

Environmental and Sanitary Impacts of Waste at Autonomous Port of Cotonou (Benin, West Africa)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BS and SST designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BS, BGT, SST and CH managed the analyses of the study. Authors HS and LBM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of this study was to analyze the environmental and health impacts of poor waste management at the autonomous port of Cotonou, Benin.

Materials and Methods: The socio-anthropological investigations were carried. The collected data was used, through appropriate analysis, to identify the diseases linked to the environment degradation in Cotonou.

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Results: The results of this analysis shows that the port environment is affected by several pollutants. Thus, the chemical substance contain in the discharged pollutants into the port basin are often accumulated in the food chain by some aquatic species (fishes, shrimp, crab...) that enter the population's diet. Pollutants found on soil and in the atmosphere have negative effects on the environment, causing depletion of stratospheric nitrogen, acid precipitation, and amplification of the greenhouse effect. The degradation of the port environment can be involved in several diseases that affect users such as food poisoning, malaria, diarrhea, sinusitis, bronchitis, asthma and other food infections diagnosed among the port worker.

Conclusion: Due to the efforts made by port authorities, the severity of those diseases are in regression since some years.

Keywords: Environment; impact; port of Cotonou; waste management; diseases.

1. INTRODUCTION

The environment consists of a set of factors (physical, chemical, economic, socio-cultural and political) that interact [1]. Thus, an environmental problems must be a major concern for most of governments. The most important and current problems observed are those affecting the environment degradation inducing the imbalance of natural ecosystems [2-3]. To face these environmental degradation, the international community becomes aware of the risks associated with the strong human agglomeration. Indeed, human agglomeration are known to generate big amount of waste. However, the amount of waste generated per inhabitant and per day is strongly linked to the population density in a given city [4].

In Benin, one of the cities with biggest human density is Cotonou. Thus, in this city, the average daily waste production per habitant was estimated at 0.42 in 2002 [5]. Considering the continuous increase of the population, due to rural migration, in this city the previously reported values may probably increase nowadays. This observation may not be surprising because, the port cities are reported to generate large quantities of various kind of waste [5-6]. In addition, in 2012, the World Bank reported that dirty water and poor sanitation were responsible for more than 62% of deaths in sub-Saharan Africa [7].

Without appropriate management of wastes, the quality of water is considerably affected through the ground water [8]. The pollution of the ground water comes from human and animal feces, wild rubbish dump, and household rubbish used as embankment in marshy areas. The wastewater system and its mismanagement are very harmful to health [9-11] in a big city like Cotonou and particularly in the port area [3]. This mismanagement of waste causes serious

environmental and health problems in the port area. Bad management of damaged products affects not only populations but also the environment [12-14]. So, the problem of insalubrity in Cotonou may be linked to the economic, institutional and legal factors that influence the management of urban waste in the largest city of Benin [15]. It is thus important to propose new management approaches following environmental standards of solid waste collected in Cotonou and especially in the autonomous port of Cotonou. Thus, the aim of this study was to conduct analyses of the environmental and health impacts of poor waste management at the autonomous port of Cotonou.

2. MATERIALS AND METHODS

2.1 Study Area

The present study was carried in the Port of Cotonou (Fig. 1). Thus the port, the greatest economic platform of Benin, is covering an area of 240 hectares (120 hectares of land and 120 hectares of sea) divided into six zones (zone 1-6).

The zone 1 in the main port gate (entrance and exit) and the most frequented area with various activities (loading and unloading of goods, customs control ...). This part of the port also concentrate most of the administrative offices and the docking side of ships in transit to Cotonou. The zone 2 is exclusively the containers storage area of private companies (COMAN, SMTC ...) and the engine maintenance area of the SOBEMAP. Concerning the zone 3, it houses the terminal of the artisanal fishing port whereas the zone 4 (also calls Gabonese port) is the handling place of certain products (clinker, petroleum, vegetable oil and seafood) and the transit point for passengers mainly from or to Gabon.

The zone 5, is occupied by a large hydrocarbon deposit of ORYX group. It is the cleanest area of the port area. The zone 6 is the sea water body of the port basin.

2.2 Sampling

Sampling was random because of the heterogeneity of our field of study. Specific questions were developed and administered to 289 port users in all categories, including five resource persons. Thus, three persons per company were randomly surveyed from 23 private companies' operators. In addition, 200 users randomly selected were investigated, one person per company of 5 over 8 solid waste collector companies were surveyed. Also, seven store managers and 5 authorities in charge of managing the port environment were interviewed.

