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MARINE POLLUTION RELATED TO WASTEWATER DISCHARGES FROM STORMWATER DRAINAGE CANALS: EXAMPLE OF THE POLLUTION OF THE WARF OF SOUMBÉDIOUNE BY CANAL IV IN DAKAR, SENEGAL

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ABSTRACT

This study aims to assess marine pollution related to liquid effluent discharges from stormwater drainage channels. The methodological approach consists of a literature review, field visits and observations, interviews with resource persons, sampling, and analysis of physicochemical and biological parameters at the Camberene Wastewater Treatment Plant. The results obtained show that the liquid effluents discharged at the Soumbédioune warf are of domestic origin. With 309.28 mg/L of BOD5 and 1267 mg/L of COD, the concentrations of the physicochemical parameters of the waters of Canal are well above the Senegalese standards for the discharge of liquid effluents into the natural environment. The concentration of fecal coliforms of about 11.3 105 FC/100 ml largely exceeds the limit of the new European directive on bathing waters (2006/7/EC) which is of the order of 200 FC/100 ml for excellent quality bathing waters. The liquid effluents from Canal IV must undergo a treatment process in a WWTP before being discharged into the sea.

Introduction

Pollution means the introduction by man, directly or indirectly, of substances or energy into the sea, including estuaries, which are liable to create hazards to human health, harm living resources, and marine ecosystems, to cause hindrance to legitimate uses of the sea including fishing, to impair the quality for use of sea water, and to lead to a reduction of amenities.

To alleviate the problems associated with stormwater drainage, open channel systems are among the options implemented in several countries. This is the case in Senegal, which, like other countries, has designed drainage networks for wastewater and stormwater. Thus, in Dakar, between 1915 and 1929, major works were set up. A good example of this is the main sewer and several drains in various streets of the Plateau over a length of 14 km, the canal of Champs de course, and that of Gueule Tapée (Badaoui, 1996). There is also Canal IV, which connects several neighborhoods in Dakar. The Canal IV was built in 1952 to evacuate rainwater from the Sicap-Liberté area to Soumbedioune, crossing the neighborhoods of Grand Dakar, Fass, Point E, and Amitié.

These drainage networks are often in poor condition due to a chronic lack of maintenance (Desbordes and Bouvier, 1990). Added to this is the silting up of the structures caused by the winds in the dry season, which constitutes a problem of sanitation of stormwater in Dakar (Diop, 2006). In addition, these structures are often clogged with solid waste (bags, plastic, and garbage). These canals have become garbage causing heavy pollution of marine waters.

For these different reasons, this work has been initiated to evaluate marine pollution related to liquid effluent discharges from stormwater drainage channels.

Materials and Methods

Presentation of the study area

Built in 1952, Canal IV was intended, on the one hand, to drain rainwater from watersheds going from Sicap Liberté to Soumbédioune via Grand Dakar; and on the other hand, from Sacré Coeur to Fass via Sicap, Amitié, Point E. The canal has two independent sections upstream which are Canal IV upstream and Canal IV upstream bis which make a junction at the level of HLM Fass Paillote to form Canal IV downstream (figure 2).

Figure 1: Location of the study area

Literature Review

The literature review collected informative data through the study of official or academic documents. These include theses or dissertations of other students, specialized periodicals, statistical documents, graphics, and official documents.

Field visits and photography

In this research, numerous visits were made to various places such as Canal IV and its secondary canals, the warf of Soumbédioune, and the surrounding structures including, the artisanal village, the National Park of the Magdalen Islands (NPMI). These visits were accompanied by photo shoots to better illustrate the information collected in the field. The photos were taken with a digital camera brand "SONY HD Movie" 720p.

Interviews and data collection with stakeholders

Interviews were key to collecting data related to the expected results. Interview guides were developed for each category of stakeholder. They were conducted with the following stakeholders

- The Head of Technical Services of the city of Dakar;
- the head of the decentralized cooperative and the municipal council of the Fass Colobane Gueule Tapé town hall;
- the Municipal Secretary General of the Town Hall of Amitié Fann Point E;
- the Conservator of the National Park of the Magdalen Islands;
- the Delegate of the districts Gueule Tapée and Fann Hock;
- the associations of wholesale fish traders in Soumbédioune.

Sampling

The samples were taken on April 17, 2018, between 10:00 am and 12:00 pm at different points (Figure 3). The collected water samples were stored in 500 mL polyethylene bottles. However, for the determination of coliforms, the samples were taken with specific tubes intended for bacteriological analysis. Point P0 represents the sampling point at the outlet of Channel IV. Point P1 represents the contact zone between the wastewater and the seawater. Points P2, P3, and P4 are respectively located at 250, 500, and 750 m from the edge of the warf (Figure 2). The collected samples were stored in a cooler and transported to the Cambérène wastewater treatment plant for analysis.

Figure 2: Map showing the different sampling points at the Soumbédioune warf.

Determination of the different parameters studied

Salinity, pH, electrical conductivity, and temperature are measured directly using a HANNA brand multi-parameter pH meter. TS, TSS, COD, and BOD5 are analyzed in triplicate through conventional methods according to the procedures indicated in the Standard Methods for the Examination of Water and Wastewater (Eaton et al., 2005). Fecal coliforms were enumerated on agar culture medium according to NF ISO 4832.

Results and Discussion

The results of the analyses are reported in Table 1 in comparison with the Senegalese standard NS 05 061 for discharge into the natural environment (NE) or into a pipeline leading to a wastewater treatment plant (WWTP) and the new European Bathing Water Directive (2006/7/EC) (EU, 2006).

