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Assessment of the biomedical wastewater treatment station of the National University hospital of Cotonou Benin, West Africa

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Abstract

Poor management of biomedical wastewater is a major threat for the environment and the public health. This study aims to assess the activated sludge wastewater station of CNHU-HKM of Cotonou, the biggest hospital in the country. Purposely, some parameters such as temperature, pH, dissolved oxygen, total dissolved solids, biological oxygen demand, and chemical oxygen demand were measured at the entry and at the exit of the station. Some microbiological parameters such as fecal coliforms and total coliforms have also been investigated. It came out of our investigations that the wastewater treatment station is undersized compared to the current needs of this hospital. Parameters measured at the exit are far beyond admitted World Health Organization standards. Frequent dysfunctions are observed. Wastewater is frequently rejected inside the center without any prior treatment. This results in the pollution of the ground as well as groundwater and constitutes a real threat for public health.

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Introduction

Hospital waste management is a major component in the continuous improvement of the quality of care and services as well as in the protection of hospital staff. The World Health Organization (WHO) reports the dangers of poor management of hospital waste in Africa (WHO, 1999). African countries register since a few decades a demographic growth and a rapid urbanization. This results in an increase of the production of waste in general and biomedical waste in particular due to the proliferation of health centers. These biomedical wastewaters are today a major public health problem (Naidoo S, Olaniran AO, 2013). Poor management of this biomedical waste, specifically the biomedical wastewater is a danger for the communities because it can seep into the soil and contaminate groundwater (Boillot, 2008). Recent studies have shown the interest that health professionals, as well as public authorities, have to this particular topic (CLIN, 1999; Naidoo S and Olaniran AO. 2013; João P. Cabral S, 2010). The chemicals used in health care institutions, the blood, feces and urine of patients with contagious diseases are a potential sources of pollution, mainly for water from sinks and sewers. The chemical and biological risk induced by the poor management of these wastewaters represents a real threat for the populations (Billau, 2008). It is thus important to examine how low incomes countries such as Benin manage biomedical waste particularly biomedicalwastewater produced by daily activities in hospitals. The purpose of this study is to access the efficacy of the wastewater treatment station of National University Hospital (CNHU HKM) the biggest hospital in Benin.

Material and methods

This study is conducted at the CNHU-HKM, which has a central wastewater treatment unit. After having selected this hospital, services of this hospital were listed. Direct observation was made over the whole process of liquid waste management. Wastewater at the entrance and at the exit of the treatment unit has also been sampled for laboratory analyses.

Sampling

The samples were collected at the entrance and exit (effluent) of treatment basin, and at different times of the day (9.00 am, 1.00 pm and 5.00 pm). In total, 18 samples were collected and analyzed in the laboratories LARECBA of Polytechnic School of the University of Abomey-Calavi and of the CNHU-HKM respectively for chemical and microbiological analyses. Three sampling campaigns were carried out during this study. The laboratory methods used are those developed by the American Public Health Association (American Public Health Association, 1995). For measurements of the Biological Oxygen Demand (BOD) and the Chemical Oxygen Demand (COD), six water samples have been collected per day over a period of three weeks.

Laboratory procedures

Physical parameters were measured with multi parameters.

Chemical Oxygen Demand (COD) and Biological Oxygen Demand (DBO_5)

For the Chemical Oxygen Demand (COD), 50 ml of the sample was introduced into a flask of 500ml with 1 g of mercury sulfate HgSO4, a few glass beads, and finally slowly added 5 ml of sulfuric acid reagent. The tube is preheated in a reactor at 150 ° C for 2 hours and allowed to cool. The value of the COD was read on the HACH 620 nm spectrophotometer.

To determine the concentration of the Biological Oxygen Demand (BOD_5), 164ml of the sample was collected in brown vials. Magnetized Baro were added to the sample added with pellets of potassium (KOH). The vials was closed with the oxitops and put in an incubator at 20 ° C for five (05) days.

The search for parasites

The search for parasites (cysts and parasites eggs) is made from water samples after centrifugation at 3000 rpm for 5 minutes followed by the direct examination.

The germs pollution index

The germs pollution index search is done through the bacteriological analysis in three steps in the laboratory.

Samples are placed on different culture media: the Eosin Methylene Blue Agar (EMB) for fecal coliforms (*E. coli*), Slanetz media for fecal streptococci, Salmonella -Shigella media (SS) for Salmonella and Shigella, Chapman media for staphylococci, D-coccosel media for enterococci. The boxes with the samples were incubated at 37 ° C for 24 and 48 hours respectively for fecal coliforms and fecal streptococci.

The count of colonies was made by binocular magnifier.

The identification of bacteria (enterobacteria) was performed by the API 20E Gallery and that of fecal streptococci by API20 Strep.

