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The effects of industrial waste water discharges on the coastal zone of Cameroon

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THE EFFECTS OF INDUSTRIAL WASTE WATER DISCHARGES ON THE COASTAL ZONE OF CAMEROON

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

16 August 1999

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Dedication

To my loving considerate husband Martin Inack Mbaï for his frequent letters,

weekly encouragement and support

To my kids

Kevin, Loïc, Maeva and Jory Inack

And their cousin Stephan
For their understanding and moral support

To my mother Henriette and father Mathias Bissoy

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ABSTRACT

Title of Dissertation: **The Effects of Industrial Waste Water discharges on the Coastal zone of Cameroon**

Degree: **Master of Science**

This dissertation discusses the impacts of water pollution loads from industrial effluents in the Cameroon littoral zone. The area covers 9,670 km2. It is a concentrated zone of industries, people and a natural habitat for fauna and flora. The polluting wastewaters (WW) contain critical pollutants such as organic matters, nutrients and metals, likely to endanger significantly the marine and coastal ecosystem. In other words, the ecosystem is suffering from the effects of untreated WW released directly into the rivers and the sea. The high concentration of pollutants creates diminution of oxygen within the receiving waters and the milieu put out of balance becomes unhealthy for the ecosystem. This situation leads to death or extinction of aquatic species. In addition, the problems inflicted by the WW within this area include impacts on society and economics concerns.

To cope with this wastewater, law and regulations are set out although they are not adequately implemented. Thus, proposed measures and opportunities have been made for control and minimisation of pollution at sources in order to deal with cleaner production within the factories. Moreover, to monitor and manage the contamination of this waste, the implementation of the measures will need not only financial assistance from donors, but also involvement of the government, industrialists and all the people on the whole. Recommendations are made in the way to enhance the effectiveness of the industrial cleaner production and the environmental protection.

KEYWORDS: Impacts, Pollutants, Wastewater, Industrial, Ecosystem, Coastal.

TABLE OF CONTENTS

CHAPTER 1

Introduction

1.1 The problem within the coastal zone

Many industrial plants are attracted to coastal locations because of the ready availability of ways to discharge effluent without expensive treatment, sometimes, without any proper treatment at all. Cameroon's coastal land area extends from the Rio del Rey estuary to the coastal mangrove estuary of Kribi. It covers an area of 9670 km^2. It is the location for 90% of the major industries of the country and is, at the same time, a receptacle for industrial material draining into the rivers towards the sea. The coastal population density of 132 people per km is also high, as the overall population has been growing rapidly over the years. Thus, as a result of discharges of wastes, and particularly untreated or insufficiently treated waste water, the potential for degradation of the marine and coastal environment in this area, is a cause for grave concern.

Industrialists and the public at large hardly seem to be aware of the impacts of industrial waste although industrialisation is increasing. In contrast, the Government seems to be aware of this concern but its attitude is characterised by the absence of clear, legally binding regulations and limited institutional capacity, lack of appropriate equipment and trained personnel. Thus, it is critical to enquire whether pollution loads and discharges are responsible for the degradation of the environment in the coastal zone or whether the main problem in this regard is simply the lack of

proper regulations, institutional capacity, lack of equipment and personnel due to absence of financial means and the will to do anything to solve the problem.

1.2 Importance of the dissertation topic

Water pollution is a subject of growing public interest but in Cameroon it does not seem to generate much expressed concern. In contrast, conservation and protection of the forests in the country is widely known. Although liquid wastes is not an international issue (Professor Wiswall's WMU lecture, 1999) it deserves more attention than generally accorded. Hence the choice of this dissertation topic.

Marine pollution is an on-going problem and dealing with industrial waste water (WW) requires continuous improvement. The world of water and industrial wastewater management as it is known is changing, and people in Cameroon should follow this trend. The 5th International Conference on Water Pollution, 1999 pointed out that environmental problems caused by the increase of pollutant loads discharged into natural water bodies are of a great concern.

Furthermore, as beneficiaries of nature, people should all be responsible for looking after the environment, collectively and individually. Thirdly, through regulation and technology, the littoral zone should be rationally managed in order to conserve and to protect the biodiversity. Finally, it seems that significant gaps remain in knowledge, awareness and information at the level of marine pollution from industries ashore.

1.3 Objectives

The approach adopted in this work is to limit the study on the effects of industrial wastewater in the coastal zone although the statistics of the water pollution loads include sanitary and domestic services. However, it is unthinkable that this dissertation might offer a complete identification and analysis of environmental,

legal and economic issues that surround the topic. The aim of the present study is to attempt to show how untreated industrial waste water can contribute to the pollution of the environment.

After the Introduction, Chapter 2 will describe the littoral zone of Cameroon. It will point out relevant industrial activities and other characteristics found within the area. Chapter 3 will examine the characteristics of the pollutant substances and their effects on the marine environment.

Chapter 4 will show how the current topic requires a complex body of legislation for setting out frameworks of regulation and control. In addition, it will present a concrete approach to be undertaken for industrial projects to comply with environmental regulations. As the marine and coastal environment is to be protected, suggestions of ways to deal with the impacts of waste water on the environment will be provided in chapter 5.

Chapter 6 will offer a general summary pointing out other threats that endanger the coastal and living marine resources. This Chapter will conclude with recommended practices for the future of a clean and modern industry at the level of the people, the Government and industry.

1.4 Methodology and difficulties encountered

The dissertation focuses specifically on wastewater from industries. As part of the preparation of this dissertation, a questionnaire was addressed to 15 different factory managers. It has not been easy to obtain information from people individually. Contact with relevant persons was difficult because some managers do not care enough about clean production but treat minimising wastewater generation as an afterthought. Nevertheless, some authorities in relation to management of the

environment responded more or less favourably, giving pieces of data and asking to remain anonymous.

In view of the scarcity of available data at the sources, the basis of data acquisition for this dissertation has been the Coastal Profile and “Analyse de la Pollution Industrielle, Portuaire et des Transports”. Internet has provided a means for significant data collection through which personal contacts have been made and relevant materials on the topic obtained namely, "Quantitative Estimation of Land-based sources of pollution in Cameroon". Many other important sources have assisted in carrying out this work such as: conversations with students at WMU, library books and other articles published in journals, in particular the periodical "Industrial and Environment".

If the content of this work can raise any interest, it is hoped that its very incomplete achievement should make business leaders and government reconciles their thoughts in order to maintain clean industries.

CHAPTER 2

Analytical Description of the Cameroon Coastal Zone

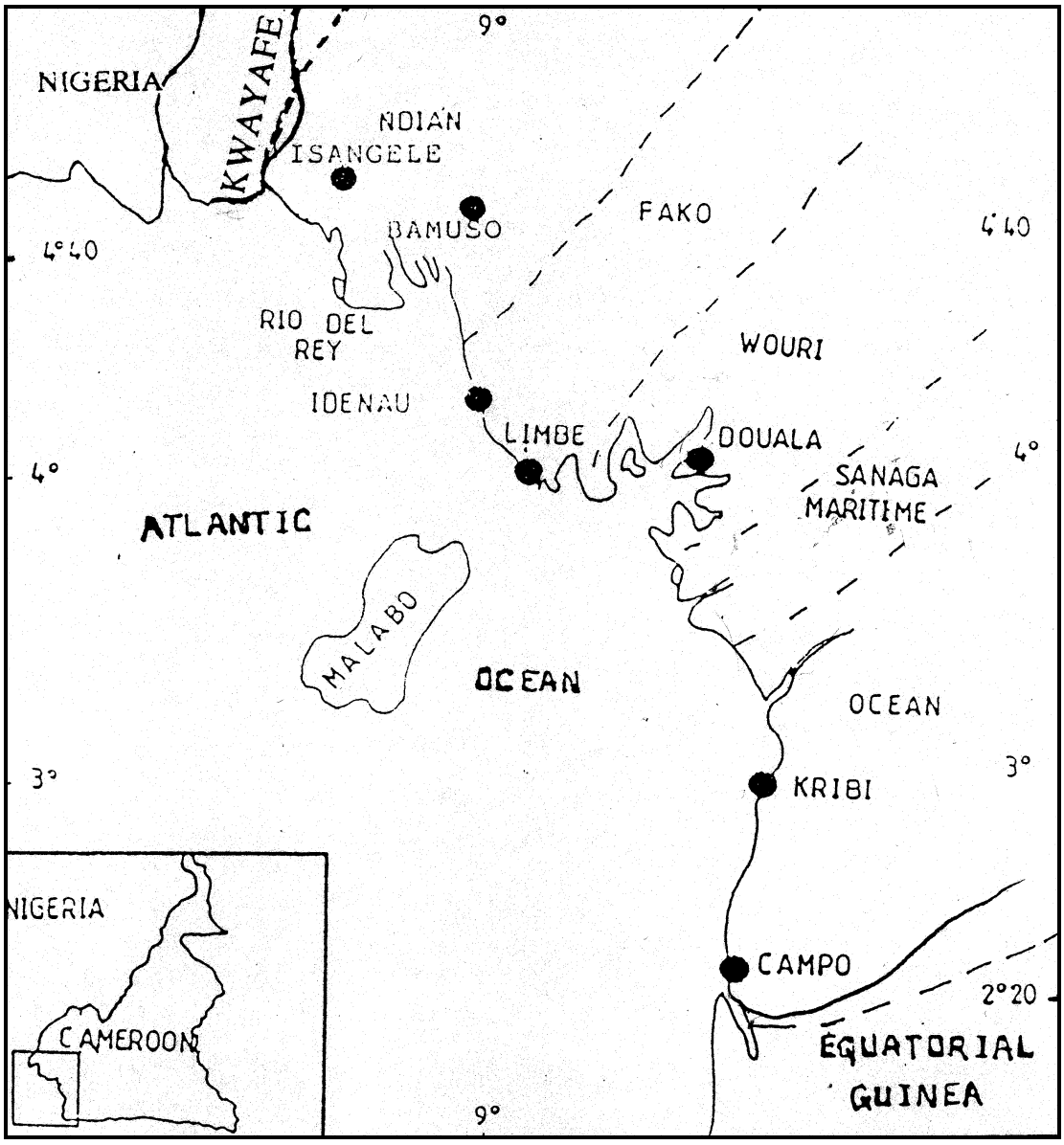
Nearly all-major factories in Cameroon are located in the coastal area. This coastal area located on the Gulf of Guinea is supplied by waters from inland rivers and the Atlantic Ocean. It is a concentrated area of people, a natural habitat for rare species of fish, animals and mangroves. This chapter will briefly describe the region and its inherent activities. Then it will discuss the economic and social dimensions of the activities including the environmental aspects.

