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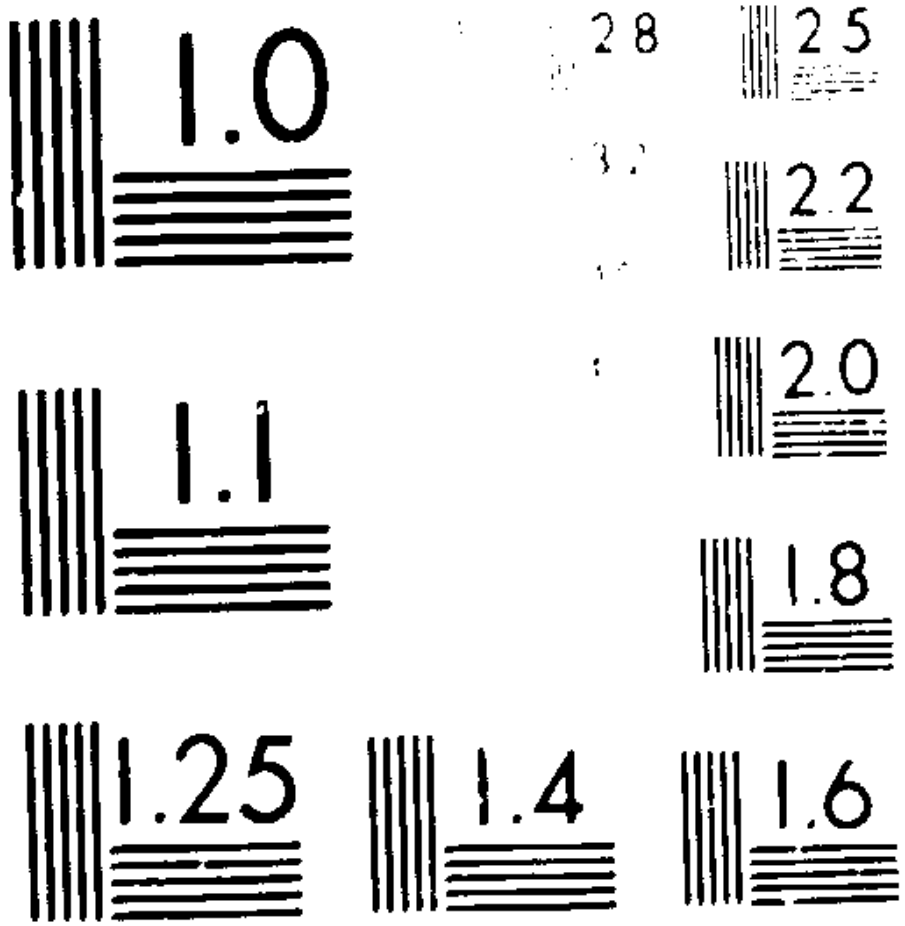
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# SURVEY OF MARINE POLLUTANTS FROM INDUSTRIAL SOURCES IN THE WEST AFRICAN REGION

EP/INT/79/009

Report on mission to the Gambia

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

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

80-42097

Explanatory notes

The monetary unit in the Gambia is the dalasi (D). During the period covered by the report, the value of the dalasi in relation to the United States dollar was $US 1 = D 1.72.

References to tons (t) are to metric tons.

