Preliminary survey of the state of pollution of the coastal environment of Ghana

Estuaries
Lagoons
Beaches
Pollution
Sewage

Estuaires
Lagunes
Plages
Pollution
Effluents

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ABSTRACT

The physico-chemical state of estuaries, lagoons — open and closed — and beaches along the coast of Ghana was studied to assess their state of pollution. Aspects of the chemistry of the coastal waters are also discussed.
The study was aimed at providing base-line data for the monitoring of pollution in the Ghanaian coastal environment. It also draws attention to the need for control and mechanisms for controlling pollution.
The main sources of pollution were identified as sewage of both industrial and domestic origin and oil in the form of tarballs.
Of the 16 lagoons investigated, 12 were found polluted, 2 grossly. The grossly polluted lagoons, the Korle and Chemu serve as receptacles of industrial and domestic wastes. The estuaries were generally slightly polluted or " clean ". Sewage pollution of beaches was usually associated with high population areas.

Oceanol. Acta, **1982.** Proceedings International Symposium on coastal lagoons, SCOR/IABO/UNESCO, Bordeaux, France, 8-14 September, 1981, 39-43.

RÉSUMÉ

Étude préliminaire de l'état de pollution des côtes du Ghana

Des mesures physico-chimiques ont été effectuées dans des estuaires, des lagunes et sur des plages de la côte du Ghana pour évaluer leur état de pollution. Quelques aspects de la chimie des eaux sont également envisagés.
Le présent travail rassemble des données de base pour le contrôle de la pollution le long des côtes ghanéennes. Il met également en évidence la nécessité de connaître les mécanismes pour maîtriser la pollution.
Deux sources principales de pollution sont identifiées : effluents d'origine industrielle ou domestique, et hydrocarbures.
Sur les 16 lagunes étudiées, 12 se sont révélées polluées dont 2 fortement. Ces lagunes très polluées, Korle et Chemu, sont des réceptacles de déchets industriels et domestiques. Les estuaires sont généralement peu pollués ou « propres ». La pollution des plages est généralement associée à de fortes concentrations humaines.

Oceanol. Acta, **1982.** Actes Symposium International sur les lagunes côtières, SCOR/IABO/UNESCO, Bordeaux, 8-14 septembre 1981, 39-43.

INTRODUCTION

Like other countries along the Gulf of Guinea, the coastal regions of Ghana, especially Takoradi, Tema and Accra (Fig. 1) have been the major area for industrial development. This trend has always been associated with increases in the population of the coastal areas, with their attendant problems of modification and pollution of the coastal environment.

Pollution has been defined by the Group of Experts on Scientific Aspects of Marine Pollution (GESAMP) as the " introduction by man directly or indirectly of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, imparing of quality for use of sea water and reduction of amenities " (Portman, 1978).
Coastal waters account for most of the world's fish catches