2.1 Description of the littoral area

2.1.1 Geographical aspects of the region: location and boundaries.

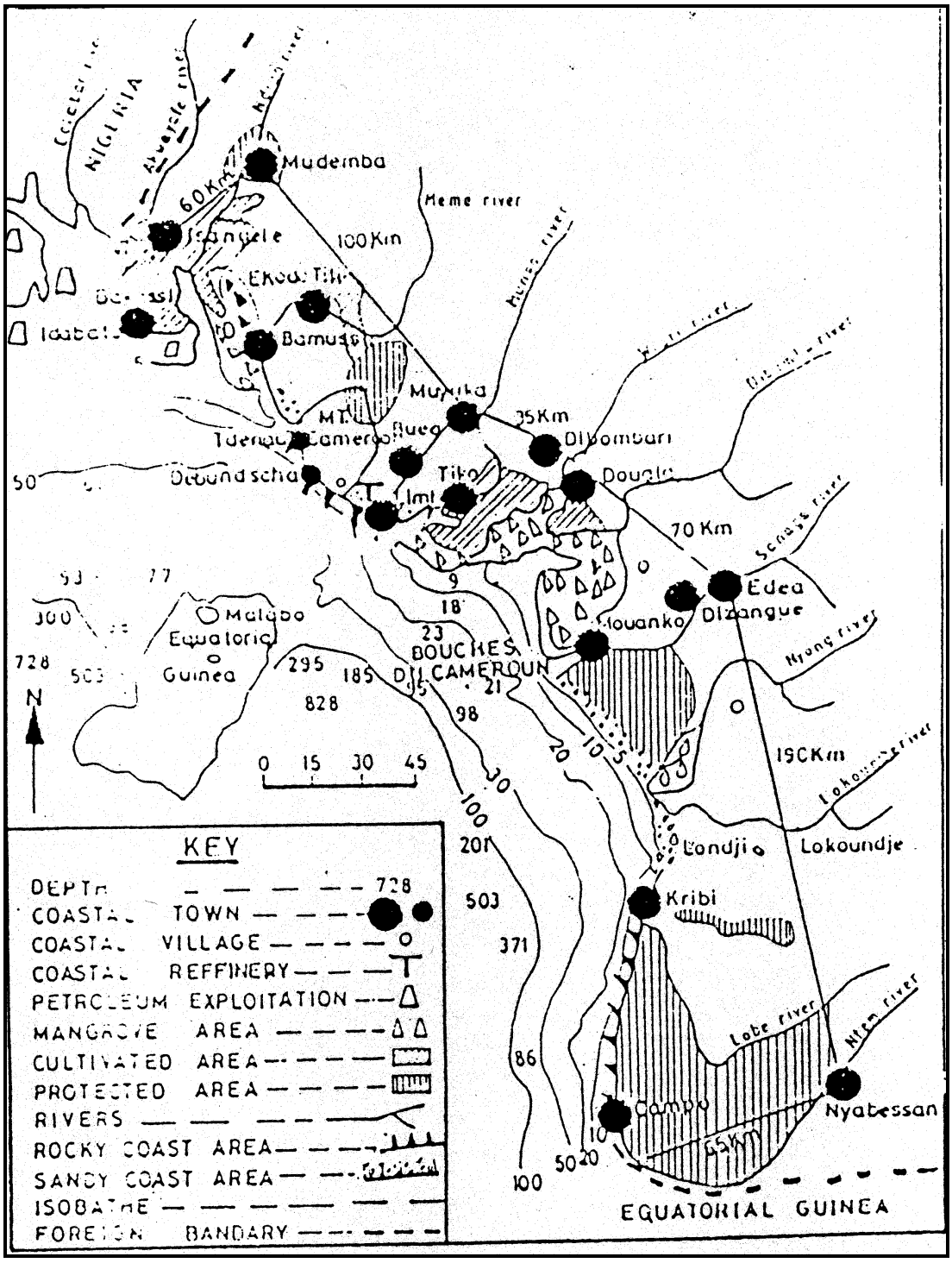
The Cameroon coastline of about 402 km is open to the Atlantic Ocean. It lies from the Nigerian border (Akwafe River) at the latitude $4^{o}40'$N to the Equatorial-Guinea border (Campo River) in the south, latitude $2^{o}20'$N (Fig 1). The coastal region here includes estuaries from the level of high tides up to 60 km over the continental shelf and slope. It comprises rivers, which obviously find their way into the ocean. A continuous line linking towns from North to South marks the continental boundary. This zone partially covers three provinces the Southwest province in the north, the Littoral in the centre and the South province in the south (Fig. 2) and five administrative divisions: Fako, Ndian, Wouri, Sanaga Maritime and Ocean division.

Figure 1: Location of the Cameroon Coast



Source: Folack and Galega, 1996, page 1

Figure 2: Definition and boundaries of the Cameroon coastal zone



Source: Folack et al., 1996, page 2

2.1.2 Physical and hydrographical context

The continental shelf area is about 25 nautical miles wide on the average while the southern portion is 15 nautical miles. It appears that sea swells are from the south to the south-west and of distant origin. The relief shows a rocky zone with intermittent occurrence of sandbanks. Here is the area where the mixing of nutrients reaching deep water with surface water occurs.

The main river systems within the coastal landscape and draining into the ocean are Dibamba, Ntem, Nyong, Mungo, Wouri and Sanaga. The Sanaga River is the most important. It waters half of the meridional part of the country with its 900 km. These waters have high discharges into the Gulf of Guinea and are receptacles of water discharges from the industries. Thus, they are a site for biological productivity because marine pollution from organic material of the food chain takes place there. Mungo enters the sea through a delta while the others together form the Cameroon estuary. Always under the scope of the hydrographic aspect, this littoral zone includes two sedimentary basins: the Campo basin of 45 km^2 and the Douala Rio-del-Rey basin. The latter appears more important as it is a concentration of most factories and the area where the author's investigations were made. It lies from the second to the fifth parallel north and covers an area of 9500 km^2.

2.1.3 Climatic and oceanographic factors

The coastal climate, just as in the rest of the Gulf of Guinea results from the combined effects of the tropical oceanic low-pressure zone and the inter-tropical front within the continent. Monsoon winds that cause humidity value to be almost at saturation point largely contribute to make Debunscha the second wettest place in the world (Angwe and Gabche, 1997); a rainfall-recorded value shows an average annual of 11,000 mm. Air temperature is above 25^oC throughout the year, the water temperature is almost as high. However, it is not the case of coastal waters in the other West African countries such as Benin, Ghana and Togo (Folack et al., 1996). Nethertheless, depending on the location and the season, water temperatures vary

between 18 and 20 on the one hand and remain above 25^{o} on the other. This thermocline between the two layers plays an important role in the dynamism of the living organisms, as it is a predilection as a reproduction area for many species of fish and crustacean (Appendix 1).

From the information given in the paragraphs above, it can be seen that the basins are not concentrated. However, there might be a great exchange of water with the Atlantic and the mixing of water from the estuary. At this stage, there should be dispersion and dilution of pollutants in surface coastal waters. Although the water is almost warm, evaporation however might be less, due to the great amount of inflows from the rivers (Table 1). In addition, due to high rainfalls along the coast combined with the dense river network, the Cameroon coastal waters might be characterised by low salinity and weak water circulation. In 1987, peak salinity values of 20% were recorded at 15km from Douala Port in the dry season and less than 12% in the rainy season (Folack et al, 1996).

Table 1**:** Cameroon's major coastal rivers and hydrological zones

Major rivers	Drainage area in km2	Estimated discharge (m^3/s)	
		Minimum	Maximum
Mungo	2420	27,5	636
Wouri	8250	49,0	1425
Ntem	26,350	50	764
Nyong	26,400	25,7	376
Sanaga	131,500	171,0	7570

Source: Folack et al., 1996, page 5 and Angwe and Gabche, 1997, page 6.

The table 1 shows estimation of water discharge in m^3/s, from 1974 to 1989. To confirm what has been said earlier about the Sanaga River, it is clearly shown that its inflow is much greater than the other rivers combined. It can be also noted that this river converges with other streams along its paths from the plateaux.

2.1.4 Biological and ecological considerations

The coastal ecological system is characterised by a high diversity including coral reefs, algae, fish, mangrove seagrass and other animals. Cameroon coastal fauna is composed of a rich diversity of animals, such as mammals, wild boar, crocodiles and giant frogs that measure 30cm and weigh 2.4kg. A variety of fish, crustacean and lobster is found along the coastal sea (Appendix 1). Birds such as parrots and heron are also part of the population.

Available evidence strongly suggests that mangroves here are highly productive. They cover 2,700km^2 (Folack and Galega, 1996) and constitute excellent shelter for shrimps, molluscs and fish that spawn in mangrove waters. It is said that within this coastal forest, there are several vegetable species widely used in traditional medicine and undoubtedly have pharmaceutical value. Also found is small grass with potential for horticulture.

These diversified species seem to be endangered by coastal activities such as industrialisation from which the discharges of effluents into the marine environment are a concern. In this context, if the ecosystem is not preserved, human life will be indirectly affected. That is, if one component is affected, the adverse effect will eventually work on human beings. Thus, the objective should be to protect this coastal environment and prevent marine pollution at the source. The next chapter will show what kinds of substances pollute this zone and endanger its species. The following steps will describe some of the economics of this littoral zone.

2.2 Social and economic aspects

2.2.1 Population

The coastal zone divided into three provinces represents almost 20% of the total population of the country. The estimated population of the country in 1997 was about 15 million inhabitants with an annual growth rate varying between 2 and 6%. Cameroon is a largely urbanised country compared to other west and central African countries (Angwe & Gabche, 1997). The main coastal towns are Douala, Limbe, Kribi, Edea, and Buea. Douala is the most populated city and the country's industrial heartland. It might be useful to emphasise that the high concentration of factories is located in the commercial port city of Douala; the port being situated on the Wouri River, 25 km from the sea. The Limbe Port at Cape Limboh is a petroleum terminal.

2.2.2 Agricultural and fisheries sectors

Agriculture is the most important contributor to the gross domestic product. The agro-industry of this zone is composed of crops such as palm oil, rubber and tea. Part of the harvest is exported in their raw form while the rest is transformed locally by the industries. Industrial crops such as cocoa, coffee and cotton are not suitable in the coastal area. In general, the soil in this continental zone is wet, which renders agricultural activities weak. Following this, and knowing that Cameroon is an agricultural country, in this coastal zone there seem to be fewer jobs in the primary sector of agriculture but more in the secondary industrial and tertiary sector. Thus, 36.9% of people are engaged in the primary sector as against 71,9% for the whole country. 21.4% and 41.7% are in secondary and tertiary sector respectively as against 7.3%and 20% for the country. On the whole, this area is considered as the economic heart of Cameroon as it holds 90% of the economic activities of the entire country.

Regarding fisheries, and according to the Research Centre for Fisheries and Oceanography, fishing in Cameroon constitutes the second most important socio-economic activity after agriculture. Within the coastal area artisan fishing is

practised in the rivers and two nautical miles offshore. It accounts for approximately 65,000 tons of fish annually. Industrial fishing had a production estimated at 73,000 tons in 1993.

2.2.3 Activities and characteristics of the industries

Manufacturing industries in Cameroon account for 17% of the Gross National Product, nearly 90% of national production. As mentioned earlier, industries are concentrated along the coastal area and particularly in Douala. Particular attention will therefore be given to this city. Edea has also been a centre of attraction not only because of the Sanaga River into which there should be possible waste water discharges but also because of the presence of ALUCAM, the aluminium plant and the power plant. The whole industrial activity deals with:

- manufacture of soap and detergents due to an impressive availability of locally produced palm-oil
- production of plastics for packaging although wastewater is not produced
- breweries and beverages
- textile manufacturing
- paint processing
- tanneries

Cameroon has been a producer of crude oil since 1972. The annual production is 2,000,000 tons per year although it was 3 million tons in 1985 (SONARA, 1998). Oil is refined in Limbé by the National Refinery Company Ltd (SONARA). The country also possesses reserves of natural gas off shore estimated at 115 billion m3 (Anonymous, 1998). The non- exhaustive list of the principal industries is shown in appendix 2.

