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Physico-chemical Characterization of Wastewaters Discharged into Songolo River at Pointe-Noire, Republic of Congo

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Authors' contributions

This work was carried out in collaboration among all authors. Author KMB defined the subject and wrote the first draft of the manuscript. Author BDK performed the analysis. Author JMO wrote the protocol and supervised all the study. All authors read and approved the final manuscript.

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ABSTRACT

Songolo River receives daily domestic and industrial wastewaters from households, laboratories, small and medium size industries (SMEs) and the Loandjili hospital, which are discharged directly into it without prior treatment. The objective of this study is to evaluate the physico- chemical quality of wastewaters discharged into the Songolo River at Pointe-Noire in Republic of Congo. To do this, 56 wastewater samples were taken. Physicochemical analyzes as temperature, pH, electronical conductivity, total dissolved solids, chloride ions, nitrate ions and total hydrocarbons, were carried out on wastewaters. These analyzes showed that in terms of time, during wet periods (April to June), the values of the physico-chemical parameters (conductivity, total dissolved solids, chlorides ions, nitrates ions and total hydrocarbons) are the lowest due to the dilution phenomenon brought by the rains. On the other hand, the beginning of the dry season (July) is marked by much higher levels. The results of physico-chemical analyzes of these effluents also revealed that

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conductivity, total dissolved solids and total hydrocarbons often have values higher than those recommended by the WHO standard for wastewaters intended for release into the natural environment.

Keywords: Songolo River; wastewater; sewage; physico-chemical parameters; pollution.

1. INTRODUCTION

Problems of water pollution by untreated effluents are a growing concern for developing countries as they represent potential damage sources of the quality of water [1] and health [2]. Population growth, the diversification of economic activities as well as new modes of life and consumption, have led to an exponential development of the industrial sector: water has become an essential material for factories operations. Parallel to this situation, water has become the receptacle of many industrial wastes, causing deterioration of water quality and then a disruption of ecosystems. Indeed, these untreated effluents produce environmental stress capable of inducing significant destabilizations in some organisms or even their death in the event of massive discharges. In general, the first impact of a change of an environmental parameter occurs at the cellular level with direct action on respiration, ion exchange and more specifically on defence capabilities [3]. According to the environmental audit report of the Congolese coastline of the city of Pointe-Noire, wastewater from industrial, hotel and hospital establishments are discharged without prior treatment into the natural environment, particularly into the sewers and Tchinouka and Songolo rivers [4]. These rivers receive all types of wastes coming from sewages outfall. These wastes contain various organic and inorganic pollutants which contain various organic and inorganic pollutants that will accumulate in the rivers system gradually at concentration higher than acceptable limits. The use of rivers as average disposal of wastewater has enormous consequences on the environment [5]. These wastewaters impact negatively our environment. So, a quantitative and qualitative environmental assessment of these wastewater is required to predict their impacts on the receiving environment with a view to advocating appropriate remedies [6]. The aim of the present study is mainly to investigate the physico chemical quality of wastewater collected in Pointe-Noire sewers and discharged into the Songolo river. Influence of physical parameters such as temperature, pH, conductivity, total suspended solids was studied and chemical substances such as chlorides, nitrates and total hydrocarbons were also dosed in these wastewaters.

2. MATERIALS AND METHODS

2.1 Sampling Waterwaste

We carried out the wastewater sampling at the gutter of the national road n°5 in the Mongo Mpoukou district in Pointe-Noire city. This gutter is the main wastewater outfall in which are collected effluents coming from laboratories, SMEs and Loandjili hospital. These sewage flow up to the Songolo river. We used a sampling according to standardized method of the French Association of Normalization (AFNOR). The samples were preserved in pre-cleaned glass containers prior to analysis. Fifty-six (56) samples were collected at the rate of fourteen (14) per month during four (4) months, from April to July 2016.

