

Full Length Research Paper

Physicochemical evaluation of wastewater from the main sewer in Abidjan city

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In many parts of the world, health problems have often been caused by untreated wastewater. The objective of this study was to determine the pollution level of wastewater in Abidjan city and to evaluate their impact on marine environment. Thus, wastewater samples were collected and analyzed according to French Association of Standardization (FANOR). The results showed that the values of these parameters are ranged on average between 14500 and 18500 mg/L for Biological Oxygen Demand (BOD₅), between 36000 and 41800 mg/L for Carbon Oxygen Demand (COD) and between 75 and 145.5 mg/L for Suspended Matters (SM). All these values are beyond World Health Organization recommendations for wastewater discharge. However, the analysis of the ratios between the COD and BOD₅ of the different effluents showed that it is ranged on average between 1.44 and 2.60. That means that wastewaters have a domestic character and are therefore easily biodegradable. So, the government should build a sewage treatment plant in Abidjan city to minimize health and environmental risks.

Key words: Wastewater, physicochemical analysis, population health, Abidjan, Cote d'Ivoire.

INTRODUCTION

In most cities of developing countries in general and particularly in Côte d'Ivoire, wastewater management has become urgent and very critical problem.

The city of Abidjan, one of the most modern metropolises west Africa, has known a strong demographic growth in the Sixties and Seventies characterized by a migratory flow and an annual growth rate of about 10%. Today, this growth rate is around 4.3%. A recent study taking into account this growth rate and the demographic data of 1990 to 1996, indicates a current population of about 3.6 million (Yao et al., 2007). This demographic pressure leads to a significant increase in the volume of wastewater discharge causing the excess of self-cleaning of receiving environment (El-Guamri and Belghyti, 2006). This is because these wastewaters are discharged into

the receiving environment without any treatment (Derwich et al., 2010).

This study was carried out to determine the physicochemical parameters of the wastewater from the main sewer in order to evaluate the impact of these discharges of sewage on marine environment and to appreciate the opportunity of building a wastewater treatment plant.

MATERIALS AND METHODS

Site of study

Abidjan city is located in south of Côte d'Ivoire and lies between latitudes 5°00' and 5°30' N and longitudes 3°50' and 4°10' W. It has a sewage-type unit with a length of 22.6 km which connects Abobo town in the north of Port-bouet town located on the seafront. It extends from the sea by a messenger which is about 1.2 km (Figure 1). In this study, twenty four wastewater samples were collected in the main sewer. All this system allows evacuating about 37500 m³/J

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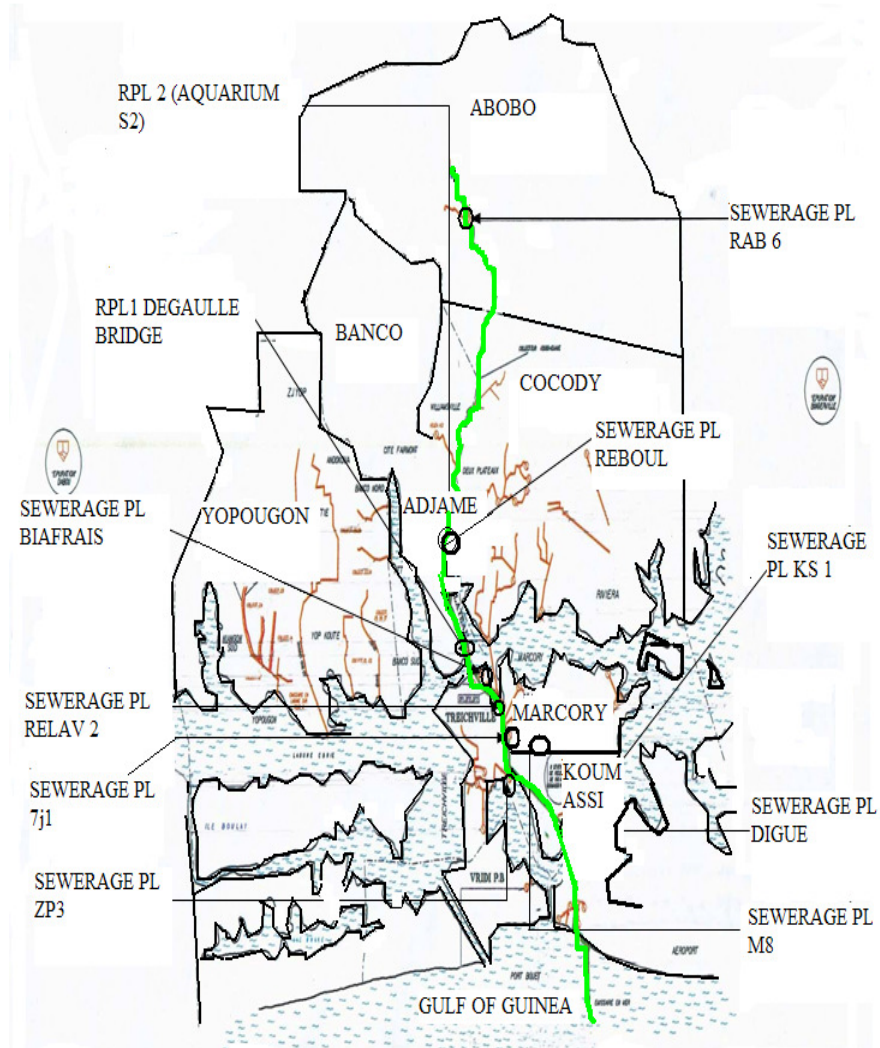


Figure 1. Sewerage system map of Abidjan City of Water Supply Company in Côte d'Ivoire (SODECI). Arrows indicate the different sampling points.

wastewater (Ministry of Health, 2000).