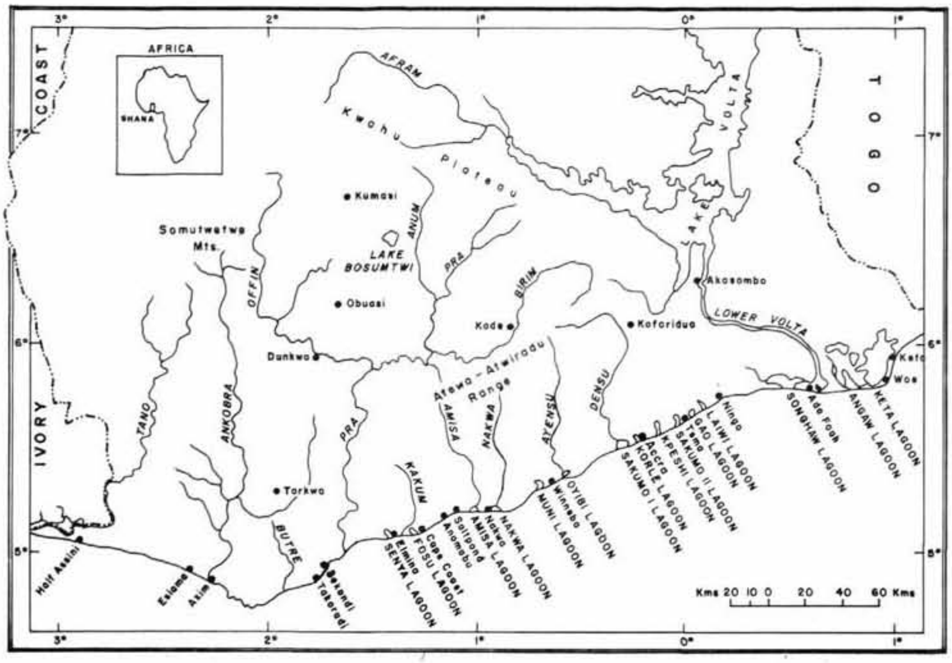

Figure 1

Map of Southern Ghana showing major rivers and lagoons.

and therefore in terms of the protection of living marine resources, prime attention should be given to the coastal region.

Waldichuk (1977) estimated that coastal waters to the edge of the continental shelf, which constitute only 10 % of the world's oceans produce 99 % of the world's fish catches. Since most of the marine pollution originates on land and usually passes through the coastal zone first, it is obvious that long before the open ocean exhibits a dangerous degree of pollution, the coastal environment in many places will have become intolerably polluted. Thus controlling of pollution of the coastal environment by the coastal states may also relieve or at least delay pollution of the global oceans.

This preliminary study, undertaken between May and August 1980, reports on the state of pollution, sources of pollution and their effects on the coastal waters and beaches of Ghana. It also aims at providing base-line data which in the long term, could be used as a basis for the monitoring of pollution and the development of the coastal environment.

Physical features

The coastline of Ghana (550 km), which is part of the Gulf of Guinea, stretches from 3° W to 1° 10′ E and lies between 4° 5′ and 6° 6′ N (Fig. 1). It is a low lying area — not more than 200 m above sea level — and is subject to two wet seasons in a year — May to mid-June and August to September. Most of the coastline is fringed by coconut trees interspersed by lagoons and river estuaries. The continental shelf is narrow, extending outwards for about 30 km.

With the exception of the Volta River, all the rivers studied take their source from the mountain ranges below the Kwahu Plateau (Fig. 1). The Densu, Ayensu, Nakwa and Amisa originate from the Atewa — Atwiredu Range and flow into the Atlantic Ocean through lagoons.

More than fifty lagoons occur along the coastline of Ghana (Mensah, 1979) and these have been classified into two main types by Kwei (1977). The first type which occurs more in the eastern region, is associated with relatively small rivers and remains cut off from the sea for most part of the year by sandbars. These include the Gao, Laiwi and Kpeshie Lagoons. The second type of lagoon is associated with larger rivers and usually forms extensively branched estuaries, such as the lagoon system at the mouth of the River Volta.

METHODS

For this survey, the coastal environment was divided into three parts, viz. estuaries, lagoons and beaches. Eight estuaries, sixteen lagoons and twenty-one beaches from Keta to Axim (Fig. 1), were studied. Physico-chemical parameters measured at the sites and on collected water samples formed the basis of assessing the state of pollution. These were :

1) Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) — measured by a modification of the Winkler method (FAO, 1975).

2) Nutrients :

a) orthophosphate (PO_4-P), determined according to Mackereth *et al.* (1978) ;

b) ammonia — nitrogen (NH_3-N), measured by the indophenol blue method (FAO, 1975) ;

c) nitrate — nitrogen (NO_3-N), determined by hydrazine reduction followed by diazotizing to form an azo dye which was measured colorimetrically.

3) Transparency — estimated by the use of a Secchi disc.

4) Algal enumeration — estimated according to Palmer (1962).