2.2 Sample Analysis

All the parameters were determined at Trait Labor laboratory in Pointe- Noire. Samples were analyzed mainly using three techniques: potentiometry, colorimetry and complexometry. All analyses were performed according to AFNOR standards methods [7]. Water temperature and hydrogen-ion concentration (pH) were measured in-situ, by potentiometric method according to NF T90-008, using a digital pH-meter with integrated thermal sensor 3310WTW. The Hach Sension5 conductivity meter was used to determine the electrical conductivity according to NF T90-031. Total dissolved solids (TDS) and nitrate ions were measured with the Hach DR/850 colorimeter according respectively to NF T90-105 and NF T90-045 standards. Chloride ions were determined by precipitation according to standard NF T90-014: the dosage of the chloride ions was carried out by complexation method with silver nitrate in the presence of potassium chromate as an indicator (Mohr method). The total hydrocarbon (TH) content is measured using an InfraCal TOG/TPH Analyzer spectrometer according to standard NF T90-203. The principle is to extract the hydrocarbons contained in the water sample with an extraction solvent, tetrachlorethylene ($C2Cl4$), then carry out a purification with florisil ($SiO2$: MgO) to remove polar organic substances. A calibration curve was developed using five standard solutions at 0, 10, 30, 60 and 100 mg/l total hydrocarbons (TH). The results of the absorbance analysis of the five standard solutions helped to trace the infracal curve represented by the characteristic equation: Abs = 1.0682x [C] +8.6727.

3. RESULTS AND DISCUSSION

Sewages are constituted of many pollutants likely to contaminate environments in which they are discharged. This study offered physico chemical quality information about the sewages which are discharged into Songolo river. These wastewaters quality depend on various parameters. The results of the studied physical and chemical parameters for the fifty-six wastewater samples are given in Table 1.

Temperature: Sewage temperature values vary lightly according to a seasonal rhythm between April and July (Table 1). The monthly variation of temperatures (Fig. 1) shows that they oscillate between 26°C and 31°C during wet period (april and may) and between 24°C and 26°C in dry period (June and July). The hottest sewage are those of April and May; they appear lower in June and July. This difference in temperature could be explained by the fact that the temperature of the water is closely linked to the air temperature [8] and that the discharge temperatures of the open drainage channels undergo naturally daily variations of temperature, consequence of the influence of winds and sunstroke [9]. Surface waters are subjected to various parameters like temperature. Temperature is one of the external parameter which influence aquatic ecology [10] because all physical, chemical and biological reactions are governed by temperature in the aquatic environment [11]. However, the mean temperatures (Table 1) of these effluents remain below the temperature considered as the limit value for direct discharges into the receiving environment according to WHO (30°C). The effluent temperatures measured do not therefore disturb the ecological balance of the rivers in which they flow. They are thus in a temperature range favorable to microbial activity [8], biological treatment and self-purification of wastewater [12].

pH: Monitoring and analysis of this parameter show that the pH values are between 6.1 and 8.2 (Table 1), as well in wet season (April and May) and in dry season (June and July). This shows the lack of any seasonal action on the pH variation of the gutter wastewater of the national road n° 5 in Mongo Mpoukou district. The relative constancy of the mean pH values shows a general tendency of wastewaters to tend toward neutrality. Mean pH values range from 7.2 to 7.4 for the months of April, May and June (Table 1). The minimum values were noted in July with a mean value around 6.5. The mostly pH values (Fig. 2) and the mean pH values (Table 1) are acceptable according to the WHO wastewaters standard (6.5 <pH <-8.5). So, the pH of these wastewaters directly discharged into the receiving environment should not affect negatively the quality of surface water.

Electrical Conductivity (EC): Electrical conductivity (EC) is a good assessment of the degree of mineralization of water. The conductivity recorded values show significant monthly variations (Table 1): In April, they fluctuate between 1288.6 and 24266.6 µS/cm; in May, the values of conductivity vary between 1661 and 14360 µS/cm; they vary between 5183.3 and 8320 µS/cm in June and between 7936.6 and 16756.6 µS/cm in July. These high values could be due to the concentration of water in mineral salts by evaporation and the increase in alkalinity [13]. The mean values of the electrical conductivity which vary between 6226.4 and 12221.16 µS/cm (Table 1), largely exceed the above of 3000 µS/cm. when EC value are above of 3000 µS/cm, effluents treatment is necessary before release in nature [14].

