Journal of Water Resource and Protection, 2016, 8, 1251-1265
http://www.scirp.org/journal/jwarp
ISSN Online: 1945-3108
ISSN Print: 1945-3094

Assessment of the Physicochemical and Microbiological Parameters of a Teaching Hospital's Wastewaters in Abidjan in Côte d'Ivoire

Sadia Sahi Placide[1], Berté Mohamed[1], Loba Evelyne Marie Hélène[1], Appia Foffié Thiéry Auguste[1], Gnamba Corneil Quand-Meme[1], Ibrahima Sanogo[2], Lassiné Ouattara[1]

[1]Laboratoire de Chimie Physique, UFR SSMT, Université Félix Houphouët-Boigny de Cocody, Abidjan, Côte d'Ivoire
[2]Centre Hospitalier Universitaire (CHU Treichville) de Treichville, Abidjan, Côte d'Ivoire
Email: ouatlassine@yahoo.fr

How to cite this paper: Placide, S.S., Mohamed, B., Hélène, L.E.M., Auguste, A.F.T., Quand-Meme, G.C., Sanogo, I. and Ouattara, L. (2016) Assessment of the Physicochemical and Microbiological Parameters of a Teaching Hospital's Wastewaters in Abidjan in Côte d'Ivoire. *Journal of Water Resource and Protection*, **8**, 1251-1265.
http://dx.doi.org/10.4236/jwarp.2016.813096

Received: October 6, 2016
Accepted: November 25, 2016
Published: November 28, 2016

Abstract

This work deals with the physicochemical and microbiological characterization of a hospital wastewater that is directly discharged in water bodies without treatment. Our focus was paid on the teaching hospital of Treichville (Cote d'Ivoire). For the purpose, various physicochemical parameters such as temperature, pH, dissolved oxygen, total dissolved solid, conductivity, nitrate, phosphate, chloride, chemical oxygen demand (COD), biological oxygen demand for five days (BOD_5), salinity, and total suspended solids have been assessed. For the microbiological investigations, the parameters consisting in *Pseudomonas aeruginosa*, Salmonella and total coliforms have been assessed. From the analysis, it has been found that the wastewaters of the teaching hospital of Treichville are highly loaded in organic pollutants and in pathogens bacteria. The values of nitrate, dissolved oxygen demand, COD, BOD_5 and biological parameters do not respect the international (WHO) values recommended for the water to be discharged in the environment. The ratio COD/BOD_5 has been determined to vary between 1.25 and 2.80. The results showed that the studied wastewater is a domestic type wastewater composed either by mostly biodegradable pollutants or a mixture of biodegradable and non-biodegradable organic pollutants. These wastewaters constitute therefore a risk for the populations since they are discharged in water bodies without any treatment and used by communities.

Keywords

Physicochemical Parameter, Chemical Oxygen Demand, Hospital Wastewater, *Pseudomonas aeruginosa*, Salmonella

1. Introduction

Today, in human's life, pharmaceuticals of different therapeutic classes are consumed in a large number as well as in household or in hospitals to prevent them from diseases [1] [2] [3] [4]. Unfortunately, pharmaceuticals are not totally destroyed after ingestion in human's body; thus metabolized or unmetabolized pharmaceuticals are discharged in the environment through urine and feces [4] [5] [6]. Moreover, in households, the unused and expired pharmaceuticals are disposed with normal household waste or discarded into sink or toilet and released into sewage systems [7] [8] [9] [10] [11]. In developing countries where there are wastewater treatment plants, trace of pharmaceuticals is found in discharged water after the wastewater treatment plant (WWTP) operation [12]. Such situation has raised much concern about the pollution of water bodies by pharmaceuticals such as antibiotics, and iodide contrast products. Contribution of the total load of pharmaceutical products in the environment is brought from hospitals or pharmaceuticals manufacturers. In Côte d'Ivoire, a developing country located in the west of Africa, the consumption of pharmaceuticals has got increased. In this country, the wastewater treatment plant built after the independence does not operate anymore because of the lack of maintenance so that the hospital wastewaters are directly discharged in the environment without treatment. Upon entering the water environment, the pharmaceuticals and their metabolites become potential risks to the health of aquatic life and human beings. The adverse effects on aquatic communities include the feminization of male fish, and development of pathogen resistance. At present, there is a lack of information on the pollution level of the wastewaters in the hospitals of Côte d'Ivoire. In order to contribute in developing a strategy for the treatment of the hospital wastewater in the near future, the main goal of this work was to assess the physicochemical and microbiological parameters of one of the most used teaching hospitals in Abidjan, the teaching hospital of Treichville named CHU of Treichville (CHUT). In the current work, some physicochemical parameters such as temperature, pH, conductivity, nitrate, phosphate, chloride, chemical oxygen demand (COD), biological oxygen demand for five days (BOD_5), salinity, total suspended solids (TSS) and some microbiological indicators such as *Pseudomonas aeruginosa*, Salmonella and total coliforms will be assessed.

2. Material and Methods

The teaching hospital of Treichville (CHU of Treichville) where the current work has been carried out is located in the south of Abidjan in the district of Treichville. It covers an area of 420,000 m^2. In this hospital, the wastewaters have been collected in three sites called S1, S2 and S3 (**Figure 1**). The site S1 was the main receptor located at the former wastewater treatment plant (WWTP) area. The site S2 was located on downstream of the site S1 and received the wastewater coming from the heart services. The site S3 received the wastewater coming from the infectious diseases services. Built in 1966 and because of a lack of maintenance, the former wastewater stopped operating in 1975 so that the services built after that period were not connected to the main receptor located

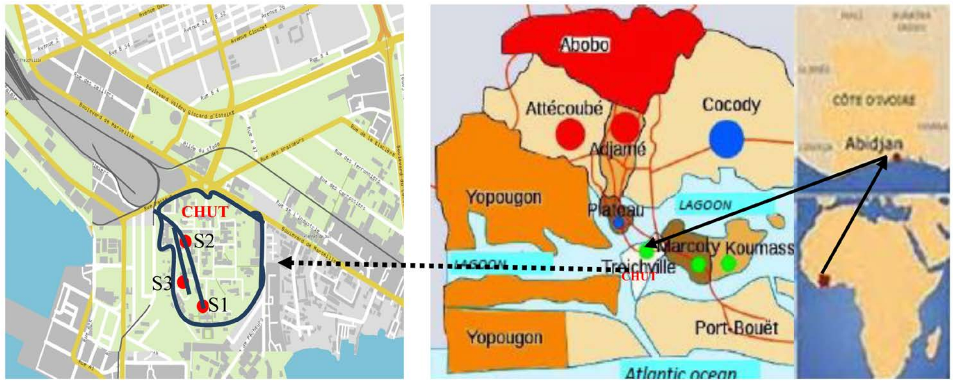

Figure 1. Location of the teaching hospital in Treichville (CHUT) in Abidjan in Ivory Coast in the west of Africa. The site S1 is the main receptor of the wastewater of most of the services of the CHUT. The site S2 is on downstream of the site S1 but receiving the wastewater coming from other services like the heart services and the site S3 received the wastewaters coming from the infectious services.

at the WWTP area. So is the case of the heart services.

