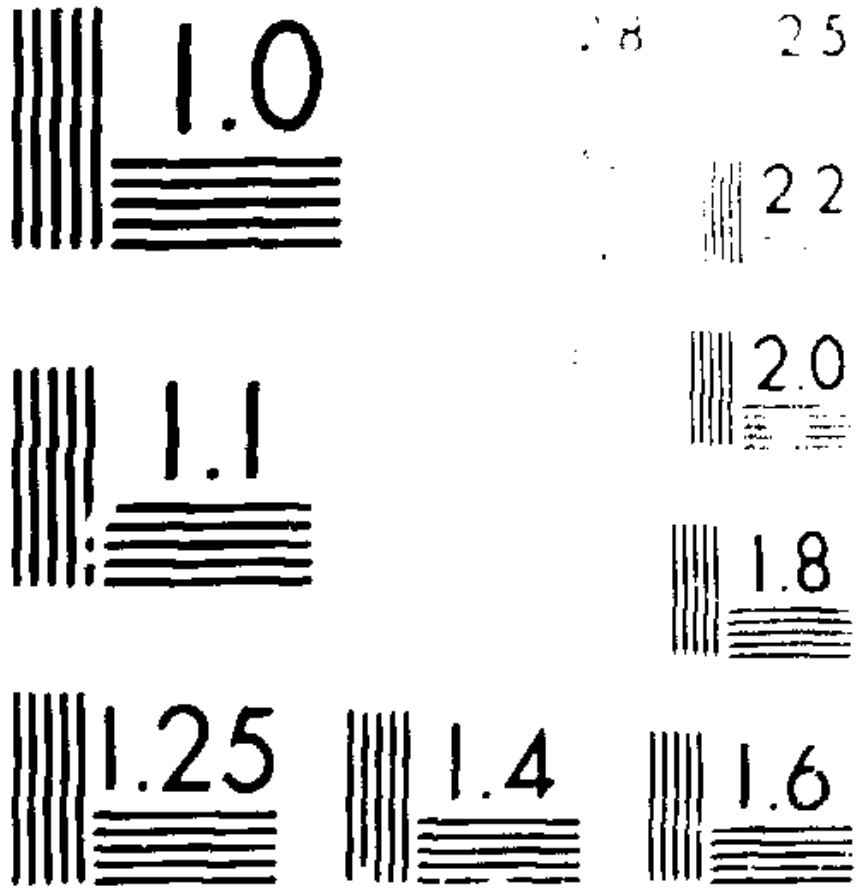
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SURVEY OF MARINE POLLUTANTS FROM INDUSTRIAL SOURCES IN THE WEST AFRICAN REGION

EP/INT/79/009

Report on mission to Ghana

Prepared by the United Nations Industrial Development Organization,
co-operating agency of the United Nations Environment Programme

Based on the work of Alexander G. Rozanov,
UNIDO expert

80-42098

Explanatory notes

References to tons (t) are to metric tons.

In tables totals may not add precisely because of rounding.

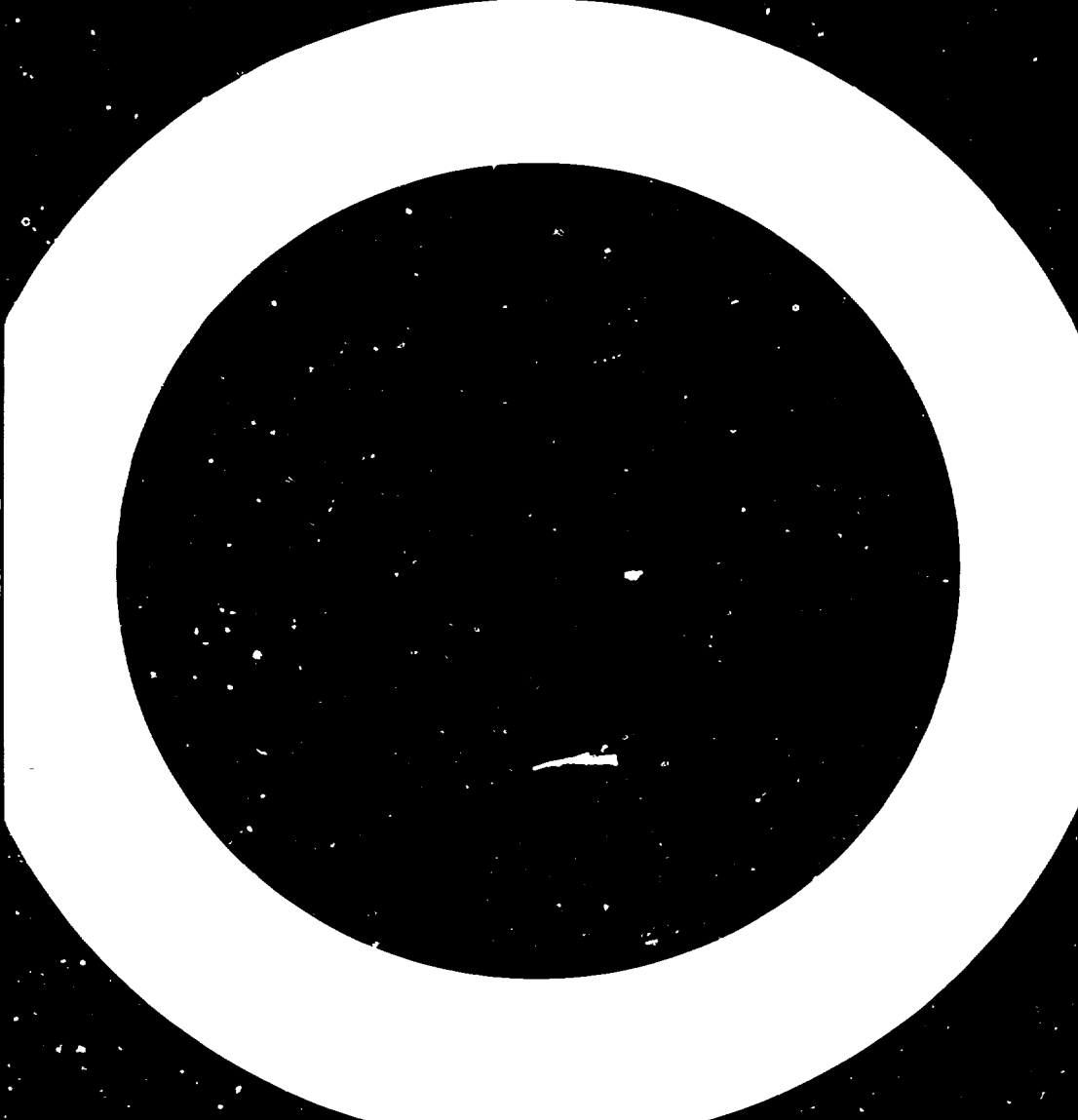
Besides the common abbreviations, symbols and terms, the following have been used in this report:

API	American Petroleum Institute
BOD_5	Biochemical oxygen demand after five days
COD	Chemical oxygen demand
CSIR	Council for Scientific and Industrial Research
GEMS	Global Earth Monitoring System
SS	Suspended solids
TDK	Tema Development Corporation
TSD	Tema Steelworks Division
TSS	Total suspended solids
VALCO	Volta Aluminium Company
VSS	Volatile suspended solids
w.w.	Waste water

ABSTRACT

As part of the parent project "Survey of marine pollutants from industrial sources in the West African region" (EP/INT/79/009) which is being carried out by the United Nations Industrial Development Organization (UNIDO) in co-operation with the United Nations Environment Programme (UNEP), an expert was sent from 30 May to 24 June to Ghana to gather information on the type and quantity of pollutants from major land-based industrial sources entering the marine environment through direct costal discharges or indirectly through rivers, and to assess the present status of industrial waste treatment and disposal practices in the country.