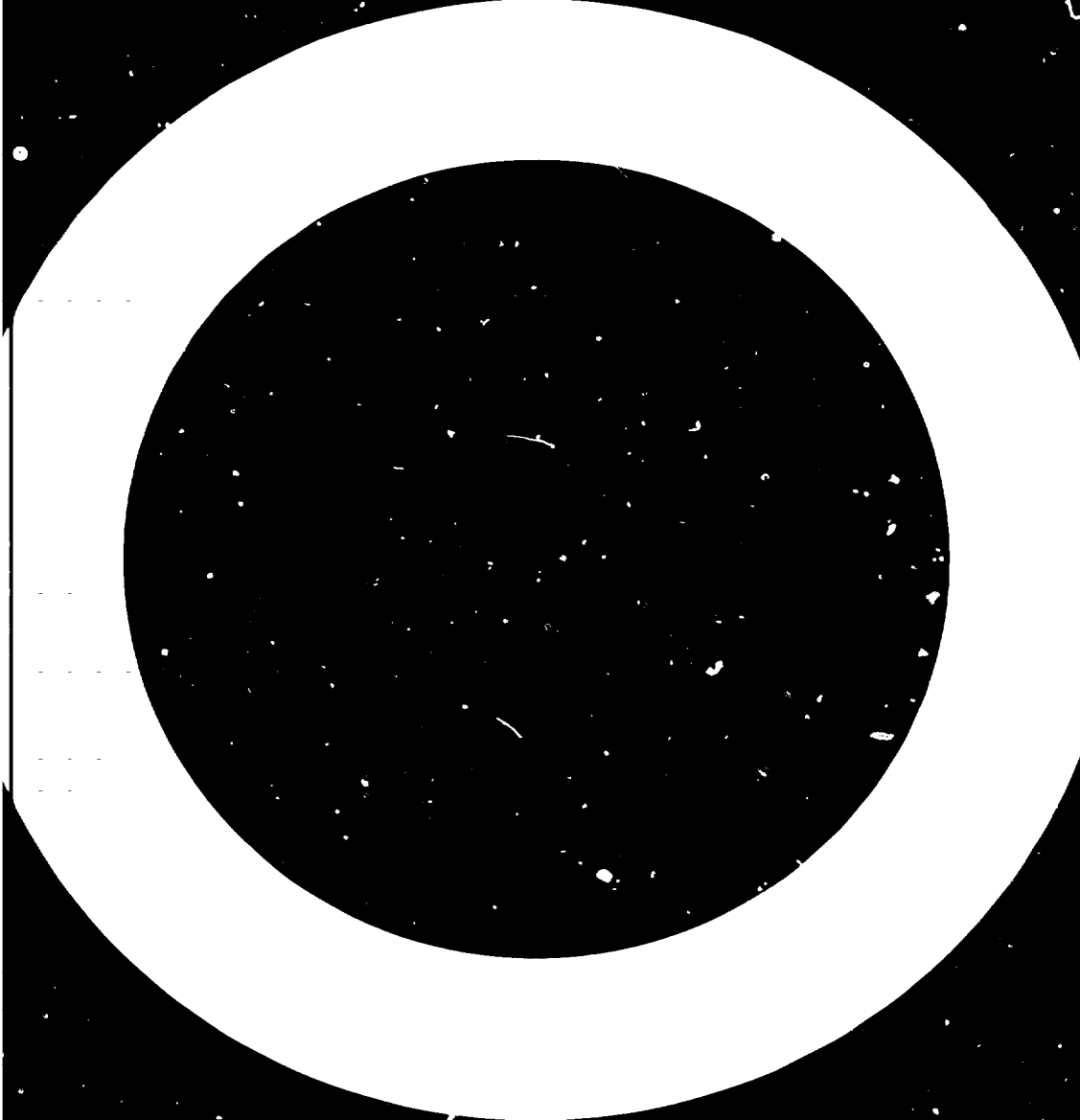
Besides the common abbreviations, symbols and terms, the following have been used in this report:

| | |
|---|---|
| $BOD_5$ | Biochemical oxygen demand after five days |
| COD | Chemical oxygen demand |
| FMC | Fish Marketing Corporation |
| GDP | Gross domestic product |
| n.r.t. | Net register tons |
| SS | Suspended solids |

## 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 24 June to 9 July 1980 to the Gambia to gather information on the type and quantity of pollutants from major land-based industrial sources entering the marine environment through direct coastal 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 Atlantic Ocean have been estimated. His report includes a study of the existing and planned environmental legislation in the Gambia 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 the Gambia 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 the Gambia from 24 June to 9 July 1980. The 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 Atlantic Ocean have been estimated. A list of persons met and places visited in the Gambia is contained in annex I.

The counterpart agency in the Gambia was the Ministry of local Government and lands. In this connection the expert wishes to express his gratitude to H. D. Dodwell and M. B. Jey who kindly arranged the survey of the industrial sites and 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 waters 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 it 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

The Gambia is one of the smallest countries in West Africa. It stretches out 325 km, east to west, as a narrow strip of land along the river Gambia. The maximum distance from north to south is 48 km. The Gambia is generally a flat country, slightly inclined westwards. The population is close to 600,000 of mainly agricultural occupation (35%) [2,3]. Agriculture is mostly rainfed and the dominant product is groundnut.

## Marine environment

### Continental shelf

The continental shelf extends to around 40 miles off shore with depths up to 100-110 metres. The surface of the shelf bottom area is mainly flat, but in some places, especially near the continental slope, there are rocks of 20-25 metres. The sediments are sandy; at depths of more than 200 metres clays appear [4].

### Climate

In the marine area of the Gambia there is a monsoon climate. From December to April the northern winds blow, June to September the south-west monsoons dominate. At other times winds gradually change their direction.

### Ocean currents

The main ocean currents here are the cold Canarian current flowing from the north at an average speed of 0.5-0.7 knots, and the warm branch of Equatorian counter current from the south flowing at up to 0.7 knots [5]. The former dominates in winter time, the latter in summer. The zone where streams meet is an area of increased biological production where fish concentrate. The temperature of surface ocean water increases from 20°C in February to 29°C in September and the salinity ranges from 36‰ in the open ocean to 28-30‰ at the mouth of the river Gambia.

Visually, especially from the air, one can observe a strip of muddy water all along the West African coast. The width of the strip varies greatly,

i.e. from ten metres to ten miles, and depends on hydrodynamic, mostly tidal, activity in the area. It is remarkable that fish concentrate on the border of the clean and muddy waters. Active currents along the Gambian coast, the tidal movement, the mixing of oceanic and river waters and, to a smaller extent, waves, are factors causing a perfect mixing of all the loadings discharged into the ocean, including pollutants.

Fisheries

The fisheries in the Gambia are controlled by the limits for territorial waters now set at 200 nautical miles. Within the present 1,500 square miles of shelf area in the Gambia, there is a stock of commercially exploitable demersal species of approximately 4,000 tons annually; it is also estimated that the potential exists for annual yields of 8,000-12,000 tons [6].