To estimate the physicochemical parameters, samples have been collected and some parameters have been measured directly on sites and the others were delivered to the laboratory for measurement. Parameters such as Temperature, pH, conductivity, dissolved oxygen, total dissolved solid and salinity have been determined on sites. Chemical Oxygen Demand (COD), Biological Oxygen Demand in five days (BOD_5), nitrate $\left(NO_3^-\right)$, phosphate $\left(PO_4^{3-}\right)$ and chloride (Cl^-) have been determined in the laboratory as soon as the samples are delivered to the laboratory. For the transportation, samples were kept in a cold area at around 4˚C. Conductivity, salinity, pH, Dissolved oxygen, total dissolved solid, temperature have been measured with a multiparameter BANTE 900P. The Chemical Oxygen Demands (COD) have been determined by heating 2 mL of the sample or diluted samples in ready for use dichromate reagent (HACH) under 150˚C for 2 h and then red with a HACH spectrophotometer DR6000. The Biological Oxygen Demand in five days (BOD_5) was determined with an Oxitop. Nitrate and phosphate have been determined using powder pillows nitraver 5 and phosver 3 respectively and measured with the DR 6000 at wavelengths of 500 nm and 800 nm respectively. The Total Suspended Solids have been determined by weighting a filter containing the Total Suspended Solids after a one hour heating process at 105˚C (ISO 11923). For such investigation, a precise volume V (mL) of the collected wastewater was filtered on a weighted filter. Chloride has been determined volumetrically by Mohr method in presence of silver nitrate (ISO 9297). For microbiology, the following references have been followed: Reference ISO 16266 for the *Pseudomonas aeruginosa*, reference ISO 19250 for the salmonella and reference ISO 9308-1 for the total coliforms.

3. Results and Discussion

3.1. Physicochemical Parameters Assessment

The water consumption in the teaching hospital from 2009 till 2014 has been registered and consigned in Table 1. Table 1 shows that the daily water consumption average is about 750.58 m^3/day which is almost equal to about 1.62 m^3/day/population (average value). It is worth noting that all the daily consumed water is not transformed into hospital wastewater. But from our investigations (a survey), about 80% of the waters are used for hospital (heal) purpose. The sampling operation has been performed on each site of the three sites S1, S2 and S3 at the same period of time by three operators simultaneously. The physicochemical parameters, as mentioned before (temperature, pH, conductivity, salinity, TDS, COD, BOD_5, Cl^-, nitrate, phosphate…) have been carried out. Figure 2 shows the measured temperature on the three sites during the entire period of the campaign. On the site S1, the temperature is almost constant with a minimum value of 26.3˚C and a maximum value of 28.5˚C. The average of the temperature on the site S1 is about 27.2˚C ± 0.7˚C. On the site S2, the temperature varies between 26.2˚C as the minimum value and 29.1˚C as the maximum value. The average of the temperature on the site S2 for the whole campaign period is 27.4˚C ± 0.7˚C. On the site S3, the temperature varies between a minimum value of 26.1 and a maximum value of 28.2˚C with an average of 27.3˚C ± 0.8˚C. One observed that the temperature of the wastewater of the teaching hospital of Treichville is almost constant and is around 27.3˚C.

In Figure 3, the histograms related to the values of pH measured on the three sites S1, S2 and S3 are presented. On the site S1, the minimum pH is 5.80 and the maximum is 8.60 with an average of 7.31 ± 0.71 on the whole investigated period. On the site S2,

Table 1. The consumption of water in the teaching hospital of Treichville (2009-2014).

	2009	2010	2011	2012	2013	2014	Average
Number of beds	515	519	458	396	394	490	462
Water consumption (m^3)/day	790.85	721.98	750.86	730.55	802.01	707.24	750.58
Water consumption/day/population	1.54	1.39	1.64	1.84	2.04	1.44	1.62

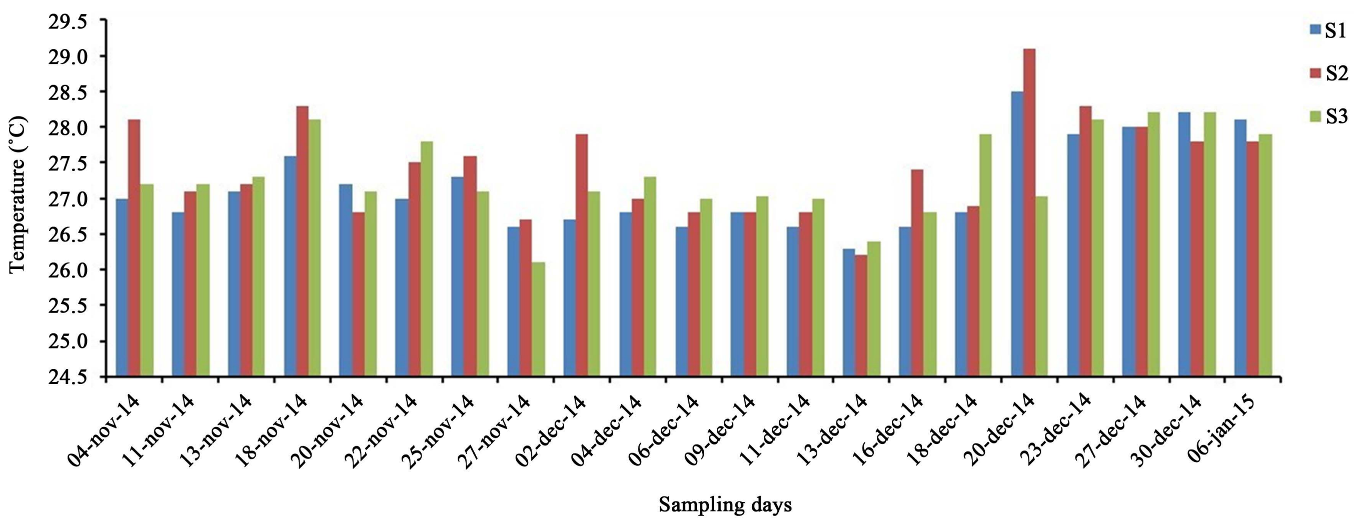

Figure 2. Spatiotemporal evolution of temperature of the hospital wastewaters on the sites S1, S2 and S3.

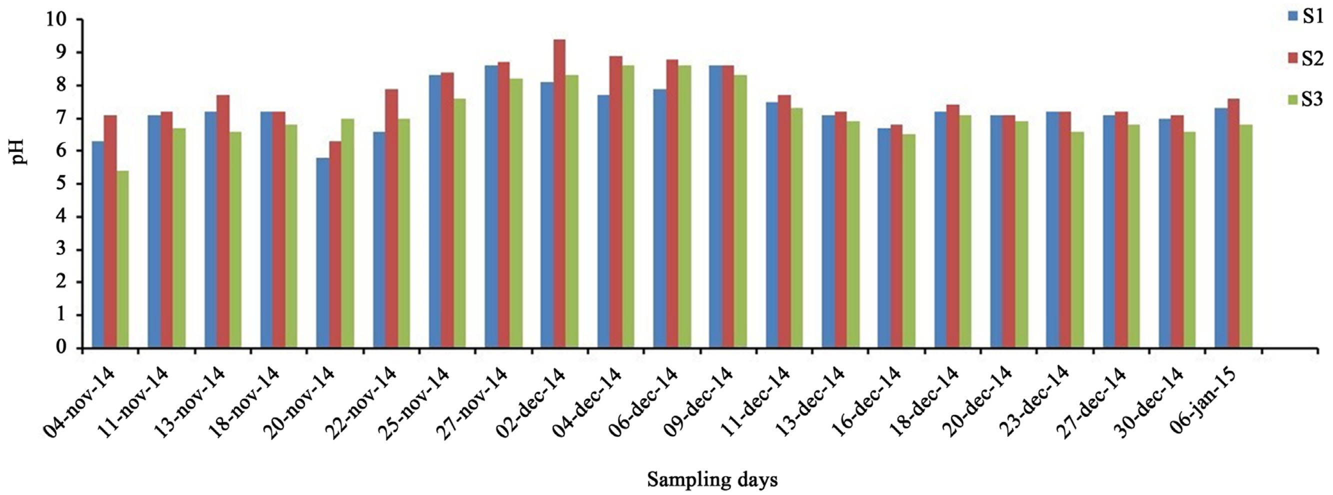

Figure 3. Histograms of the pH recorded on the sites S1, S2 and S3 in the teaching hospital.