The expert visited various industrial sites, surveyed processing units in their current activity and inspected places where waste waters and solid wastes were discharged. As a result the nature and quantity of pollutants entering the Gulf of Guinea and the Atlantic Ocean have been estimated. His report includes a study of the existing and planned environmental legislation in Ghana and the organizations concerned with environmental protection as well as some general recommendations for the control of industrial marine pollution.



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INTRODUCTION

The mission to Ghana covered by this report is a contribution to the project "Survey of marine pollutants from industrial sources in the West African region" (EP/INT/79/009) carried out by the United Nations Industrial Development Organization (UNIDO) in co-operation with the United Nations Environment Programme (UNEP). The purpose of the project is to get 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 practice).

The expert visited Ghana from 30 May to 24 June 1980. During a previous mission of another UNIDO consultant in March 1980 the necessary preliminary work had been done. The present report was drawn up on the basis of material selected in the country, visits to industrial sites, survey of processing units in their current activity and inspection of the places where waste waters and solid wastes were discharged. As a result the nature and quantity of pollutants entering the Gulf of Guinea and the Atlantic Ocean have been estimated. A list of persons met and factories visited in Ghana is contained in annex I.

The counterpart agency in Ghana was the Environment Protection Council (EPC) headed by E. A. Boateng. In this connection the expert wishes to express his gratitude to all EPC officials who assisted him in carrying out his mission.

Method used for the study

Apart from some surveyed enterprises, relevant data on industrial wastes are not available. Shortage of appropriate figures on industrial pollutants required the use of an indirect method to estimate the type and quantity of pollution loadings. For this purpose a survey questionnaire prepared in UNIDO beforehand was very helpful. Reasonable estimates were derived from the quantities of goods produced at the factories. A special table (see annex II) had been compiled for this purpose by E.J. Middlebrooks (later referred to as EJM table) taking into consideration the finished product and the corresponding technology. In parallel, the estimates were derived from the volume of waste water discharged. The necessary figures on the pollutant contents in the waste water were taken from the reference table [1]. The method of field work in the country comprised visits to the factories, talks with the managers, visual survey of the processing conditions and wastes, and filling in the questionnaires which the persons responsible for this usually left for some days. Unfortunately, in some questionnaires was not pointed out either the quantity of production, or the amount of waste water, or both. In those cases the estimates seem to be quite uncertain.

General characteristics of the country

Geographically, Ghana takes a central place among the countries in the Gulf of Guinea. Its territory of almost rectangle form covers some 672 km from south to north and 536 km from east to west with an area of 239,460 square kilometres. The population of Ghana is estimated at 10 million [2]. Ghana is predominantly an agricultural country though the industry is valuable. Agriculture including fisheries and forestry employs some 60% of the active population. The portion of industry (including mining and construction) in the total national product is 17% [3]. The dominant culture is cocoa, giving some 60% of the total foreign currency inputs to Ghana.

Marine environment

Coastal line

The coastal line of some 540 km is rather straight, without natural bays. Sandy beaches are smooth and low. There are no islands. Rivers entering the ocean create many lagoons especially in the east or west areas of the coast. As a law the lagoons are separated from the ocean by sandy bars which periodically interrupt a water discharge creating stagnant conditions inside the lagoons. From time to time the bars are broken through to be created again by the surf. The low land is streched out as a narrow stripe along the coast line enlarging up to ten kilometres in the Cape Coast, Winneba, Accra and the delta of the Volta areas. Somewhere the coastal landlow is divided with single hills of 300-500 m of height.

Continental shelf

The continental shelf has the largest width (50 miles) in the vicinity of Takoradi [4]. Here at the site of 110 miles along the coast there are a lot of fish (sardines and others) and very active fisheries. To the east and west the shelf is becoming more narrow (10-15 miles at the Volta mouth). The surface of the shelf is smooth (see figures I and II). At the external part of the shelf and continental slope the steps and terraces are met (figure III). The river deltas go on as underwater valleys cutting down the shelf area and creating a rather complicated relief (figure IV). The bottom sediments of terrigenic origin are usually reduced and contain hydrogen sulfide. This is important for the prediction of marine pollution, because reduced sediments have a specific absorption capacity for some pollutants such as organic matter or heavy metals.