No surveys have been carried out for pelagic species, though sample surveys of present landings indicate figures of 5,000-6,000 tons per year, as opposed to the now frequently quoted estimate of 12,000-15,000 tons [7].

Though the Gambia has a limited coastline it is said to be one of the richest fishery zones in West Africa. Rational planning and management could make the fishing industry the most important one in the country as far as benefits are concerned.

Fishing in the Gambia is to a large extent done on an artisanal, small-scale level. Frame surveys for 1978 show that 582 boats are involved in the fishing (Fisheries Department), the majority of them based on the Atlantic coast and the rest along the estuary and the river. It is estimated that 5,000 fishermen are involved in sea fishing and that the majority is engaged full time.

Bouga (Ethmalosa fimbriata), a pelagic species, forms the bulk of fish landings in the Gambia. The majority of landings are on the Atlantic coastal villages, namely at Gunjur, Tanji and Brufut, where most of the fish is smoked for export. It is estimated that between 70 and 100 tons of lobsters are exploited annually, though recent figures indicate much higher landings. Dried cockles are exported to other West African countries and the estimate is 150 tons annually. Between 1971 and 1976, shrimps were being exploited on relatively large scale by industrial ventures. In 1973 the figure reached a declared

310 tons, representing the highest tonnage produced within the period of operations. Figures for 1974 and 1975 were 185 tons and 200 tons respectively. This information was received from the Fisheries Department of the Ministry of Agriculture and Natural Resources. According to a personal communication no particular influence of industrial or other pollutants on fish and fisheries has been noticed in recent years, neither in the estuary nor in the ocean.

The estuary of the river Gambia

The estuary is closely under affection of the adjacent ocean environment. At the mouth of the river, the St. Mary Island is situated with the capital of Banjul. Banjul, which has a population of about 55,000, and the Kanifing industrial area, can be considered the main sources of domestic and industrial pollution for the coastal environment. The island is connected with the mainland by a bridge. A sandy bar separates the estuary of the river Gambia from the ocean, but its height does not prevent the water from freely moving back and forth. The estuary is steadily ventilated with tides of 1-2 m, which affect the river up to the eastern border of the country. It results in saline water in the river within 80 km up to a maximum of 250 km from the coast, depending on the time of the year. High salinity makes the use of river water impossible for irrigation below the limit of saline incursion. The river Gambia is unique in Africa insofar as oceanic vessels with 3.8 m below the water-line can go up 286 km to the Mac Carthy Island, and in the rainy season up to 320 km.

A visual survey of the estuary from the boat showed that in the mouth the river water does not differ from oceanic water, i.e. it is of a greenish-green colour. Only around the Dog Island, about 10 km up the river, remarkable stripes of brown-green water appear.

On the banks of the estuary there are practically no villages. They are occupied with mangrove swamps behind which the palms can be seen, then the baobabs with their modest green and a little farther, the luxurious crones of the silk cotton trees. The end point of the trip was the St. James Island, 25 km from the coast, which is a small bird island with the ruins of an old fortress. The birds are attracted here by the large numbers of fish. On the right bank just opposite the St. James Island is the village of Albreda, where farmers and fishermen are living. In the estuary dolphins, flying fish and many birds can be seen.

No traces of pollution, including oil spots, were noticed anywhere. The part of the country lying up the river has no industry.

Because of the tidal action, the pollution from industrial and domestic wastes from Banjul or even oil pollution from the ocean can penetrate into the estuary and can be absorbed by the mangrove swamps. This fact should be considered for future development; the present level of industrialization in the Banjul region does not constitute a nuisance in the estuary area.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The limited industry of the Gambia is located mainly round the capital of Banjul and does not discharge dangerous quantities of pollutants to the marine environment. The pollution loadings are being eliminated by extremely active hydrodynamics of the coastal and estuary area.

The major portion of the industrial wastes are discharged by the food factories. Elevated quantities of $BOD_5$ and oil are essential components thereof. The total value of industrial $BOD_5$ discharged around Banjul is comparable with $BOD_5$ of the Banjul domestic sewers.

Being located at the mouth of the river Gambia, the town of Banjul can be a source of partial pollution of the estuary when the tidal movement is directed up the river.

Oil pollution from the town of Banjul (rainfalls, the sea port, the dockyard and others) is limited by value but has a great aesthetic impact on the sea environment especially in the view of tourism.

National environmental legislation is in progress, but practical measures for environmental control are minimal.

### Recommendations

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

2. As a matter of priority, waste waters discharged by the industries located in Banjul itself should be treated, paying special attention to the removal of oil.

3. The officials concerned with 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. A national environmental agency or council should be established to oversee all environmental problems.

5. A national field unit should be created which would carry out appropriate chemical and other analyses for the estimation of environmental conditions and the control of the contaminants.

## I. ENVIRONMENTAL LEGISLATION AND RESPONSIBLE ORGANIZATIONS

At present the Gambia has no legislation establishing an environmental protection authority, requiring environmental assessments of actions, or specifically addressing environmental planning, development, or protection [9] There are, however, miscellaneous sections within various other non-environmental laws which in effect provide for some indirect environmental protection.