5) Hydrogen-ion concentration (pH) and temperature measured using a portable Griffin pH meter and glass thermometer respectively.

6) Pollutants cast and scattered on beaches were catalogued and quantified using quadrants.

The places visited and studied are shown in Figure 1. They include :

1) Estuaries of rivers Volta, Densu, Ayensu, Nakwa, Amisa, Kakum, Pra and Ankobra.

2) Lagoons : Keta, Angaw, Songhaw, Laiwi, Gao, Chemu, Sakumo II, Kpeshie, Korle, Sakumo I, Oyibi, Muni, Nakwa, Amisa, Fosu and Benya.

3) Beaches : Keta, Ada, Ningo, Prampram, Tema, Labadi, Mamprobi/Chokor, Botianor, Winneba, Saltpond, Abandzie, Anomabu, Biriwa, Cape Coast, Elmina, Shama, Sekondi, Takoradi, Busua, Axim and Esiama.

RESULTS AND DISCUSSION

The results of physico-chemical analyses of estuarine and lagoon waters have been summarised and presented diagramatically or in tables. Table 1 shows the concentration

Table 1
Concentration range of parameters.

Parameter	Estuary	Lagoon
DO (mg l^{-1})	4.16 – 10.27	0.0 – 8.29
BOD (mg l^{-1})	2.05 – 7.0	1.02 – 80.0
PO_4-P (mg l^{-1})	0.012 – 0.069	0.0 – 0.859
NO_3-N (mg l^{-1})	0.033 – 1.31	0.0 – 0.868
NH_3-N (mg l^{-1})	0.023 – 0.67	0.004 – 3.97
pH	6.3 – 8.2	7.0 – 9.4
Transparency (cm)	11.25 – 214.0	14.0 – 100.0
Total algal counts/ml	13.0 – 182.0	7.0 – 6872
Temperature (°C)	25.3 – 29.7	25.5 – 36.3

range of parameters analysed. The mean concentration of pollutants measured on beaches is presented in Table 2.

Table 2
Mean concentration (g/m²) of some beach pollutants.

Location	Tarballs	Plastics	Metals	Charcoal
Ningo	10.25	2.2	6.0	n.e.*
Prampram	4.93	4.0	2.0	n.e.
Tema New Town	21.57	200	0.0	n.e.
Tema Beach Club	5.0	14	2.0	n.e.
Nautical College	6.7	0.2	0.0	n.e.
Labadi	0.9	0.0	0.0	n.e.
Botianor	0.2	7.5	0.0	10.75
Sakore	1.1	162	n.e.	27
Winneba (GAF)	1.5	0.4	0.0	n.e.
Saltpond	0.9	0.0	0.0	n.e.
Biriwa	0.2	0.01	0.0	13.65
Cape Coast (West)	24.54	0.03	0.0	n.e
Elmina Hotel	—	0.7	0.12	8.9
Elmina Castle	7.05	0.0	0.0	n.e.
Sekondi	3.9	4.0	0.0	12.6
Takoradi	22.3	0.022	1.0	n.e.
Busua Beach Club	13.5	0.1	0.2	11.0
Axim	30.85	38.7	n.e.	20.2
Ankobra Vill	5.0	n.e.	n.e.	n.e.
Esiamah	n.e.	0.1	n.e.	n.e.

*n.e. : not estimated.

Oxygen and nutrients

The mean concentration of dissolved oxygen in estuarine surface waters ranged from 4,16 to 10,27 mgl^{-1} (Fig. 2).