From the information given by the services of Mine Water and Energy and the Ministry of Environment and Forest (MINEF), petroleum activities generated in the process of the off-shore drilling of crude oil are important. On the other hand, 15% of the country's pollution found in the coastal zone results from the diversity of these industries and the products they manufacture or use (UNITAR and EC, 1997).

New industries are still growing. Manufacturing activities within this littoral area has had a profound effect on public services and water supply. Environmental quality and public health have been severely affected by irrational industrial development and the continued deterioration of the environment due to industrial waste water pollution (hereafter referred to as WW)

Regarding the specific case of the Douala-Bonaberi industrialisation, there are two main streams into which the "trade effluents" (a term used by Rhodas meaning waste water) of the factories found their ways: the rivers Ngoua and Bany. In their turn, they empty into the Wouri River towards the Atlantic Ocean. Within the Bonaberi industrial zone, residual effluents are directly discharged into the Mungo River and Wouri River. Some diseases are endemic in this city. Hazardous residues from industries and their discharges into the waters cause severe degradation. Environmental problems will be discussed further. However, it should be emphasised that most synthetised industries' residuals are toxic, persistent and biomagnifiable and tend to accumulate in the receiving environment (Lassig, 1999).

2.3 Comments

The Cameroon continental shelf gradually descends through 0, 30, 50 and 100m depths. In other words, the country has a low-lying coastal zone. Consequently, there is generally weak water circulation. The coastal zone has a dense river network and only one drainage basin, the Atlantic Basin through which all the rivers drain into the continental shelf of the ocean.

In addition, the Cameroon maritime and coastal zone is endowed with a large biodiversity and potential and most of the factories are located within this area. It has also been noticeable from the investigation that most of the industries are characterised by the absence of control measures concerning waste disposal and management.

Concerning WW, there was no adequate treatment and no common discharge for the waste. Therefore, the trade effluents are purely and simply released into nature via the sea. Because there is low circulation, the water here might be polluted. Obviously, the untreated WW is a threat to the environment and to human health. By virtue of this, it is expected that the protection of ecosystems might be of highest priority in environmental protection. For that matter, the framework law on environmental coastal and marine pollution addresses these issues (MINEF, 1998). In practice, it appears that there is no proper management of this ecosystem.

Nevertheless, industrialisation seems to increase and is encouraged in order to advance economic growth and improve standards of living. This behaviour seems to be in the first position of the Government and industrialists who measure their contribution to social welfare instead of caring about the environment.

This position seems to prevail in most developing countries. It is the reason why Bigham wrote; “the primary industrial problem to be faced by national government may well be that of achieving a sufficient national income to rise … rather than to be concerned with immediate problems of pollution”. Similarly, answering a questionnaire, one said, “we are not in a hurry to prevent or solve problems of marine pollution”. To him, it is not necessary to care about the use of the marine environment therefore, discharging WW into nature should not be a question of any importance. Nevertheless, is it not the same environment that is a scarce resource since its use for WW disposal may produce any kind of adverse result? Should it be understood that even if laws are enforceable, a project for protection of the marine environment might not be affordable for the time being? Alternatively, should not industries comply with legislation in order to protect the environment?

CHAPTER 3

Aspects of Environmental Issues of Water Discharges

3.1 Introduction

In assessing the pollution of the coastal zone from industrial WW, it appears that industries involve the use of a variety of products such as chemicals and water as inputs. The different factories that use water ultimately generate WW from their activities. This effluent may come through manufacturing processes, washing and cleaning operations and may contain pollutants harmful to the coastal and marine environment. Pollution of the watercourse of rivers and estuaries may be caused by single factors or by a combination of different types of industrial discharges. As industrial activities deal with manufacturing of mixed substances and chemicals, this chapter will identify some products and chemicals used in different kinds of activities. It will analyse the impacts of untreated WW on the environment. Finally, it will discuss some problems encountered and relating to the threat of WW from the industries.

3.2 Industrial Waste Water

3.2.1 Identified products entering the processes

3.2.1.1 Water

The significant industries within the coastal zone of Cameroon have included agriculture and livestock, cement, food processing, chemical, metal working

factories, petroleum products and textile. Within the area of investigation, some industries are not concerned about WW generated in the production process. For instance, it was said that SOPICAM (Insecticide company) does not use nor release waste neither does CIMENCAM (Cimenterie du Cameroun), which is located in the port area. It releases only solid wastes. In the case of the latter industry, it pollutes the air with very fine particles of cement dust. Of course, these particles are later dispersed and deposited on the land and in the water. The quantity of water entering the industrial process varies widely and is highly representative. This water is used for cooling, chemical processes or washing. Unfortunately, the overall indication of this input has not been available. Nevertheless, after a considerable time of patience and pressure on a few industries, it appears that CEP (Compagnie Equatoriale de Peinture) utilises 4 to 5 million tons per day. ALUCAM (Aluminium du Cameroun) uses 12 million m^3 per day.

3.1.2.2 Chemicals used

“Nearly a hundred varieties of chemicals are used during the paint processing," said a guide when asked to identify the type of chemicals entering the process. “ We use industrial chemicals," said another elsewhere. “We do not pollute with consumer chemicals," said an interviewee in a company. It can be underlined that of course, a single product does not always pollute, but when mixed with or in the presence of another product, might have a serious impact on water quality, that is pollution may occur. It is known however that soda is one of the main chemicals used in soap processing. Products such as polyol and toluene dysocyanate are present in the foam industry. Fluorine is used in aluminium refining. In some factories, it was found that a high concentration of caustic soda and formoline solution is used to clean tanks. So is Chlorine. In tanning industry production process, it is used a wide range of chemicals including sodium sulphide, chromium, sodium chloride, sodium carbonate, formic and sulphuric acid (Anonymous, 1998).

On a global scale, the overall use of chemicals is, as mentioned before, in the manufacture of soap and detergents, foams, textiles, aluminium refining, oil refinery

and cosmetics. According to the studies done jointly by MINDIC and MINAGRI in 1996, the total amount of chemicals used in 1990 was 1,165,3324 tons. Petroleum products were the greatest amount with 820,000 tons followed by industrial chemicals with 193,370 tons (UNITAR et al., 1997 and Anonymous, 1998).

A study by the Ministry of Environment and Forest (MINEF) had assessed the global production of industrial wastewater in 1995. The estimated industrial WW discharges is shown in Table 2 below.

Table 2: Annual Production of liquid waste (MINEF, 1995)

Type of activity	**Annual quantity (m3)**	**Pollutants**
Agro-industries	4 224 000	Nitrates & nitrites, organic matter, phosphates
Chemicals industries:	2,267,155	Acids, Mercury, Lead detergent, solvents, Cyanide
Metallurgic industries	1,400, 800	Heavy metal, Carton, PCBs
Other small industries	598,554	Pesticides
Total	**8,490,509**	

Source: MINEF 1995, UNITAR et al., 1997

All pollution loads refer to year 1995. It was estimated that almost 8,500,000m^3 per year of untreated industrial waste water deposited intentionally find their way into rivers via the sea. The contribution from agro-industries liquid waste of 4,224,000m^3 is relatively half of the total annual production. The contribution of industrial chemical waste water of 2,3millions m^3, is almost a quarter of total discharges; the largest contribution being soap processing with around 6000m^3 a day.

3.2.1.3 Others

On the other hand, The diversity of industries leads to the thinking that there is also a variety of materials entering manufacturing and processing. Subsequently some agro-industries, such as breweries use malt, houblon, wheat and maize; others use national raw products, such as cocoa, sugar cane, tee and palm oil. It may be useful to point out that although some products are imported, a considerable amount is national crops. Aluminium comes from Guinea. Crude oil is imported from Libya and others.

3.2.2 Variety of pollutants.

Industrial activities generate different kinds of effluents that contains a considerable amount of harmful substances which are pollutants (Table 3). Due to the geographical position of most industries, WW has been discharged into the streams and rivers to the sea with no, or minimal (mostly insufficient) treatment. The untreated liquid is susceptible to degrading the physical, chemical and biological characteristics of the environment. The importance of the stress on the marine environment is the function of the chemical and biological characteristics of the pollutant agent. Also, factors such as concentration persitences and bioaccumulation stress the marine environment.

Substances that are released in low concentration may not be immediately harmful to the marine environment. For this matter, some companies without proper WW treatment plants try to do their best by neutralising or cleaning liquid wastes hoping that the effluents will have less impact on the environment. For instance in some factories, the mixture of ammoniac with water is used to decontaminate WW before it is released in the watercourses. However, when marine organisms absorb pollutants, concentrations in their tissues may increase to toxic level. That means that the effect exits even at low levels. Similarly, pollution can be expressed by excess siltation which itself is not a toxic process (Quing, 1987 p. 19). In addition, eutrophication is not a toxic expression of pollution but is harmful to water life.

Thus, it should be noted that pollution of marine or coastal waters derive not only from toxic effects.

3.2.3 Importance and effects of critical pollutants

As most industries are concentrated in the coastal area, this zone is generally considered the most polluted one. As far as the potential effects on the marine organisms, ecosystems and human health are concerned, the most critical pollutants (Table 3) from the trade effluents include, among others, suspended solids (SS), organic matters e.g BOD (Biological Oxygen Demand) as a result of pollution, nutrients such as phosphorus and nitrogen, petroleum, hydrocarbon, metals, e.g. mercury, lead and zinc.

Table 3: Estimated water pollution loads (t/y) from the industrial effluents in the Cameroon. coastal zone.

Activity	Production per year	BoD5		SS		Oil		N		P	
		Load	%	Load	%	Load	%	Load	%	Load	%
Food Processing											
Oil Palm Manufacture		24 300		37 700							
Others		38 000		54 400							
Total	34 100	62 300		92 100		13.11	<0.1	2.9	<0.1	0.42	<0.1
Beverage production (beer, liquor)	504 300	6 497		2 646							
Chemicals											
Soap	83 700	83 200	<0.01								
Others	147 800	9 800	3.0	3 920	2.4						
Total	231 500	18 060	10.3	5 504	2.8	25.8	<0.1	51.6	1.5	344	26.2
Petroleum products											
Oil refinery	806 900	58 823	33.5	14 686	7.5						
Others	90 000	7 177		2 314	1.2						
Total	896 900	66 000	37.6	17 000	8.7	104 000		26 000			
Metal products											
Alumina from Bauxite											
Iron steel		5 684	3.2								
Total	104.7	5 684	3.2	37 935	19.5			52.9	0.2		
Textiles	73 700	374.7		114 300							
Agro industry	980	55.75		665.7				21.73	0.1	6.25	0.5
Sanitary	2400	16 560		38 400				7 920	22.9	960	73.3
Total		175 531.5		194 685				34 513.53		1 310.67	

Source: Angwe et al., 1997 and Folack et al., 1996

A brief discussion of these materials will be useful in assessing the impact of industrial wastewater. It should be stated that the accurate values of different parameters in mg/l have not been available. Therefore, it should be considered that the discharges of effluents being in excess, the rate of the parameters is assumed to be greater than the normal admitted value. It should be noted that water temperature is another parameter that affects marine living resources.

3.2.3.1 Suspended Solids

Suspended solids are a very common characteristic for all industries. The estimated SS annual load that reached the coastal zone is 194,685 tons of which food processing industries discharge effluents contain a load of 92,420 ton per year (t/y). Based on the assumption above, the high discharge of SS might affect the quality of the water and largely disturb the conditions in the habitat. The water can lose its clarity. Low transparency over an extended period of time can degrade the health of a water body as the decreased amount of light penetration reduces the area for aquatic plants and primary producers to grow. In addition, many marine organisms feed by filtering water and large amounts of suspended matter may foul their filter-feeding systems. In addition, the decomposition of SS may lead to diminution of oxygen within waters. For instance, the River Ngoua releases a heavy odour of rotten eggs (Personal observation, 1998) “recalling depletion of sulphur” (Nzeuguem 1996). Only rare types of species such as bacteria can live in such a toxic area.

