



Pollution-mediated Consequences of Anthropogenic Activities on the Coastal Town of Moanda, Central Kongo, Democratic Republic of Congo: Mitigation and Remediation Alternatives

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Authors' contributions

This work was carried out in collaboration among all authors. Author MKM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors ONN, GON, GAM and DEM managed the analyses of the study. Authors MKM and EMB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aims to evaluate anthropogenic activities and other sources due to natural factors likely to cause pollution on the coast of the city of Moanda in the Democratic Republic of Congo in order to analyze their negative impacts on the physical environment of this coastal zone with a view to proposing adequate mitigation and remediation measures.

Study Design: This research consists of four parts, an introduction with literature review, a description of the materials and methods used, finally the results obtained and their discussion.

Place and Duration of study: Research on the analysis of the anthropogenic activities was undertaken in the coastal zone of Muanda. This site is in the province of the Kongo-Exchange in Democratic Republic of Congo. This study covers the period going from the year 2016 to 2017.

Methodology: The method of the direct observation (description, analyzes and synthesis) was used and supplemented by the technique of investigation per questionnaire. The methodological approaches deployed to collect the data on the ground and at the laboratory arise as follows: prospection of the site, information retrieval, sampling, investigation, data-gathering, identification of the nature of the anthropogenic activities in the coastal zone of Muanda,

Results: These results show that the coast of Muanda is threatened by numerous anthropogenic activities and other sources of pollution including oil extraction industries (42%), waste drained by the sea current (22%), gas from Muanda flares. (15%), waste from cities bordering the Congo River (11%), illegal fishing by foreign trawlers (7%) and deballasting (3%) likely to lead or which already leads to its pollution as long as the mitigation or remediation measures would not be taken.

Conclusion: The principal results obtained attest that many anthropogenic activities are carried out in the coastal zone of Muanda with the environmental risks. As a long time as measurements of attenuation or remediation would not be taken into account, the coast of Muanda will be always threatened by many likely anthropogenic activities of to lead or which already lead his pollution.

Keywords: Assessment; anthropogenic activities; pollution; moanda; mitigation; remediation.

1. INTRODUCTION

The attractiveness of the coasts operates on many levels (economic, commercial, tourist, etc.), the coastlines have become particularly developed territories. They can be considered as geo-historical constructions with strong heritage implications [1].

Today, the challenges of managing the coasts and their resources are as diverse as the actors in the coastal system. At the forefront, we find the issues of protection and sustainable development of this space which is weakened and threatened by different uses.

The Democratic Republic of Congo (DRC) has a 40 km long marine coastline also including 50 km of brackish water located upstream of the Congo River estuary. This area is important economically due to the presence of its seaport in Banana and especially for the hydrocarbon processing and extraction industries. The once rich and diverse fauna and flora are facing very serious threats following very increasing pollution.

The DRC with its territory of Muanda in the Kongo-Central province is not spared from this reality where this coastal city is increasingly under pressure from anthropogenic activities beyond oil exploitation activities. For more than 30 years, underground oil in the Muanda territory has been exploited. Far from constituting a windfall for the socio-economic development of the area, oil extraction generates significant environmental impacts which pollute the water, air, soil, destruction of food crops, and depletion of fisheries resources [2].

The origins of water pollution are varied and closely linked to human activities such as domestic, industrial and agricultural pollution. These three major sources of pollution are responsible for the introduction by humans of pollutants into water and other natural environments. This study aimed to analyze anthropogenic activities and other sources due to natural factors likely to cause pollution on the coast of the town of Muanda in the Democratic Republic of Congo in order to evaluate their effects on the physical environment of this coast with a view to proposing mitigation and remediation measures to this situation.

2. MATERIALS AND METHODS

2.1 Study Area

Administratively, the Congolese coastal zone covers the entire Bas-Fleuve district. It is limited to the northwest by the enclave of Cabinda (Angola), to the northeast by the Cataracts district and to the southwest by Angola. The length of the Congolese Atlantic coast is 40km, with an important mangrove established as a Mangrove Marine Park up to its northern border with the enclave of Cabinda (Angola). This western region of the coastal zone occupies approximately 110,000 hectares (Fig. 1).

The Mangrove Marine Park, was created by ministerial decree No. 044/CM/ECN/92 of May 2, 1992, is located at the estuary of the Congo River, in the territory of Moanda, Bas Fleuve District, Kongo Central Province. Its surface area is of the order of 66,000 ha, and its geographical coordinates are between 5°45' – 6°55' south latitude and 12°45' – 13° east longitude; the altitude being less than 500m.