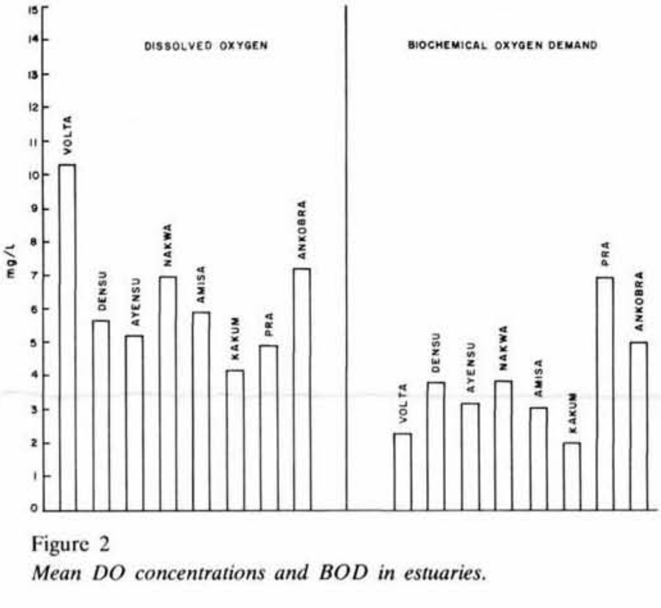

Figure 2
Mean DO concentrations and BOD in estuaries.

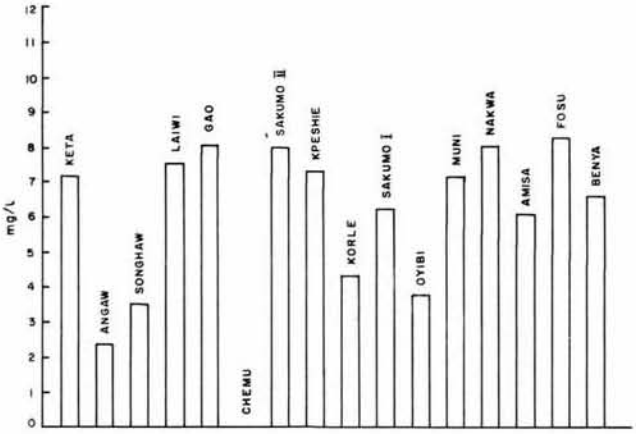

Figure 3
Mean DO concentrations in lagoons.

Within this range however, there was higher oxygen saturation at the mouths even where they were influenced by domestic sewage such as the case of river Pra at Shama. This was attributed to mixing of water at these points. In the lagoons DO concentrations ranged from 0,0 in the Chemu and parts of Korle to 8,28 mgl^{-1} in the Fosu where large phytoplankton populations had oxygenated the water (Fig. 3). Deoxygenation in the Chemu and Korle lagoons was due to excessive discharges of both raw domestic and industrial effluents into them. Such discharges were also responsible for the high mean BODs of these lagoons (Fig. 4). The presence of large phytoplankton populations in the Fosu and the Sakumo II contributed to their high BODs. The elevated mean BODs of the Pra and Ankobra estuaries (Fig. 2) were the result of serious sewage pollution and the prevailing unclean surroundings.

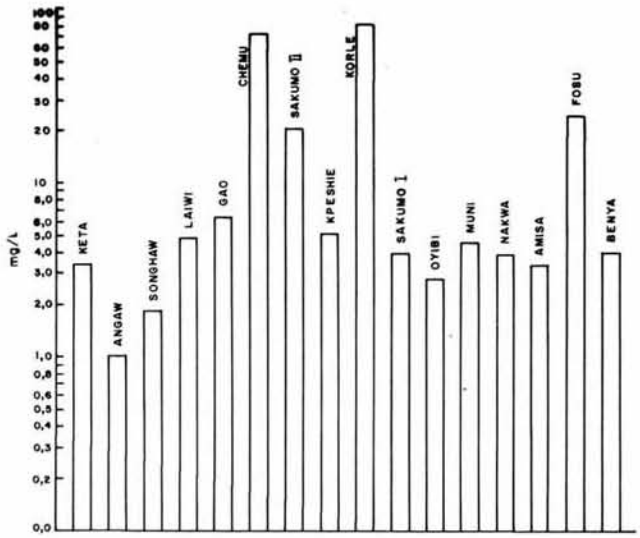

Figure 4
Mean biochemical oxygen demand of lagoons.