3.2.3.2 Organic Matters

Taking into account the inflow of industrial and municipal WW, as well as storm waters and in the absence of available data regarding Chemical Oxygen Demand, the annual pollution load of BOD corresponds to 175,531 t. The major pollutant industries were, in order of significance, petroleum refining, food processing and chemical production. Not all food processing industries might be responsible for high discharges of BOD loads. Thus, within this type of industry, palm oil manufacturing and corn milling jointly contributed a BOD of 32.2 t/y out of the 35,5 t/y.

Furthermore, it is noteworthy that discharges from domestic and associated sanitary activities contributed 16,500 t/y BOD and 38,400 t/y SS.

Discharge of organic matter into receiving waters in large quantities, continuously in excess, is liable to result in eutrophication. The most serious consequences of eutrophication are the depletion of dissolved oxygen in the marine waters (Lassig, 1999). The continuous "rain" of organic matter from the eutrophicated water layers above ceases in areas where there is no oxygen left at all in the bottom water. The continued decomposition process results in the formation of hydrogen sulphide. This toxic gas makes life impossible for all life forms except various types of bacteria. Bottoms with hydrogen sulphide are easily classified as "dying" or "dead", but should more correctly be referred to as "temporarily lifeless" (Binko, 1998). The damage can be repaired if the pressure is lifted, either through improved input of new oxygen or through decreased load of organic matter or, preferably, through both. Animal life will gradually return and the seabed will be recolonized.

It should be noted that dissolved oxygen concentration is an important factor controlling the presence or absence of estuarine species. Aquatic plants and animals require a certain amount of oxygen dissolved in the water for respiration and basic metabolic processes. Waters that do not contain high amounts of dissolved oxygen are unhealthy for the ecosystems and are not capable of sustaining several species of aquatic organisms. As mentioned earlier, Cameroon's wetlands and mangroves provide a shelter for various living organisms, fauna fish and plant species. In addition, these areas are vital feeding and nesting zones. Curiously, they are one of the victims of water pollution, which can lead the endangered species to be driven into extinction. Within this area, algae that is an essential part for the food chain is found. When massive quantities of organic matter from chemical pollutants are released into the water streams, more algae and other aquatic plants grow and bloom at a faster rate. The excessive amount of algae can affect the area in two ways.

First, with time, they start to die and decay. The decay operation attacks the area and leads obviously to further depletion of oxygen concentration in the streams i.e. the

milieu become anaerobic. The ecosystem put out of balance leads for instance to the death of aquatic organisms and fish. On the other hand, fish can migrate to other places more suitable for their life and organisms such as plant biomass will be in competition for a comfortable environment. Second, the algae reduce the amount of light able to penetrate the water. The insufficient light that reduces photosynthesis can affect the growth of other aquatic plants, which need light for their life. An important consequence of these adverse effects is that mass mortality of organisms occurs or species may eventually become extinct.

3.2.3.3 Nutrients

The addition of nutrients, such as nitrogen and phosphate, into marine waters can have a considerable effect on the water quality, particularly for near shore habitats where nutrient input typically occurs and tends to be confined. The greatest impact these nutrients may have is the sudden increase in aquatic plants, in terms of biomass. The amount of light that can penetrate the water column and the amount of nutrients in the water affect phytoplankton growth in terms of photosynthesis.

Nitrogen is the primary nutrient that controls or limits the growth of phytoplankton in marine waters. Although nitrogen occurs naturally in the marine environment, when massive quantities from chemical pollution enter the waters, they can lead to activate algae blooms and eutrophication. When blooms occur, water conditions (such as reduced water clarity and dissolved oxygen) may become unfavourable for aquatic organisms. It should be emphasised that eutrophication is the most significant effects caused by nutrients as abnormal introduction of nutrients into the marine environment always result in increased organic matter (Kuwabara, 1984 p. 16 and Lassig, 1999). An increase in phytoplankton biomass may cause a decline in dissolved oxygen as the phytoplankton cells respire and decay. The impact of eutrophication on the oxygen balance in the marine waters and ecosystem's function has been explained above.

Phosphorous is an essential element for aquatic plants and a fundamental element in the metabolic process for both plants and animals. Total phosphorous includes both organic phosphorous and inorganic phosphates. Inorganic phosphates are rapidly taken up by algae and other aquatic plants, although phosphates are usually not the limiting nutrient in marine waters. However, large inputs could cause algae blooms, which could lead to unfavourable conditions.

3.2.3.4 Petroleum hydrocarbons

Table 4: Water pollution loads (t/y)- Toxic chemicals.

Type of industry	Phenol		Cr		F		CN		S	
	Load	%	Load	%	Load	%	Load	%	Load	%
1. Metal products	2.04	0.1			4.5	100	7.6	17.2		
2. Petroleum products	3.494	99.9	2.76	100			36.7	82.8	759	100
TOTAL	**3.496**	**100**	**2.76**	**100**	**4.5**	**100**	**44.3**	**100**	**759**	**100**

Source: Angwe et al., 1997.

In Limbé, although WW from the refinery is thoroughly treated before being discharged into the sea, it however encounters oil spill problems. Beaches are polluted and oil is clearly seen on the water surface. 'It is just small negligent spill' mentioned an agent of SONARA! However, one thing to remember is that oil, the "ugly pollutant" as it is called, seems to be ubiquitous of all the contaminants regardless of the quantity of the spill. That is why Bulloch wrote "…marine ecologists generally agree that chronic low levels of oil are more damaging to marine life than a single catastrophic oil spill". Although seawater contains natural bacteria to degrade oil, continuous spills might not be readily degraded within a particular marine environment.

Spills come from the refinery, ships or off shore drills. One thing is certain and that is that oil is biologically toxic and depletes O_2 in the water due to biochemical and

chemical demand (Pardo, 1998). They affect marine organisms in their larval or juvenile period. Consumption of contaminated seafood such as mollusc and shellfish by humans may be a serious health hazard. In addition, in the very long term, plant life near the sea, will be contaminated and will break; mangrove being difficult to clean pollution might be adequately prevented from the sources whatever they are. Now, fishermen complain about drop in fish cash within Limbé area.

3.2.3.5 Metals

Metal production, mainly manufacture of alumina, was also a major contributor to water pollution by SS (Table 3). The annual SS production of the factory was 37,935t representing 20% of the total load. There is no clear-cut way to define poisonous natural element or toxic metal. The physiological action of any element depends on its mischief. For instance, Bulloch wrote that:

> Barium in ion form is poisonous. Yet, barium sulphate is so soluble that it can be swallowed in large quantity by impurity. The metal will be toxic or harmful only if it is assimilated or accessible to man by plant or animal at a significant level.

It is the case of heavy metals, particularly mercury and cadmium, which are well known to be accumulated in marine organisms and can have detrimental and often irreversible effects on human health through consumption of contaminated sea food. The poisonous effects of mercury have been demonstrated in the poisoning incidents at Minamata in Japan.

3.2.3.6 Pesticides

These substances are known to be persistent and highly toxic to marine organisms, ecosystems and humans. Specifically, untreated industrial WW effluents contain pesticides that can contaminate ground water around the Douala area (Binko, 1998). Within this urban zone groundwater resources are vital for water consumption. Ngo-Bissoy (1990) indicated that this unhealthy water might be a problem in that when

ingested the human nervous system can be affected through the water that is carcinogenic and an endocrine disrupter.

3.2.3.7 Thermal

Water temperature is an important factor in an estuary and should be monitored for several reasons. In Edea, 'water entering the process is used only for cooling and does not contain harmful substances and is released through pipes into the River Sanaga' (Interview with ALUCAM personnel, 1998). Also, discharges from the power plant may be entering the same river. Nevertheless, a study on industrial pollution reveals that this WW are discharged with a high unacceptable temperature (Nzeuguen 1996). Whether or not it is so, it might be useful to note that discharge of warm water into natural streams decreases oxygen solubility in water. In addition, as water temperature rises, biological and chemical activity increases, adding to the potential occurrence of phytoplankton blooms as higher temperatures facilitate the uptake of nutrients. Moreover, some pollutants introduced into water are in themselves inoffensive to the marine environment, but when they are mixed or in the presence of high temperature, they become toxic. It is the case of substances such as cyanide, zinc and copper. They become very toxic when in contact with high temperature. In other words, any discharge of warm water into rivers, mangroves or estuaries is a threat to the marine environment leading, for example to adverse effects on production of fisheries.

3.3 Further discussion of the problems

The problems inflicted by the lack of WW treatment facilities within the Cameroon coastal zone include the environment, impacts on society and economic concerns.

3.3.1 Environment

With the continuation of untreated WW being discharged into the water systems, the ecosystem will continue to degrade at a fast rate. With the high rate of wetland habitat destruction, all types of aquatic and terrestrial species would be affected.

Since most wetlands are used for breeding, nesting and food resource grounds for species, by destroying them, a possibility of these species becoming extinct or endangered must be taken into account.

Another aspect of the environment is the ground water which is a source of fresh water access and runoffs into the nearby water systems and rivers. Nearby industrial plants that discharge untreated chemically contaminated effluents are continuously destroying the groundwater and water systems. With the lack of wastewater treatment procedures within these industrial plants, there will be a continuation of discharging pollution into the environment. Another factor that affects the environment is the depletion of plant biomass due to eutrophication. As mentioned earlier, eutrophication is mainly caused by the overload of nutrients entering the water system. Without pre-treating the effluents, the continuation of nutrient rich water will be discharged into the water systems as well. By negatively altering the ecosystem in various ways, the natural services that the ecosystem provides can not harvest the natural renewable substances to keep within the regeneration rate. With time, these once sustained ecosystems and environmental conditions are altered beyond their reparable state.

It should be pointed out that the littoral area is not only threatened or polluted by industrial activities. It is known that there is a continuous stretch of pollution of several of other land-based marine pollution (LBMP) sources. These sources of LBMP are domestic sources, agricultural run-off, radioactive and river discharges.

Other threats to the coastal and marine environment that cause the physical destruction of important habitats are ones activities such as the building of ports, tourism, clearance of mangroves and fishing practices with the use of chemicals. These activities give rise to alteration of coral reefs, shorelands and seafloor. The introduction of alien species can also have serious effects upon marine ecosystem integrity. These physical alterations can result in possible changes in estuarine conditions and interference with fish migration. This destruction of habitat exacerbates overharvesting of these living marine resources leading to a growing risk

that they are being depleted. In other words, physical alterations and destruction of habitats adversely affect biological diversity and biological productivity (GPA, Internet 1999).

3.3.2 Social Aspects

Within the vicinity of Douala city, people lack access to pipe borne water so rivers are the main supply of water supply to the population. A shortage of potable water is always observed especially during the dry season when the demand for water is high and the use of rivers receiving the WW increases for domestic needs. Consequently, people might be affected by the polluted waters. Research made by UNITAR in 1997 revealed that most rural areas do not have access to potable drinking water and so depend on wells and surface water. In addition, the configuration of Douala City is such that the area has been suffering from severe flooding during the rainy season. Linkage overflows from sanitary septic tanks could thus contaminate the water affecting the wells and streams. Up to now it has not resulted in any a massive deaths that have been recorded, such as in Memosata in Japan.