The Government is currently considering the establishment of a permanent environmental unit, which, if created, would likely be mandated by appropriate legislation. At present a temporary Environmental Unit, located in the Ministry for Local Government and Lands, has been co-ordinating environmental matters to a limited extent. This Unit has no legal status or power.

The Gambia's National Five-Year Development Plan 1976-1980, while not legislation, contains a clear commitment by the Government to development that is environmentally sound. Chapter 8, entitled "The Environment", specifies as the Government's "clear objective" the ordering of development in the Gambia "in such a way as to ensure a continuance of its sources of potential welfare in the future. This will involve not only reclamation, restoration, and preservation, but also enhancement of the environment" (para. 8.2).

The following agencies are responsible for the adminstration and implementation of environment legislation:

(a) President's Office:

- (i) Police Department: generally responsible for the enforcement of any provisions, including those attached to environmental legislation, related to offences, fines etc.;
- (ii) Department of Wildlife Conservation; responsible for implementing the Wildlife Conservation Act No. 1, 1977;

(b) Ministry of Agriculture and Natural Resources:

- (i) Department of Forestry; implements Forestry Act No. 8, 1977;
- (ii) Department of Fisheries; implements Fisheries Act No. 17, 1977;
- (iii) Department of Hydrometeorology; most likely to oversee water legislation;
- (iv) Department of Crop Protection; most likely to oversee pesticide regulation;

(c) Ministry of Health, Labour and Social Welfare: administers Public Health Act, Cap. 154, 1935;

(d) Ministry for Local Government and Lands; deals with local government and provincial matters; administers Mining Act (Mineral Act, Cap. 121, 1954); oversees almost all activities in the provinces executed through local area councils or other authorities at district and village levels. Physical Planning Office; approves building applications;

(e) Ministry of Works and Communications, Ports Authority; responsible for dealing with pollution in Gambian waters.

Management of the coastal zone

The Ministry for Local Government and Lands holds the leases for the entire coastal strip to a depth of one half mile. This area has been set aside as a tourism development area. Since a major objective in planning this area was to preserve the natural beauty of the coast, the proposed tourism development has been confined to limited areas, i.e. to three sites at Kotu and three at Brufut. Between the sites, areas of considerable size are defined as nature reserve or forest park. To prevent environmental deterioration, efforts are being made to regulate the development of the tourism development area with the aid of detailed land use and infrastructure maps of the area.

Under the Mining (Mineral Oil) Act, Cap. 122, 1955, the Minister for Local Government and Lands may make regulations as to any matter in connection with the mineral oil mining industry in the Gambia, including regulations for the prevention of pollution of land or water by mineral oil. Under the Continental Shelf Act, Cap. 32, 1965, any person allowing the discharge of oil of more than 100 ppm from vessels, pipelines, or as a result of operations in connection with the exploration of the seabed and subsoil or the exploitation of natural resources is guilty of an offence unless he took reasonable steps to prevent it, and after it was discovered, took all reasonable steps to stop or reduce it.

The Government has established the territorial sea at 12 miles and a fisheries zone of 200 miles.

Under the Ports Act, No. 21, 1972, the Ports Authority has the independent duty to prevent pollution in Gambian waters. Gambian waters is defined to include the territorial and inland waters such as the river Gambia and all tributaries thereof, or creeks, within the limits of the Gambia. No water standards or specific measures to abate or prevent pollution of Gambian waters have as yet been established.

Under the Minerals Rules, Cap. 121, 1954, restrictions have been made in the form of conditions of leases on pollution of water courses by tailings. Under the Mineral (Mineral Oil) Act, Cap. 122, 1955, the Minister responsible has authority to make regulations to prevent pollution of land or water by mineral oil; this regulation is usually accomplished through lease and license conditions.

Within the continental shelf (Cap. 32, 1965), if any crude oil, fuel oil, lubricating oil, heavy diesel oil, or any mixture containing such oil is discharged, the person responsible is guilty of an offence unless he can prove he took all reasonable steps to stop the discharge.

The Fisheries Act, No. 17, 1977, gives the Minister of Agriculture and Natural Resources the general authority to make regulations to conserve, manage, and protect fish resources. This power could encompass pollution control where fish are affected.

The Navigation and Pilotage (Consolidation) By-Laws, Cap. 129, regulate the shipment of dangerous goods within Gambian waters. Most of the existing legislation in this area is primarily confined to health and safety.

Recently the Department of Hydrometeorological Services and Water Resources has prepared and submitted to the Government the Water Act [7]. In this document the principles of water supply, consumption and control as well as the status of appropriate institutions and responsibilities of water consumers are worked out in detail. From the total of 137 pages of the Act only half a page is cited here concerning the protection of beaches and fisheries.

" (1) No person, municipality, township, commercial undertaking, industry, or other user of water shall be permitted to discharge effluent into the sea in close proximity to the shore;

(2) All sea discharges shall be subject to permission from the Water Board who after consultation with the Department of Fisheries and other competent authorities shall require such treatment of the effluent as will render it harmless to fish and marine life;

(3) The Water Board shall require full details of the constituents and substances contained in the effluent and of the quantities of each that it is proposed to discharge;

(4) If considered necessary, the Water Board may order that the effluents be discharged by a suitable sea outfall of such length as will ensure that no beach or shallow water fisheries are adversely affected."