2.2 Materials

The coastal basin of Muanda constituted the main material of this study. The equipment which made it possible to collect the data in the field are: the Notepad, the Pen, the GARMIN brand GPS, a Canon brand camera.

2.3 Methods

The following methods were used to collect field data:

- Observation: made it possible to observe the realities on the ground in relation to anthropogenic activities likely to cause pollution of the coastal zone of Muanda;
- The descriptive method: made it possible to describe the investigation area as well as the main anthropogenic activities carried out in this area;
- The analytical method: made it possible to analyze the sources and realities of pollution on the Atlantic coast of DR Congo.

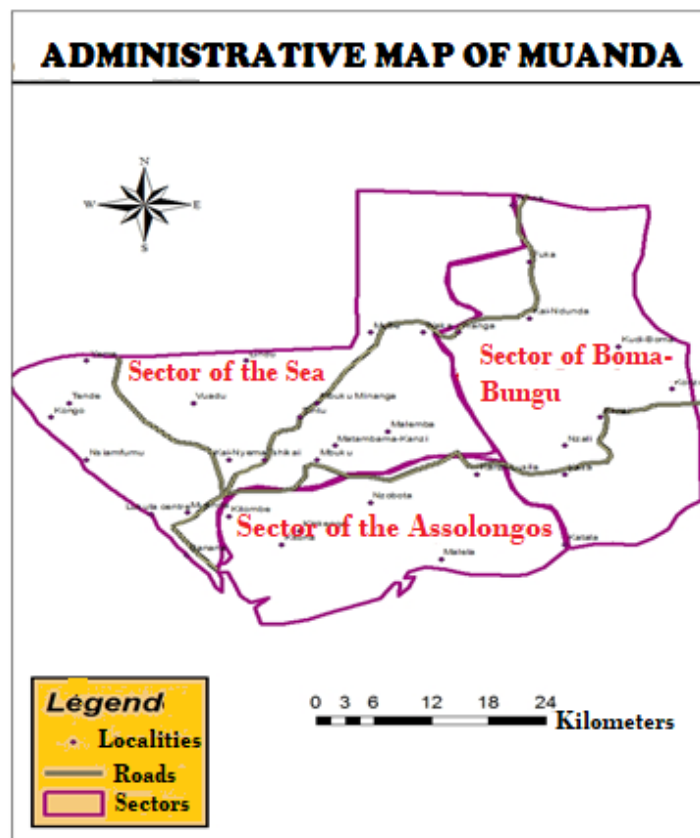


Fig. 1. Administrative map of Muanda [3]

These methods were supported by the following techniques: documentary research, survey or interview, sampling, remote sensing, geographic information system (GIS) and data processing.

2.3.1 Sampling

For this stage of our study, we used purposive (non-probabilistic) sampling. To properly carry out field investigations, a random sample of 120 individuals was drawn from the local population in order to question them on the problem of pollution of the coastal zone of Muanda by anthropogenic activities.

The results obtained are extrapolated over the entire population as described by [4] so that the distribution of the descriptive criteria of the sample selected is identical to that of the population studied.

2.3.2 Data processing

The data collected as well as the results obtained were analyzed using Word and Excel 2013, ArcGis and Google Earth software.

3. RESULTS

3.1 Results Relating to the Anthropogenic activities

This figure shows that according to field investigations, the dumping of solid waste in the ocean (40%) is the main anthropogenic activity carried out directly in the coastal area of

Muanda, followed by wastewater discharge (30%), urban expansion (12%) and energy production (10%).

From this figure it appears that the main anthropogenic activities carried out on the soil of the Muanda coast are: the storage of fuels or other dangerous materials (34%) followed by the landfill or elimination of waste (20%) and oil production (11%).

3.2 Results Relating to the Environmental Effects of Anthropogenic Activities

The results of this figure show that according to the investigations carried out on the ground the main direct environmental effects of anthropogenic activities on the coastal zone of Muanda are: Alteration or degradation or degradation of the fish habitat and other marine habitats (42%), decline in fish populations (21%), degradation of water quality (15%) and socio-economic effects (10%).

3.3 Results Relating to the Environmental Effects of Anthropogenic Activities

This figure illustrates that according to field investigations, the main environmental effects of anthropogenic activities on the soil of the coastal zone of Muanda are: contamination of soil and groundwater (29%), erosion or desertification (16%), degradation or destruction of wetlands (15%), reduction of biodiversity (14%) and increase in surface runoff from rainwater (12%).