However, the health factors include the effects on humans due to the toxins and hazardous pollutants in the water systems. Diseases such as skin diseases, cholera, typhoid and dysentery have massively affected the population in Douala during the past ten years. It should be noted that during those years, contamination, which occurred, led to either hospitalisation or death. Polluted WW not only affects humans, but it also affects the farmlands on which the polluted WW is used. Since the WW is used for irrigation of farmlands, the pollutants can affect and contaminate the vital crops such as grain. With a decrease in the food supply from subsidy crops, starvation and a decrease in agriculture can affect the society.

3.3.3 Economic Issues

It should be noted that many are aware of the impact of pollution due to the discharge of untreated WW into nature. In order to plan a WW treatment facility,

factors that arise can include, among others funding, land reclamation and duration of building. In a country facing an economic crisis, funding should be taken into serious great consideration. To build an industrial WW treatment plant would cost an estimated US$ 5.7 million (Internet 1999). A study in Cameroon in 1996 (before the devaluation of the regional money, CFA) revealed an estimated cost of 14.2 million FF (French francs) dispatched as shown in Table 5 of Chapter V. For these estimated costs, will industrialists fund such a project within a weak economic situation, and where environmental concerns are still backward? There are institutions such as the World Bank, of course, which should provide the loans.

Regarding the land, some industries are situated within a confined area so that even if there were a possibility to install a WW treatment plant, there would not be enough space for additional installations. Therefore, they would have to move away to other wider areas. This should be a major concern since the factories will stop, which will affect people in terms of jobs and profit. It would be difficult to cover the economic losses due to the unproductive period.

Another economic concern with the same consequences is the duration of building a WW treatment plan, which could last 2 - 4 years (Anonymous, 1999). Moreover, this amount of time can never be regained in terms of income. Bearing in mind that the first purpose of the economy is the growth of GDP, it is noticeable that economic concerns of self-interest seem to predominate over environmental solutions. It would appear that this problem is common in most less developed countries in Africa and elsewhere (Interview with WMU students, 1999).

3.4 Conclusion

Biodiversity loss and ineffectual management of natural resources are of growing concern due to the introduction of high quantities of untreated industrial wastewater. The need to resolve the conflict between continued discharges and preservation of marine ecosystems must be recognised in assessing the environmental impacts on the coastal and marine environment. Greater co-operation among all affected parties:

local, state, and federal governments; universities; interest groups; and private industry in developing and implementing natural resource management goals is fundamental to achieving use and protection of marine ecosystems.

Nevertheless, these problems caused by the lack of wastewater treatment facilities must be solved. Thus, to maintain the integrity and biological diversity of habitats, which are of major socio-economic and ecological interest and for better production within the industries, strategies must be planned to build efficient WW plants. Therefore, it should be recommended that the waste water be treated efficiently, and that environmental regulations be implemented and enforced. These combined opportunities can help reduce the amount of trade effluent. Although the WW project plan will take some time for completion, the long-term effects of improving the quality of water resources will be extremely beneficial in every aspect.

CHAPTER 4

Environmental Policies and Regulations

4.1 Introduction

The discharges into the waters should be controlled and monitored by the competent authorities. These authorities might carry out the necessary measures for environmental protection. In Cameroon, the main Ministries involved in the management of the littoral area might also ensure that the legal framework is preceded by a coastal environmental impact assessment (EIA).

4.2 Legal and institutional aspects

The concept of industrial marine pollution arose in Cameroon in 1990 by the Presidential Decree No 76/372 of 02 Sept 1976 regulating unclean and dangerous industries. Thus, it is only by Law No 51/MINDIC/ICI f 28 Dec 1990 of application of Ordinance No 90/001 of January 1990 of the industrial free zone, that industrial marine pollution has been underlined within the management of the Cameroon coast. However, provisions in this regulation were inadequate and unsuccessful. Even implementation of the law over the industries besides the free zone was not significant.

Considering the importance of the Cameroon coastal area and the fragility of its ecosystems, one would logically expect a stricter protection of this zone. The concept

of purely environmental legal measures covering the zone seems to be non-existent, which emphasised in extent the saying that " there is no integrated coastal area management plan in operation as yet, in any of the countries of the West and Central African region" (Kouassi, 1999 p. 75). Based on the problems illustrated in Chapter 3, one can think that even the creation of an institutional framework to fulfil the requirements in the coastal area has failed to raise awareness of the need to protect and preserve this zone. In fact, despite the provisions of Law No 96/12 of 5 August 1996 relating to environmental management, this area seems to remain the receptacle for all kind of wastes. Industrial WW discharges are subject to neither efficient nor appropriate control.

4.2.1 Industrial Activities and regulations

Industrialisation of the littoral area and particularly Douala City took place without adequate consideration of environmental issues. In fact, according to Shresta, the conventional phases of a typical industrial project are pre-operation, which is project formulation and planning. The second phase is operation corresponding to project implementation; finally, post -operation valuable for waste management and disposal. However, management and planning institutions created by the government namely MAGZI (Mission d'Aménagement et de Gestion des Zones Industrielles) or MAETUR (Corporation for Urban and rural Planning) did not adequately address the environmental problems related to their projects nor did they carry out long-term planning projects with environmental consideration. For instance, MAGZI is the agency with efficiency and economical means placed in charge of the rational condition of building industrial systems in Cameroon. According to Nzeuguem, this institution has failed to accomplish its objectives. It has failed, in that, instead of properly doing its job, it has only stopped on clearing aspects of land, creating and building pipes whereas environmentally sound prevention is ignored.

Furthermore, the refinery whose obvious pollution of the environment seems to be predominant is regulated by a law relating more to financial needs rather than to prevention of damage to the environment. This is the case in law No 78-24 of Dec 1978, which completed hydrocarbon regulation by the mining legislation of Law No 64-LF-3 of 06 April 1964 and laid stress on exploitation or exploration with systematic control and monitoring provisions. In addition, this law is silent on environmental impacts, sanctions and penalties in spite of mining activities or handling hydrocarbons. Yet, strong sanctions methods are laid down in Law 96/12. These cases illustrate the fact that with respect to protection of the coastal area in Cameroon, laws were formulated with economic rather than environmental concerns in mind.

4.2.3 Water pollution control

Cameroon's legislation on fresh water pollution control strategies was essentially based on two main laws: law No 84/13 of 5 December 1984 on water regimes and Law No 73/16 of 7dec 1973 on spring and mineral water. Two other decrees completing and modifying the later are: Decree No 74/372 of 9 April 1974 giving the text of application of law No 73/16 0f December1973 and decree No 90/1479 of November 1990 modifying the latter.

To reinforce the framework of environmental needs and because the environment might be suffering from the effluent discharges from industry or because of general awareness, a recent decree No 98/005 of 14 April 1998 on water regime was promulgated (Cameroon Tribune, the national news paper, 1998). This Law revises the 1984 Law on water regimes by introducing aspects on preservation and conservation of the natural aquatic environment and resources. This should further consider provision of logistics for continuous monitoring of the quantity and quality of liquid effluents entering the respective water bodies. In addition, this Law clearly regulates aspects on protection and control over water, establishing sanctions for the

polluter and responsibility of parties involved in the control of the waters. However, the task of the Minister of Mine, Water and Energy (MINE) among other things, should be to control actively and efficiently, residual liquid for reduction of maximum pollutants. 'Pollution control should be done every 6 months focusing on safety measures of pollution loads' (Anonymous 1999).

It can be seen that the government makes efforts in the enactment of laws regulating and controlling pollution by liquid effluents within the country. However, these measures are handicapped not only by the lack of any enabling provisions (Textes d'application), but especially by not having a definition of strategies controlling the quality of the coastal aquatic environment against liquid effluents.

Legislation and control measures show that the environment must be protected. The Ministry of Environment and Forestry (MINEF) under the umbrella of the government, should embark on a process of establishing a national framework for a definitive enabling text for possible incentives of environmental industrialists on the one hand, and penal sanctions for environmental culprits on the other. Also, the legal framework might be preceded by a coastal environment impact assessment

4.3 Focus on the EIA: Analysis

In the context of the London Dumping Convention, "the EIA is a systematic examination with a view to determining if a project is environmentally harmful or not" (Cohen, 1998). The EIA has been initiated into the development process of Cameroon in August 1996 and expected to play a major role in regulating activities and development projects within the littoral area. Assuming that regulations, practical implementation framework and a suitable institutional set up are well defined, it can eventually be needed to analyse how efficiently the EIA can be conducted.

4.3.1 Methodology

Methodology relates to the identification, collection and organisation of environmental impact data, which might serve as a basis for project appraisal, in particular social and economic data. As a rational instrument the EIA shall be undertaken for proposed activities that are likely to have adverse impacts on the environment and are subject to a competent authority. This is why it is stipulated that "the promoter or owner of any development, labour, equipment or project which is likely to endanger the environment, due to its dimension, nature of impact of its activities on the natural environment shall carry out an impact assessment" (Law 96/12, 1996).

4.3.2 Projects requiring an EIA

The European Community like the World Bank is engaged in such projects and has divided them and their activities into three categories A, B and C. With reference to Cohen's handout (1998) a full-scale EIA is required for category A such as land clearance and levelling. A partial EIA is needed for category B such as industrial projects not included in A. The partiality arises here because the projects falling into this category might have a less adverse environmental impact than in A; but EIA is normally not required in category C. Apparently, a national text stating the list of various categories and laying down conditions under which an EIA in categorised projects will be established is not published yet.

Nevertheless, based on the project categories in an EIA perspective, large-scale wastewater (WW) treatment project belongs to category A and WW treatment facilities relates to category B. In any case a development project for which an EIA is not mandatory is subjected to the opinion of the MINEF. This opinion will help the ministries such as MINDIC and organisations such as MAGZI, in for instance, the allotment of management of land for industrial purposes.

4.3.3 Role and responsibilities

In the absence of an applicable text of the EIA the list of the entire participants cannot be exhaustive. However, the following parties have been identified through Folack's (1996) investigation.

The promoter can be a physical or moral person belonging to a private or public sector and proposing to carry out any project for which EIA is compulsory. He will then be responsible for carrying out an impact assessment and compiling specific documents relating to the study and methodology of EIA as described in 4.3.1.

The interministerial committee (IC) attached in appendix No 3, is responsible for assisting, the government in formulating, co-ordinating and monitoring national environmental policies and activities. This is why its participation in the EIA process might create a feeling of commitment to delineate its priorities. Under the umbrella of the MINEF, the IC would need to focus on reinterpreting the available laws, national or international from a Cameroonian perspective and enforce them strategically according to local specifics and needs.

The permitting authority, also known as the ministerial department, should issue a permit to the promoter. This contract should contain simple and readable terms; it should also contain conditions such as the level of pollution control of discharge from the industries. Both the decision-makers and members and of the public who will be affected by the development of the project should understand the terms.

The public, as beneficiary, must safeguard the environment and contribute to its protection. The public's opinion on any development that affects the environment must be required and taken into consideration during the planning process of the EIA. The right of the public to environmental information is well addressed in Cameroon's constitution. However, the participation of people needs to be increased

and strengthened. Nevertheless, the provision and the improvement of the EIA process might encounter obstacles.