Total dissolved solids: Total dissolved solids measured in wastewater effluents are between 31 and 494 mg/l from April to July (Table 1). Analysis of the total dissolved solids results shows that the wastewater are characterized by an average concentration of 114.7 mg/l in April, 87.56 mg/l in may, 53 mg/l in June and176.43 mg/l in July (Table 1). All total dissolved solids values are largely above the WHO standard of wastewater for the release into natural environment, namely 20 mg/l (Fig. 3). Such values can lead to an increase of total dissolved solids in receiving steams, which will prevent the penetration of light, decrease dissolved oxygen, reduce habitat quality of organisms [15] and then limit the development of aquatic life by creating imbalances between the various species [16].

Table 1. Values of temperature (°C), pH, conductivity(102µS/cm), total dissolved solids(mg/l), chloride and nitrate ions (mg/l) in sewage

Temperature (°C)				
Samples	**April**	**May**	**June**	**July**
1	29.9	29	26.5	25.1
2	30.2	28.2	26.6	24.7
3	31.1	28.4	26.2	24.5
4	30.2	28.9	25.7	24.3
5	29.6	28.4	25.5	24.8
6	27.6	29.1	26	24.8
7	27.5	28.5	25.7	24.9
8	28.1	27	25.1	25.1
9	28.3	26.7	24.8	24.5
10	29.8	26.8	25.4	23.9
11	29.8	26.8	25.6	24
12	28	27.3	25	24
13	28.4	26.3	25.1	24.7
14	28.8	26.9	25.1	24.9
Mean	29.1	27.7	25.6	24.6

pH				
Samples	**April**	**May**	**June**	**July**
1	7.1	7.6	7.4	6.3
2	7.1	7.6	7.5	6.2
3	7.2	7.7	7	6.4
4	6.1	7.4	6.6	6.5
5	6.3	8.1	7.6	6.4
6	7.1	7.1	7.6	6.4
7	7.1	7	7	6.3
8	7.7	6.6	7.7	6.6
9	7.8	6.7	8.1	6.5
10	7.9	6.9	7.8	6.4
11	7.9	6.8	8.2	6.6
12	8.3	7.7	7.9	6.6
13	8	7.4	7.6	6.9
14	7.5	7	6.1	7.2
Mean	7.4	7.3	7.4	6.5

Conductivity-EC (102µS/cm)				
Samples	**April**	**May**	**June**	**July**
1	1767	11103	5283	7937
2	1401	10513	5200	8220
3	1288	14360	5183	8307
4	1356	13480	5750	8367
5	24267	13677	5403	8343
6	9037	1661	5517	9270
7	9063	2094	6203	9220
8	12690	3920	6380	14980
9	12693	4600	6513	16173
10	13533	4970	6623	16757
11	13533	5333	6660	15890
12	13000	5350	6977	15487
13	12620	5240	7157	15887
14	12193	5173	8320	16260
Mean	9889	7248	6226	12221

Total dissolved solids-TDS (mg/l)				
Samples	**April**	**May**	**June**	**July**
1	69	96	42.3	98
2	51.3	124	39.6	129.3
3	42	113	41	160.3
4	37	118.3	44.3	164.3
5	53	188	55	185
6	38	131.3	41.6	371.3
7	31	70.6	50.3	167
8	52	47.3	58	181.3
9	49	84.6	53.3	156
10	158.6	53.6	58	156
11	172	49.3	55.6	152.6
12	201	53.3	57.6	174.6
13	158	47.6	59	178
14	494	49	86.3	196.3
Mean	114.7	87.6	53	176.4

