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Physico-Chemical, Microbiological and Toxicological Characterization of Effluents from the Hospital and University Center of Lomé

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Abstract Hospital anthropization generates biomedical waste which promotes the emergence and diffusion in the environment of chemical pollutants and antibiotic-resistant microorganisms. Hospital effluents could be doubly implicated by carrying antibiotics and multi-resistant bacteria. The objective of this work is to assess the risks to human health and the environment caused by these dangerous chemical substances and the antibiotic-resistant microorganisms present in these effluents. A sample of hospital liquid effluents was taken for analysis in order to map the different pollutants and determine the different risks. Effluent management was assessed in the health structure targeted by the project throughout the production chain until elimination. According to the results of the analysis of the elimination sector, the system for treating hospital and veterinary effluents to which is added the system based on the process of evacuating effluents through the drain connected to a watertight pit currently exist in the center. This is a system based on the septic tank effluent treatment process equipped with soakaways or sumps. It should be noted that the health facility does not have an effluent management facility. The physicochemical characterization of the effluents from the septic tanks studied are the pH which oscillates between 5.26 and 8.65. The variation noted in the pH measurements of hospital effluents is less than 1 pH unit. The COD/BOD5 ratio is 2.5<COD/BOD<5 and means that the effluents are not susceptible to biological treatment or requiring prior acclimation of the microorganisms involved. This COD/BOD5 ratio greater than 3 indicates pollution of industrial origin or the presence of toxic substances inhibiting biological activity. Ammonium NH_4^+ (0.41mg/l); BOD5 (48.09mg/l); COD (161.67 mg/l); MES (106.23) (106.23mg/l); Cd (0.007 mg/l); As (9.284 µg/L); Hg (0.2 µg/L) have a concentration in the effluents above the limit value with fairly significant microbial pollution. As a recommendation for better management of these effluents, a wastewater treatment and purification plant (STEP) was proposed.

Keywords: Biomedical waste, Risk, Toxicity; Health, Environment

1. Introduction

Hospital anthropization generates biomedical waste which promotes the emergence and diffusion in the environment of chemical pollutants and antibiotic-resistant microorganisms. Hospital effluents could be doubly implicated by carrying antibiotics and multi-resistant bacteria. Despite the risks associated with hospital effluent, very often, in Togo there are no legal requirements for the treatment of hospital effluent before its discharge into the municipal collector or directly into surface water after pretreatment. Indeed, in the majority of countries, it is impossible to find regulations concerning the management of hospital effluent and not even specific references in regulations referring to wastewater management in general. The only existing guidelines concerning hospital effluent are those of the World Health Organization (WHO) in 1999: "Safe management of healthcare waste" (WHO, 1999) and updated in 2014 (WHO, 2014). Hospital wastewater management could pose a risk mainly in developing countries, where the majority of healthcare wastewater, without prior or partial treatment, is discharged into surface waterways or underground aquifers by leaching. Through the discharge of untreated wastewater into the environment, the nutrient can lead to the proliferation of algae which will promote the production of potentially dangerous bacteria, for example cyanobacteria. Wastewater released uncontrolled into the environment can lead to several water-borne diseases that threaten human life, especially in developing countries.

Despite this effort and the existence of some initiatives in favor of good management of medical waste, current medical waste management practices in Togo do not always meet WHO recommendations. Indeed, health services in rural or urban areas inexorably generate waste which can be dangerous to health or have harmful effects on the environment. Some of these wastes, such as sharps, medical laboratory cultures, or infected blood, have greater infection and offensive potential than any other type of waste. Absence or poor management measures to prevent exposure to hazardous healthcare waste result in significant risks to the general public, inpatients and outpatients, and medical and service personnel. Additionally, improper treatment or disposal of healthcare waste, such as open incineration, can be a significant source of environmental pollution through the release of substances such as dioxins, furans or mercury. (Makoutoude,.al.1998). At the same time, they produce liquid effluents, polluted by pathogenic microorganisms, by radioelements and by chemical substances, some of which may have a poorly biodegradable nature.

The presence in the environment of chemical substances originating from hospital activities represents an important subject of research in the field of risk assessment for human health.

The most frequently encountered contaminants are pathogenic microorganisms (some of which are multi-resistant to antibiotics), heavy metals (Leprat, 1998; EPA, 1989), radioisotopes (Rodier, 1971; Erlandsson and Matsson, 1978), detergents (Deloffre-Bonnamour, 1995; EPA, 1989), organo-halogenated compounds (arising in particular from the action of bleach on organic molecules present in effluents) and drug residues (Richardson and Bowron, 1985; Gartiser et al., 1996). Some of these pollutants, particularly drug residues and organo-halogenated compounds, most often leave wastewater treatment plants with little degradation (Kümmerer, 2001).

The objective of this work is on the one hand to carry out a physicochemical and toxicological characterization and on the other hand to assess the risks contained in dangerous chemical substances and antibiotic-resistant microorganisms present in effluents from the University Hospital Center of Lomé (CHU –Campus).