pH varies between 6.30 and 9.40 as minimum and maximum values respectively with an average of 7.69 ± 0.91. On the site S3, the minimum and the maximum of the measured pH are 5.40 and 8.60 respectively with an average of 7.18 ± 0.79. The means of the averages of the sites leads to a value of 7.39 indicating that the pH of the wastewater of the teaching hospital is almost neutral.

Figures 4-6 show the histograms giving the evolution of the conductivity, of the total dissolved solid (TDS) and the salinity of the teaching hospital's wastewater on the three sites S1, S2 and S3 during the whole period of the campaign. On the site S1, the conductivity (Figure 4) varies between 342.67 µS/cm and 659.33 µS/cm with an average of 555.49 ± 80.81 µS/cm. The total dissolved solid (Figure 5) values presents a minimum of 171.33 ppm and a maximum of 329.66 ppm with an average of 273.45 ± 46.18 ppm. The salinity (Figure 6) varies between 0.17 PSU and 0.32 PSU with an average of 0.27 ± 0.05 PSU. On the site S2, the minimum and the maximum of the conductivity values (Figure 4) are respectively 641 µS/cm and 1030 µS/cm with an average of 814.47 ± 102.33 µS/cm. The total dissolved solid (Figure 5) values vary between 320.5 ppm and 515 ppm with an average of 407.23 ± 51.42 ppm. The salinity (Figure 6) varies between 0.32 PSU and 0.51 PSU with an average of 0.40 ± 0.05 PSU and on the site S3, the conductivity (Figure 4) varies between 81.9 µS/cm and 789.33 µS/cm with an average of 503.05 ± 179.87 µS/cm. The total dissolved solid (Figure 5) values present a minimum of 40.95 ppm and a maximum of 394.66 ppm with an average of 251.52 ± 89.93 ppm. The salinity (Figure 6) varies between 0.04 PSU and 0.39 PSU with an average of 0.25 ± 0.09 PSU. The means of the averages of the conductivity, the total dissolved solid and the salinity of the teaching hospital wastewaters are 624.33 µS/cm, 310.74 ppm and 0.31 PSU respectively.

The total suspended solids have been investigated and the results are presented in Figure 7. From that figure, the total suspended solids values vary between 0.23 mg/L and 1.80 mg/L with an average of 0.66 ± 0.44 mg/L on the site S1. For the site S2, the determined values are between 0.27 mg/L and 2.07 mg/L with an average of 0.74 ± 0.45

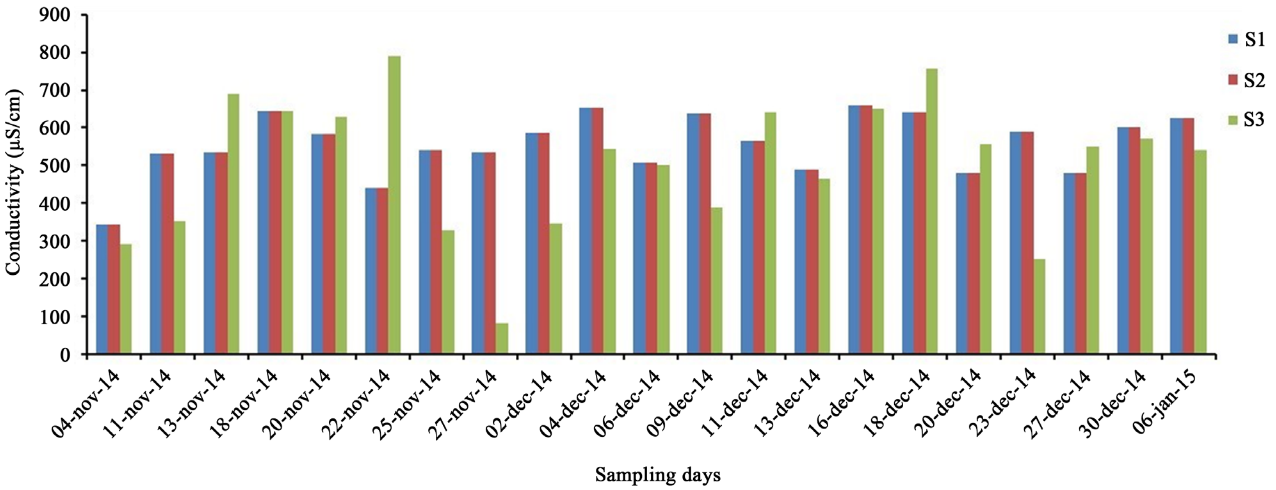

Figure 4. Spatiotemporal evolution of the conductivity of the hospital wastewaters on the sites S1, S2 and S3.

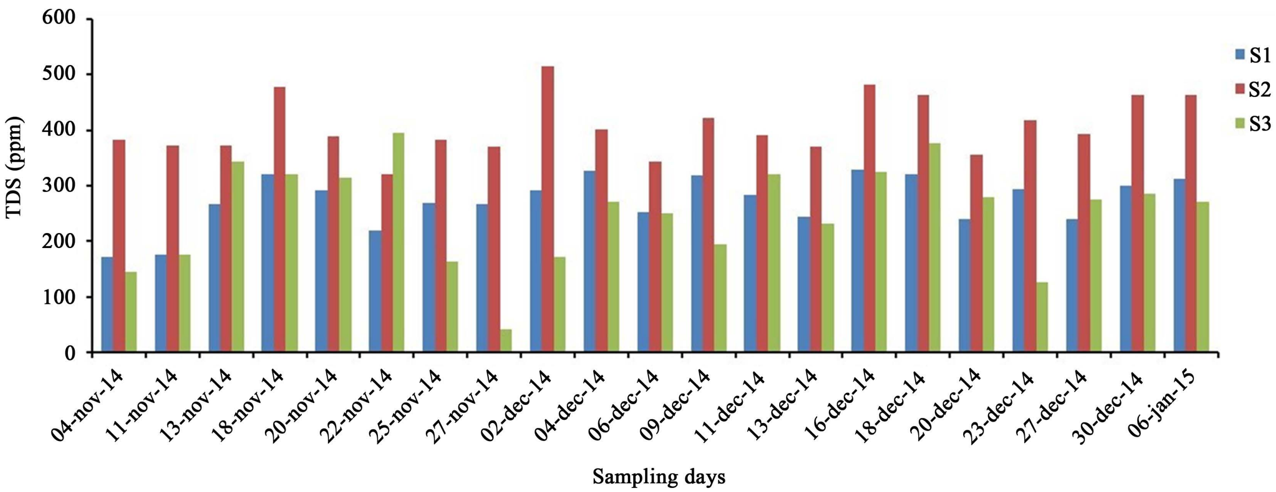

Figure 5. Spatiotemporal evolution of the total dissolved solid of the hospital wastewaters on the sites S1, S2 and S3.