Figure I. Profile of the shelf at Takoradi

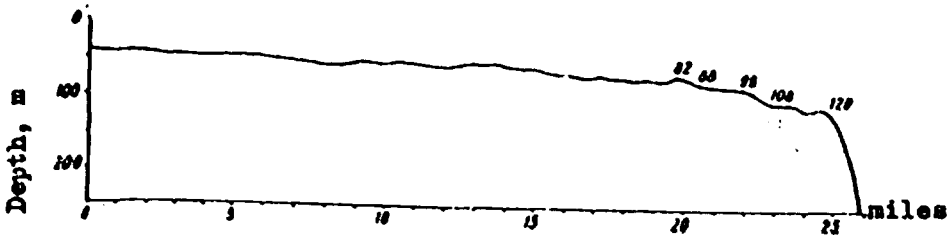


Figure III. The margin of the shelf and continental slope at Three Points Cape

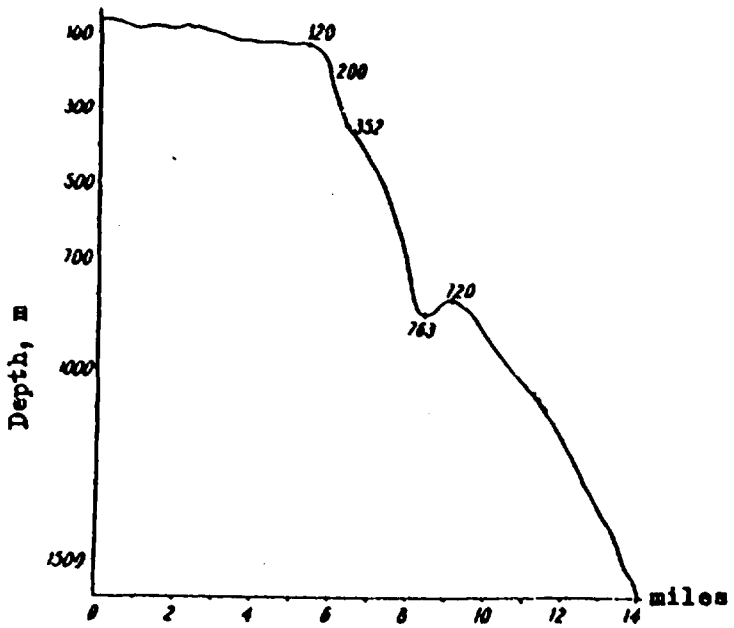


Figure II. Profile of the shelf at Accra

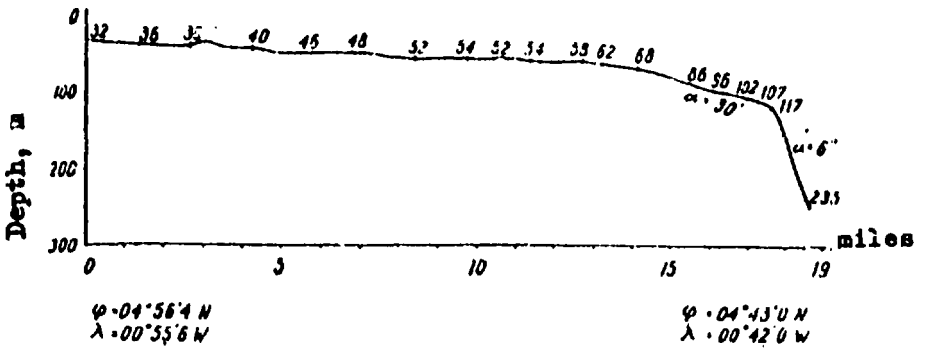
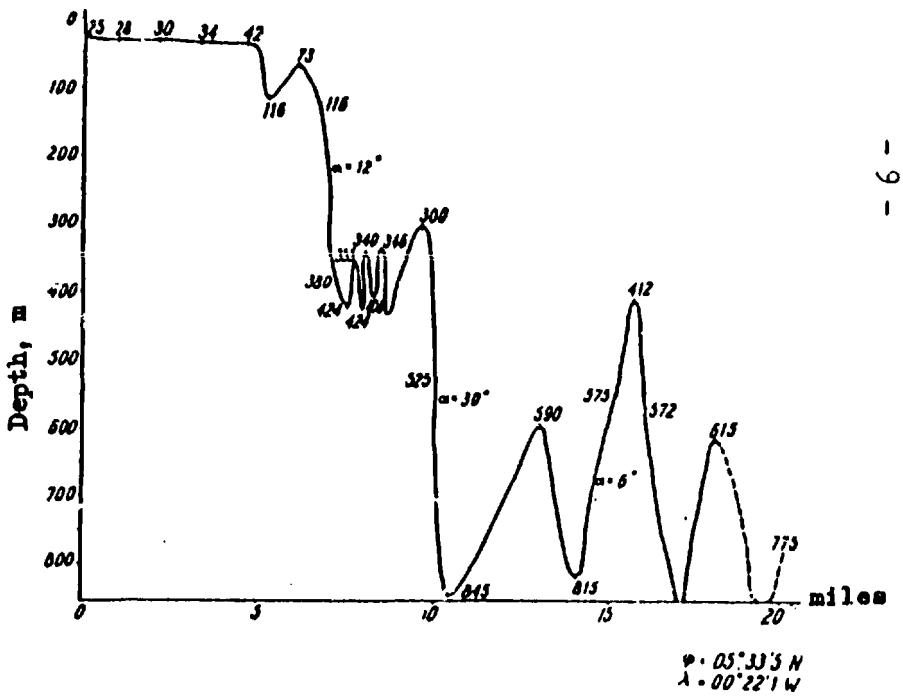


Figure IV. Profile of the ocean bottom at the Volta mouth



Climate and currents

The climate and currents are closely connected. As in many tropical countries there are in Ghana no sharply marked seasons but dry and rainy periods. In winter dominates the dry north-east passat (the Harmattan), in summer the south-west monsoon brings the wet air from the southern Atlantic. The latter wind creates two rain periods around May and September. The highest temperatures usually occur between February and April just before the rains begin and are near the coast around 28°C. The coolest month is August with temperatures around 24°C. Annual rainfall varies from 2,000 mm in the west of the coast to 760 mm in the Accra region.

Along the coast of Ghana flows eastward the Guinean surface current, maximal in May and June at 2 knots/h and more. During the strengthening of the Guinean current, the counter current appears near the bottom directed westwards [5]. East from the Three Points Cape the Guinean current creates one or more cyclonic eddies. The water circulation determines the rise of bottom waters providing the exchange and mixing. Additional mixing is caused by tidal currents acting up to 10 miles off shore. This results in the erosion of the beaches and appearance of muddy water along all over the coast of Ghana.

Generally, the active hydrodynamics of the coastal zone of Ghana promotes the fisheries due to the entrance of biogenic elements from the ocean deeps, thereby increasing the primary plancton and fish production, and provides the perfect mixing water, dilution and oxydation of the substances, including pollutants discharged in the marine environment. From the other side stagnant conditions might be created in the coastal bottom sediments of the ocean as well as in the lagoon environment.

Fishery

Eighty per cent of the fisheries in Ghana are ocean fisheries. The annual yields exceed 200,000 tons. Fishing is to a large extent done on a small level. About 120,000 fishermen and 8,000 boats are involved in the coastal fishing. There are about 120 trawlers operating in the open ocean [3]. The sardinella (Sardinella aurita) is most important for the fisheries. The fish concentrate at the border between the coastal water (low salinity) and the water of the Guinean current (high salinity), which results in the migration of the sardinella to and off shore depending on the season [5].

Considering the fisheries in the coastal area it is necessary to mind that fish is one of the sensitive elements of the marine environment with regard to pollution, including industrial contaminants.

Navigation

There are two important oceanic ports in Ghana, Tema and Takoradi. The annual cargo turnover is some 3 million tons. It should be noted that cargo and especially oil unloading operations are the sources of pollution, estimation of which requires special consideration.

Some patches of oil spill have been found from time to time in the coastal water. Investigations carried out by the Environmental Protection Council of Ghana four years ago showed that there were tar balls on many parts of the beaches. These tar balls and the patches of oil spill were found to arise from discharges of oil tankers. Oil discharged due to offshore drilling in the Cape Coast area can be considered as a potential source of oil pollution.

The most important source of pollution in Ghana is domestic sewage. All coastal cities, towns and villages discharge sewage directly into the sea without treatment. However, this question will have to be investigated at a later date, the subject of interest of the present study being marine pollution from industrial sources.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Industrial as well as domestic wastes in Ghana enter the marine environment practically with no treatment.

The main contaminant discharged from industrial sources into the marine environment is organic matter which is estimated by the level of BOD_5 (biochemical oxygen demand). The value of BOD_5 from industrial sources is almost one order lower than BOD_5 discharged with domestic sewage, i.e. 3,713 and 25,094 t/a respectively.

The quantity and the nature of industrial pollutants do no create an immediate danger for the country or the marine environment as a whole. An active movement of the coastal sea water, the smooth relief of the bottom and the high temperature promote the rapid dilution and degradation of the contaminants discharged.

However, in some places where waste water is discharged, especially in the lagoons such as the Korle lagoon at Accra, the Chemu lagoon at Tema and some others, there exists a danger of pollution and special control is required.

Oil pollution of local origin as well as from sources outside of Ghana is a remarkable nuisance for the beaches and the coastal water and constitutes an obstacle in the development of tourism. An increase of the oil production can be dangerous for the fisheries.

In Ghana there are some institutions and specialists capable to carry out environmental investigations. The development of a national environmental legislation is in progress and the country possesses a state organ, the Environmental Protection Council (EPC), which is responsible for environmental policy and control.

Recommendations

1. In any planning of industrial development, environmental problems, pollution loadings and waste treatment should be considered as a matter of course.

2. In addition to developing a national legislation, practical measures for environmental control should be established such as the organizing an environmental field network and monitoring.

3. The officials concerned with the industrial development of the country should be educated and trained with a view to make them aware of the importance of the protection of the marine environment.

4. The sponsoring of some Ghanian institutions which could carry out environmental investigations would be desirable.

5. Industries discharging wastes of considerable volume should be required to install equipment for the treatment for wast water or to improve existing ones.

I. ENVIRONMENTAL LEGISLATION AND RESPONSIBLE ORGANIZATIONS

The Environmental Protection Council (EPC) is responsible for ensuring that industries follow sound environmental practices. To this intent the research staff of EPC visits from time to time the industrial sites. Complaints about pollution and other industrial environmental matters are also investigated. A register of toxic chemicals used in the country is being prepared by the Toxic Chemicals Committee of EPC. The first part of the register covering pesticides has already been completed. The EPC also has an Industrial Pollution Control Committee on which representatives from the Universities, the Council for Scientific and Industrial Research (CSIR), the Ghana Standards Board, the Ministry of Health, the Ministry of Trade, the Ministry of Industries, Science and Technology are invited to serve as well as other individuals in their own capacity. The Committee advises the Council on all matters related to industrial pollution and has already initiated action towards the development of standards for the control of various pollutants.