2.3 Data Collection

The participatory approach is the method used to conduct the study. A total of 289 persons independently to their profession were randomly investigated. Thus, data on the research topic were collected through individual interviews and discussion sessions with groups were conducted using the questionnaires and the interview guide respectively to collect information. Direct observations on the ground led to a better understanding of the problems of insalubrity and a better appreciation of the state of sanitation in

the port. However, before conducting the study, the questionnaires were tested to identify and solve eventual problems related to the process.

2.4 Data Analysis

Manual processing and the organization on the basis of the models of the various essential were carried out with the Excel spreadsheet. Thus, the influence of the various parameters was measured in order to apprehend in a synthetic way the confirmation or the invalidation of the hypotheses formulated through the phenomena observed. The work plan developed was used as the basis for the analysis and interpretation of the various data collected.

The PSIR (Pressure/State/Impact/Response) approach was used to analyze the collected information (Fig. 2). In a practical way, all these have been identified the pressures (forces acting and that can induce changes in a usual state) then the state (basic situation with the intervention of pressure factors), impacts (damage and risks due to Pressures) and responses (corrective measures to mitigate the phenomenon). Indeed, the diversity of port activities required various conditions of transport, storage and conservation of goods; when they are bad lead to the damage of the products. This pressure on the goods causes the destruction of the latter, causing pollution of the environment. In the face of these impacts, strategies have been developed.