The mean concentration of orthophosphate in estuarine waters ranged from 0,012 to 0,069 mgl^{-1} while that for nitrate was 0,033 to 1,31 mgl^{-1} (Table 3). The low variation in phosphate concentrations may be the result of some buffering mechanism whereby phosphorus is released from or absorbed by the sediments depending on its concentration in the overlying waters. In lagoon waters, similar variations in nutrients were observed with the mean concentrations of phosphorus and nitrate ranging from 0,0 to 0,859 and 0,0 to 0,868 mgl^{-1} respectively. The high levels recorded in the Chemu and Korle lagoons were due to excessive industrial and domestic discharges. Thus very high concen-

Table 3

Mean concentrations of orthophosphate, nitrate nitrogen and ammonia nitrogen in the investigated estuaries and lagoons along the coast of Ghana.

Location	PO_4-P (mg l^{-1})	NO_3-N (mg l^{-1})	NH_3-N (mg l^{-1})
Estuaries			
Volta	0.01	7.6	0.04
Densu	0.03	5.1	0.08
Ayensu	0.07	0.4	0.02
Nakwa	0.06	0.7	0.67
Amisa	0.03	0.3	0.20
Kakum	0.06	4.4	0.03
Pra	0.07	6.7	0.40
Ankobra	0.06	13.0	0.09
Lagoons			
Keta	0.02	1.7	0.10
Angaw	0.01	6.3	< 0.01
Songhaw	0.00	8.3	0.02
Laiwi	0.01	2.7	0.02
Gao	0.04	8.6	0.01
Chemu	0.60	3.0	1.30
Sakumo II	0.09	1.8	0.15
Kpeshie	0.11	3.4	0.30
Korle	0.86	3.0	3.97
Sakumos	0.03	4.8	0.01
Oyibi	0.08	2.0	0.08
Muni	0.07	0.3	0.50
Nakwa	0.07	0.3	0.50
Amisa	0.03	0.6	0.70
Fosu	0.07	0.2	0.26
Benya	0.02	0.0	0.10

trations of ammonia nitrogen (Table 3) were recorded in these lagoons. In well aerated waters, ammonia is readily oxidized through nitrite to nitrate. This should account for the generally low mean concentrations of ammonia-nitrogen in the estuaries and most of the lagoons.

pH, temperature and transparency

The coastal waters had an alkaline status. This was true for all the lagoons and the estuaries with the exception of that of the Ankobra. The general alkalyne state is partly due to the influence of sea water which has a pH range of 7,5 to 8,4 (Riley, Chester, 1971).

Surface water temperatures ranged between 22 and 36 °C. The higher value recorded for the Chemu lagoon at Tema was the result of thermal pollution originating from industrial sources. It is significant to note that no fishes were observed in this lagoon.

Secchi disc transparency readings ranged from a mean of 11,25 cm in the muddy waters of the Pra estuary to 214,3 cm in the clear waters of the Volta estuary (Fig. 5). In the case of the estuaries of Pra and Ankobra, low transparency readings recorded were mainly due to discharges of muddy effluents from mining operations in their catchment zones. In some lagoons such as Fosu and Sakumo II dense populations of phytoplankton (up to 8 000 counts/ml) were responsible for the low transparencies. The surface waters of the Volta estuary were very clear with a mean Secchi disc transparency of more than 200 cm. This was attributed to a dam at Akosombo (Fig. 1) behind which the bulk of the Volta's water collects and sediments, resulting in clear and silt free water downstream. This clarity, coupled with the shallowness of the estuary as well as the general warmth of the waters encouraged the growth of submerged aquatic weeds such as *Vallisneria, Ceratophyllum* and *Potamogeton.*

Classification of estuaries and lagoons

Rivers have been classified in terms of pollution based on BOD, DO, turbidity and occurrence of pollution discharges (Report of a River Pollution Survey of England and Wales, 1970) as follows:

a) " unpolluted and recovering from pollution ": waters with BOD of less than 3 mgl^{-1}, which are well oxygenated and are known to have received no polluting discharges;

b) " grossly polluted ": waters which have a BOD of 12 mgl^{-1} or more under average conditions or are completely deoxygenated or are the source of offensive smells;

c) between the two extremes are waters of " doubtful or poor quality " and needing improvement.