EPC is participating in the Air Pollution Monitoring Programme of the Global Earth Monitoring System (GEMS) and has accordingly installed one high-volume air sampler in the industrial area at Tema. A programme for the monitoring of liquid and gaseous effluents from industries has been planned. For the time being EPC uses laboratory facilities of the University of Ghana, the Ghana Standards Board and the CSIR. However, steps are being taken by the EPC to acquire certain basic items of equipment which are either not available in the country or not easily accessible. EPC also collaborates with these institutions in its work. The Ministry of Industries, Science and Technology is taking steps to involve EPC in the granting of licences to prospective industrialists for the establishment of industries. This will ensure that environmental matters are given due consideration already at the initial stage. The EPC has also prepared a draft water pollution control decree which will, among other things, control industrial discharges into water bodies.

EPC has powers to invite any industrialist to its office for questioning on matters relating to the environment. With the proposed involvement of EPC in the granting of licences to industries to commence operations, the jurisdiction of the EPC over industrial activities will soon be enlarged and strengthened. The proposed water pollution control decree now being discussed will also give additional powers to EPC. Under that decree, EPC can delegate some of its powers to local authorities. There are various bye-laws of local councils and legislative instruments of certain government departments such as the

Ministry of Health and the Ghana Water and Sewerage Corporation, which control to some extent industrial pollution. It is envisaged that all these legislations and some new ones will be codified into a composite legislation under the auspices of the EPC. With regard to the facilities for the control of industrial pollution, laboratories of certain government institutions are used but steps are being taken to strengthen these laboratories and also to develop facilities within the Council itself.

In Ghana there are many institutions that carry out environmental investigations or have the potential for such investigations. The following organizations could be considered as basic for research work, consultance, field activity and environmental control:

EPC
Department of Chemistry, University of Ghana
Department of Biochemistry, University of Ghana
Department of Zoology, University of Cape Coast
Fisheries Research Unit of the Ministry of Agriculture, Tema
Water Resources Research Unit, CSIR
Institute of Aquatic Biology, CSIR
Ghana Standards Board

II. SURVEY OF INDUSTRIAL ENTERPRISES DISCHARGING WASTES INTO THE MARINE ENVIRONMENT

It was not possible to estimate the level of the Ghanian industry as a whole owing to the lack of statistical figures for the last years. According to the personal communication of senior executives of the industrial enterprises visited during the UNIDO mission, the industry operates at the moment at only 10 to 30 per cent of its capacity. The industry is short of raw materials and energy. The new Government is taking measures to improve the situation but it will take time. Nevertheless, during the survey it was tried to estimate the work of industries in their full volume.

According to a list of Ghanian enterprises existing in 1975, the major part of the industry is located along the Gulf of Guinea coast.

Table 1. Location of Ghanian enterprises

Industry	Total number of enterprises	Number of enterprises located in the coastal area
Food-processing	71	48
Beverages	24	14
Tobacco	3	3
Textiles	74	58
Pharmaceuticals	14	10

The large-scale industry is dominating in Accra and Tema.

For the survey of the industries discharging waste waters into the environment the EPC suggested a list of factories which, in sum, would enable to estimate the effect of the coastal industry as a whole.

Food processing industry

The food industry operates the processing and preservation of local agricultural products such as meat, fish, fruits and vegetables. The respective enterprises are of small or medium scale. The major food processing operations are undertaken at the breweries, milk, tobacco and cocoa factories. These factories are of fundamental importance for pollution loadings into the marine environment and many of them have been visited by the expert.

Food specialities

This largest milk cannery of Ghana processes annually 7,000 tons of milk powder, 2,500 tons of butter oil, 1,350 tons of malt extract and 700 tons of maize. The end products are condensed milk, Milo (cocoa beverage), Cerelac (baby food), Nescafe and some sauces. The factory has 705 employees working in three shifts.

Water from the municipal system is used in the following quantities: for processing 710 m^3/d, for cooling 10 m^3/d, for the boiler 80 m^3/d, for the cleaning equipment 120 m^3/d and for sanitary purposes 80 m^3/d. There are three outfalls: for processing waste water (66,000 m^3/a), for cleaning water (30,000 m^3/a) and for sanitary waster (24,000 m^3/a). Waste water without treatment goes to the lagoon, sanitary wastes go to the TDC-system (municipal sewerage). Processing waste water has no colour or odour and a pH of 7-7.5; other parameters have not been determined. The solid wastes are incinerated. The pollutants discharged were estimated according to the table for milk canneries ([1], table 156, page 367). It gives 96 tons $0_2/a$ (BOD_5) and 33.6 tons SS/a. From the EJM t ble the waste can be calculated, using the amount of processed dry raw material (7,000 + 2,500 + 700 = 11,550 t/a) and the average amount of water being consumed for milk product preparation (1:5). This gives an amount of finished dairy products of 69,300 t/a, which corresponds to BOD_5 = 0.9 kg/t x 69,300 t = 62.4 t, SS = 1.35 x 69,300 = 93.6 t and COD = 2.3 x 69,300 = 159 t discharged annually.

Accra brewery

This is one of the two beer factories on the Atlantic coast of Ghana, producing bottled beer and soft drinks and employing 700 workers. About 250,000 m^3 of processing waste waters pass the settling tank and then go to the Korle lagoon joining the other wastes of the city. The estimates of pollution loadings have been derived according to the tables for breweries ([1], table 176, page 382) and this gives annually 247 tons 0_2, 148 tons SS and 300 tons O (COD).

An analysis of the waste water (w.w.) carried out in 1973-1974 showed the following results:

1. pH 7.0-11.4 (average 9.9)
2. ml 0.1 HCl used to bring 100 ml w.w. to pH 7.07 — 0-5.50 (average 2.4)
3. ml sediment per 1 l w.w. after 2 hours — 2-40 (average 9.5)

4. Dry matter of sediment from (3) in g, after 2 hours at 105°C	0.04–11.5 (average 1.11)
5. Ashed dry matter from (4) in g, after 20 minutes at 650°C = inorganic substance	0.0159–1.2568 (average 0.4347)
6. ml 0.01 n $KMnO_4$ used per 1 ml w.w. (1:100 dilution)	2.6–23.0 (average 7.62)
7. mg organic substances per 1 l w.w. (1 mg $KMnO_4$ = 5.25 mg organic substances)	4.478–29.363 (average 12.847)

From these data the following estimates have been derived: SS - 278 t/a (item 4); alkalies (as NaOH) - 25 t/a (item 2); and organic substances 3.2 t/a (item 7).

The last figures seem to be somewhat doubtful because waste water from breweries has usually a neutral pH value or is slightly acidic and also because the quantity of organic substances derived from BOD must be much higher. The amount of SS, on the other hand, is twice as high as our estimate.

Tata Brewery

This brewery produces 150,000 hl of draught beer per year and employs 543 workers. The waste water is discharged into the Korle lagoon without any treatment. The amount of waste water is derived from the water consumption (600 m^3/d x 365 = 220,000 m^3/a). The content of the pollutants is taken from the table for breweries ([1], table 176, page 382). It gives 218 tons O_2 (BOD_5), 130 tons SS and 264 tons O (COD) annually. The corresponding figures from the EJM table are somewhat lower: 153 - 71 - 168 tons, respectively.