4.4 Identification of current problems

"A study of environmental assessment in Africa has revealed that the provision of an EIA process in the environmental legislation though a major tool for planning does not guarantee adequacy and enforceability or good environmental assessment practice" (Folack et al., 1996 p. 33). To illustrate this evidence, the obstacles and findings that can arise in the industrial waste management on the one hand and the implementation of an EIA on the other are as follows:

4.4.1 Non-existence of WW treatment infrastructures

Waste equipment is inadequate within the industries and the procedures in terms of WW pollution prevention are quasi absent. These shortcomings are brought about due to nonchalance and insufficient motivation of the industry' s officials. In addition, it can be observed that sufficient financial resources needed to carry out such programmes arising from the unfavourable economic crisis in the country do not exist. This lack of funds related to chronic budget deficits might be common in many developing countries (Anonymous, 1998; Students' opinion at WMU, 1999).

4.4.2 Inappropriate technology

It should be noted that the available technology within the industries has become obsolete. It is worth mentioning in this context that the officials concerned with the prevention of industrial pollution are most often ill informed regarding industrial pollution prevention technology. Furthermore, it appears that funding constraints have always obliged industrialists to resort to the use of ill-adapted technologies.

Nevertheless, laboratories within industries check out the quality of their products as part of their production planning.

4.4.3 Insufficient qualified personal staff

Alongside problems linked to information insufficiency relating to appropriate pollution prevention, it is necessary to point out the inability of training the qualified personnel needed in this domain. In fact, and particularly in the case of industrial WW, there is an observed lack of trained manpower to monitor the composition of the WW. In other words, there is no reasonable amount of knowledge available within the companies about technologies and methods of cleaner production. At the government level, however, a growing number of public servants can apply for short and long training courses abroad in the area of environmental protection. This should be one of the objectives of local environment assessment capability, which needs to be strengthened through the development of managerial skills, the use and the training of local experts (Anonymous, 1999).

4.4.4 Lack of an information network

There is a lack of concrete access to information on the experience of other countries concerning the industrial environment. Information on paper publications of the various databases can be found by accessing, for instance, the Internet. However, only a few ministries possess computers. Similarly, and despite the development of communications world wide, companies do not seem to be interested yet in accessing the Internet for the sake of identification, selection of industries and awareness about applicable technologies that are relevant to them. In fact, lots of environmental organisations and web pages are found through Internet. Guidelines for industrial pollution are shown by accessing to Internet. Therefore, education and awareness purpose, information, interaction etc are available through Internet. Visible proofs are some references in this dissertation.

4.4.5 The non-implementation of existing regulations

The direct cause of this hurdle is the failure by the government services to enforce the implementation of the regulations on the one hand and the non-application of existing sanctions on the other. Moreover, not only are the levels of fines very low but also there are no sufficient sanctions of any defaulters arising from the laxity of the officials responsible for implementing the existing regulations (Le Mèche, 1998). Once again, it is necessary to emphasise that industrial polluting problems do not appear to be a priority to the industrialists or the government yet. Furthermore, there is a quasi ignorance on the part of population vis-à vis the dangers of industrial pollution when Shresta (1995) strongly believes that the problems with regards to enforcement strategies might also be a concern for people.

4.4.6 Unforced decisions

Apart from the difficulties linked to the non-implementation of existing regulations, it is worth mentioning that the regulations have failed in the fight against industrial pollution management, although it should be emphasised that the government does not under-estimate environmental issues. However, regarding the particular domain of industry, there is a predominant use of foreign norms with characteristics, which do not fit national needs. The need for sufficient scientific and technical data, indispensable for the drawing up of specific norms for the country, should never be overstated.

Regarding inadequate legal capacity, and based on Folack's (1996) analyses, it seems that the EIA process in Cameroon remains inoperational since there is no text of application to complement several sectorial aspects of law No 96/12. He states, "there is an emergency to establish the categories and the conditions for applying the EIA as well as the environmental compliance standard". This might be understandable by the fact that, on the part of national business, there is also a real

fear of the cost implications of having new standards in the companies. Hopefully, the water regime laws 98/005, a most recently adopted one, will be harmonised within environmental law.

Equally, institutional structures and interrelationships might be essential to the efficient implementation of the EIA process. Sharing Hanbock's idea, 'continuing to create institutions could lead to a proliferation of fragmental institution and an overlapping of jurisdictions'. What should be done is to ascertain the text of application to clearly define the role of all authorities involved in the EIA process on one hand, or to draw up national standards in order to delineate their powers on the other. On the whole, if industrialisation developments and prevention of waste pollution has to be sustained, a break from the attitudes of the past is required. Thus, the authorities should enforce the rules by setting controls and enabling the early detection of any threat or breach of permit.

4.4.7 Insufficient Regional and International approach

Environmental degradation on the coastal and marine zone from marine threats is transfrontier. Hence, as Mr Lassig (1999) mentioned during his lecture, “the wellbeing of waters must be shared among the countries belonging to the same area of concern”. Cameroon is a contracting party of the communal project "Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea", which was funded by the Global Environment Facility in the region. Without proper awareness and understanding in advance among all those participating, it will be simply impossible to act in concert. Therefore, harmony is needed on environmental standards.

4.5 Conclusion

Industrial establishments are governed by a variety of laws that are created to minimise, prevent or reduce environmental degradation. These "pieces of legal instruments" (Folack, 1996 p. 39) are a sign that the government is making efforts to follow the growing trend of environmental problems caused, for instance, by the increase of pollutant load discharges into the water bodies. Despite the fact that this concern requires a complex body of regulations and control there is a need for the Cameroon authorities to address the specific text of application. Such texts should be preceded by the EIA. Although "the process is still in an embryonic stage in Cameroon" (Anonymous, 1998), it has encountered many gaps. To fill the gaps and try to tackle the problems that arise, the following recommendations may be helpful although recommendations are contained in chapter 6 of this paper.

Among others it should be recommended that:

- Command and control should be provided as well as incentives to all the parties concerned
- A clear text of applicable of law should be established.
- Decisions and policy makers should seriously consider results from the EIA process to ensure better planning and a sustainable development and management of coastal and marine natural resources.
- A sustained policy is necessary in prioritising the needs of the EIA process.
- Broad public participation should be more necessary than ever to create the right atmosphere for implementing environmental measures.

The strong support of the international and regional community should be of great importance for the improvement of industrial WW pollution management.

CHAPTER 5

Proposed measures to manage industrial wastewater

5.1 Introduction

Treating and controlling industrial WW are not different procedures. The methodology may change or extend, but the purpose remains the same. In addition to regulatory systems for industry (Chapter 4) to reduce effluent contaminants, various opportunities to lower pollutant levels within the factories also exist. For the purpose of this chapter, firstly, the strategy to lower industrial wastewater (WW) will require looking at the definition of pollution control. Secondly, design processes that reduce the generating of contaminants will be examined. Thirdly, a particular focus on WW treatment will point out the different types of processes. Finally, the measures proposed in this chapter will raise the financial aspects involved in the treatment of the WW.

5.2 Pollution prevention

At the time that governments began to implement a “first generation” regulatory system for industrial site bases, the practical idea was to control pollution at the point of discharge (Mc Even, Internet, 1999). Similarly, Pearce (1998) wrote "monitoring environmental contaminants was of greatest concern in the sixties". Today, both government and industry seem to recognise that it is necessary to avoid, eliminate and reduce pollution at source. Therefore measures to undertake pollution control

should involve identifying key contaminants and propose “the most efficient ways to collect, analyse and store such materials” (Pearce, 1998). That is pollution prevention.

Concerning industrial WW today, the challenge for the companies should be to fully integrate pollution prevention into their environmental management system and combine a strategic business plan in order to take full advantage of potential opportunities. This should require a company among other things to:

- Undertake a comprehensive study of the production system process in the factory and identify the WW point sources.
- Identify the input by selecting and ranking the products entering the process namely raw materials and chemical products; as it can be confirmed that “the more spoilt raw material the more pollution”.
- Evaluate the output of finished products and the amount of trade effluent.
- Introduce cleaner production processes within the company in order to improve its long-term environmental performance goals and strategy.

5.3 Low waste water loads.

Reduction of WW pollution loads is an important method in determining whether the technology available has brought about any economic results and benefits. This can be achieved by applying various methods.

5.3.1 Water saving activities

Although the amount of water used in breweries, milk processing and other factories has not been available during the investigation in December 1998, studies elsewhere and personal investigation show that these industries, for instance, use large quantities of water, which should increase the amount of matter being washed out. It has been noticed that flexible nozzles are permanently used for cleaning and water

running continuously. Andersen and Jespersen (1995) think that this loss of running water should be avoided by introducing automatic valves that stop water. They add that increasing the operators' attention to water use may also help to reduce its consumption. Similarly, Nzeuguen (1996) emphasised that 'galvanising the material drain should considerably reduce pollutant loads because if the pipes were protected, dropping and leakage would be avoided.

Furthermore, water can be recycled through recirculation and reuse. In the Boston area in the USA, for instance, water has become more and more expensive due to the high costs of treatment through the local sewage authority. Therefore, the solution for the industry was to evaluate and recycle more frequently. Other examples are reused water for washing bottles in a brewery, and recirculation systems for thawing. However, it should be noted that recirculation of water always needs to be carefully evaluated, as hygiene precautions may need to be taken.

5.3.2 Collecting systems

Since WW has different levels of pollution from different industries, it might not be possible in practice to construct a sewer in a way such that all WW is treated at the same time. Therefore, less polluted effluent should be collected in the way as it is done in the WW treatment plant in Malmö, Sweden (Study visit at the plant, 1999). In fact, during this training visit, it was said that this sewage treatment plant collects and treats sewage as the name indicates and it treats WW from some less polluted industries. On the other hand, high-polluted effluent should be treated separately in a treatment plant or locally within each industry concerned (Nyberg, 1999). With regard to the present case of Cameroon there is no industrial WW collection at all.

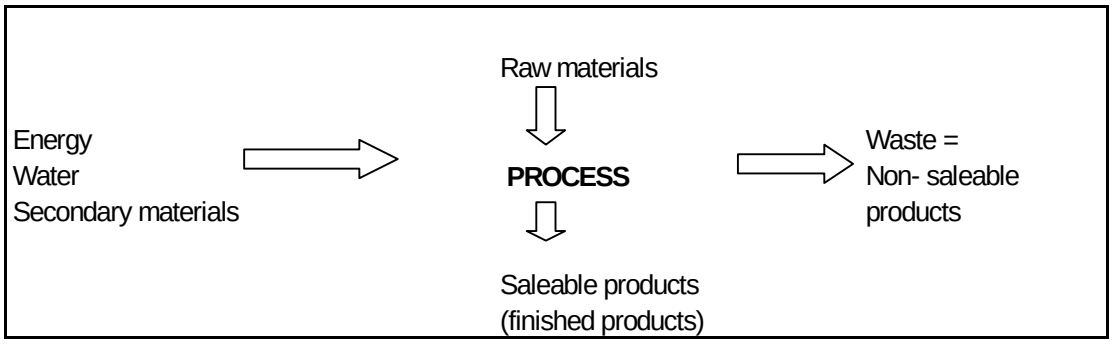
5.3.3 Dry system evacuation

Thick residue in the bottom of the tanks can be dried through the introduction of filterband conveyors instead of using water to pump them into the pipes. Thus the introduction of a filterband for WW cleaning can reduce the discharge of the effluent significantly. In the case of a brewery using this method, the BOD and COD would certainly drop as well as the suspended matter within.