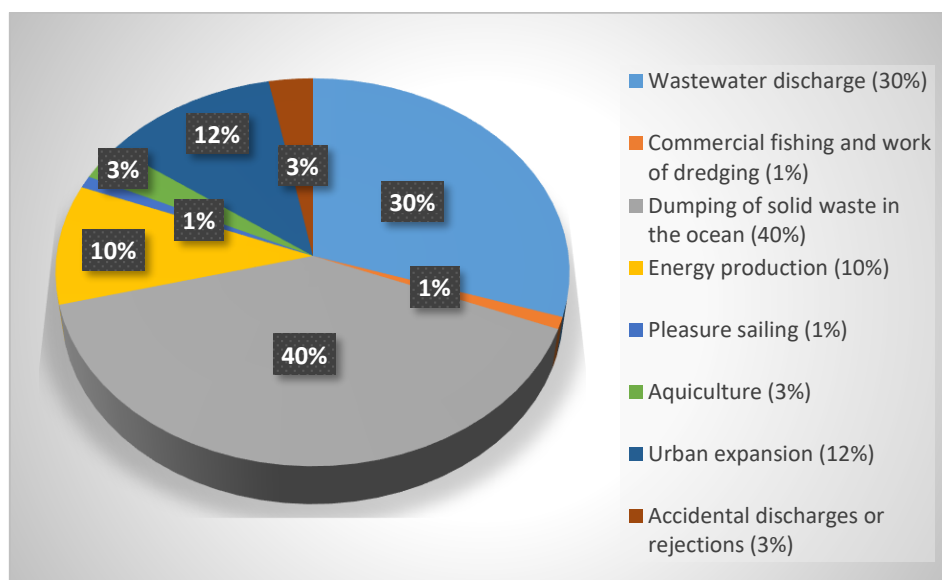


Fig. 2. Anthropogenic activities carried out in the coastal zone of Muanda

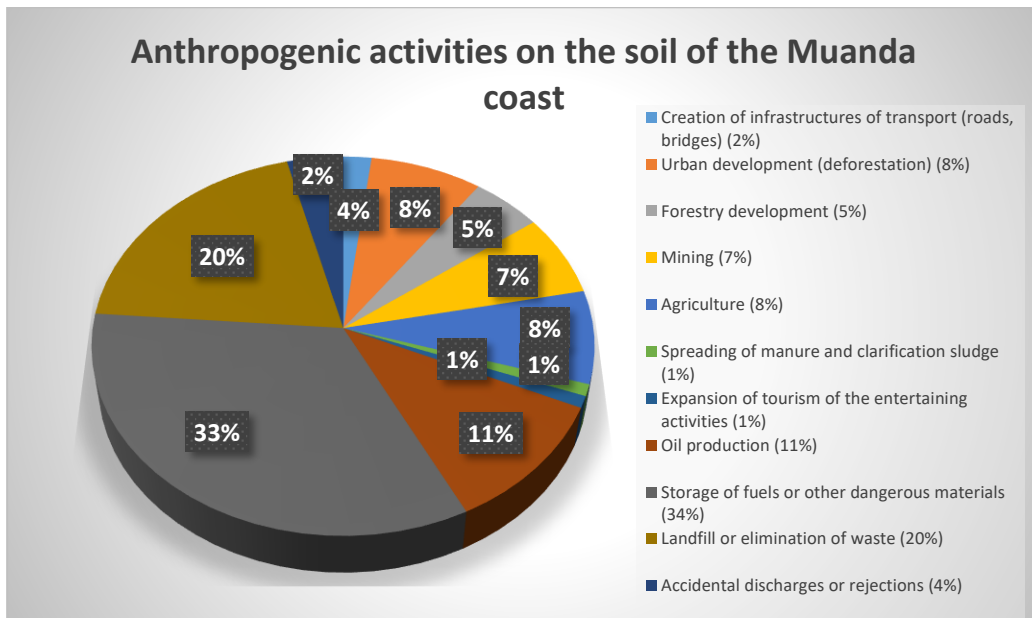


Fig. 3. Anthropogenic activities carried out on the soil of the Muanda coast

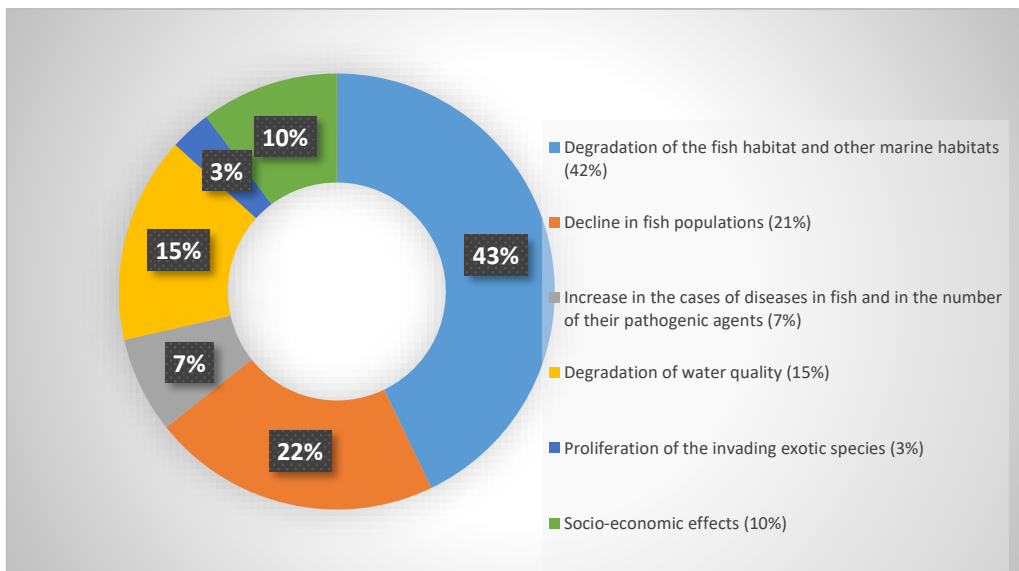


Fig. 4. Environmental effects of anthropogenic activities on the coastal zone of Muanda

3.4 Results Relating to the Mapping of Occupation of the Muanda Coast by Anthropogenic Activities

This figure shows the current land use of the coastal zone of Muanda marked by the following anthropogenic activities: unclassified activities, agriculture, clearing (bare soil), activities in the savannahs, buildings, activities