Cl^-(mg/l)				
Samples	**April**	**May**	**June**	**July**
1	260	283.3	54.6	61
2	180	226.6	61.6	74
3	170	304.6	66.3	70
4	183.3	276.6	66	77
5	1010	263.3	57	65.6
6	276.6	39.3	65.3	75.6
7	300	46	59	63.3
8	363.3	59	67.6	298.6
9	350	59	57.6	350.3
10	366.6	68.3	62	357.3
11	376.6	65.3	57.6	323
12	330	69.6	62	322.6
13	293.3	67.6	59	301.3
14	280	80.3	73.3	291
Mean	338.6	136.3	62.1	195.0

NO_3^-(mg/l)				
Samples	**April**	**May**	**June**	**July**
1	0.87	1.01	0.5	0.94
2	0.85	0.91	0.4	1.45
3	0.3	1.1	0.42	1.52
4	0,31	0.99	0.47	1.75
5	0.58	0.91	0.5	1.82
6	0.47	2.49	0.48	1.99
7	0.45	0.39	0.12	0.51
8	0.47	0.41	0.5	0.42
9	0.48	0.42	0.47	0.37
10	1.49	0.43	0.51	0.43
11	1.5	0.46	0.49	1.59
12	1.78	0.13	0.12	1.76
13	1.43	0.1	0.1	0.41
14	2.43	0.47	0.55	2.26
Mean	0.96	0.73	0.40	1.23

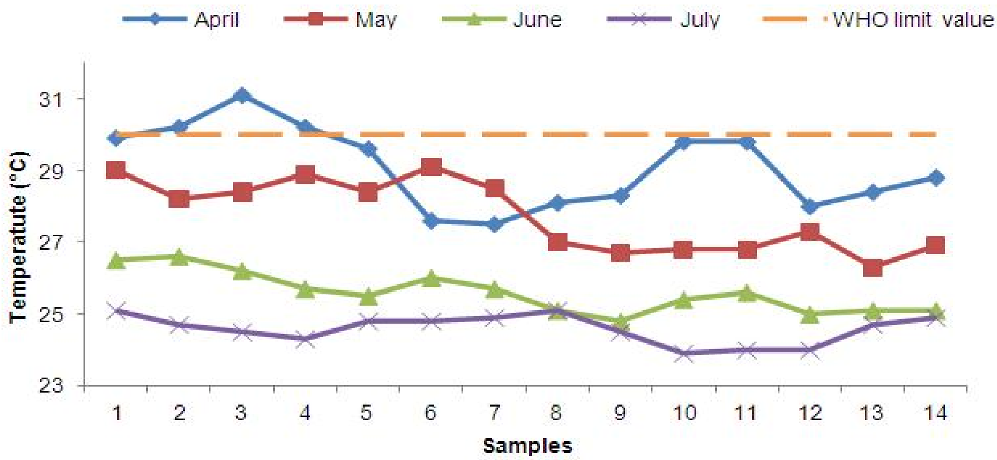

Fig. 1. Monthly variation of temperatures of wastewater discharged in Songolo River