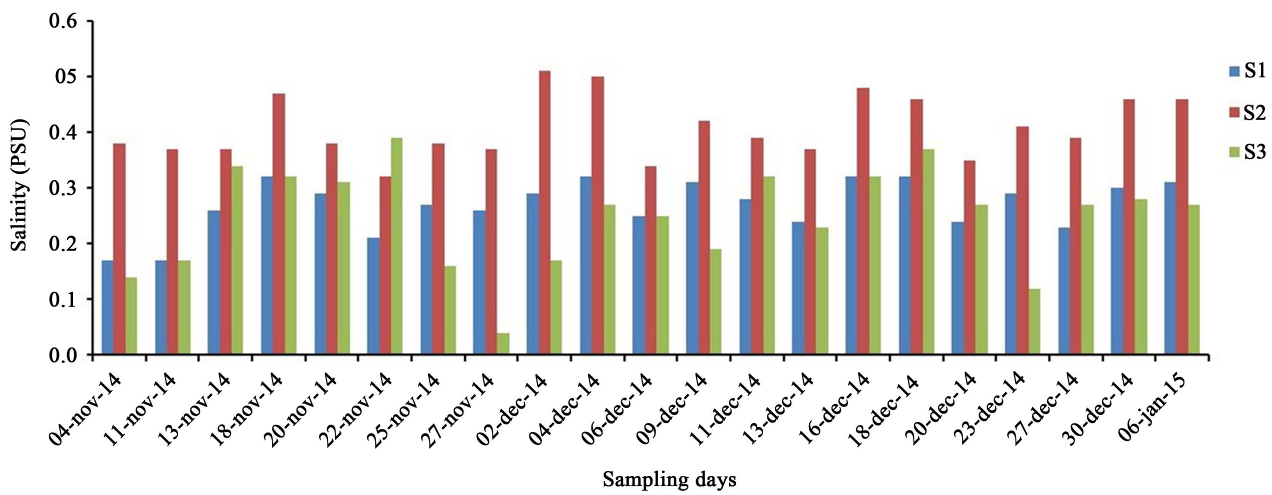

Figure 6. Spatiotemporal evolution of the salinity of the hospital wastewaters on the sites S1, S2 and S3.

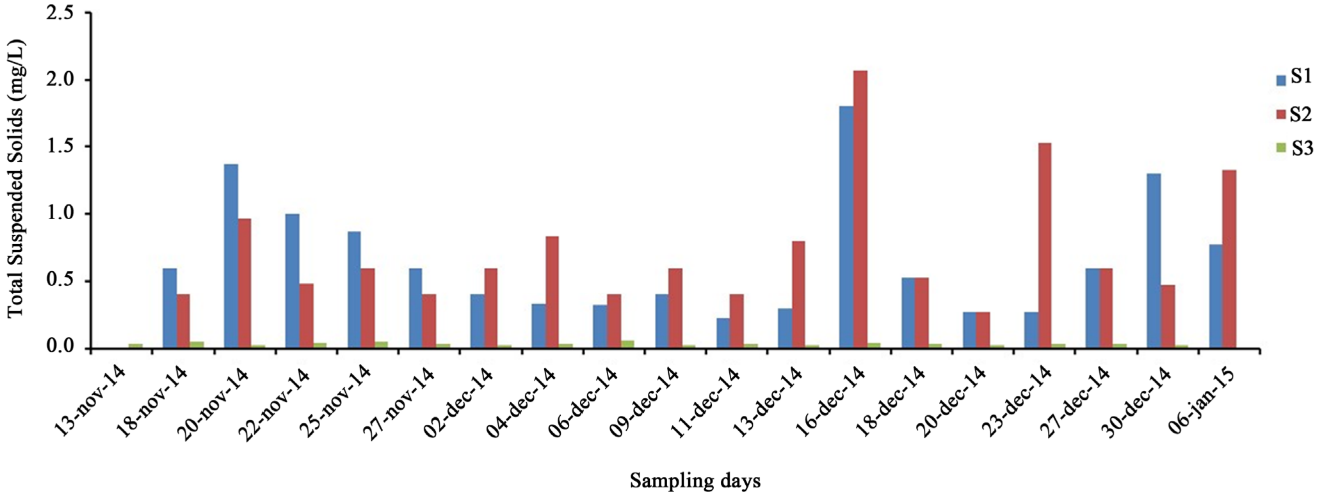

Figure 7. Spatiotemporal evolution of the total suspended solids of the hospital wastewaters on the sites S1, S2 and S3.

mg/L. On the site S3, the obtained values are 0.02 mg/L for the minimum and 0.06 mg/L as the maximum with an average of 0.03 ± 0.01 mg/L.

In Figure 8, the histograms representing the evolution of the dissolved oxygen of the hospital wastewaters were presented. On the site S1, the values of the measured dissolved oxygen values vary between 1.04 mg/L and 1.58 mg/L with an average value of 1.23 ± 0.09 mg/L. For the site S2, the values are ranging between 1.17 mg/L and 1.82 mg/L with an average of 1.51 ± 0.21 mg/L. On the site S3, the minimum value registered is 1.04 mg/L and the maximum value is 1.76 mg/L with an average of 1.38 ± 0.26 mg/L. The means of the average of the dissolved oxygen value is 1.37 mg/L.

Nitrate and phosphate have been analyzed and the results are presented in the Figures 9-11. On the site S1, the concentration of nitrate (Figure 9) varies between 1.33 ppm and 4.73 ppm with an average of 2.78 ± 0.89 ppm and that of phosphate (Figure 10) varies between 2.03 ppm and 4.87 ppm with an average of 3.35 ± 0.69 ppm. On the site S2, the concentration of nitrate (Figure 9) varies between 0.50 ppm and 2.60 ppm with an average of 1.62 ± 0.60 ppm and that of the phosphate (Figure 10) varies between 1.93 ppm and 4.68 ppm with an average of 3.43 ± 0.60 ppm and on the site S3, the concentration of nitrate (Figure 9) varies between 0.33 ppm and 3.75 ppm with an average of 1.27 ± 0.75 ppm and that of phosphate (Figure 10) varies between 1.28 ppm and 4.87 ppm with an average of 3.42 ± 1.04 ppm.

Figure 11 presents the results of the analysis of chloride in the hospital wastewaters. The concentration of chloride varies between 40.18 ppm and 71.19 ppm on the site S1. On the site S2, the values are between 81.06 ppm and 172.62 ppm. On the site S3, the concentration of the chloride is between 29.10 ppm and 63.33 ppm with an average of 46.22 ± 9.81 ppm.