in forests, activities in watercourses and in marshy areas. On this map the Atlantic Ocean is to the west and the coast extends for 40 km.

3.5 Results Relating to Other Sources of Pollution

It appears from this figure that the main sources of pollution identified in the surveys other than anthropogenic activities are: oil extraction industries (42%), waste drained by the sea current (22%), gas from flares of Muanda (15%), waste from cities bordering the Congo River (11%), illegal fishing by foreign trawlers (7%) and deballasting (3%).

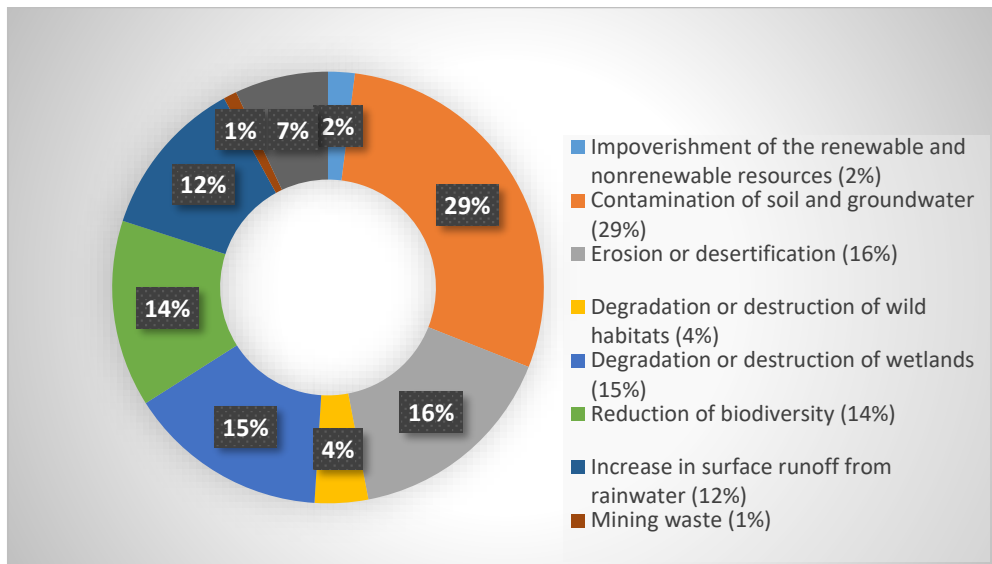


Fig. 5. Environmental effects of anthropogenic activities on the soil of the coastal zone of Muanda