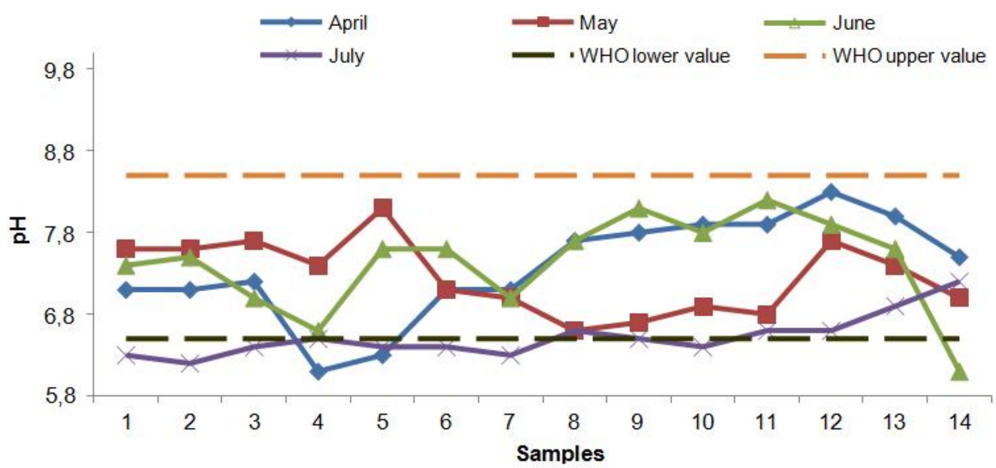

Fig. 2. Monthly variation of ph in wastewater discharged into Songolo River

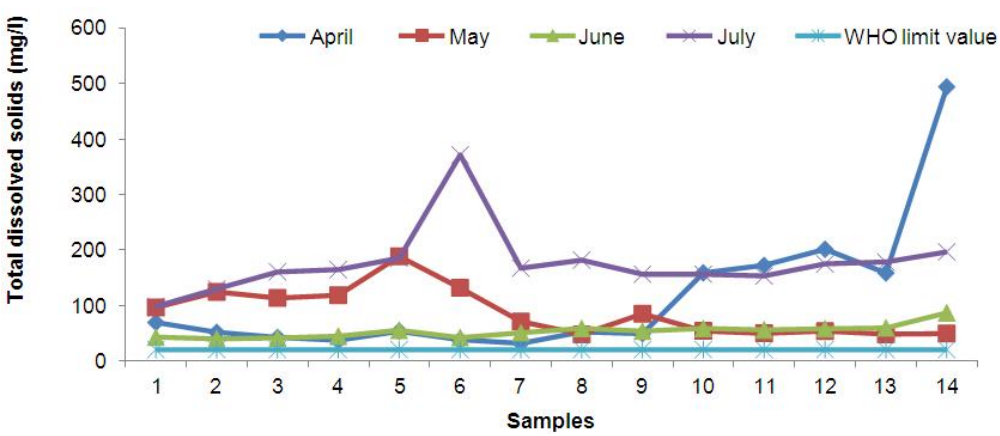

Fig. 3. Monthly variation of total dissolved solids in wastewater discharged in Songolo River

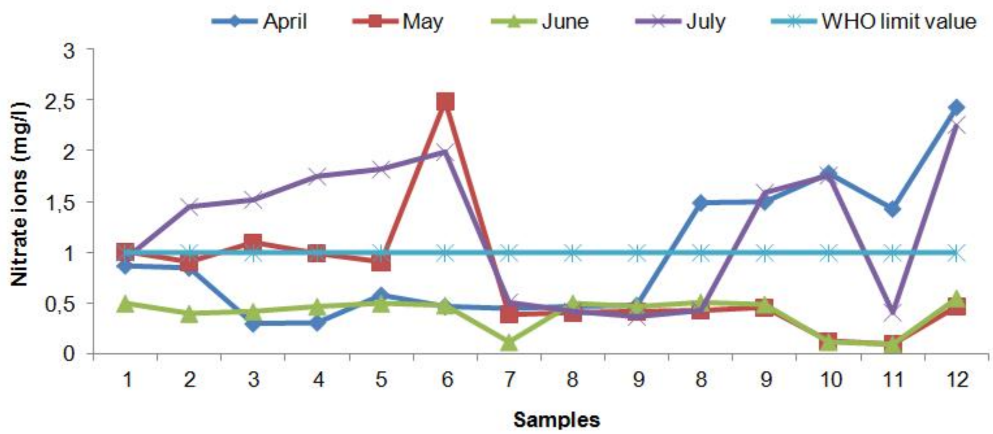

Fig. 4. Monthly variation of nitrate ions in wastewater discharged into Songolo River

Chloride ions: The concentrations of chloride ions found in the liquid effluents during the months of April to July, range from 39.3 to 376.6 mg/l (Table 1). A decrease of the mean chloride content is observed from April (338.55 mg/l) to June (62.06 mg/l). The temporal evolution shows a rise in average chloride levels (Table 1) during the month of July resulting from the absence of dilution by rainfall in the dry season.