Pioneer Tobacco

This factory produces pipe tobacco and cigarettes, processing 200 tons of tobacco per year. The number of workers is 600 (two shifts). The total water consumption is 130 m^3/d. The main pollution loading is discharged by the process and cooling waste water, i.e. (22.7 + 4.5) x 365 = 9,900 m^3/a. Considering the high concentration of organic matter in the wastes one can assume a BOD_5 concentration of as high as 1,000 mg O_2/l. The annual pollution loading from Pioneer Tobacco is therefore 1,000 mg/l x 9,900 m^3/a = 10 t.

Cocoa Products

This company produces cocoa butter (5,208 t/a), cocoa liquor (4,200 t/a), cocoa cake (5,376 t/a) and a small quantity of cocoa powder. The number of

workers is 630 (four shifts). The total water consumption is 140 m^3/d and it is assumed that the same amount for waste water is discharged, i.e. 140 x 365 = 51,100 m^3/a. The content of the pollutants, if taken from the table for oil extraction factories ([1], table 162, page 367), gives an annual discharge of 12.2 tons O_2, 7.6 tons SS and 15.3 tons COD. The EJM table gives substantially different figures: 116 - 102 - 291 tons respectively.

Pollution discharges from all food-processing industries

Based on the number of food-processing industries in the country and by comparing them with the industries described before, an attempt has been made to estimate the total annual pollution discharged by all factories in this field. The summary is given in table 2.

Table 2. Annual pollution discharges from food, beverage and tobacco industries into the marine environment of Ghana

(tons)

Enterprise	BOD5		SS		COD	
	Table [1]	EJM table	Table [1]	EJM table	Table [1]	EJM table
Food specialities	96	62	34	94	115	159
Gudbury Ghana	(96)	(62)	(34)	(94)	(115)	(159)
Others	(200)	(130)	(70)	(380)	(250)	(320)
Total	400	250	150	570	500	640
Accra Brewery	247	(173)	148	(80)	300	(189)
Tata Brewery	218	153	130	71	264	168
Total	470	326	280	150	570	357
Pioneer Tobacco						
Takoradi plant	10	(10)				
Accra plant	10	(10)				
Total	20	(20)			(30)	(30)
Cocoa Products						
Takoradi plant	12.2	116	7.6	102	15.3	291
Tema plant	12.2	116	7.6	102	15.3	291
Total	25	230	15	200	31	580
Gross total	915	866	450	920	1 150	1 600

Note: Figures in brackets have been assumed.

Textile industry

The textile industry is one of the most advanced industries in Ghana operating in spinning, weaving, dying and finishing both synthetic and natural fibres. The Government of Ghana has given the expert the opportunity to visit almost all big textile factories in the coastal area.

Freedom textiles

This factory produces yearly 1,600 t grey cotton yarn and 5.76×10^6 m printed dress material of 1.2 m width. It processes 2,000 t raw cotton and 6×10^6 m grey cloth. The number of workers is 500 (two shifts). Water from the municipal system is used for bleaching, printing, cooling, for the boiler and for sanitary purposes. In the survey questionnaire the administration indicated that 26,000 t waste water are discharged annually. This figure is improbably low. For 1 t of finished cotton dress material factories normally use 150-350 m^3 (average 250 m^3) of water ([1], page 343, N25, 26) and discharge the respective amount of waste water. Accordingly, the amount of waste water discharged off the factory must not be less than 260,000 t/a. The printed dress material produced has a size of $1.2 \times 5.76 \times 10^6$ m^2 or, if converted into tons, $0.15 \times 1.2 \times 5.76 \times 10^3$ t = 1.02×10^3 t. The average water requirement would therefore be 1.02×10^3 t $\times$ 250 m^3/t = 254,500 m^3, i.e. about ten times more than the quantity indicated in the questionnaire.

The concentration of pollutants taken from the table for cotton material factories ([1], table 136, page 320) gives the following pollution loadings discharged annually: BOD_5 - 117 t, SS - 130 t, COD - 247 t. The estimates based on the production rate (EJM table) are different: BOD_5 - 23.7 t, SS - 60.3 t, COD - 293 t. For the latter calculations the weight of the finished product (1.02×10^3) and the following averages for BOD_5, SS and COD per ton of textile production were used: 22.7 kg for BOD_5, 58 kg for SS and 282 kg for COD. For the sake of comparable estimation of the textile industries the same figures will be used throughout.

Tema Textiles

The annual production of this factory is 22×10^6 m of printed material of 1.2 m width. The main processes involved are spinning, weaving, dyeing and printing. Tema textiles employ 2,300 workers. Water from the municipal system is used for bleaching and finishing of the fabrics as well as for boiler and sanitary needs. The waste water is discharged through a drainage system

into the sea. Sanitary wastes go to the municipal sewerage. The amount of process waste water is assumed to be as high as 3,301 x 365 = 1,205,000 t/a. For an annual production of 22 x 10^6 m = 1.2 x 22 x 10^6 m^2 = 0.15 x 1.2 x 22 x 10^3 t = 3.96 x 10^3 t of printed material the pollution loadings would be the following: BOD_5 = 22.7 x 3.96 x 10^3 = 89.9 t/a; SS = 58 x 3.96 x 10^3 = 230 t/a, COD = 282 x 3.96 x 10^3 = 1,116.7 t/a.

Ghana Textile Manufacturing

This is one of the largest textile factories in Ghana employing 2,257 workers in three shifts. The annual production is 36 x 10^6 m cotton cloth and the processing water consumption is some 1,800 m^3/d. The waste water flows to the sea through the Chemu lagoon. The pollution loadings calculated from the production rates are: BOD_5 = 147 t/a, SS = 376 t/a, COD = 1,827 t/a.

Ghana Textile Printing

This factory, which employs 1,990 workers, produces 18 x 10^6m printed material per year. The main processes consuming water are bleaching, dyeing and washing; water is also used for the boiler and for sanitary purposes. Industrial waste water goes through a settling tank which has been installed in the shop where the wax is being used. Considering the production rates, the annual amounts of pollutants are as follows: BOD_5 = 73.5 t, SS = 188 t, COD = 914 t.

West Coast Dyeing

About 240 t of cotton and rayon yarns are dyed yearly in that factory. Water is consumed for the preparation of the dye solutions, for washing and for the boiler. The waste water is discharged without treatment into the lagoon. The annual amount of pollutants based on production rates is: BOD_5 = 5.4 t; SS = 13.9 t; COD = 67.7 t.

Total pollution discharges from the textile industry

The factories surveyed represent the major part of the active textile industry in the coastal area of Ghana. To complete the picture it is worth to add the BH Industry-factory which had not been surveyed, but the production of which is, according to a personal communication, of the same value as that of the Freedom Textiles. The summary data on pollution loadings from textile industry into the marine environment are presented in table 3.

Table 3. Annual pollution discharges from textile industries into the marine environment of Ghana (according to EJM table)

(tons)

Enterprise	BOD_5	SS	COD
Freedom Textiles	23.7	60.3	293
Tema Textiles	89.9	230	1 116
Ghana Textile Manufacturing	147	376	1 827
Ghana Textile Printing	73.5	188	914
West Coast Dyeing	5.4	13.9	68
BH Industry	(23.7)	(60.3)	(293)
Total	363.2	928.5	4 511

Metal industry

Ghana has such high-quality bauxites and fine iron-ore deposits that the direct reduction processes could be used for the production of primary aluminium and steel from these ores. Nevertheless, the industries use only local scrap (Tema Steelworks Division) or imported bauxites (Volta Aluminium Company). There are high-quality manganese ores and a wide variety of silica sand which could be used for the production of ferro-manganese and ferro-silicon respectively.