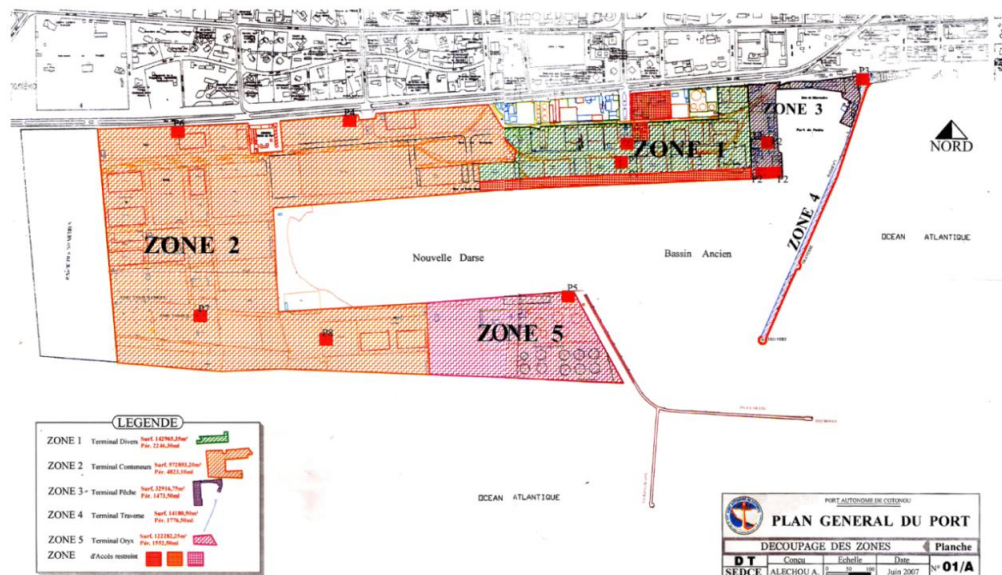


Fig. 1. Representation of the study area

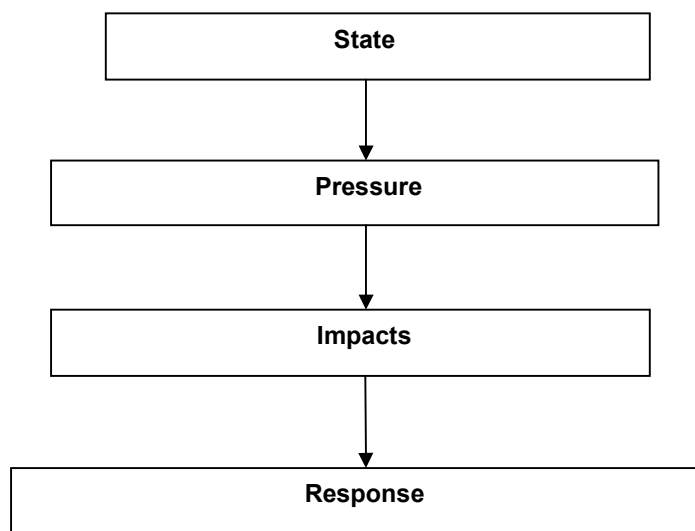


Fig. 2. Methodological framework for analyzing results using the PSIR method

3. RESULTS AND DISCUSSION

3.1 Environmental Pollutions

The investigation shows that several component of the environment (water, air, soils...) are variously affected by the impropriated waste management in the port area (Table 1). The results of our surveys show inadequate waste management practices that negatively affect the port environment. Thus, it was observed that an important part of the waste are directly thrown into the port area and another part put in the garbage bins. It was also recorded that some of the waste are thrown into the port basin. Those practices and particularly the direct throw of waste in the port basin are dangerous for the environment. Also, soil are currently contaminated by heavy metals, organic matters, household rubbish (biodegradable or non-biodegradable). Indeed, the biodegradable matter are destroyed by fermentation diffusing nauseating odors attracting flies swarms. Whereas the non-biodegradable's (mostly plastic matters and Hg-based batteries) are very harmful to the soil.

The frequent pollutants belong to the following families: diesel oil and related, heavy products such as fuel oil, petrol and assimilated, waste oils, chemicals or petrochemicals matters (especially acids), fertilizers and phytosanitary products (pesticides, insecticides, etc.) and then urine and solid waste from ships, especially

those from Gabon. These observation must be seriously taken in consideration especially because when these products are dumped, certain aquatic species such as algae swallow the toxic substances contained in this liquid waste [16-17]. Thus we can easily observe a contamination along the food chain, and at the end, for human. The risk of gastroenteritic diseases, nervous disorders, intoxications, cancer, and paralysis are to be expected. The climatic conditions (temperature, humidity ...) are the supplementary factors that accelerate/increase the expansion of pollution around the port basin. This can induce and disseminate nauseous odors in the atmosphere [18-20].

In the other hand, the port area is currently clogged with large trucks giving off exhaust fumes that are potential sources of air pollution. This observation is to be add to the important amount of smoke recorded during the destruction process of damaged products. These gases have the ability to mix with many other gases in the atmosphere such as natural carbon dioxide, oxygen, nitrogen to form more complex and toxic compounds. So, primarily, the pollutants released are lead, carbon monoxide and dioxide, nitrogen, oxygenated sulfur, alkanes, alkenes, alkynes and their derivatives. These pollutants are harmful for the environment and are involved in depletion of stratospheric nitrogen, acid precipitation and the amplification of the greenhouse effect.

3.2 Sanitary Impacts of Inappropriate Management of Waste at the Port of Cotonou

As previously mentioned, in the port area, the atmosphere is polluted by odors, dust, smoke and vehicle exhaust. Port area users are then exposed to several pollutants (CO, CO₂, NO ...) that may cause serious damage to their health (Table 1). So, our investigations in the various health centers affiliated with the port (Health center of the SOBEMAP and the infirmary of the Port) revealed the infections recorded from 2004 to 2009 in relation to pollutants. Thus, we can see that the pollution of the port environment by the waste presents enormous disadvantages for the users of the port. Indeed, air pollution affects several systems but the target is the Broncho pulmonary apparatus which is subjected to three types of infections: asthma; chronic bronchitis; Broncho pulmonary cancers. Apart from these diseases, there are also some related to air pollution such as conjunctiva irritations, corneal ulcerations, rhinitis, migraines and sometimes changes in the blood formula. The effects of pollution are usually chronic but rarely acute and the long time exposure to air pollution combined with socio-professional conditions are the major risk factors.

The decomposition of biodegradable wastes are not only source of foul odors but also participate to the proliferation of arthropods and the development of several pathogenic microorganisms [18-19,21]. So, the development of potential parasites and vectors drew our

attention on the probable resurgence of parasitic and infectious diseases such as diarrhea, dysentery, poliomyelitis, malaria, yellow fever, filariasis, schistosomiasis and other intestinal diseases. From 2004 to 2009 the registers of the health centers around the Port of Cotonou indicated that the main infections are malaria, diarrhea, sinusitis, asthma, chronic bronchitis, and various disorders (Fig. 3). However, the major treated disease among the port area workers (~3000) was malaria by affecting about 1000 persons in 2004 and 2006. After malaria follows, in term of the number of affected peoples, diarrheal diseases, sinusitis, chronic bronchitis, and asthma.