Figure 12 shows the chemical oxygen demand of the hospital wastewaters. From the histograms, one observes that the values of the COD vary between 83.33 ppm and 213 ppm on the site S1 with an average of 121.70 ± 29.52 ppm. On site S2, the COD values

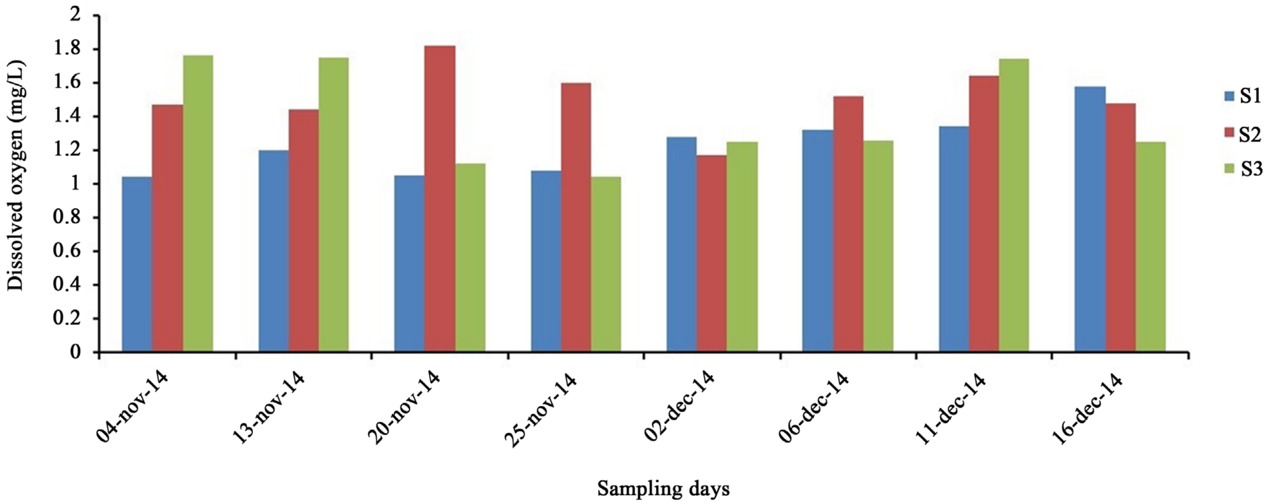

Figure 8. Spatiotemporal evolution of the dissolved oxygen values of the hospital wastewaters on the sites S1, S2 and S3.

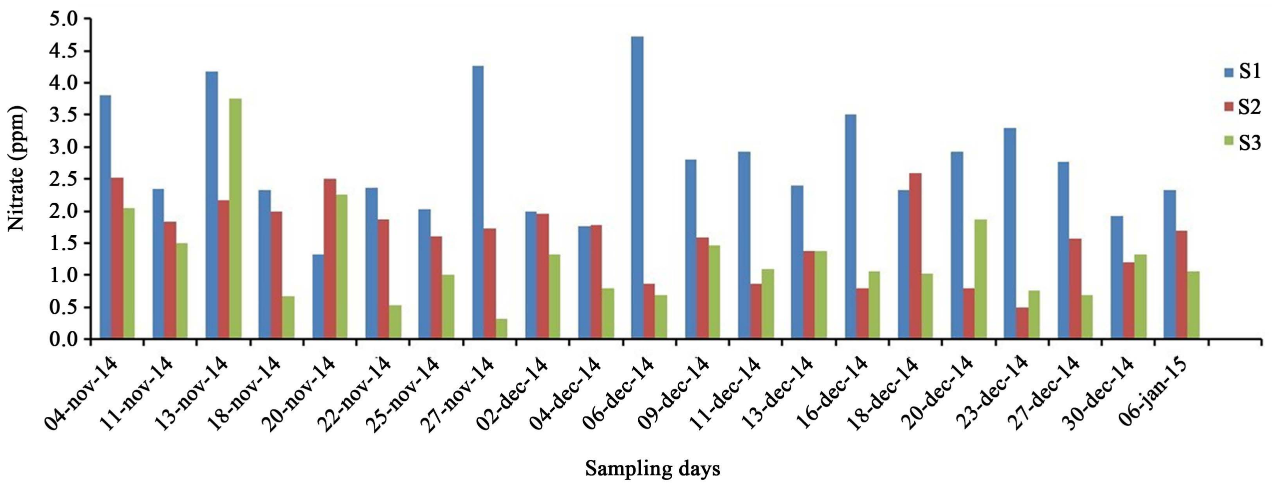

Figure 9. Spatiotemporal evolution of the concentration of nitrate of the hospital wastewaters on the sites S1, S2 and S3.

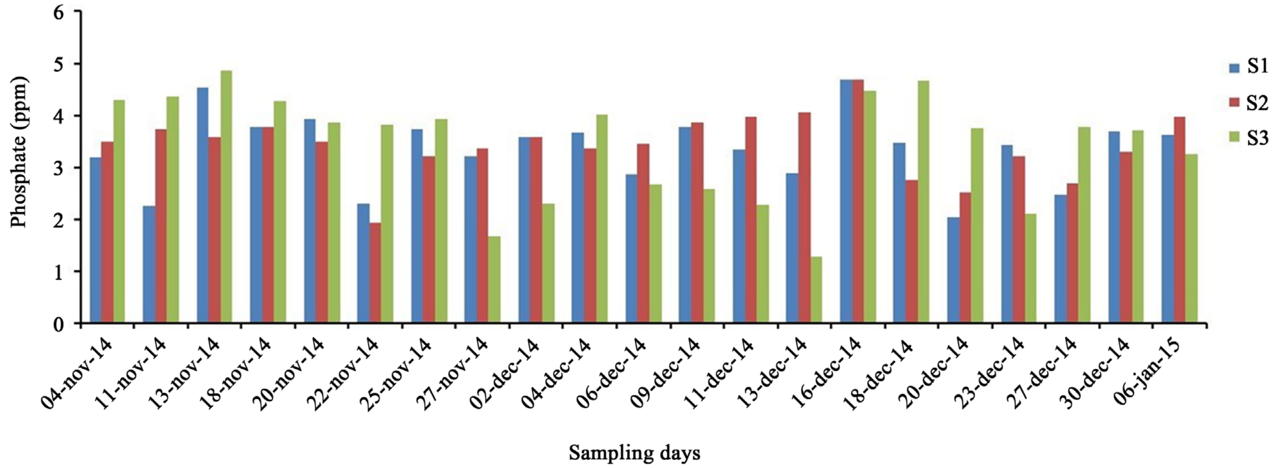

Figure 10. Spatiotemporal evolution of the concentration of phosphate of the hospital wastewaters on the sites S1, S2 and S3.