Tema Steelworks Division (TSD)

So far TSD has produced some ferro-manganese from local manganese ore and the quality obtained had a Mn content of 64-70% as compared to the imported quality which contains 75% Mn. This is a remarkable achievement considering the limited research done under unsuitable conditions. TSD is now using the locally-produced ferro-manganese and work is being stepped up to produce also ferro-silicon for local use [7].

The estimates on TSD have been based on an annual production of 30,000 tons of steel rods. According to the EJM table it gives SS - 0.24 kg/t x 30,000 t = 7.2 t/a; oil and grease = 0.073 x 30,000 = 2.1 t/a.

Volta Aluminium Company (VALCO)

The expert visited VALCO, which is the largest metal plant not only of Ghana out of the entire West-African region. It produces 187,442 t of primary aluminium per year and employs 2,380 workers.

Alumina (2,362,731 t), criolite (5,436 t), aluminium fluoride (5,436 t), coke (84,097 t), pitch (23,901 t) and cathode paste (1,113 t) are used as raw materials. Water being taken from municipal system is used for:

(a) Cooling purposes, i.e. to chill the cast aluminium and in heat exchangers for the furnaces and compressors. This water recirculates and is not drained daily;

(b) Steam production in the boiler. The steam is used in the green carbon plant to process the carbon mixture and water is added at various locations to make up for losses through evaporation;

(c) Sanitary sewage which is discharged into the TEMA Development Corporation sewage system.

Industrial waste water comprising mainly of the surface rainfalls from the smelting shop and the scrap yard are not accounted and go to the Gao lagoon (outfall N1). The outfall looks extremely small, i.e. it is a thin stream. The other portion of the surface rainfalls as well as waste water from the cooling system (104,493 m^3/a) and the boiler (600 m^3/a) are flowing off through a drainage system to the Chemu lagoon (outfall N2) where waste waters from other industries of Tema are collected. The waste water is not being treated.

Analyses of the wastes, carried out from time to time, gave the following results (1979-1980):

	Outfall N1	Outfall N2
Temperature ^{o}C	29	29
Colour	dark	clean
Odour	no smell	normal drain water
pH	9.7	8.5
TSS, mg/l	93	202
VSS, mg/l	7	37
Na^+, ppm	748	25
CN^-, ppm	< 0.005	< 0.005
F^-, ppm	130	3

The territory in the vicinity of the outfall N2 is used for planting vegetables.

The plant produces inorganic solid wastes of 5,000-7,000 t/a which are transported for land fill or are partly (5%) incinerated. Gaseous wastes, containing fluorides, coal-tar volatiles, particulate alumina and chlorine, are discharged through 152 m high elevation stacks. The contents of gaseous contaminants is not available at present but can be provided at a later time.

An estimate of SS discharged by VALCO derived from the analytical data would amount to 202 mg/l x (104,493 + 600) m^3 = 21.2 t/a (outfall N2). Addition of the outfall N1 could double this figure up to 43 t/a. An estimate based on production rates gives: 10 kg/t x 187,442 t = 1,874 t SS annually.

Therefore, the total quantity of SS discharged by the metal industry of Ghana (TST and VALCO) is estimated to be 1,874 t + 7.2 t = 1,381 t annually.

Other industries

GHAIP Oil Refinery

This is the only topping refinery in Ghana providing the country with L.P. gas (70,000 t/a), gasoline (257,600 t/a), kerosine (194,000 t/a), gas-oil (257,000 t/a) and residual fuel oil (336,000 t/a). The refinery processes 1,250,000 t crude oil which is imported mainly from Nigeria. The number of workers is 660 (three shifts).

For the cooling of the refinery columns 480,000 m^3/d of sea water are used, which are pumped from the harbour into a basin. For the boiler 450 m^3/d of municipal water, previously treated by ion exchange method, is used. The water consumption for sanitary and other technical needs is 400 m^3/d.

Industrial waste water (15,906,000 m^3/a) and sanitary wastes (99,000 m^3/a) flow out separately. Industrial waste water is treated with American Petroleum Institute (API) separation. The oil residue is being re-distilled. Visually the quality of skimming is bad; the waste water is still strongly contaminated with oil. The annual pollution loading estimates based on production rates are as follows: BOD_5 = 0.094 kg/t x 1,214,000 t = 114 t; SS = 0.08 kg/t x 1,214,000 t = 97 t; oil and grease = 0.029 kg/t x 1,214,000 t = 35 t; COD = 0.47 x 1,214,000 t = 571 t; ammonium nitrogen 12 t; phenols 0.73 t; and total chrome 1.94 t.

The refinery also discharges gaseous emanations such as CO_2 and SO_2, but the amounts are uncertain.

Liver Brothers soap and detergent factory

This is the largest enterprise in Ghana producing soaps and non-soapy detergents. The annual production was not indicated in the questionnaire, possibly because the current level of production is extremely low and does not reflect the normal situation. Fats and oil, caustic soda, phosphates and alkalies are used as raw materials. The daily water consumption for soap making, sulphonation and other processes is 2,230 m^3, for the boiler 216 m^3 and for sanitary purposes 419 m^3. Industrial waste water flows out separately from the sulphonation plant (10% Na_2SC_3) and from the soap-making section. The latter passes through a separation trap, where the fat is being removed (efficiency 60%). There is no other treatment. These discharges which look like muddy foam are flowing out to the lagoon whilst the sanitary wastes are discharged into the municipal sewage system.

Pollution loadings discharged were estimated on the basis of the main contaminants taken from [1](table 162, page 367). The total volume of waste water is assumed to be equal to the process water consumption, i.e. 2,230 m^3/d x 365 = 813,950 m^3/a. This gives for BOD_5: 2,400 mg O_2/l x 813,950 m^3/a = 1,953 t/a; for SS: 1,500 mg/l x 813,950 m^3/a = 1,221 t/a; for COD: 3,000 mg/l x 813,950 m^3/a = 2,442 t/a.

Takoradi Veneer and Lumber

This factory has an annual production of 3,750 m^3 plywood, 3,000 m^3 lumber and 50,000 pieces doors. About 1,000 workers are employed at the factory and for the forest operations. Municipal water is consumed for glue mixing (20 m^3/d), for the boiler (45 m^3/d) and for sanitary needs (5 m^3/d). Industrial waste water of 3,000 m^3/a go directly to the sea. The pollution loadings entering the marine environment from the EJM table estimated are: BOD_5 = 0.62 kg/m^3 x 3,750 m^3/a = 2.32 t/a, COD = 1.56 kg/m^3 x 3,750 m^3/a = 5.85 t/a.

About 18 t/a of solid wastes - mainly sawdust - are removed to a piece of land near the plant.

L'air Liquide

This company produces 70,000 m^3/a of oxygen from condensed air and 26,000 m^3/a of acetylen from calcium carbide. The number of workers is 27 (three shifts). Water from the municipal system is consumed for processing and

cooling. Waste waters are discharged into the sea. No estimation of quantity of the waste water and the contents of contaminations was carried out.

The data on the metal industry, the oil refinery, as well as on the soap and veneer industries are summarized in table 4.