Table 1. Pollutants observed in the port area of Cotonou and diseases they may likely cause

Pollutants	Potential diseases
Dust, CO ₂ , CO, O ₃ , SO ₄	Asthma
S, SO ₄	Bronchitis (chronic)
Hg, HgO	Broncho pulmonary cancers
Air pollutants	Conjunctiva irritation/ Corneal ulceration
Pb and others	Modification of blood count

However, between 2007 and 2009, there was a gradual decline in each of these diseases because of the actions of the Department of Environmental Management in the port area in terms of management of the port environment. We observed that the diseases recorded are highly linked to the environmental condition and

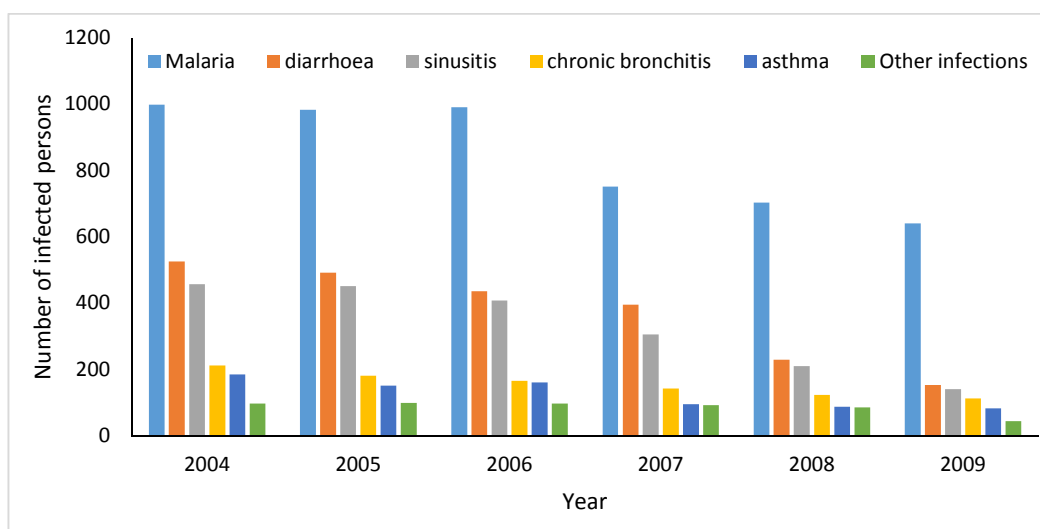


Fig. 3. Variation of diseases case reported in the port of Cotonou between 2004 and 2009

its management. It is an interesting action that may be maintained and alternatively, new strategies must be envisaged to create better environmental (sanitary) conditions for the port area users.

We can thus see that most diseases related to insalubrity are transmissible. Those diseases are often classified according to their transmission mechanisms or according to the nature of the pathogenic agents responsible. So, according to their contamination mode, we can have diarrhea, dysentery, and enteric fever; viral diseases such as poliomyelitis and hepatitis A; worms without an intermediate host such as hookworm, worms with an aquatic intermediate host (bilharziasis), worms requiring animals as an intermediate host (tapeworm). Also, there are diseases transmitted by insect vectors that require water to proliferate and diseases of the skin and eyes such as trachoma or other disease such as typhus carried by a louse.

4. CONCLUSION

The quantities of waste produced at the port of Cotonou are high through activities related to its exploitation. This study shows that the efficient management of solid waste initiated by the port authority is less accompanied by insufficient technical and organizational arrangements. The consequence of neglect of environmental issues concerned economic (degradation of marine and coastal fisheries, loss of socio-economic infrastructure, etc.) and health (food poisoning). So, the health of an individual is linked to his environment and the users of the port of Cotonou are victims of certain diseases related to environmental pollution. Thus, the port authority and civil society organizations have an obligation to organize themselves to better manage all kinds of waste produced on the port area. It is certain today that the development and protection of the port environment is of great necessity for the competitiveness of the port of Cotonou and the preservation of the health of its users. However, efforts remain insufficient because a better port waste management policy is the responsibility of all port stakeholders and port users in order to respect the principles of sustainable development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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