Nitrate ions (NO_3^-): Nitrate ions concentration for samples range between 0.3 and 2.43 mg/l in April, 0.1 and 2.49 mg/l in may, 0.1 and 0.85 mg/l in June, 0.37 and 2.26 in July (Table 1). Our samples show the lowest values of nitrate ions than permissible WHO value in June (Fig. 4). The average nitrate levels recorded for the months of April to July are respectively 0.96 mg/l, 0.73 mg/l, 0.4 mg/l and 1.23 mg/l (Table 1). Analysis of the results shows that most maximum values are been recorded in the dry season in July. This rise in NO_3^- content during the dry season could be explained by the fact that during the self-purification phenomenon, the degradation of organic matter is accompanied by an intense production of nutrients and mainly the accumulating nitrates and consequently their increase in wastewaters [15]. On the other hand during the wet season the nitrates ions produced by phenomenon of self-purification are diluted by rainwater which is very abundant during this period [8]. The mean nitrate levels of liquid effluents remain below the WHO standard for wastewater intended for release into the natural environment, ie 1 mg/l from April to June (Table 1). As nitrate levels in natural waters are between 1 and 10 mg/l [16], nitrates from liquid effluents are not expected to have a significant negative impact, such as eutrophication, on the receiving natural environment.

Total hydrocarbons (HT): Total hydrocarbon concentrations for all samples examined in this study are presented in Table 2: They range from 5.38 to 13.67 mg/l in April, 5 to 12 mg/l in May, 9.21 to 25.39 mg/l in June and 8.15 to 24.88 mg/l in July. Average concentration of total hydrocarbons in wastewaters show a growing increase when going from April to July. The mean values recorded range from 8.54 (April) to 17.45 mg/l (July). The total hydrocarbons increasing can be explained by the gradual decrease in precipitation from April to July, which contributes to lowering the dilution of the organic load emanating from wastewater. In addition, the activity of microorganisms responsible for the degradation of organic matter intensifies with the the warming of water [17]. These results show that liquid effluents are polluted by organic matter as they often exceed the range of organic matter contents of the international discharge standards which is around 10 mg/l. This situation could have negative effects on quality of the surface water in which these wastewaters are discharged and then on the aquatic ecosystem [11]. In addition to their toxicity, hydrocarbon substances may limit the supply of oxygen to surface water when present in high concentrations. Polycyclic aromatic hydrocarbons (PAHs), for example, are relatively stable and poorly soluble in water. They are highly absorbed by sediments [18], and are highly soluble in fats, which promotes their bioaccumulation in human and animal tissues. Several PAHs are classified as possible carcinogens by WHO. Other hydrocarbons as BTEX include pollutants such as benzene, toluene, ethylbenzene and xylene can have toxic

Table 2. Values of total hydrocarbons TH (mg/l) in sewage

Sample	April	May	June	July
1	8.79	5	10.92	16.47
2	5.38	17	9.21	15.74
3	13.67	7.9	25.39	24.88
4	7.8	11.8	22.58	22.01
5	7.1	12	10.51	8.15
Mean	8.58	10.74	15.72	17.45

impacts on health [19] as decrease of the immune response, neurotoxic effect and irritation of the respiratory tract.

4. CONCLUSIONS

At the end of this study concerning the characterization of wastewaters discharged into the Songolo River at Pointe-Noire, we can conclude that the use of watercourses as means of elimination of industrial and domestic effluents can have a negative impact on water resources. Indeed, the monitoring of the physic chemical parameters of these effluents shows on the one hand an intense mineral contamination of the wastewaters, which leads to particularly high values of conductivity, and on the other hand an organic and particulate contamination of the wastewater with high levels of suspended solids and total hydrocarbons. The results of this study highlight the persistence of discharges of untreated wastewaters contributing to the deterioration of the water quality of the Songolo River and its natural ecosystem.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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