Further ten very strict points call for protection of the marine environment of the Gambia.

Development plans and the environment

The economy of the country consists mostly of traditional small enterprises holding rural activities, agriculture, livestock and fisheries accounting for 60 per cent of the national GDP and employing about 85 per cent of the active population. Ground-nuts are almost the only cash crop of the Gambia, are its main source of foreign exchange, and constitute the basis for the country's major industrial activity, ground-nut oil milling.

In 1976 the Government published its first National Plan for Economic and Social Development (1975/76-1979/80). The objective of the plan is the promotion of socio-economic development of the rural areas over urban ones, a general improvement of living conditions throughout the country emphasizing rural development, self-sufficiency in basic foodstuffs, creation of a more equitable distribution of income, better educational opportunities and increased participation of people in the planning process and development.

The realization of this mostly agricultural plan will cause such substances as fertilizers, pesticides and products of soil erosion to enter the river Gambia and its tributaries. An on-going project of the development of the Gambia river basin directed to irrigated agriculture, the construction of a dam and a hydroelectric power station and the improvement of river transportation could cause irreversible change to the river environment. These projects concerning the upper and middle part of the river basin will, however, also have influence on the lower part of the river Gambia as well as on the coastal marine environment.

As the nucleus for the development of the fishery industry, the Fish Marketing Corporation (FMC) was established in 1977. The FMC is charged with the responsibility of developing marketing and distribution within the country. The FMC has the power to license and register fishing vessels and is the only body that has the right to export out of the country. This corporation is still in the stage of organization. In the future it is planned to include a fish freezing and canning factory as part of its operations.

There is another fisheries company operating in the Gambia since 1972, the Seagull Cold Store Co. Its monthly production figures average over 1,000 tons of sardines. Its fishing operations are carried out by steel purse seiners, steel stern and side trawlers. Treatment of fish is a well-known scurce of specific pollutants entering the marine environment.

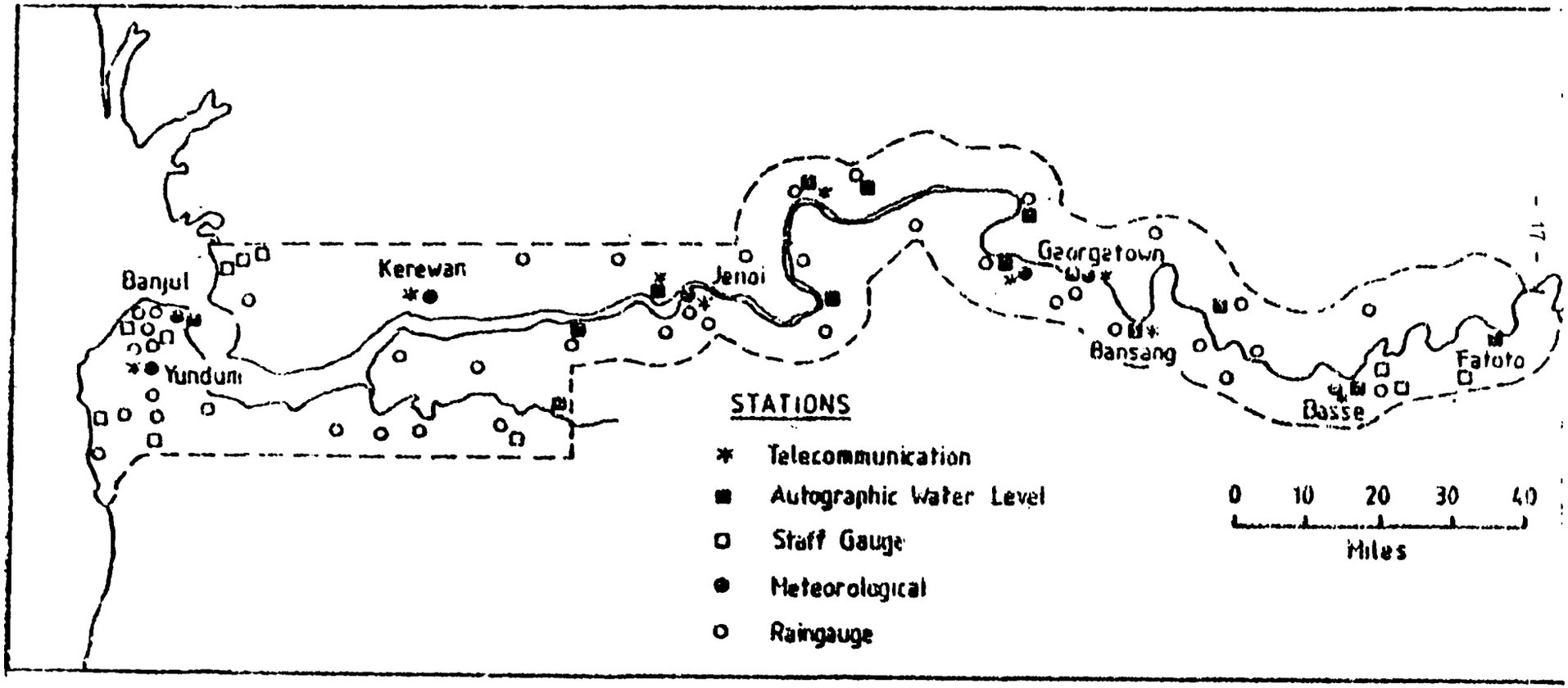
It should be mentioned that the dam project, although it has been submitted to the appropriate organizations, is still far from materialization and so are the projects for a sugar plant, an oil refinery and some other industries. A plan for domestic sewerage and drainage of the Banjul and Kombo St. Mary areas [11] is more real for implementation and the construction of pipes could be completed in a few years. The suggested location for the sea outfall has been selected after a detailed oceanographic study of the Banjul Gambia River Estuary [12]. This is an area about 1,000 m off-shore, north-east from the Banjul point with depths of 15-20 m.