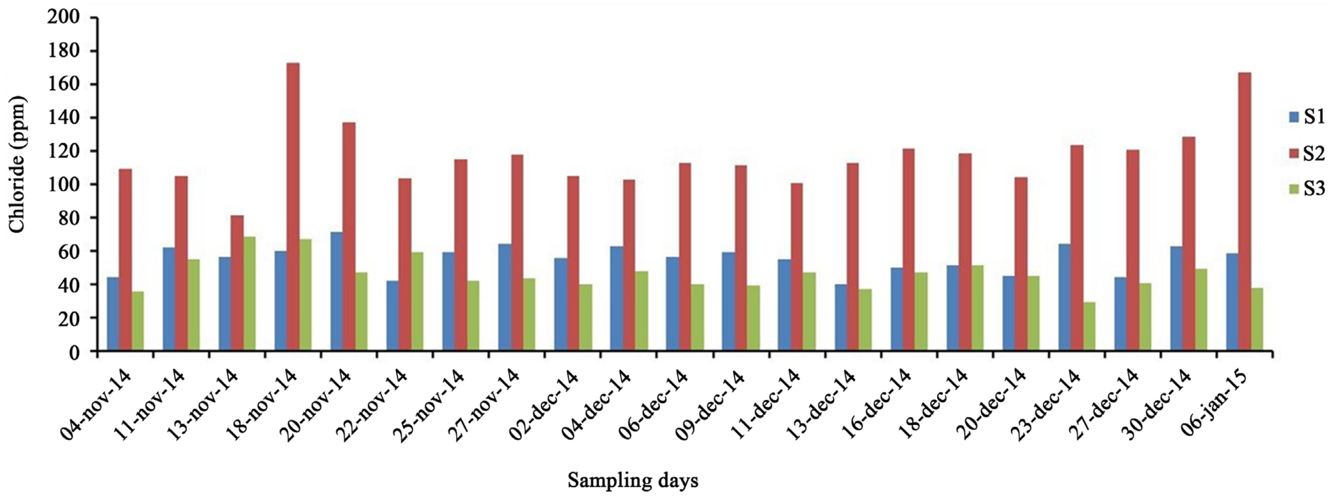

Figure 11. Spatiotemporal evolution of the concentration of chloride of the hospital wastewaters on the sites S1, S2 and S3.

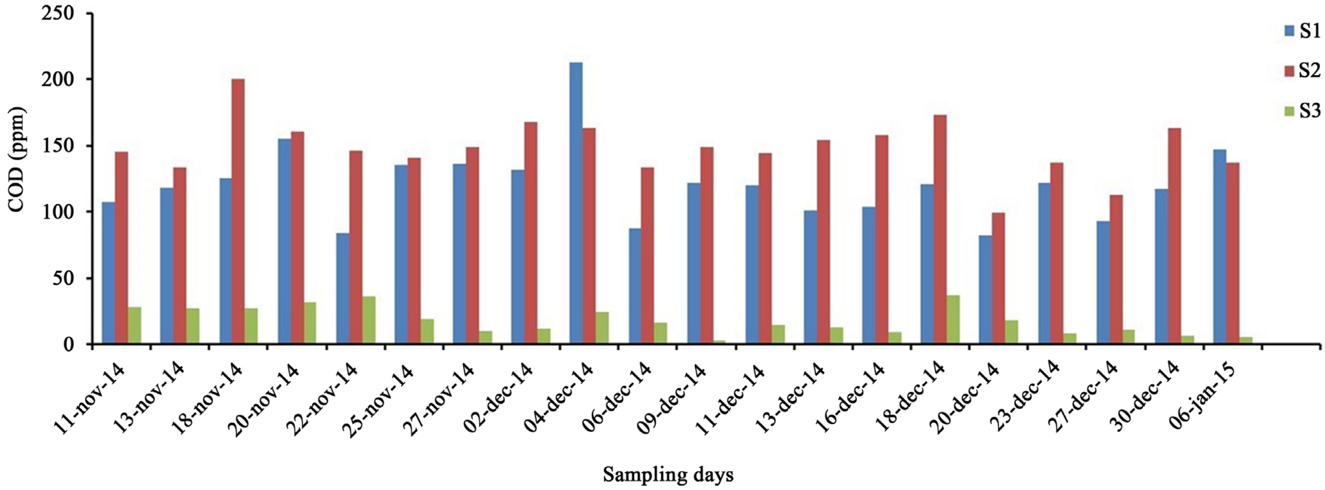

Figure 12. Spatiotemporal evolution of the chemical oxygen demand of the hospital wastewaters on the sites S1, S2 and S3.

are between 99 ppm and 200.3 ppm for an average of 148.27 ± 21.66 ppm. For the site S3, the obtained COD values are ranging between 2.67 ppm and 37.00 ppm with an average of 17.64 ± 10.47 ppm. The means of the average of the COD is 95.87 ppm.

From Table 2, one observes that the values of the biological oxygen demand vary from 65 to 125 mgO_2/L on the site S1. On the site S2, the BOD_5 values vary between 55 and 140 mgO_2/L. For the site S3, the value of the BOD_5 is very low and is about 7 mgO_2/L. The COD/BOD_5 ratio is between 1.3 and 1.82 for the site S1, between 1.25 and 2.8 for thesite S2. That of site S3 is about 1.57. The means of the average of the BOD_5 is 86 mgO_2/L for the wastewater of the teaching hospital of Treichville.

3.2. Microbiological Investigation

Some microbiological parameters have been determined such as *Pseudomonas aeruginosa*, salmonella and total coliforms. The results have been consigned in Table 3. It

Table 2. Values of the biological oxygen demand and the ratio COD/BOD_5.

DATES	SITES	COD	BOD_5	Ratio COD/BOD_5
18/11/2014	*SITE*1	150	90	1.67
	*SITE*2	202	140	1.8
25/11/2015	*SITE*1	182	100	1.82
	*SITE*2	155	55	2.8
06/01/2015	*SITE*1	126	65	1.94
	*SITE*2	187	85	2.2
25/03/2015	*SITE*1	162	125	1.3
	*SITE*2	144	115	1.25
	*SITE*3	11	7	1.57

Table 3. Results of the biological analysis.

Microbiological parameters	Unity	SITE S1	SITE S2	SITE S3
Pseudomonas aeruginosa	UFC/100ml	0.75×10^5	0.74×10^5	0.004×10^5
Salmonella	UFC/100ml	Presence	Presence	Presence
Total Coliforms	UFC/100ml	0.6×10^5	3.0×10^5	0.6×10^5

appears that all the hospital wastewaters contain bacteria flora. Results in **Table 3** show that all the waters collected contain the *Pseudomonas aeruginosa* with its concentration ranging between 0.04×10^5 - 0.75×10^5 UFC/100mL. The salmonella were found to be present in the sampling wastewaters. The concentration of the total coliforms were found to be in the range of 0.6×10^5 - 3×10^5 UFC/100mL.