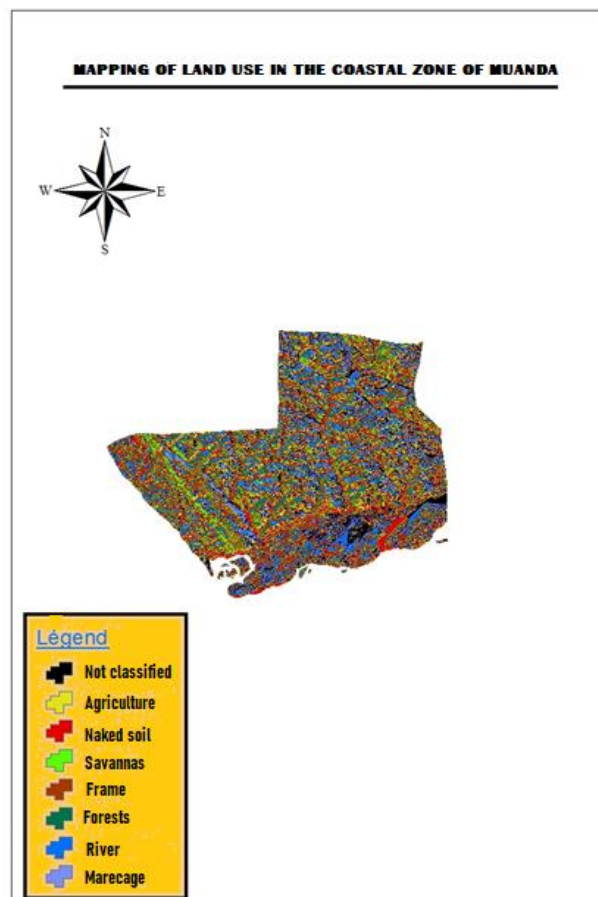


Fig. 6. Mapping of land use in the coastal zone of Muanda [3]

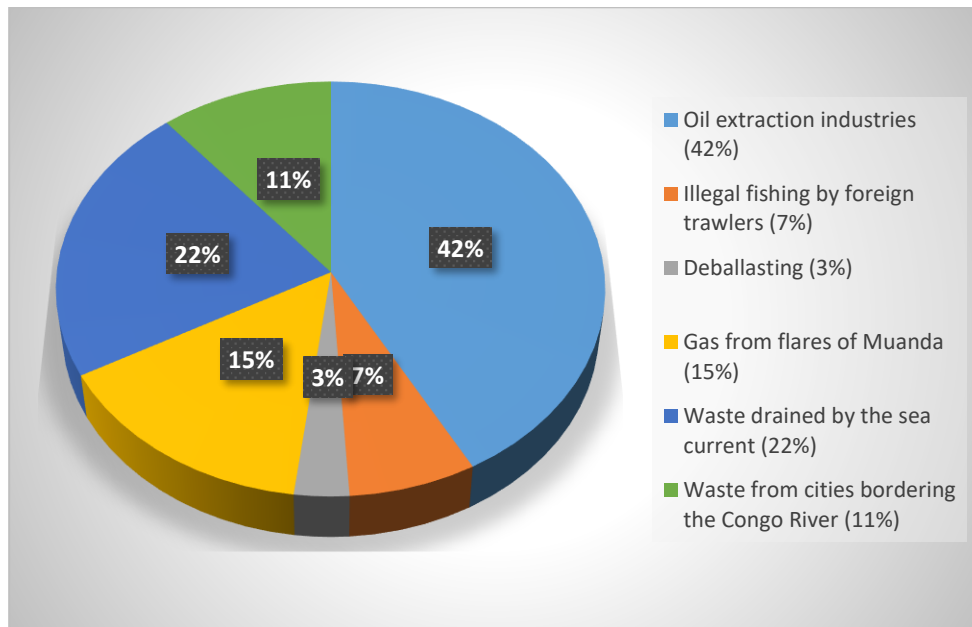


Fig. 7. Others sources of pollution of the coastal zone of Muanda

4. DISCUSSION

The results relating to anthropogenic activities carried out directly in the coastal zone of Muanda show that the dumping of solid waste in the ocean is the main anthropogenic activity carried out directly in this area, followed by wastewater discharges (30%), expansion urban (12%) and energy production (10%). On the other hand, the main anthropogenic activities carried out on the soil of the Muanda coast are: the storage of fuels or other dangerous materials (34%) followed by the landfill or elimination of waste (20%) and the production oil and gas (11%). Improper waste disposal can result in the formation of leachate, a liquid produced when water comes into contact with decomposing waste. This substance poses a risk, among other things, to groundwater and waterways.