Mining of ilmenite, rutile and zircon from the coastal sands has been temporarily stopped because it was not profitable. Oil exploitation is far from materialization; foreign companies continue sea drilling on the continental slope mostly for oil prospecting and oil pollution on the Atlantic coast depends on the season: in summer time oil spots reach the beaches. The expert could see oil in the vicinity of the Sea port, the dockyard, the GUC power station as well as along the coast of the Atlantic Hotel where he lived in July 1980.

Environmental control and improvements

In the country there is a rather well-organized network of hydrometeorological observation stations (see figure), which serve mostly the needs of the agriculture i.e. they are used to control the water level along the river Gambia. With this network, if it were appropriately equipped, standard chemical determinations could be carried out, including the determination of pollutants or, at least, the collection of samples. In 1979-1980 under United Nations a number of chemical analyses of ground and surface water of the Gambia have been carried out in the Abuko Chemical Laboratory at Banjul. There were determinations of pH, EC (electroconductivity), alkalinity, chloride iron ($Cl^-$), fluoride iron ($F^-$), hardness, silica, iron and maganese as well as nitrates ($NO_3^-$), ammonia and phosphates [8]. In 1978 other furdamental hydrochemical and microbiological investigations were carried out in the vicinity of the Banjul Gambia river estuary [12]. The latter was undertaken in connection with the

HYDROMETEOROLOGICAL NETWORK OF THE GAMBIA



planned construction of a domestic sewerage system and was limited to sampling. The samples were later analysed in the Federal Republic of Germany. In the Gambia there are rather limited possibilities to carry out environmental chemical analyses because of the lack of specialists, equipment and appropriate financial support. A similar situation prevails in the field of patrolling or monitoring the coastal and estuarine waters. The Government is very anxious to protect the nature, the wildlife and the environment of the Gambia. There is a small natural reserve of 180 ha at Abuko not far from Banjul. Organizations of the Sine-Saloun Reserve adjoining the Saloun Singalese National Park, of the Kiang West Reserve in the middle part of the River Gambia, near Kwinela, and the Baboon Island National Park are in hand.

## II. SURVEY OF INDUSTRIAL ENTERPRISES DISCHARGING WASTES INTO THE MARINE INVIRONMENT

According to estimates of the gross domestic product in 1977/1978 from large-scale manufacturing in the Gambia, employing 30 or more workers [10], the contribution of five important industries is given below:

| | Gross output in dalasi |
|---|---|
| Fish processing (freezing) | 2,484,000 |
| Production of ground-nut oil | 35,500,000 |
| Decortication of ground-nut | 1,416,000 |
| Soft drinks | 1,348,000 |
| Beer | 3,134,000 |

Other enterprises which could be estimated to be of large scale are either located in areas of the upper river (rice milling, cotton ginning) or have minimal industrial wastes, considering both, the production value and the technology used (bakeries, manufacture of furniture, printing, production of rubber shoes).

Therefore, the expert's survey of industrial wastes comprised visits to the following factories:

Seagull Coldstore (freezing fish)
Gambia Produce Marketing Board (oil mill, decortication plant)
Banjul Brewery ("Jul Brew")

Very useful were also the visits to the electric power station (Gambia Utilities Corporation) and the enterprises of the Gambia Port Authority (sea port and dockyard). All enterprises of coverage are located at Banjul or in its vicinity. Their wastes are discharged, without any treatment, either directly into the sea or indirectly through the river Gambia or coastal swamps. A detailed description of sites visited is given below.

### Seagull Coldstore

In this factory 4,800 tons per year of sea fish are being frozen. The number of employees is 174. Fresh water from the municipal system (14.8 $m^3$/day) is consumed for cooling freezers, ice preparation and washing. Recycling is used for the cooling water. The most polluted water is the water used for washing fish, which goes directly into the sea. The plant has a collecting tank, which to some extent is a settling and filtrating tank, but only a small portion of the washing water passes through it.

If half of the total water consumed is used for washing, the result is 5,340:2=2,670 $m^3$/y of waste water, the rest being used for cooling or passing through the tank and thus not containing any pollutants. The appropriate data on the content of pollutants for the first portion of waste water are taken from the tables ([1], tables 161, page 364) for factories producing salt fish ($BOD_5$, SS, oil). Such estimates give for $BOD_5$ - 1.8 t $O_2$/y, for SS - 2.56 t/y, and for oil - 0.65 t/y. An estimate according to the EJM table gives a substantially different figure for SS, namely 54.2 t/y, which is possibly due to uncorrect data for the waste water discharged.