However, in the tropics where reactions involving oxygen utilisation take place at higher temperatures, it may be necessary to shift the lower BOD limit to around 4 mgl^{-1} for estuaries and 6 mgl^{-1} for lagoons and the upper limit in excess of 12 mgl^{-1}. Based on this criteria, the estuaries of rivers Volta, Kakum, Amisa and Ayensu were classified as unpolluted and those of Pra, Ankobra, Densu and Nakwa as of doubtful quality. Despite the low mean BODs recorded in the Densu and Nakwa estuaries (Fig. 2), they are known to receive some polluting domestic discharges which were indicated by the high total algal counts in these estuaries (60-182 counts/ml). Of the 16 lagoons, 12 were classified as polluted to various extents. While the Korle and Chemu were grossly polluted, the Keta, Gao, Kpeshie, Sakumo I, Oyibi, Nakwa, Amisa and Benya were only slightly polluted. Although the Sakumo II and Fosu lagoons had very high BODs (Fig. 4), they could not be considered grossly polluted since they do not receive excessive polluting discharges. The Oyibi lagoon, although fed by the unpolluted Ayensu river was not well oxygenated and appeared turbid. The Laiwi, Angaw, Songhaw and Muni lagoons were unpolluted.

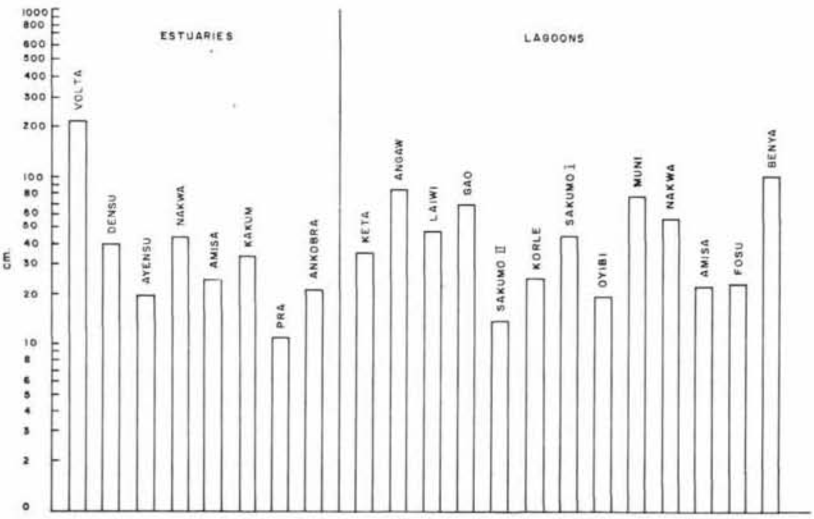

Figure 5
Mean secchi disc transparency.

Beach pollution

Along the beaches of Ghana, the major source of pollution was domestic sewage. There are no sewage treatment plants in Ghana and raw domestic as well as industrial sewage are discharged from coastal towns and cities on to the ocean front. The practice of dumping raw human excreta en masse on beaches or in near-shore waters still continues. In areas where proper sanitary facilities were not available, residents used the beaches for such purposes.

Tema has the only satisfactory disposal system in the form of an outfall one mile offshore which discharges both domestic and industrial sewage. Even here, the problem of sewage pollution of the ocean front still existed especially in adjacent settlements like Tema New Town. Sewage pollution occurred nonuniformly along the coastline and was usually observed in areas of high population. Thus, the concentrations of plastics and metallic objects (Table 2) followed this trend. Charcoal, which possesses the ability to float, appeared to be distributed almost uniformly along the coastline.