Results

Description of the wastewater treatment station of CNHU

Depending on its design, the wastewater treatment station of CNHU-HKM is an activated sludge system. Its treatment capacity is around 350m3/day. It was built to operate on a cyclic mode divided into three phases, namely: an aeration phase; a decantation phase; an evacuation phase of the effluent and sludge**.** Aeration is ensured by two aerators that provide mixing and air insufflations as micro bubbles. The removal of the effluent is carried by a surface floating pump. The effluent is treated with chlorine before being discharged. The sludge is fed into a silo where, after to anaerobic digestion for 15 to 20 days, they are removed to be dried.

Table 1. Physical parameters at entrance and exit of the treatment unit.

Paramètres	Symbols and Units	Entrance	Exit
Température	T (°C)	30,8	31,7
Ph	Ph	7,02	7
Dissolved oxygen	O2 (mg/l)	1	1,15
Conductivity	(µS/cm)	865	780
Total dissolved solids	TDS (mg/l)	360	420

Observation carried during our study shows that this wastewater treatment unit currently works as simple tank that receives wastewater and provides sludge deposition. Pumps no longer function and there is no disinfection of wastewater prior to discharge. Same is for sludge. More than 30% of the tank is fulfilled by sludge. Effluents are discharged into the hospital through a pipe located downstream of the station.

Laboratory tests

The physical parameters measured during this study are summarized in table 1. It shows the values of parameters such as pH, the temperature, the total dissolved solids and the conductivity at the entrance and exit of the station. The table 2 reports the wastewater and the nature of their risks according to the different services. The risks are essentially infectious and toxic for the biological, chemical, mixed and radiological effluent. The table 3 shows the BOD_5 and COD at the entrance and exit of the treatment process. This demonstrates that there is a malfunction of the treatment station.

Bacteria identified at the entrance of the station are almost the same as at the exit. In culture, there is a much greater diversification at the entrance than at the exit (Table4).

Discussion

Management of wastewater remains an important

issue in low income countries. Very few papers have been published in this area in Benin. To assess the functionality of the treatment basin of the CNHU HKM, we were interested in the measurement of physicochemical parameters such as temperature, pH, dissolved oxygen, conductivity and the total dissolved solids. The determination of these physical parameters shows that the pH is close to 7 and temperatures vary between 30.8°C and 31.7°C respectively at the entrance and exit. Theses temperatures are not in favor of a degreasing, which requires a temperature below 30°C. Touré in 1998 found a pH of 7 and a temperature below 30°C. Our results show the same pH but the temperature is slightly lower (Toure, 1998). It's well known that a high temperature leads to depletion of dissolved oxygen by lowering the value of saturation (Rodier, 2005). Regular monitoring of the pH of wastewater treatment station is therefore necessary as acids and bases can strongly change the pH and cause the disappearance of aquatic life. (Clin Paris Nord, 1999; Rodier J 2005; Vassal S.*et al*, 1994). As for the dissolved oxygen, it remains close to the value at the entrance of the station. The wastewaters at the entrance as well as at the exit are highly conductive for electricity, however, the wastewater at the entrance of the station is more conductive than at the exit and the total dissolved solids at the exit is higher than at the entrance.

Table 2. Types of liquid waste according to different services at the CNHU and nature of the risk.

Medico-technical services			
Service	Type of waste	Nature of the risks	Specifications
Surgery Unit	biological, chemical and mixed	Infectious, toxic	blood, urine, stool, gastric liquid, trachea-bronchial draining liquid, peritoneal or pleural liquid -Detergents, medicines
Central sterilization	Chemical	Toxic	Detergents.
Laboratories	biological, chemical and mixed	Infectious, toxic	Blood, sputum, urine, cerebrospinal fluid, reagents
Radiology	chemical and radiological	Infectious, toxic	Developers, fixers, silver tailings, hydroquinone, glutaraldehyde
Pharmacy	Chemical	Infectious, toxic	Products with mutagenic, teratogenic, carcinogenic properties
Morgue	biological, chemical and mixed	Infectious, toxic	Rinse water, formalin, alcohol
Hospitalization	biological, chemical and mixed	Infectious, toxic	Waters of wash basins, bath, the w.c, detergent, disinfectant, glutaraldehyde, mercury
Stomatology	biological, chemical and mixed	Infectious, toxic	Dental amalgam waste, blood, sputum
Dialysis	biological, chemical and mixed	Infectious, toxic	Citric Acid, acetic, Peracetic acid, hydrogen peroxide, chlorinated derivatives and aldehydes
Functional rehabilitation	Chemical effluents	Toxic	Disinfectant, detergent

We also evaluated the COD and BOD_5. BOD_5 is a parameter which measures the fraction of biodegradable organic pollution. COD is the amount of oxygen required to oxidize the organic matter chemically. According to our results, the rates of reduction of the organic loads are very low. These data reveal a malfunction of the treatment system and the low effectiveness of the station. The first study on this station by Toure in 1998 showed the same results.