Gambia Produce Marketing Board - ground-nut oil mill

This mill produces annually 13,000 tons of ground-nut oil, 15,000 tons of cake and about 1,000 tons of soap. The number of employees is 300 in 3 shifts. The factory uses 351 $m^3$/day of fresh water and 16,344 $m^3$/day of sea water. The fresh water is consumed for the boiler and for the oil separation and the sea water for cooling. The latter leaves the plant practically unpolluted whilst the used fresh water looks oily and muddy and is discharged without any treatment.

If the data on the contents of the pollutants are taken from the tables for oil extraction factories ([1], table 162, page 367), the oil mill is estimated to give off annually $BOD_5$ - 302.7 t $O_2$; SS - 189.2 t; COD - 378.4 t O. Figures derived from the EJM table are comparable. The solid wastes are disposed of on land.

Banjul Brewery ("Jul Brew")

This brewery produces approximately 30,000 hl beer and soft drinks per year. Fresh water from GUC (government water supplier) is used for brewing malt, fermentation, pasteurization, as well as for cooling, boiler supply and sanitary needs. The administration of the factory could not provide, for some reason, either figures on their water consumption or the volume of waste water. By comparison with other breweries (see report on the expert's mission to Ghana, UNIDO/IS.189) the volume of effluents could be estimated to be about 50,000 $m^3$/y. The waste water is collected in a settling tank and then pumped through a natural drainage system (4 km swamp) into the sea. The appropriate figures for pollutant contents taken from the tables for breweries ([1], table 176, page 382) give the following annual values for this plant: $BOD_5$ - 49.4 t $O_2$; SS - 29.6 t; COD - 60 t O. Figures according to the EJM table are two times higher, but in such calculations this is quite acceptable.

Gambia Utilities Corporation

This electric power station which employs 100 workers in 3 shifts produces 250,000 kW/y. Fresh water from the municipal system is used for the cooling of the generators. The water consumption is 218 $m^3/y$, which is unbelievably low, and conventionally the same figure can be accepted for waste water. This waste water enters the sea without treatment. Visually the effluent seems to contain oil and grease. The contents of pollutants, if taken from the tables for heat power stations ([1], table 9A, page 41), is as follows: $BOD_5$ - 0.026 t $O_2/y$, SS - 0.043 t/y, oil - 0.01 t/y.

More reliable estimates can be derived if they are based on United Nations statistics [13]. According to these data the capacity of electric generating stations in The Gambia is estimated to be $9 \times 10^3$ kW. If it is assumed that half of the total electric energy is produced in the coastal area, this gives a value of $9 \times 10^3 : 2 = 4.5 \times 10^3$ kW = 4.5 MW. During a year this electric power station can produce 4.5 MW x 8,760 hours = 39,420 MW-hours. One MW-hour of electric energy production corresponds to 0.03 $m^3$ of waste water (we accept 0.1 $m^3$ for tropical temperatures) which is used for the cooling of the gas turbines, with recycling of water being provided. If there is no recycling system, the corresponding figure would be 38 $m^3$ ([1], page 47, N7). According to these calculations, the power station consumes 3,942 $m^3/y$. If the contents of contaminants is taken from [1], table 9A, page 41, the figures for pollution loading are as follows: $BOD_5$ = 120 mg/l x 3,942 $m^3$ = 0.473 t/y; SS = 200 mg/l x 3,942 = 0.788 t/y; oil = 50 mg/y x 3,942 = 0.197 t/y.

Gambia Port Authorities

This authority is charged with the operation of the Banjul sea port and the dockyard. It is rather difficult to estimate the quantity of the main pollutant, which is oil. For the sea port two figures were reported: in 1979 the cargoship treatment was 777,500 n.r.t. (330 ships) and the oil products 48,300 tons; for the dockyard the water consumption is 3,096 $m^3/y$. At the dockyard boats are built and small ships are repaired. The water is used for cooling motors and for sanitary needs and the total effluent, full of oil and grease, is discharged directly into the sea.

Summary estimation of marine pollutants from all industrial sources

All revelant data on the visited factories are summarized in annex III. From the other factories that had not been visited it is worth mentioning at least the following two, which discharge considerable quantities of pollutants:

(a) The freezing factory of the Fish Marketing Corporation; according to a personal communication by M. Sieh are both, production and wastes, comparable with those of the Seagull Coldstore;

(b) The "Chellarams" factory, which produces soft drinks and can be compared in pollution discharges with "Jul Brew".

These data allow to estimate the total quantity of certain pollutants entering the ocean. In making these estimates, the action of the drainage system in the case of the drinks factories has been neglected to some extent. In all other cases the industrial waste water enters directly into the marine environment.

Among the pollutants being counted first are $BOD_5$ as well as COD, that characterize the content of organic matter in the wastes. The main industrial sources of organic wastes discharged into the coastal area are the oil mill and the drinks factories ($BOD_5$ 302.7 t/y and 49.4 x 2 = 98.8 t/y respectively). These factories are also discharging annually 189.2 and 29.6 x 2 = 59.2 t of suspended matter. The total $BOD_5$ figure for industrial discharges into the coastal area is close to 400 t $O_2$/y. The quantity of suspended matter from all industrial sources is estimated to be about 250 t/y [1]. Corresponding figures derived from the EJM table are comparable, except the ones for the fish freezing factories.