Sampling

On the main sewer, 12 sampling points were selected, including 5 in the northern zone and 7 in the south zone. During the period of 4 December 2004 to 15 March 2005, wastewater samples were collected in 500 ml bottles previously rinsed with distilled water and stored in a cooler containing ice cooler previously frozen. Electric Conductivity (EC), pH and temperature were measured *in situ* respectively by a conductivity meter (315 i/set WTW) and a pH meter (330 i/set and a WTW). Concentrated sulfuric acid (0.05 mol/L) was used as adjuvant conservation in bottle used to determine parameters such as the orthophosphate (PO_4^{3-}), COD and ammonium (NH_4^+).

Waste water analysis

After collection, samples were immediately transported to the laboratory for analysis. Wastewater samples were collected and

analyzed according to French Association of Standardization (FANOR, 1994). The ammonium (NH_4^+) was analyzed by the method of molecular absorption spectrophotometry at 655 nm using a spectrophotometer (HACH DR/2010). The orthophosphates (PO_4^{3-}) were assayed by the method of molecular absorption spectrophotometry at 880 nm using a spectrophotometer (SHIMADZU UV-1205). The COD was determined by the method of potassium dichromate oxidizability. The BOD was determined by manometric method with a BOD-meter (Bod Trak). The Suspended Matters (SM) were determined by the filtration method using cellulose filter and electronic balance (OHAUS ANALYTICAL). A sterilizer (SELECTA) was used for drying glassware and filter discs used for determination of suspended matters.

Data analysis

Data were entered on the spreadsheet Excel 2007. Arithmetic average (X), standard deviation (S), coefficient of variation (CV) which is the ratio between the average and standard deviation were determined using Excel software. When $CV < 2\%$, the measurements of parameters studied are very homogeneous, $2\% <$

Table 1. Parameters of wastewater pollution of the main sewer in Abidjan city.

Environmental factors	Upstream			Downstream			WHO guide values (1973)
	Average \pm SD	Min - Max	% CV	Average \pm SD	Min - Max	% CV	
Temperature ($^{\circ}$ C)	30.7 \pm 2.2	29.2 - 32.3	7.1	30.2 \pm 2.26	28.6 - 31.8	7.5	-
pH	7.5 \pm 0.8	6.9 - 8.1	11.3	8.3 \pm 2.7	6.4 - 10.3	33	-
Electric conductivity (μ S/cm)	1170.5 \pm 932	511 - 1830	79.7	2720.5 \pm 3160	511 - 4930	114.9	-
Biological oxygen demand (mg/L)	18500 \pm 10606	11000 - 26000	57.3	14500 \pm 4959	11000 - 18000	34.2	30
Carbon oxygen demand (mg/L)	36000 \pm 23758	19200 - 52800	66	41800 \pm 35921	16400 - 67200	86	90
Suspended matters (mg/L)	75 \pm 66.5	28 - 122	88.7	144.5 \pm 183.1	16 - 275	125.9	30
Ammonium (mg/L)	107.8 \pm 102	35.7 - 180	94.7	124.8 \pm 72.5	73.6 - 176	58	0.5
Orthophosphates (mg/L)	8.2 \pm 11.2	28.6 - 31.8	136.5	34.4 \pm 41	5.3 - 63	119.6	-

Min: Minimum; Max: Maximum.

Table 2. Maximal concentrations of main pollutants in effluents according to french legislation.

Parameter	SM (mg/L)	BOD ₅ (mg O ₂ /L)	COD (mg O ₂ /L)	Temperature	pH
Limit values	100	100	300	30	5.5 to 8.5

Source : Order of 1st March 1993 (France) relating to water use in addition to discharges of all types of installations classified for the environment protection subject to authorization. The implementing regulations for law n^o 96-766 of 3 October 1996 (Côte d'Ivoire) establishing the Code of Environment is being prepared.

CV < 30%, the measurements of parameters are homogeneous and CV > 30%, the measurements of parameters are heterogeneous (Koné, 2008).

RESULTS AND DISCUSSION

The results of analysis performed on wastewater from the main sewer are showed in **Table 1**. According to this table, we noted that the measurements of different parameters are heterogeneous (CV > 30%) with the exception of temperatures where the measurements of parameters are homogeneous (CV < 30%).