Table 4. Annual pollution discharges from the metal industry, the oil refinery and from other industries into the marine environment of Ghana (according to EJM table)

(tons)

Enterprise	BOD_5	SS	COD and others
Volta Aluminium		1 874	
Tema Steelworks		7.2	Oil and grease: 2.1
GHAIP Oil Refinery	114	97	COD: 571 Oil and grease: 35 $N - NH_4$: 12 Phenols: 0.73 Chrome: 1.94
Liver Brothers	1 953	1 221	COD: 2 442
Takoradi Veneer	2.3		COD: 5.8
Subtotal	2 070	3 200	COD: 3 019
Other branches (20% of subtotal)	414	640	604
Total	2 484	3 840	3 623

Pollution loadings from all Ghanian enterprises discharged into the marine environment

Some branches of the industry had left out of consideration when the survey was prepared by the expert. The pharmaceutical industry, due to lack of data, the cement industry because the questionnaires from Fulgarit, Precast Spun Concrete Products and Premix Asbestos Concrete Products were lost in the Ministry of Industry, Science and Technology, and the oil storage because the questionnaire from the Shell Bitumen Plant was not received in time. Nevertheless, these industries as well as other enterprises of small scale were accounted by increasing the total pollution loading of table 4 by 20%.

Summarizing the data of tables 2, 3 and 4 (see also annex III), the total pollution loadings from Ghanian industry can be estimated. These total values, based on EJM tables, are as follows:

BOD_5 = 866 + 363 + 2,484 = 3,713 t/a
SS = 920 + 928 + 3,840 = 5,688 t/a
COD = 1,600 + 4,511 + 3,623 = 9,734 t/a

The population of the coast area of Ghana is some 1,250,000 of which about 1 million live in the towns of Accra, Tema, Cape Coast, Secondy-Takoradi and Wineba. The estimate of the value of BOD_5 from domestic sewers entering the marine environment is 55 g/habitant/day x 1,250,000 x 365 = 25,094 t/a.

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Annex I

PERSONS MET AND FACTORIES VISITED IN GHANA

Accra

Freedom Textiles and Chemicals Co. Ltd.
Shen Chou, General Manager

Accra Brewery Ltd.
Brookman Amissah, Administrative Manager
F. G. Edzeame, Development Manager

Imperial Chemical and Pharmaceuticals
Mr. Moncar, Production Manager

Fulgurit

Precast Spun Concrete Products and Premix Asbestos Concrete Product
E. K. Otoo, General Manager

Achimota Brewery
Adu Gyamfi, Managing Director
Osei Bonsu, Production Manager

Tema

Ghaip Oil Refinery
C. A. Simpson, Refinery Manager
G. K. Folson, Production Manager

Volta Aluminium Co. (VALCO)
A. Phillips, Resident Manager
S. C. Manaktala, Technical Director

Food Specialities
Mr. Grob, Plant Engineer
Mr. Wittle, Production Supervisor

Tema Textiles Ltd (TTL)
C. A. Iokko, Mill Manager

Ghana Textiles Product (GTP)
Mr. Evans, Mill Manager

West Coast Dye
S. A. Winful, Administrative Manager

Lever Brothers Ghana Ltd.
H. Pease, Managing Director
Dr. Tagoe, Technical Services Manager

Ghana Textiles Manufacturing Co. (GTMC)
Mr. Lieu, General Manager
Mr. Wong, Factory Engineer

Tema Development Corporation
Ashiley Okine, Chief Engineer

Sekondi-Takoradi

Pioneer Tobacco Co. Ltd (PTC)
Mr. Adadevor, Factory Manager
G. K. Fenny, Factory Engineer

Ghana Cocoa Products Factory
Isaac Vander Puiye, General Manager
Mr. Markade, Production Manager

L'Air Liquide
Mr. Larbi, Factory Manager

Takoradi Veneer and Lumber Co. Ltd. (TVLC)
Anim Bonsu, Managing Director
J. K. Tandoh, Chief Engineer

Shell Bitumen Plant
N. K. Bulley, Operations Manager
Gyasi Adonten, Plant Manager

Environmental Protection Council, Accra

Prof. E. A. Boateng, Executive Chairman
F. K. Jiagge, Secretary
Dr. B. W. Garbrah, Sc. Co-ordinator
J. K. Danso, Assistant Res. Officer

Ministry of Industries, Science and Technology, Accra

G. Attoh Oikine
Adu Frimpong

UNDP field office, Accra

W. Holzhauzen, resident representative
C. Buhder, assistant resident representative

Annex II

RAW WASTE LOADS BASED ON PRODUCTION RATES USED TO ESTIMATE POLLUTION DISCHARGES FROM WEST AFRICAN COUNTRIES

Type of Industry	Raw Waste Loads, kg/ton										Reference
	BOD_5	SS	Oil + Grease	COD	Ammonia Nitrogen	Phenols	Total Chrome	Fluoride	Cyanide	Total Phosphorus	
Canned and preserved fruits and vegetables	5.13	6.33		12.8							EPA, 1977a
Southern (nonbreaded) shrimp		253.3	80.0								EPA, 1977a
Alaskan bottom fish processing		11.3	0.60								EPA, 1977a
Corn wet milling	9.02	8.93		22.6							EPA, 1977a
Corn dry milling	0.71	0.63		1.78							EPA, 1977a
Bulgur wheat flour mills	0.10	0.10		0.25							EPA, 1977a
Parboiled rice	0.93	0.53		2.33							EPA, 1977a
Ready-to-eat cereal	2.67	2.67		6.68							EPA, 1977a
Wheat starch gluten	13.3	13.3		33.3							EPA, 1977a
Simple slaughterhouse (kg/ton LKW)	0.80	1.33	0.4	2.0							EPA, 1977a
Dairy products	0.90	1.35		2.3							EPA, 1977a
Crystalline cane sugar	5.73	1.20		14.3							EPA, 1977a
Edible oils	22.3	19.5	14.0	55.8							Middlebrooks, 1979
Brewery	10.2	4.73		11.2							Middlebrooks, 1979
Soft drinks	3.15	4.33		7.9							Middlebrooks, 1979
Flavoring extracts (chocolate, etc.)	Insignificant discharges										Middlebrooks, 1979
Coffee	625	50		1,562							Nemerow, 1978
Bottling wine	3.15	4.33		7.9							Middlebrooks, 1979
Alcohol production (kg/m^3)	4.85			12.12							Middlebrooks, 1979
Petroleum refining (topping)	0.094	0.080	0.029	0.47	0.010	0.0006	0.0016				EPA, 1977a
Petroleum refining (cracking)	0.126	0.080	0.048	0.35	0.026	0.0006	0.0016				EPA, 1977b
Petroleum storage and washing			0.5								Carmichael + Nemerow, 1977
Petrochemicals	0.144	0.116	0.047	0.85	0.084	0.0009	0.0024				EPA, 1977a
Manufacturing soap flakes and powders	0.067	0.067	0.067	0.33							EPA, 1977a
Manufacturing bar soap	2.27	3.87	0.27	5.67							EPA, 1977a