Table 3: Parameter values in samples

Parameters	P0	P1	P2	P3	P4	NS 05-061 Standards		2006/7/CE
						NE	WWT	
pH	7.8	7.7	7.3	6.7	6.3	5.5 à 9.5	6 à 9	
ORP (ms/cm)	1537	27.6	52.3	52.7	52.8			
To (□C)	22.8	21.3	19.3	20.2	20.1	□ 30	□ 30	
Salinity (mg/L)	0.6	16.9	34.1	34.5	34.5			
TSS (mg/L)	552	366	94.8	33.6	32	□ 50	≤ 600	
TS (g/L)	1 076	18 684	37.38	37.90	39.92			
FC (n/100mL)	34*103	11.3*103	324	32.	14	2.000		200-400
BOD5 (mg/L)	309.28	103.1	24	08	0	50/80	≤ 800	
COD (mg/L)	1 267	320	640	160	420	200	≤ 2.000	

Physical parameters such as temperature, pH, and conductivity comply with the values defined by the NS 05 061 standards for the discharge of liquid effluents into the natural environment (ISN, 2001). On the other hand, COD, BOD5, TSS, and FC of the liquid effluents collected at the level of Canal IV largely exceed the limit values. Indeed, the concentrations recorded at P0 (i.e. in the canal) are of the order of 1267 mg/L, 309.28 mg/L, 552 mg/L, and 34,000 FC/100mL for COD, BOD5, TSS, and FC respectively, whereas the authorized limits for discharge into the natural environment are 200 mg/L, 80 m/L, 50 mg/L and 2,000 FC/100mL respectively.

The high coliform concentration shows that the poor quality of the canal water is due to contamination by domestic wastewater. Indeed, according to Krepsky et al. (2021), fecal coliform concentrations of the order of 105 are evidence of contamination by untreated domestic wastewater. In fact, in the absence of sufficient sanitation facilities, the populations of these localities discharge their effluents into this canal. This is done through clandestine connections, and opportunistic discharges of effluents into these structures, which has allowed us to observe permanently the presence of liquid discharges in these channels designed for the evacuation of rainwater. The discharge of domestic wastewater into the canal is shown in figure 3.

(a) (b)

Figure 3: Domestic wastewater discharges to Canal IV

The discharge of such water quality into the natural environment should therefore be formally prohibited at the risk of polluting the discharge environment.

The concentration of fecal coliforms at points P1 and P2, respectively, is higher than the guide value of the new European directive on bathing water (2006/7/EC) (EU, 2006), which limits concentrations to 200 FC/100 ml for excellent bathing water quality. This high pollution of marine waters

would be caused by a lack of sanitation of domestic wastewater as shown by Leboulanger et al. (2021). Indeed, in studies conducted on the Brazilian coast, Muniz et al. (2015) showed that samples collected near the outfall of pipes had higher concentrations of contaminants associated with domestic wastewater.

These discharges into the marine environment can have adverse health consequences on populations because according to Wu et al. (2011) the presence of fecal contamination indicators is often correlated with that of pathogenic organisms. However, at polluted beaches, Lamparelli et al. (2015) and WHO (1998) reported high levels of disease among swimmers, while Bouvy et al. (2008) mentioned risks for fish consumers.

In line with these results, swimming at Soumbédioune warf can only be considered possible from P3, i.e. from 500 m from the warf. Indeed, at points P3 and P4, located respectively at 500 m and 750 m, FC concentrations are of the order of 32 and 14 FC/100mL respectively and are below the guide value of the new European Bathing Water Directive (2006/7/EC) (EU, 2006), which limits concentrations to 200 FC/100 ml for excellent bathing water quality.

Stormwater drainage systems drain large amounts of solid waste along with domestic sewage (Figures 4 a and b).

(a) (b)

Figure 4: Soumbédioune warf invaded by solid waste (a) polluting the marine waters at the outlet (b)

According to (Boadi and Kuitunen, 2002), this poor waste management is due to difficulties in collecting solid waste. These authors reported from their studies conducted in Accra that the failure to collect waste results in discharge into open drains. The large quantities of solid waste will lead to pollution once discharged into marine waters (Figure 4 b) (Duraisamy and Latha, 2011).

The mismanagement of solid waste also leads to high levels of plastic waste pollution (Lestari and Trihadiningrum, 2019) as shown in Figure 4 a. This high generation of waste would be caused according to (Lestari and Trihadiningrum, 2019) by the high density of the population. At the townships-level, the average population density that has access to Canal IV is around 10,111 inhabitants/km2 (ANSD, 2014).

The discharge of waste into the canal can lead, beyond the environmental and health consequences, to aesthetic degradation. Aesthetic issues play a large role in people's perception of recreational water spaces (Oldridge, 1992). WHO (1980) reports that the main aesthetic concern is disgust associated with obvious pollution of the water body, turbidity, scum, or odor. This pollution can cause a nuisance to residents and tourists, as well as environmental problems (WHO, 1980). This situation is particularly alarming in so far as the warf in Soumbédioune is used for fishing and tourism activities with the pier for the Madeleine Island. This site has also schools and a handicraft village.

CONCLUSION

Wastewater from Canal IV has a high concentration of fecal coliforms, which shows contamination by domestic wastewater. They also drain a lot of solid waste. At the level of the outlet, they create strong pollution of marine waters making swimming possible only from 500 m. They also create an aesthetic degradation incompatible with the various activities carried out at the level of the warf.

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