5.3.4 New equipment solutions

The options here depend on how to deal efficiently with restrictions on effluent level. Cleaner production (CP) should be introduced in a developed industry in order to avoid, or at least minimise the generation of WW. The choice of the equipment used should, however, take into account the estimated costs involved in the technology in order to exploit the economic and environmental benefits of CP. By applying CP then, any type of production can be illustrated as shown in fig. 3.

Figure 3: Any type of production

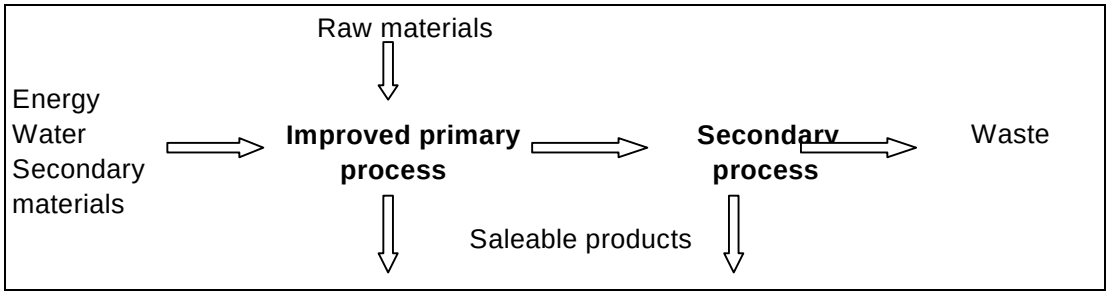


Source: Anderson and Jespersen, 1995, page 20

For this purpose, better exploitation of the raw material should increase the amount of finished products without increasing the amount of raw material. The material not transformed into finished products should be used in manufacturing other types of saleable products within the same industry or elsewhere. In addition, the result,

the consumption of energy, water and secondary material should be reduced within the process. After the introduction of the CP, the above production can be illustrated as shown below.

Figure 4: Following the introduction of clean production



Source: Anderson and Jerpersen, 1995, page20.

5.4 Wastewater treatment

It is evident that there are significant potential negative impacts of the untreated WW. These impacts can be reduced by treating trade effluent through different types of treatment equipment. Whatever equipment is used, the general approach is, among other things, to minimise waste generation and optimise production. Methods of treatment generally fall into three categories namely, physical, chemical and biological. The combination of the three is necessary in order to reach the efficient operation of the treatment process.

5.4.1 Physical treatment

This first stage of treatment relies on mechanical devices to separate solid matters from water. According to Nyberg, Rhoades (1997) and others namely Nichols, manager of water and WW services in California, this process includes systems such as screening. The system consists of installing screens the sizes of which depend upon the solid matter to be removed from the flow. As a result of installation of the

screens, the pollution load will be reduced, downstream equipment will be protected from damage, and blockage of pipelines and pumping equipment will be prevented. In the case of the WW treatment plant in Malmö, the remaining trash is collected and trucked to the landfill for disposal (Observation from visit to the plant, 1999).

Microfiltration is the most porous cross filtration method, handling particles from 0.01 microns to 5 microns. Ultrafiltration removes particulate that would not be separated by gravity. The system can also remove very large molecular weight dissolved-organic materials, depending on how fine the ultrafilter membrane is. At this point, heavy particles settle to the bottom, as sludge will be processed separately from the liquid. Most of the big stuff is gone from the WW. The water is brownish-gray in colour and ready for secondary treatment.

5.4.2 Biological process

In order to operate efficiently, biological treatment requires a reasonably constant flow including control of pH (Percentage of hydrogen). It uses micro-organisms to consume harmful organic matter in the WW (Visit to the Malmö Sewage Treatment Plant 1999) and restricts toxic chemical, which are toxic to micro-organisms. The treatment also requires correct nutrient balance, if not, WW treated on their own may need to have the nutrients added. It should be noted that at the stage of the treatment referring to sedimentation, micro-organisms and solid wastes mix to form clumps and settle some of, which is called “activated sludge”. This mixture can be mixed with air again and be reused in the aeration tank. After the final clarification tank, the fat and old micro-organisms create great amounts of sludge.

It should be emphasised as shown in appendix 4 that, each of the three treatment stage yields a different type of sludge. This sludge, after a passage into a blending tank, is piped into a digester. In the digester the micro-organisms digest the sludge

and emit methane gas, which is used to generate electricity. In Sweden for instance, this energy is used in houses. The remaining sludge is disposed for landfill purposes.

5.4.3 Chemical treatment process

This method is used to aid settlement. For example, the additions of chemicals to a solution containing metals react to form a precipitate, which is removed by settling. This is the case of phosphorus removal from WW in Australia, where at Jetflote, phosphorus is removed in the flotation process by the selection of an appropriate chemical-dosing regime (Personal communication with Jetflote, 1999). In Sweden alum or ferric chloride, are the chemical used at this stage of the process to remove substances like phosphorus. On the whole, the process consists of neutralisation of acidity or alkalinity. At the end of the process the water can be discharged into pipes to the rivers going towards the sea.

5.5 Financial aspects

5.5.1 Estimated costs

Nzeuguem (1996) shows that an amount of 14.2 million FF (French francs, before the devaluation) is needed to diminish the pollutants in the effluent of 3,800m^3 per day including BOD and COD respectively 738mg per day and 1645mg per day. The specific expenses are shown in the table below.

Table 5: Estimated Cost

Treatment	**Investment**	**Operating costs**	**Total**
Primary treatment	4,000,000 FF	400,000 FF	4.4million
Secondary treatment	4,000,000 FF	400,000 FF	4.4 million
Tertiary treatment	5,000,000 FF	400,000 FF	5.4 million
Total	**13,000,000 FF**	**1,200,000 FF**	**14.2 million**

Source: Nzeuguem, 1996, page 8

5.5.2 Acquiring the capital

Based on the illustrative list of funding sources and mechanisms of the Global Programme Action (GPA) found in Internet (1999), the possible funding sources that may be appropriate and which will need to be considered include financing sources internal to the country and external financing.

Regarding internal sources, the polluters can be charged, i.e., those who impose burdens on the aquatic environment by discharging waste water, can be required to contribute to the external cost of their actions. Moreover, municipalities that benefit from improvements in water management can contribute to the costs of those improvements from local taxes. This can be done through a specific tax for the purpose of water management or through a contribution from general tax revenues. In addition, where the costs of some local improvement in water management would bear on the local community concerned, or where the improvement benefits the public at large, the national budget can contribute part or all of the costs.

Concerning external capital, and among many other sources, loan finance for larger projects and technical assistance should be provided by the World Bank and regional development banks. Loan for smaller projects should be provided through financial intermediaries in the borrowing country, at rates lower than those obtainable on the commercial market. Similarly, export credit agencies are a source of shorter-term project financing, especially for specialised equipment.

Furthermore, and following the recommendations of the GPA, twinning arrangements could be made between parties with similar interests and concerns. Thus, arrangements between authorities of Cameroon and their counterparts within the regional countries could be an important mechanism for effective and sustained transfer of experience.

5.6 Conclusion

The protective measures cited above are a good foundation for establishing a policy of environmental upgrading and protection of the Cameroon coastal and marine environment. However, evidence shows that there is lack of fundamental knowledge that is needed for industrial WW management. Since the creation of the first industry in 1948, and despite the conditions of Law 96/12, only a few industries contribute to the improvement of the ecosystems. Nevertheless, the 'Compagnie Equatoriale des Peintures (CEP), is willing to save the environment through its treatment of 3000 litres of WW a day.

WW environmental management also suffers from a lack of technical solutions based not only on the absence of awareness and education among industrialists and people but particularly on insufficient or lack of financial means. Fortunately, there are multilateral and bilateral financing agencies that are prepared to assist and should be approached. The Government and industries should follow policies of cleaner production bearing in mind that environmental problems are among the most pressing matters which all must unite to deal with.

CHAPTER 6

Conclusion and Recommendations

6.1 Conclusion

6.1.1 Summary

The geographical morphology of Cameroon contributes to the fact that major industrial plants are attracted to coastal locations by the ready availability of cooling water and the possibility of discharging effluent without expensive or with total absence of treatment. The discharges have resulted in the pollution of the nearby aquatic environment. Further effects of pollutants are diminishing fisheries and reducing the ability of fringing reefs to protect coastal property. Another major concern is human health because people depend on water and the food chain, which contains persistent contaminants such as persistent organic pollutants.

Based on that stated above, there is a need to control and regulate the discharges to ensure that they will not have an unacceptable effect on the environment which they enter. In Cameroon like in most West African countries, there is no clear statutory power nor *texte d'application* for local authorities to change the industrialists from committing illegal activities. In fact, the existing legislation is neither comprehensive

nor sufficient to tackle the growing need for protection of the coastal areas. Nevertheless, if EIAs are appropriately integrated into the industrialisation process, it can become a very important tool. It can help in finding alternative ways of designing and operating the technology. The process can assist in concerving raw materials and energy, eliminating toxic raw materials, and reducing the quality and toxicity of the emission of waste water.

In order to comply with the broader system of the cleaner production within the industries, a wide range of options for treatment methods of industrial waste water (WW) are available. These methods concern partial or complete treatment of the effluents. They include physical, biological and chemical methods. At this stage it can be pointed out that the main cause of the present environmental deterioration by business activities are lack of awareness and money.

6.1.2 Remarks

With regard to lack of awareness, education and understanding of the impacts of WW on the marine environment, it is noted that a large majority of Cameroonians, including administrators, workers and industrialists, totally ignore the significance and importance of WW in the abatement of marine pollution. They believe that WW does not deserve the same attention as the deterioration of forests. Thus, before pollution actually occurs, people already accept that such discharges are normal and natural. They conclude that water systems are free and subject to any kind of management. In other words, pollution is free for them. This, of course, is a big mistake, a false appreciation of the use of water systems and the coastal environment. It can be concluded that the overall level of the understanding of people of land-based marine pollution in general, and industrial pollution in particular, is very low.

It should not be assumed that the Government is reluctant to ensure the protection of marine pollution from industries. However, it is not easy for the government and industrialists to focus on the establishment of WW treatment plants at a time when the country is in economic crisis. This will not be viewed as a pro economic stance at a time when there is a retrenchment in most of the public and some private sectors, and when people may be in poverty and the bare necessities of food and clothing are the highest priorities.

Therefore, money is crucial for overcoming these difficuties. If there is a possibility to fill the financial gap there will be possible investment, at least for the principal part, of the industrial WW treatment. At the same time, the cost of operating and maintaining such a system of treatment will be considered, since 'the majority of the existing industrial equipment is obsolete' (Anonymous, 1998). Hence, assistance must be sought from developed countries and aid agencies on a bilateral and multilateral basis because financially, Cameroon cannot alone successfully invest in the management of industrial pollution. In seeking this assistance a very important contribution of Cameroonians should be to unite their skills in order to hold their commitments together. Having witnessed the declining trend of industrial and Government responsibility to keep the environment clean, and the resultant unacceptable environmental damage, it is imperative that the trend be reversed.

6.2. Recommendations.

In future, strategies must be set for a better way to carry out what has been described above. Therefore, efforts need to be exerted by all sectors in the community to halt the deteriorating situation.

6.2.1 At the personal level

Governments and Municipal Councils are composed of individual people. Ngo-Bissoy (1990 p. 44) analysing the impacts of domestic WW on lakes in Yaoundé, said that

> individuals are the foundational components of all societies and must be the key initiators and implementors of any environment changes. It is individuals who benefit most and depend most on the environment to enrich their lives and supply their basic needs. If they are not aware of the need to be responsible in the management of their own personal environments, it is unlikely that governments and councils will be responsible.