Other problems were those of oil, logs and coastal erosion. Pollution by oil in the form of tarballs was common. However, tarballs occurred in uneven concentrations which did not follow any clear pattern. Oil is believed to originate mainly from external sources — tanker traffic-along the Gulf of Guinea where any surface oil would be expected to move under the influence of the prevailing currents and wind to be stranded on the beaches of countries from Ghana to Cameroun (Portman, 1978). It is also likely that some oil may originate from port discharges but the establishment of the different sources is yet to be undertaken. Tarballs generally occurred in pebble form but large blotches of semi-liquid oil were also common.

The problem of logs was serious mainly in the Sekondi-Takoradi area where timber is exported from the harbour. In the Tema area abandoned and stranded fishing vessels close to the shore were common. Portman (1978) reported that timber was floated down the Ankobra and Offin rivers in the form of rafts to the coast for direct export or processing. He indicated that some timber may break free and be found later either floating at sea or stranded on the beaches. Also where logs were processed the remnants were discarded into coastal waters. However investigations have revealed that timber has been transported by road to the coast in Ghana since the late 1940 s and most of timber processing occurs inland (major processing centres being Kumasi, Oda and Nkawkaw) with Takoradi being the only coastal town where any serious timber processing occurs. Even here the remnants of processing are useful as cushioning material in the poultry industry and as fuel in homes.

Coastal erosion was particularly serious in the Keta area because no serious efforts have been made to check this. In the Sekondi, Shama and Axim areas erosion has been checked by the erection of walls of granite blocks. Although coastal erosion may be associated with the construction of port facilities (Portman, 1978) the low lying nature of the coast land such as in the Keta area may be a critical factor.

The need for control

This survey has shown that the major sources of pollution of the coastal environment of Ghana were domestic and industrial sewage and oil. It is likely that agricultural wastes mainly in the form of persistent pesticides are an important source but facilities for their determination are unavailable at the moment. The degree of sewage treatment and the disposal practices were found unsatisfactory. Such practices are detrimental to human health in the transmission of disease by either the ingestion of contaminated sea food or by direct body contact with pathogens in waters. If untreated domestic sewage is discharged into relatively still waters with poor water exchange such as lagoons and estuaries, deoxygenation of the receiving waters may occur. If accumulation exceeds degradation the sediment becomes anaerobic leading to foul smells as in the Korle lagoon. This form of organic loading can to a large extent be overcome by sewage treatment plants although this will not significantly reduce the number of pathogenic organisms. A simple remedy would be to discharge these wastes well into the sea through pipelines. Here it would be necessary to conduct baseline studies and understand such local effects as current and wind direction. There is also the need to establish in greater detail the location, volume and concentrations of organic wastes and metals such as mercury, copper and cadmium in industrial discharges as well as their effects on the marine environment. The adaptation of remedial measures before the true nature of a problem or even proof of its existence is established could result in a waste of resources. Oil, while not a direct threat to human health, can taint seafood and may also persist in the tissues of marine organisms. Oil pollution has been attributed primarily to maritime transport but available information is inadequate. If this could be confirmed, then the only measure would be to ensure that pressure is brought to bear on the major tanker fleets so that they comply with international regulations. To make this possible, Ghana will also have to provide the necessary shore reception facilities (Portman, 1978).

Finally, there is a need for education in the causes of environmental pollution and on how it can be prevented and controlled at all levels of the population.

Acknowledgements

The author is grateful fo Dr. M. A. Odei for his guidance and to Mr. E. K. Abban for continual encouragement and support. I wish to thank Mr. S. Abu, M. T. Sappor and A. A. Essien for technical assistance given and S. Y. Manfo who typed the script. Facilities provided by the Institute of Aquatic Biology are hereby acknowledged.

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