Parasites contamination of liquid sludge from urban wastewater treatment station is an important source of pollution.(Schwartzbrod J and Banas S, 2003; Vassal S *et al* 1994., Rodier J, 2005; Naidoo S and Olaniran AO, 2013). Parasitological and bacteriological analyses conducted during this study show a low efficiency of the treatment of liquid biomedical wastewater. Touré, in his study in the same hospital in 1998 had also shown the presence of fecal coliforms and fecal streptococci as well as *Trichomonas hominis* larvae, eggs of *Schistosoma haematobium*, cysts *of Entamoeba histolitica*, at the entrance and exit of the treatment basin (Toure, 1998). These different organisms have been found at the entrance and exit of the basin in our study. This means that no progress have been made since 1998 to date. Although the choice of the biological treatment is well suited, the microbiological analyses had shown that biological treatment was poorly efficient. This constitutes a real threat for the health of populations because, the groundwater in Cotonou, the biggest city of Benin, where this hospital is located is easily reached by infiltration of wastewaters that are discharged in ground contact without any prior treatment (Adam K S and Boko M, 1993). The same observation was made in this hospital by Fagnibo (2012). In addition, according to the interview carried during this study, there was frequent rupture in chlorine bleach. The function of the station was also greatly disrupted by the failure of the maintenance of equipment. Of the two aerators installed, there was only one that has worked. Regular pump failures were the cause of overflow of effluent. A pollution of the soil is the result of this overflow. Furthermore, the sewage treatment capacity was estimated at 350 m^3 / day. This capacity is undersized considering the current needs of this hospital with over 700 beds (WHO, 1999).

Table 3. BOD and COD before and after treatment.

Days of sampling	Samples	Hours of collection	COD	BOD_5	% of reduction in the total organic loads (%COD)	%of reduction of biodegradable organic loads (%BOD_5)	COD/BOD
	Entry	9 h	1002	731			1.37
	Output	9 h	973	487	2.89	33,38	1.99
	Entry	1: 00 pm	1143	663			1.72
J1	Output	1: 00 pm	996	524	12.86	20.96	1.90
	Entry	5: 00 pm	1492	1148			1.30
	Output	5: 00 pm	1448	483	2.94	57,93	2.99
	Entry	09 h	1176	1069			1.10
	Output	09 h	1122	748	4.59	30.03	1.5
J2	Entry	1: 00 pm	1503	835			1.8
	Output	1: 00 pm	1231	615	18.10	26.35	2.00
	Entry	5: 00 pm	1209	834			1.44
	Output	5: 00 pm	1002	527	17.12	36,81	1.90
J3	Entry	09 h	1236	989			1.24
	Output	09 h	1103	710	10.76	28,21	1.55
	Entry	1: 00 pm	1584	880			1.8
	Output	1: 00 pm	1369	684	13.57	22,27	2.00
	Entry	5: 00 pm	1363	909			1.49
17 April 02	Output	5: 00 pm	1097	431	19.52	52.58	2.54

Considering the radiological effluent, a real risk exists. The liquids from this service using developers, fixers and rinse water are toxic for human and result into pollution for the environment. Direct observation at the morgue shows also direct discharge of untreated wastewater in urban pipelines. In developed countries, the technical requirements for the burial chambers recommends that effluent from

the preparation of the body room are separated and treated prior to discharge (CLIN Paris Nord, 1999). No rules or procedure on the subject in Benin regulates these services that are increasingly installed. The deterioration of the environment is a real challenge nowadays (Macy JT *et al* 2005). The management of the waste in the most hygienic and economical way by methods that minimize the risks for health and environment at all stages would be an important issue for low income countries (Billau, 2008).

Table 4. Number and classification of bacteria encountered at the entrance and exit of the basin.

Days of sampling	Dilution Rate	*Gram (-) bacteria*		*Gram (+) bacteria:*	
		Escherichia coli, Klebsiella pneumonia, Proteus mirabilis, Shigella spp.,Vibrio cholerae Salmonella spp.		*Staphylococcus aureus, Staphylococcus saprophyticus, StreptococcusbHemolytic Group A and Group B.Streptococcus Group D*	
		Entry	Output	Entry	Output
Day_1	$1/10^3$	103	102	105	-
Day_2	$1/10^4$	108	104	-	-
Day_3	$1/10^6$	TNC	TNC	-	-
Day_4	$1/10^8$	TNC	TNC	2.10^6	104
Day_5	$1/10^3$	-	-	-	-
Day_6	$1/10^3$	104	105	-	-

(-) = no colony; TNC = Colonies very numerous to be counted;

Conclusion

This assessment of the management of biomedical wastewater in CNHU-HKM allowed us to demonstrate various problems in the capacity of the wastewater treatment station. These problems are related to the design of the station as well as maintenance and functionality. Biomedical liquid waste is poorly managed in Benin. The management of biomedical waste in health facilities should aim the protection of patients, staff, and other users of the services (care givers, visitors) and respectful for the environment.

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