Type of Industry	Raw Waste Loads, kg/ton										Reference
	BOD_5	SS	Oil + Grease	COD	Ammonia Nitrogen	Phenols	Total Chrome	Fluoride	Cyanide	Total Phosphorus	
Tires and inner tubes		0.43	0.11								EPA, 1977a
Emulsion crumb rubber	2.67	4.33		53.3							EPA, 1977a
Solution crumb rubber	2.67	4.33	1.07	24.3							EPA, 1977a
Latex rubber	2.27	3.67	0.93	45.7							EPA, 1977a
Leather tanning + finishing (hair pulp with chrome tanning)	26.67	33.3	5.0	66.7			0.67				EPA, 1977a
Pulp, paper and paperboard (unbleached kraft)	18.67	40.0		46.7							EPA, 1977a
Cement manufacturing (leaching)	2.67			6.7							EPA, 1977a
Explosives	1.46	29.3		3.87							EPA, 1976
Textiles printing and dyeing (assume cloth weighs 0.15 kg/m^2)	22.7	58.0		282.0		0.40	0.40				EPA, 1977a
Paint and laquer	0.13	0.20		0.33							Margola, 1980
Plywood (kg/m^3 of plywood)	0.62			1.56		0.70					Nemerow, 1978 and BSWCWD, 1978
Veneer (hardwood, kg/m^3)	3.64			9.1							EPA, 1977a
Iron and steel		0.24	0.073		0.61	0.01			0.15		EPA, 1977a
Primary aluminum smelting by Hall-Heroult process		10.0						6.67			EPA, 1977a
Phosphate manufacturing		3.33						0.33		1.00	EPA, 1977a
Sulfuric acid		0.30	0.045								BSWCWD, 1978
Ammonium sulfate					2.5						EPA, 1977a
Plating and galvanzing		1.26					0.018	0.031		0.063	EPA, 1977a
Fertilizers		3.33						0.33		1.00	Nemerow, 1978
Pharmaceuticals	21.3	47.3		53.3							BSWCD, 1978
Batteries 1/	6.24	1,560		15.6							BSWCWD, 1978

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

Note: This table has been compiled by E.J. Middlebrooks.

Annex III

SUMMARY OF SURVEY OF INDUSTRIAL ENTERPRISES DISCHARGING WASTES INTO THE MARINE ENVIRONMENT

No.	Type, name location	Workers (shifts)	Production/a	Raw material/a	Main processes	Use of water, m^3/day		Waste water, m^3/a		Pollutants discharged, t/a			Comments and references
						Item	Total	Item	Total	BOD_5	SS	COD	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Food												
1	Food Specialities (Tema)	705 (3)	Condensed milk 1.4×10^6 cases Milo (cocoa bev.) 0.3×10^6 cases Cerelac (baby food) 0.1×10^6 cases Nescafe 0.18×10^6 cases Maggi cubes (ketchup) 17,000 cases	Milk powder 7,000 t Butter oil 2,500 t Malt extract 1,350 t Maize 700 t	Process Cleaning Boiler Cooling Sanitary	710 120 80 10 80	1,000	66,000 30,000 24,000	96,000	96 62.4	33.6 93.6	115 159	Table 156, page 357 [1] EJN table
2	Accra Brewery (Accra)	700 (2)	Beer Soft drinks						250,000	247	148	300	Table 176, page 382 [1]
3	Tata Brewery (Accra)	543 (3)	Beer 150,000 hl	Malt 1,750 t Hops 15 t Sugar 550 t Chemicals 6 t	Brewing Fermentation Pasteurisation Cooling Boiler Sanitary		600		220,000	218 153	130 71	264 168	Table 176, page 382 [1] EJN table
4	Pioneer Tobacco (Takoradi)	600 (2)	Cigarettes Pipe tobacco 200 t		Process Cooling Boiler Sanitary	22.7 4.5 43.6 59.0	130	8,300 1,600	9,900	10			
5	Cocoa Products (Takoradi)	630 (4)	Cocoa butter 5,208 t Cocoa liquor 4,200 t Cocoa cake 5,376 Cocoa powder	Cocoa beans	Process Cooling Boiler Sanitary		140	5,100	5,100	12.2 116	7.6 102	15.3 291	Table 162, page 367 [1] EJN table

1	2	3	4	5	6	7	8	9	10	11	12	13	14
6	Ghana Pharmaceuticals (Accra)		Antibiotic injections Antibiotic capsules Antibiotic syrups Chloroquine " Cod liver oil	Antibiotics Cod liver oil	Production of distilled water Washing of bottles Sterilisation of rubber caps								
	Textile												
7	Freedom Textiles (Accra)	500 (2)	Grey cotton yarn 1,600 t Printed dress materials 5.76×10^6 m (1.04×10^3 t)	Raw cotton 2,000 t Grey cloth 6×10^6 m	Spinning Weaving Bleaching Printing Cooling Boiler Sanitary	120 15 3	138	22,000 3,000 1,000	26,000 (260,000)	11.7 (117) 23.7	13.0 (130) 60.3	24.7 (247) 293	Table 136, page 320 [1] table on page 343, M25,26 [1] EJM table
8	Tema Textiles (Tema)	2,300	Printed materials 22×10^6 m (3.96×10^3 t)	Raw cotton	Process (spinning, weaving, dyeing, printing) Boiler Sanitary	3,301 211 810	4,372		1,205,000	542. 89.9	602 230	1,145 1,116	Table 136, page 320 [1] EJM table
9	Ghana Textile Manufacturing (Tema)	2,257(3)	Cloth 36×10^6 m (6.48×10^3 t)	Cotton 5.4×10^6 t Dyestuff chemicals 1,200 t	Spinning Weaving Bleaching Dyeing Finishing New printing Cooling Boiler	1,800 131 360	2,291 3,630 (max)			147	376	1,827	EJM table
10	Ghana Textile Printing (Tema)	1,990(2)	Printed materials 18×10^6 m (3.24×10^3 t)	Grey cloth	Process (bleaching, dyeing, washing) Boiler Sanitary	 150 100				73.5	188	914	EJM table

1	2	3	4	5	6	7	8	9	10	11	12	13	14
11	West Coast Dyeing (Tema)	100 (3)	Dyeing cotton and rayon yarns 240 t	Spun cotton and rayon yarns 240 t Chemicals 48 t Dyestuffs 10 t	Process Boiler Sanitary					5.4	13.9	67.7	EJN table
	Metal												
12	Volta Aluminium (Tema)	1,998 (1-3)	Aluminium (primary) 187,442 t	Alumina 362,731 t Cryolite Aluminium fluoride Coke Pitch Cathode paste	Cooling Boiler Sanitary	284 1 1,090	1375	104,493 600 3,828,850			43 1,874		Direct analysis EJN table
	Oil refinery												
13	GHAIP (Ghana-Italian Petroleum) (Tema)	660 (3)	L.P. Gas 70,000 t Gasoline 257,000 t Kerosine 194,000 t Gasoil 357,000 t Residual fuel oil 336,000	Crude oil 1,250,000 t	Cooling (sea water) Process Boiler Sanitary	48,000 200 450 200	1,000	48,000 m^3/d 140 m^3/d 60 "	15,906,000 m^3/y 99,000 m^3/y	114	97	571 oil, grease 35 $N\text{-}NH_4$ 12 phenols 0.73 total chrome 1.94	EJN table Steam condensate - API - skimming
	Soap and detergents												
14	Liver Brothers (Tema)	915 (3)	Soaps Non-soapy detergents Tooth paste Scourers	Fats and oil Caustic soda Phosphates Alkalies	Soap making Sulphonation Cooling Boiler Sanitary	2,230 216 419	2,865	813,950		1,953	1,221	2,442	Table 162, page 367 [1]
	Plywood glue plant												
15	The Takoradi Veneer and Lumber (Takoradi)	1000 (2) including forest operations	Plywood 3,750 m^3 Lumber 3,000 m^3 Doors 50,000 pieces	Timber	Glue mixing Boiler Sanitary	20 45 5	70		3,000	2.3		5.8	EJN table

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Other inorganic chemicals												
16	L'air liquide (Takoradi)	27(3)	Oxygen 70,000 m^3 Acetylene 26,000 m^3	Air Calcium carbide	Cooling Sanitary								
	Building houses												
17	Tema Development Corp.		Building houses Tema sewerage system	Cement, stone, sand, water									Sewerage pipe