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1/ For comparison, the value of $BOD_5$ from the domestic sewers of Banjul is indicated, which is 55 g/hab/day x 55,000 x 365 = 1,104 x $10^6$ g = 1,104 t/y.

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Annex I

PERSONS MET AND PLACES VISITED IN THE GAMBIA

Ministry of Economic Planning

Mr. Ashcroft, Regional Planner

Ministry of Agriculture

Hannah King, Acting Director, Department of Fisheries

E. A. Njai, Director, Department of Hydrometeorological Services and Water Resources

D. R. L. Prabhakar, Senior Officer

J. Sigismund, Deputy Director

Ministry of Local Government and Lands

M. B. Sey, Physical Planning Officer

H. D. Dodwell, Environmentalist

P. S. Njai, Assistant Secretary

Central Statistics

M. S. Singal, Adviser in Statistics (UN)

Gambia Utilities Corporation (electric generation)

T. W. Malia, Generation and Maintenance Engineer

Seagull Cold Stores

P. Bensenda, Managing Director

Gambia Produce Marketing Board

G. R. Van Haght, Chief Engineer, Oil Mill

N'Jie, Transit Manager, Decortication Plant

Banjul Brewery

O. Dommen, Technical Manager

Gambia Port Authority

Captain B. Sallah - Banjul sea port

A. O. G. Sosseh, Chief Engineer, dockyard

UNDP field office

M. E. Ayala, Assistant Resident Representative

Sham Bathija, Senior Professional Officer

F. Tambajang, Assistant Professional Officer

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 | 3.67 | 0.27 | 5.67 | | | | | | | EPA, 1977a |

| Type of Industry | Raw Waste Loads, kg/ton | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $BOD_5$ | SS | Oil + Grease | COD | Ammonia Nitrogen | Phenols | Total Chrome | Fluoride | Cyanide | Total Phosphorus | Reference |
| 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 | | | | | | | Margoia, 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 a/ | 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. | Name, location | Workers (shifts) | Production/y | Raw material | Main process | Use of water $m^3$/day | Waste water $m^3$/y | Pollutants discharged | | | | | | Comments and references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | BOD | | SS | | Others | | |
| | | | | | | | | mg $O_2$/l | t $O_2$/y | mg/l | t/y | | | |
| 1 | Gambia Utilities Corporation, Banjul | 100 (3) | Electric power 250,000 kW (11 kV) | Oil | Cooling of generators | 0.6 | 218 | 120 | 0.026 | 200 | 0.043 | Oil | | Table 9 A, page 41 [1] |
| | | | | | | | | | | | | 50 mg/l | 0.0 1t/y | Capacity from UN statistics |
| | | | | | | | | | 0.473 | | 0.788 | | 0.197 | |
| 2 | Gambia Produce Marketing Board Oil mill, Denton Bridge, (10 km from Banjul) | 300 (3) | Ground-nut oil 13,000 t Cake 15,000 t | Ground-nuts | Process Boiler | 351 | 126,129 | 2,400 | 302.7 | 1,500 | 189.2 | COD | | Table 162, page 367 [1] |
| | | | | | Cooling (sea water) | 16,500 | 5 965,560 | | | | | 5,000 mg O/l | 378.4 t/y | |
| | | | | | | | | 22.3 kg/t | 289.7 | 14.5 kg/t | 253.5 | 55.8 kg/t | 7.25 | EJM table |
| 3 | Seagull Coldstores, Banjul | 174 | Frozen fish 4,800 t | Sardines, herrings | Freezing, cooling | 14.8 | 5,340 | 338 | 1.8 | 480 | 2.56 | Oil | | Intermittent sand tank |
| | | | | | | | | | | | | 121 mg/l | 0,646 t/y | Assumed half the waste water discharged |
| | | | | | | | | | | | | | | Table 161, page 364 (salt shop) [1] |
| | | | | | | | | | | 11.5 kg/t | 54.2 t/y | 0.60 kg/t | 2.8 t/y | EJM table |
| 4 | Gambia Port Authority Dockyard, Banjul | 229 | Boat building, ship repairing | | Process Cooling Boiler | 8.6 | 3,096 | | | | | | | |
| 5 | Gambia Port Authority Sea port | | Cargoship treatment 777,500 n.r.t. Oil products 48,300 t | | | | | | | | | | | |
| 6 | Banjul Brewery - "Jul Brew" Kanifing, (25 km from Banjul) | | Beer 15,000 hl Soft drinks 15,000 hl | Malt, hops | Brewing Fermentation Pasteurisation Boiler | | 50,000 | 987.7 | 49.4 | 593 | 29.6 | COD | | Collecting basin, drainage system, 4 ha |
| | | | | | | | | | | | | 1200 mg/l | 60 t/y | Table 176, page 382 [1] |
| | | | | | | | | | 20.0 | | 15.0 | | 28.5 | EJM table |