3.3. Discussion

As it is has been indicated above, the wastewaters of the teaching hospital of Treichville are poured in the environment without any treatment. So are all the hospital wastewaters in our country and for many industries. Unfortunately, no information about the degree of water pollution of the wastewater of this hospital was found. The temperature of the wastewaters of this hospital are lower than 30˚C and the pH of the wastewaters are almost neutral. Compared to the international WHO (World Health Organization) guidelines, the determined parameters are inferior to the limiting values under which the wastewaters are allowed to be discharged. In the light to those values, one could indicate at this level that these hospital wastewaters could not affect negatively bacteria flora and the microbiological activity in the receptor. In fact, water temperature is an important factor that affects the rate of many biological and chemical processes and also the amount of oxygen that can dissolve in the water. Moreover, the beings of aquatic life is influenced by the temperature [13] [14] [15]. The pH value is also an important parameter for the evaluation of the quality of waters in terms of acidic or alkaline status. The pH is a key parameter of a paramount importance in the biological processes of wastewater treatment [16]. The pH values determined in this work are in accordance to the pH range found in other hospital wastewaters. In Turkey for instance, the pH of the hospital wastewater is around pH = 7 [17]. Other authors have found almost the same results [18] [19]. The fact that the pH is close to the neutral pH could be linked to the product used in the hospital such as detergents. For the parameters such as conductivity, salinity and chlorides, the results showed that the higher values determined for such parameters were lower than the limiting values recommended by the WHO guidelines for the water to be discharged [20] [21]. It is important to mention that all the parameters such as conductivity, salinity and chloride are well and positively correlated. The values of the conductivity determined in this teaching hospital wastewaters are lower than those found in Erbil's hospital wastewaters [22]. The values of the conductivity of the wastewaters of this teaching hospital are low. Thus for the further treatment of such a wastewater by electrochemical techniques for instance, it is would be necessary to use a supporting electrolyte to increase the conductivity of the solution in order to favor the current to flow. Nevertheless, the ions present in the hospital wastewaters could come from the release of physiologic salt, from the kitchen, from the lavatories and from the laundries. Even though the quantities of chloride are low, Goldman and Home suggested that the conductivity values higher than 500 µS/cm in a water system could be regarded as hard [23]. The total suspended solids of the teaching hospital of Treichville have been assessed. This parameter is important because it represents the total organic and inorganic particles in the wastewaters. The obtained values of this parameter, in all the water samples, are lower than 50 mg/L which is considered as the limiting values of the total suspended solids for the direct discharge of the wastewaters. This result could probably indicate that most the pollutants present in the teaching hospital of Treichville are soluble. Those values are very low compared to the findings of other authors [24] [25]. The values of the total dissolved solids are higher than 100 mg/L, the limiting values for direct reject of wastewaters according to the WHO guidelines. Such results indicate that the wastewaters under study are probably charged in dissolved material such as organics. The determination of nitrate and phosphate has been carried out and the findings showed that the concentrations of the nitrate are higher than 1 mg/L and those of phosphate are lower than 6 mg/L which are the limiting values of such parameters indicated in the WHO guidelines for the wastewaters to be discharged directly into the environment. Accumulation of the nitrate in the receptor could result in its eutrophication. The dissolved oxygen was determined and the values are found to be very low. They are in the same range as those found in the hospital wastewater of Azilalin Morocco [26]. The low values of this wastewater is characteristic of an anoxic wastewater and it is also an indication of a bad quality of the wastewater. Moreover, that situation is responsible of the bad odor released in the area of the receptor because of anaerobic activities of the natural microorganisms. The organic load of the teaching hospital of Treichville has been evaluated. The parameters that have been determined are the chemical oxygen demand (COD) and the biological oxygen demand (BOD_5). In fact the chemical oxygen demand is an important parameter for characterizing water bodies, sewage, industrial waters and treatment plant effluent [27]. It is also important to repeal that a low biological oxygen demand in five days is an indicator of a good quality of water while a value higher than 30 mg/L (WHO) is an indicator of polluted water. Additionally to the single parameters determination, the ratio COD/BOD_5 was calculated because such a ratio is a good means to point out the wastewaters pollution degree and also the appropriate treatment technique to be applied. From the results, values of the chemical oxygen demand determined in the sites S1 and S2 were higher than the limiting values, 90 mg/L, of WHO guidelines for water to be directly discharged in the environment. Those of the site S3 are very low because of the lesser activity in the period of water collection. The COD values obtained in this hospital are very low compared to those determined in the teaching hospital of Yaoundé [28]. The low values determined in the site S1 could be due to the effect of the microorganisms on the raw wastewater before water sampling operation. So is the case of the wastewater of the site S2 located in the downstream of the site S1 which underwent possibly natural microorganisms effect before water collection. The determined values of the biological oxygen demand are all higher than 30 mg/L corresponding to the limiting values under which the organic charge can be discharged according to WHO guidelines. As aforementioned in case of COD, the very low values of the BOD_5 determined in site S3 could be linked to the lesser activities in the services which wastewaters are discharged in an opened channel. In this investigation, the ratio COD/BOD_5 has been determined. A ratio inferior to three (ratio < 3) is characteristic of the presence of a great amount of biodegradable materials in the wastewater. In such a case, a biological treatment of the wastewater could be further proposed. Conversely, a high value of this ratio indicates that a great amount of the organic materials of the wastewater is not biodegradable. In this case, it is preferable to propose a physicochemical treatment technique. This ratio could also indicate if the wastewaters to be discharged directly in the environment have a domestic characteristic. The ratio determined in this work is inferior to 3. This result means that the wastewater of the teaching hospital of Treichville has the characteristic of a domestic wastewater. The obtained values are in accordance with those found in the Tumaco hospital wastewater in Colombia and at Yaoundé (Cameroon) and with the results reported in literatures [29] [30]. It is worth noting that although the main character of the wastewater under study is a domestic one, we emphasize on the fact that depending on the activities undertaken in this hospital, the ratio tending to be close to 3 indicates the presence of non-biodegradable pollutants in the corresponding wastewaters. In this case, this wastewater is composed of a mixture of non-biodegradable and biodegradable pollutants. In the overall, it can be indicated that the wastewater of the teaching hospital of Treichville is polluted. Additionally to the physicochemical parameters, some microbiological parameters have been determined. Since it has been indicated above that the wastewater of the teaching hospital of Treichville is directly discharged in the environment or in the water bodies generally used by nearby population or communities, the presence of pathogens bacteria is a potential public health hazard. In fact the presence of the pathogens bacteria in effluent may cause acute to severe disease on getting suitable host and condition [31]. The three bacteria of our focus were all present in the wastewaters of the three sites. Their amounts are higher than the limiting values, <1000 CFU/100mL, given by the WHO guidelines for the water to be discharged in water bodies or for irrigation. Those results showed values that are lower than those generally found in other hospital wastewaters. From those results, one can indicated that the teaching hospital's wastewater is of bad quality. It is known that coliforms are not pathogens but their presence in the wastewater gives the information on the existence of pathogen bacteria. In the case of the teaching hospital of Treichville, the wastewaters contain pathogens bacteria.

4. Conclusion

The wastewaters of the teaching hospital of Treichville have been assessed for the first time in order to be aware of its pollution degree. From the physico-chemical parameters, it appeared that some parameters such as nitrate, dissolved oxygen, and organic material do not respect the limiting values recommended by the international guidelines (WHO) to be discharged. Those wastewaters can be considered as poor and bad wastewaters. It contains a high load of organic pollutants. From the ratio COD/BOD_5, the studied wastewater is found to be a domestic type wastewater. Its composition depends on the activities undertaken in the hospital so that it can contain biodegradable organic pollutants or a mixture of biodegradable and non-biodegradable organic pollutants. These wastewaters contain also pathogens bacteria. They constitute therefore a risk for the populations since they are discharged in water bodies without any treatment. Regarding the organic charge and the microbiological pollution of the hospital wastewaters of the teaching hospital of Treichville, they shouldn't be directly discharged in the environment without treatment. We recommend to be built a combined process for the wastewater treatment coupling biological treatment followed by physico-chemical processes such as advanced oxidation processes.

Acknowledgements

We greatly thank the Swiss National Funds for its financial support that allowed this work to be carried out. Our Team has received part of the grant IZ01Z0_146919 for that work. We also thank Prof. Bakayoko-Ly Ramata, currently the higher educational ministry and prior the president of the University Felix Houphouet-Boigny for her help in the realization of that work.