The results of our study revealed that wastewater has a pH ranged on average between 7.5 and 8.3 (**Table 1**). These pH values are in

accordance with World Health Organization standards which set the pH values between 6.00 and 9.00 of wastewater which must be discharged into the sea or environment (WHO, 2006). Therefore, this wastewater would have no adverse impact on wildlife and flora of receiving environment. In another study, Ademoroti (1983) found the same results in Nigeria on effluents in Ibadan. However, the results of our study indicated that the average of temperatures upstream is 30.7 $^{\circ}$ C. Downstream, it slightly increases and is around 31.8 $^{\circ}$ C (**Table 1**). Temperatures higher than 30 $^{\circ}$ C are not in accordance with wastewater discharging standards (**Table 2**). In early previous study, Kouadio et al. (2000) reported also the high

temperature on their study on lagoon banks in Abidjan City. But our values are higher than those of similar work performed in Morocco by El-Guamri and Belghyti (2006) whose values are between 17.3 and 23.2 $^{\circ}$ C. The temperatures found in our study can influence the amount of dissolved oxygen that is available to aquatic organisms.

Also, electric conductivities are very important for the control of wastewater pollution level. The values of our study ranged on average between 1170 and 2720 μ S/cm. According to Nisbet (1970), these values showed a strong mineralization of discharges. In fact, the results obtained are on the one hand due to residual wastewater rich in artificial fertilizers from

industrial activities and on the other hand, by the strong mineralization of organic load. Downstream, the values obtained in the present study are superior to 2000 $\mu\text{S}/\text{cm}$, threshold beyond which wastewater has an abnormal situation (Rodier, 1996). These strong values downstream are higher than those found in other works performed on wastewater discharges (Bes-Pia et al., 2002; Endamanel et al., 2003).

Moreover, this study is interested in determination of suspended matters (SM) in wastewater which represent all organic and mineral particles contained in wastewater. Their impacts on physico-chemical characteristics of water are very harmful (change of turbidity of water, penetration reduction of photosynthesis). Nevertheless, in the present study, values of suspended matters of wastewater from the main sewer ranged on average between 75 and 144.5 mg/L (Table 1), which are not in accordance with wastewater discharge standards in the context of environmental protection set at 100 mg/L (Table 2). These high values of SM are often due to the heavy load of mineral and organic matters generated by populations, drained by the main sewer. Otherwise, the extreme values downstream reach 275 mg/L. Therefore, according to Salem et al. (2011), these wastewaters can be classified as strong and so could not be discharged into sea or used for any task.

Main sewer wastewater is further characterized by concentrations of ammonium ranged on average between 107.8 and 124.8 mg/L (Table 1). These concentrations considerably exceed the recommended limit values in the context of environmental protection (Table 2). They are well above the guide number (0.5 mg/L) recommended par (WHO, 1973). Also, these values considerably exceeded those of the work performed by Harremoës and Sinkjaer (1995). In term of orthophosphate, the concentration registered varies on average from 8.2 to 34.4 mg/L (Table 1). These results are much higher than those obtained in similar works performed in Nigeria by Ekweozor et al. (2001) and in Cameroon by Endamana et al. (2003). Thus, the concentration of orthophosphate reported in our study in addition to ammonium concentration can cause eutrophication and can be a threat to fishery resources. This strong mineral pollution is due to the intensity of industrial and domestic activities downstream of the network.

Data of COD and BOD₅ vary on average respectively from 36000 to 41800 mg/L and 14500 to 18500 mg/L (Table 1). These values indicated that the load of wastewater organic substances studied set well beyond of maximal concentrations permissible limits for pollutants (Table 2). So, the values of COD and BOD₅ are beyond recommendations of WHO which set 90 mg/L for COD and 30 mg /L for BOD₅, concerning wastewater discharge (Table 1). These high COD and BOD concentrations observed in these wastewaters might be due to the use of chemicals by the population, which are organic or

inorganic, and are oxygen demand in nature. The values of COD and BOD₅ obtained in our work are considerably higher respectively to 232.1 and 216 mg/L obtained in Nigeria by Otokunefor and Obiukwu (2005). These high values of COD and BOD₅ indicated a significant input of organic substances in marine environment. Consequently, the discharge of this effluent in marine environment could constitute a danger for receiving environment. Seeing this, the characterization of the effluents by the determination of the relationship between the organic pollution parameters was performed. According to Rodier (1996), the COD/BOD₅ ratio of wastewater which is inferior to 3.5 indicates that we have wastewater of domestic origin. However, in our study, this ratio varies on the average from 1.2 to 2.7 (Table 1). So, wastewater in our study can be regarded to have domestic origin and is biodegradable, which requires a biological treatment for purification.

Conclusion

The study revealed that the physicochemical analysis results obtained are higher than other similar studies conducted in other countries. The study also showed that the values obtained are higher than permissible limits recommended by WHO for discharging wastewater into marine environment. Moreover, in light of the ratio COD/BOD₅ measured, we find that the sewage drained by the main sewer is characterized by organic pollution related to the discharge of effluents from many household and industrial activities connected to the network. In addition to organic matter, these waters contain nutrients (NH_4^+ , PO_4^{3-}) with high concentrations may cause eutrophication of the receiving environment. To avoid this, a rational management of this wastewater by the construction of wastewater treatment plant of Abidjan city will minimize health and environmental risks associated with discharge of raw sewage into the marine environment.

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