As for the environmental effects linked to anthropogenic activities carried out directly on the coastal zone of Muanda, the main ones are: the alteration or degradation or degradation of the fish habitat and other marine habitats (42%), the decrease in populations of fish (21%), degradation of water quality (15%) and socio-economic effects (10%). The causes of biodiversity loss are multiple and largely relate to human intervention in natural environments: pollution, overexploitation, climate change, disruptions of major biogeochemical cycles, biological invasions and above all destruction of natural habitats. This last cause is nowadays

considered one of the major forces of change in biodiversity and certain models show that this will still be the case by the end of the 21st century [5]. The destruction of habitats is in fact a direct result of anthropogenic transformations of the landscape for agricultural, industrial or urbanization purposes. Man takes advantage of natural habitats for food, housing and entertainment, and demand will continue to grow for the next 30 years since by 2030, it is likely that 8.2 billion people will populate the Earth, i.e. 32% more than today [6]. However, the degradation of natural habitats is accompanied by a disappearance of their biodiversity and the effects are all the more perverse because they only appear late, when the multiple fragments of the initial habitat have suffered successive destruction and irreversible [7].

While the main environmental effects of anthropogenic activities on the soil of this coastal zone are: contamination of soil and groundwater (29%), erosion or desertification (16%), degradation or destruction of wetlands (15%), the reduction of biodiversity (14%) and the increase in surface runoff from rainwater (12%). This is the case of the Río Chili watershed in Arequipa where the construction of new homes and the increase in surface waterproofing have contributed to an increase in runoff in this watershed. This situation caused flooding, particularly from December to March, a period corresponding to the rainy season. The increase in runoff would also have an impact on the

increase in fecal and total coliforms in this river [8].

Regarding the results relating to the mapping of occupation of the coast of Muanda by anthropogenic activities, it should be noted that the current land occupation of the coastal zone of Muanda is marked by the following anthropogenic activities: classified, agriculture, clearing (bare soil), activities in savannahs, buildings, activities in forests, activities in watercourses and in marshy areas. This mapping also shows the hydrographic network of the loss of Muanda space caused by these anthropogenic activities. The mapping of the French coastal zone presented by [1] in a study carried out on the analysis of anthropogenic pressures on the European and French coastal environment shows that: "In the Atlantic Ocean and the Mediterranean, human influences decrease with the distance from the coast and bathymetry. This result illustrates the fact that the exploitation of resources decreases with increasing depth for reasons of cost and lack of techniques [9].

Finally, the results relating to other sources of pollution other than anthropogenic activities show that the main sources are: oil extraction industries (42%), waste drained by the sea current (22%), gas from flares of Muanda (15%), waste from cities bordering the Congo River (11%), illegal fishing by foreign trawlers (7%) and deballasting (3%). Coastal pollution results from "discharges of natural or anthropogenic origin arriving at sea by rivers, air, drainage of coastal territories or by direct discharges into the sea (ships and sea discharge outfalls)". There are two types of pollutants (natural or synthetic) and three types of pollution (physical, chemical and microbiological) [1].

5. CONCLUSION

This research work consisted of analyzing the anthropogenic activities which constitute a source of pollution in the coastal town of Muanda in order to assess their effects on the physical environment of this coast with a view to proposing mitigation and remediation measures to this problem.

The results obtained in this research show that the coast of Muanda is threatened by numerous anthropogenic activities likely to cause or which are already causing its pollution as long as mitigation or remediation measures are not taken.

Therefore, it is suggested as mitigation and remediation measures to this situation:

- Consideration of environmental concerns and factors early in the decision-making process (e.g. for projects or product development);
- Reduction in non-renewable energy consumption and increase in the use of renewable energy sources;
- Promotion, development and use of ecological technologies;
- Reduction in resource consumption;
- Increased reuse and recycling of natural resources (and therefore reduced production and disposal of waste);
- Eco-efficiency;
- Green procurement: purchasing products and services that are more environmentally friendly;
- Pollution prevention by avoiding the use of dangerous and toxic products, by using more ecological fuels, by using technologies allowing vehicles to produce low-polluting emissions and by using more ecological sources of energy (energy solar, wind, etc.);
- Improve emergency response and preparedness;
- Rehabilitation and construction of sanitation works for good drainage of wastewater;
- Construction of wastewater treatment plant and
- Ensure the bioremediation of sites contaminated in particular by petroleum products (hydrocarbons).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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