It is therefore recommended that people be encouraged to seek out and take up each and every opportunity to become more educated about environmental matters. In addition, they must start exercising a new level of moral discipline.

6.2.2 At industrialists level

The industries are producing waste water and chemically toxic substances. They are the main polluters of the environment and are also the main beneficiaries of the natural resources. They seek higher profits and lower costs escaping enforcement of the law and obviously, they cannot dispose of WW treatment equipment (Le Mèche, CEP 1998). Depending on the size and the needs, the industrialists must therefore:

- Multiply laboratory analysis facilities and train suitably qualified personnel in the identification, assessment, and control of industrial effluent,
- Study the different treatment technologies of WW in order to develop the most efficient and effective recycling techniques for this waste within the industries,

- Commence a process of inter-industrial co-operation in order to construct joint facilities for WW treatment and disposal in sites where there is no space for adequate private treatment,
- Create a body through which they should encourage each other to develop and abide by a code of environmental ethics. The implementation of the code should help in reducing the use of all hazardous materials in production, and in increasing the quality of waste water,
- Adopt quality standards and create environmental management systems which are appropriate for their circumstances, but which have certain specified characteristics. Such systems involve having competent staff who are assigned responsibility to deal with the impacts of their operations on the environment. The operation of these systems must be properly documented,
- Set policies to govern their environmental impacts, which must be available to the public.

6.2.3 Local and Regional Organisations

It is recognised that these groups are closer to the people than governments. Thus, there is a responsibility and opportunity for them to play a major rôle in addressing environmental problems and implementing changes. Although they may not be very widely recognised or influential at the moment, they should:

- Inform themselves of the local environmental matters that affect people's health,
- Research, coordinate and encourage environmental activities and instruction in all schools
- Investigate the possibility and viability of establishing a common information data base which should be accessible to all wanting to educate themselves and to all

others who simply wish to be informed about materials such as chemicals and their effects on the environment.

6.2.4 At the Government level

The government holds the overall responsibility as guardian of all national resources and is thus the key player in the preservation of natural resources, their utilisation by the people and their conservation for future generations. In order to achieve an acceptable level of sustainability in environmental matters, the competent authorities of the Government and associated institutions should:

- "Properly localise industrial activities by designating specific sites for industrialisation within the framework of zoning programmes" (Shestha, 1995 p 43). This will help manage industrial development in a more organised way, and thus help bring about a balance in population distribution.
- Prepare adequate legislation and regulations and strengthen the national infrastructure to monitor and enforce legislation.
- Implement, as soon as possible, a Cameroon coastal zone environment management plan.
- "Develop a national integrated information system on chemicals" (UNITAR et al., 1997 p 53). At the same time the government should ban the importation and use of insecticides such as thiodan and others, which are totally destructive of aquatic life and replace these by chemicals such as synthetic pyrethroids, which are more environment friendly.
- Establish a clear and unambiguous text of the application of Law No 96/12.
- Prioritise the needs of the EIA process, which should be conducted in all new industries. The results should be considered to ensure better planning, sustainable development and the management of natural resources.

- Introduce environmental studies in primary and secondary schools as well as in institutions of higher learning as stipulated in Law 96/12. This law also recomends that "individuals promoting the environment shall benefit from deductions of tax according to the terms and conditions laid down by the finance law". In other words, the Government should plan a "people- strategy" and call together all industrialists to inform and encourage them to care for the environment on a self- help and self-controlling basis. Parallel to that, the law requires disciplining and punishment of violators of regulations and those who endanger nature.
- Educate the public through the mass media regarding the impact of industrial pollution.
- Encourage regional co-operation with neighbouring countries and NGO's to create innovative ideas and supervise the improvement of their local environmental affairs.
- Root out corrupt elements which have proved to be indirect polluters (Le Mèche, 1998) in order to improve and manage the environment effectively for present and future generations and exercise moral integrity in dealing with all polluters regardless of their economic or personal power-bases.

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Appendix 1: Variety of fish, crustacean and molluscs

Type	Species	Ecology	Nature of the bottom
Fish	Pseudotolithus typus	Of shore surface water Hot and little salted	Muddy, sand or rocky
	Galeoides decadactylus	Coastal and estuarine waters	Sandy muddy
	Sardinella maderensis	Estuary waters	Sandy, mud
	Dentex angolensis Epinephelus aeneus	Under thermocline, water cold and salted	Sandy rock
	Lutjanus denatus	Base of thermocline	rocky
Crustacea	Parapenaeopsis Atlantica	Estuarine water, hot and little salted	Sandy mud
	Callinectes latinatus	Lagoons, rivers	Mud Mangroves
	Europus africanus	Brankish water, estuaries	
Molluscs	Sepia officinalis	Open sea	Sandy mud
	Crassostrea gasar	Rocky beaches	

Source: Folack and Galega, 1996, pp 12

Appendix 2: List of major industries in the Cameroon coastal zone and their impact on the environment.

Type of industry	Pollutant	Effect on the environment
Agro Industry and Foods Breweries, Sugar mill, chocolate, natural rubber , and. latex palm oil manufacture	Nitrogen, phosphates, organic matter	Eutrophication, Drop in the production of the food Chain
Oil and Gas Refinery Plate-forms Mobil Oil	Hydrocarbons Lead Heavy metals	Accumulation of lead in food chain, Death of faunal and floral species, Drop in fish cash
Metallurgical, power and water supply Aluminium processing SONEL, SNEC CAMSTEEL	PCBs, spent electrodes, cryolite, heavy metal mercury	Decrease in productivity of fauna and flora Accumulation of mercury
Plastic industry	Monomers for manufacture	Wasteful occupation of space
Wood preservation	Cresol, pentachlorophenol	
Chemical industry Foam processing, Pharmaceuticals, cosmetics, detergents textile and foot wear, insecticide, herbicides, pesticides (Rhone Poulenc), paints varnishes, lacquers	Lead, cyanide, Copper Organic matter Phosphate	Decrease in oxygen Decrease in productivity of fauna and flora

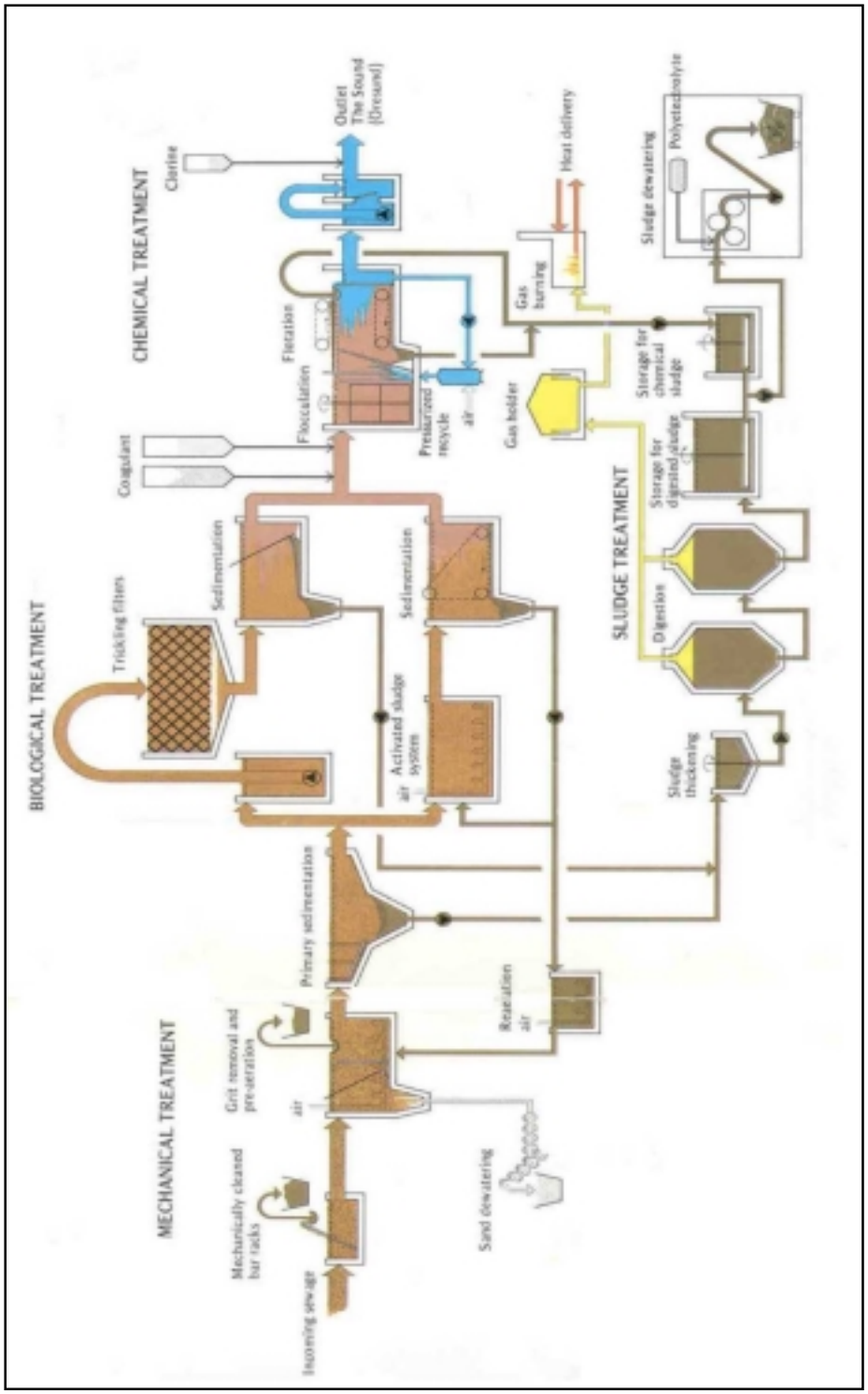
Source: Folack and Galega, 1996 pp 22 and UNITAR et al., pp 48

Appendix 3: The main line institutions involved in the management of the Cameroon marine and coastal ecosystems

Institutions	Responsibility
Ministry of Environment and forestry	Drawing up periodic reports, elaborate the National environment Plan
Ministry of Livestock, fisheries and Animal Husbandry	Protecting fishery resources in the sea, rivers and lakes etc.
Ministry of Territorial Administration	Administrating national territory. Tutelage over MAGZI
Ministry of Mines, Water and Energy	Checking industrial and commercial installations with respect to pollution, disturbances, hygiene and safety.
Ministry of Public Works	Working hand in hand with MINTRANS and taking into account environmental impact of major construction projects.
Ministry of Transport	Putting in place all necessary measures relating to safety transport on land, sea and air.
Ministry of Trade, and Industry (MINDIC)	Regulating and controlling pollution and nuisance from activities. Controlling of import of some chemicals targeted for phase-out by the year 2005, and equipment that use such substances.
Ministry of Tourism	Controlling touristic sites. MINTOUR is quite active in the management of the littoral area, since this area is a typical touristic zone.
Ministry of Agriculture (MINAGRI)	MINAGRI is involved by the existence of several industrial plantations of export crops. It administrates programmes on the use of phytosanitary products such as agrochemical.

Source: The table is built from information given by UNITAR, pp 8 of annexes; Folack et al, 1996 pp 29-31 and from an untitled document, 1998.

Appendix 4: Stages of sewage and industrial WW treatment



Source: Sewage Treatment Plant at Sjölunda (Malmö), 1982.