References

[1] Blaser, M.J. (2016) Antibiotic Use and Its Consequences for the Normal Microbiome. *Science*, **352**, 544-545. https://doi.org/10.1126/science.aad9358

[2] Brown, D. (2015) Antibiotic Resistance Breakers: Can Repurposed Drugs Fill the Antibiotic Discovery Void? *Nature Reviews Drug Discovery*, **14**, 821-832. https://doi.org/10.1038/nrd4675

[3] Kummerer, K. (2009) Antibiotics in the Aquatic Environment—A Review-Part I. *Chemosphere*, **75**, 417-434. https://doi.org/10.1016/j.chemosphere.2008.11.086

[4] Le-Minh, N., Khan, S.J., Drewes, J.E. and Stuetz, R.M. (2010) Fate of Antibiotics during Municipal water Recycling Treatment Processes. *Water Research*, **44**, 4295-4323. https://doi.org/10.1016/j.watres.2010.06.020

[5] Richardson, S.D. and Ternes, T.A. (2011) Water Analysis: Emerging Contaminants and Current Issues. *Analytical Chemistry*, **83**, 4614-4648. https://doi.org/10.1021/ac200915r

[6] Luo, Y., Guo, W., Ngo, H.H., Nghiem, L.D., Hai, F.I., Zhang, J., Liang, S. and Wang, X.C. (2014) A Review on the Occurrence of Micropollutants in the Aquatic Environment and Their Fate and Removal during Wastewater Treatment. *Science of the Total Environment*, **473-474**, 619-641. https://doi.org/10.1016/j.scitotenv.2013.12.065

[7] Glen, R.B., Helge, R., Deborah, A.G. and Mitra, S. (2003) Pharmaceuticals and Personal Care Products (PPCPs) in Surface and Treated Waters of Louisiana, USA and Ontario, Canada. *The Science of the Total Environment*, **311**, 135-149. https://doi.org/10.1016/S0048-9697(03)00138-4

[8] Brausch, J.M. and Rand, G.M. (2011) A Review of Personal Care Products in the Aquatic Environment: Environmental Concentrations and Toxicity. *Chemosphere*, **82**, 1518-1532. https://doi.org/10.1016/j.chemosphere.2010.11.018

[9] Bu, Q., Wang, B., Huang, J., Deng, S. and Yu, G. (2013) Pharmaceuticals and Personal Care Products in the Aquatic Environment in China: A Review. *Journal of Hazardous Materials*, **262**, 189-211. https://doi.org/10.1016/j.jhazmat.2013.08.040

[10] Daughton, C.G. (2016) Pharmaceuticals and the Environment (PiE): Evolution and Impact of the Published Literature Revealed by Bibliometric Analysis. *Science of the Total Environment*, **562**, 391-426. https://doi.org/10.1016/j.scitotenv.2016.03.109

[11] Hoyett, Z., Owens, M.A., Clark, C.J. and Abazinge, M. (2016) A Comparative Evaluation of Environmental Risk Assessment Strategies for Pharmaceuticals and Personal Care Products. *Ocean & Coastal Management*, **127**, 74-80. https://doi.org/10.1016/j.ocecoaman.2016.04.013

[12] Moreira, F.C., Soler, J., Alpendurada, M.F., Boaventura, R.A.R., Brillas, E. and Vilar, V.J.P. (2016) Tertiary Treatment of a Municipal Wastewater toward Pharmaceuticals Removal by Chemical and Electrochemical Advanced Oxidation Processes. *Water Research*, **105**, 251-263. https://doi.org/10.1016/j.watres.2016.08.036

[13] Hutchinson, G.E. (1957) A Treatise on Limnology. John Wiley, New York, 1015 p.

[14] Rutter, R. (1973) The Fundamental of Limnology. University of Toronto Press, 295.

[15] Odum, E.P. (1971) Fundamentals of Ecology. 3rd Edition, W.B Saunders Company, London, 547.

[16] Chitnisa, V., Chitnis, S., Vaidya, K., Ravikant, S., Patil, S. and Chitnis, D.S. (2004) Bacterial Population Changes in Hospital Effluent Treatment Plant in Central India. *Water Research*, **38**, 441-447. https://doi.org/10.1016/j.watres.2003.09.038

[17] Altin, A., Altin, S. and Degimenci, M. (2003) Characteristics and Treatability of Hospital (Medical) Wastewaters. *Fresenius Environmental Bulletin*, **12**, 1098-1108.

[18] Ouazzan, N. (1987) Lagunage experimental sous climat aride. Variation des paramètres physico-chimiques. Thèse de 3e cycle Fac Marrakech.

[19] Abouelouafa, M., Berrichi, A., El Halouani, H. and Kharboua, M. (2002) Effets de la réutilisation des eaux usées brutes de la ville d'Oujda sur quelques paramètres agronomiques et bactériologiques. *Actes Inst. Agron. Vet*, **22**, 153-160.

[20] WHO (1973) Réutilisation des effluents: Méthode de traitement des eaux et mesures de protection sanitaire. Rapport technique n°517.

[21] Ministère de l'Environnement du Maroc (2002) Normes maoraines, Bulletin officel du maroc. N° 5062 du Ramadan, 1423, Rabat.

[22] Aziz, R.J., Al-Zubaidy, F.S., Al-Mathkhury, H.J. and Musenga, J. (2014) Physico-Chemical and Biological Variables of Hospitals Wastewater in Erbil City. *Iraqi Journal of Science*, **55**, 84-92.

[23] Goldman, C.R. and Home, A.J. (1983) Limnology. McGraw-Hill International Book Company, Japan, 464.

[24] Raweh, S., Belghyti, D., Al-Zaemey, A., El Guamri, Y. and Elkharrim, K. (2011) Qualité physico-chimique des eaux usées de la station d'épuration de la ville de S'anaa (Yémen). *International Journal of Biological and Chemical Sciences*, **5**, 1-10.
http://ajol.info/index.php/ijbcs
https://doi.org/10.4314/ijbcs.v5i1.68065

[25] Oulkheir, S. (2002) Caractéristiques physico-chimiques et microbiologiques des eaux usées de Kénitra. Mémoire de 3ème cycle, Faculté des Sciences, Kénitra, 79.

[26] Idrissi, Y.A., Alemad, A., Aboubaker, S., Daifi, H., Elkharrim, K. and Belghyti, D. (2015) Physico-Chemical Characterization of Wastewater from Azilal City—Morocco. *International Journal of Innovation and Applied Studies*, **11**, 556-566.
http://www.ijias.issr-journals.org/

[27] Bartram, J. and Balance, R. (1996) Water Quality Monitoring (a Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programs). UN Environment Programme, UNEP and FN Span, Chapman and Hall, UK, 388.

[28] Severin, M.M. (2012) Evaluation de la gestion des déchets liquids hospitaliers. Casdes eaux usées du centre hospitalier Universitaire de Yaoundé. Université de Yaoundé Cameroun-Diplôme d'études supérieures spécialisées (DESS). Dans la catégorie: Sciences.

[29] Gnagne, T. and Brissand, F. (2003) Etude des potentialités d'épuration d'effluents d'abattoir par infiltration sur sable en milieutropical. *Sud-Sciences et Technologies*, No. 11.

[30] Zerkouirin, R.A. (2003) Flore globale des eaux usées de la ville de Fès et étude de la capacité de certaines espèces à diminuerla charge azotée, phosphatée et quelques métaux lourds (chrome et cadmium). Thèse de Doctorat, Faculté des Sciences, Dder El Mahraz, Fès, Maroc.

[31] Mishra, A., Mukherjee, A. and Tripathi, B.D. (2009) Seasonal and Temporal Variations in Physico-chemical and Bacteriological Characteristics of River Ganga in Varanasi. *International Journal of Environmental Research*, **3**, 395-402.