2. Materials and Methods

Study Framework

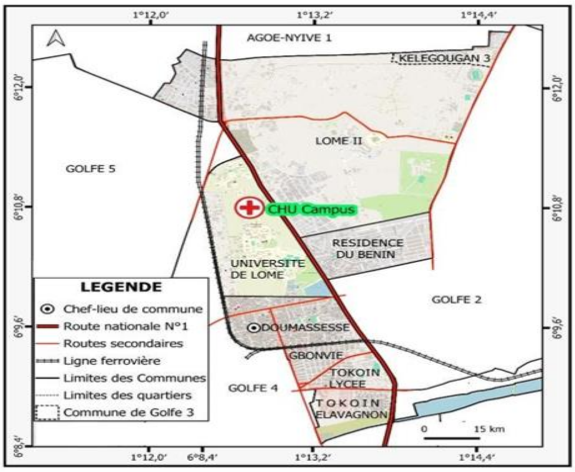

Image1: Geographical location of the CHU Campus of Lomé

Located on the university site of Lomé in its northern part, the University Hospital Center-Campus is located in district no. 5, on the edge of national road no. 1. It is limited to the South by the Faculty of Health Sciences and to the North by the Faculty of Economic and Management Sciences, to the East by national road no. 1 and to the West by Avenue de la Chance. It covers an area of 80,000 m². The CHU-Campus is a referral center for the national healthcare system. As such, it welcomes patients from all corners of Togo. The CHU-Campus has a capacity of 115 beds in 2022 while 172 beds were put into service during the same period.

Image1: Geographical location of the CHU Campus of Lomé

The CHU-Campus has several care services. We distinguish: The door service, internal medicine, pediatrics, hepato-gastroenterology, neurology, psychiatry and medical psychology, cardiology, speech therapy, clinical hematology, pediatric surgery, obstetric gynecology, ophthalmology, odontostomatology, traumatology, otolaryngology, dermatology-venerology, physiotherapy. The geological and hydrogeological study of the region where the hospital is located is mainly characterized by the presence of an aquifer of the Continental Terminal and which is the most exploited in the coastal basin, providing the city's drinking water supply. of Lomé. The flow is mainly intergranular and the aquifer is unconfined. The transmissivity is generally of the order of 10-3 - 10-2 m²/s. Storage is generally 1-8%. Drilling flow rates generally vary between 10 and 200 m³/h. The thickness of the aquifer varies between 20 and 80 m, the depth of the water table varies between 1.5 and 50 m, and boreholes are generally drilled to depths of 10 to 60 m. Affected by seawater intrusion due to overexploitation in the Lomé region, conductivity varies from 100 to 22,000 microSiemens/cm, chloride varies from 5 to 8800 mg/l, nitrates high (up to 700 mg/l) are also observed in the Lomé region, pH values vary between 4 and 7.3. Recharge occurs directly from precipitation.

The Continental Terminal aquifer in the coastal basin provides 70% of the public water supply to, through the Togolese Water Company (TdE). In addition to TdE boreholes, there are numerous industrial and private boreholes (estimated at around 2,500 in the Lomé region) which also exploit this aquifer in the Agoe plateau region. As a result, groundwater levels in the Continental Terminal aquifer decreased between 0.5 and 12 m. Salt intrusion is also a problem arising from overexploitation in the coastal region. The Ministry of Water Resources, which sits within the Ministry of Water, is responsible for monitoring groundwater. However, there is currently no national groundwater or groundwater quality monitoring program. (AFFATON P, RAHAMAN MA, TROMPETTE R and SOUGY J. 1991a).

The TdE remains the permanent source of drinking water supply via (02) two tarpaulins/tanks with a total capacity of 550 m^3 (250 m^3 and 300m^3) for an average duration of (03) three days; Thus 80% of this consumption is rejected in the form of effluent and the remaining 20% are considered losses.

This center was chosen on the one hand because the activities carried out in this center cover various disciplines, medical and medico-technical services and on the other hand because it offers a diversity of support. Charge of pathologies and one of the university research centers located at the university. The current hospital liquid waste management system does not meet environmental and health protection standards. This system can be summed up as an autonomous or individual system: septic tanks-sumps (equipped in places with a submerged pump with direct discharge) which can be drained by spiro trucks and which are difficult to cure manually. The emptying rate is twice for the year 2023. The discharge of the overflow from the pits is done directly in the enclosure behind the buildings and the emptying by trucks is transported in an unknown direction to be discharged into nature.

Material and Methods of Sampling

This was a cross-sectional study with descriptive and analytical aims on 18 samples of raw hospital effluent from septic tanks. The non-probabilistic method with the reasoned choice technique was used for the choice of septic tanks from the services to be sampled. The effluents from the services sampled were those which administered care and which produced more liquid waste, consequently presenting a greater risk of infection. The number of samples was determined on the basis of the number of septic tanks which receive effluent from healthcare services. The samples for physicochemical and heavy metals analysis were taken in plastic bottles of 1.5 liters for basic physicochemical parameters, 0.5 liters for heavy metals, rinsed three times with the effluent to be sampled and sterilized 0.5l bottles for microbiological parameters. The effluents were sampled between 7:30 a.m. and 12:30 p.m. over a period of 3 days for each phase. For filling the containers, we used an instantaneous manual sampling method. The pH measurements were used to collect the samples. Were carried out on all samples taken using this method. The containers, containing the samples from the points chosen for sampling, were carefully labeled and stored at 4oC. Once collected, they were transported in less than an hour to the various laboratories of the University of Lomé.

Data Processing and Analysis

It consisted of two parts: a first part which was devoted to laboratory analyzes and a second to statistical analyses. The laboratory analyzes were carried out in three Research Laboratories at the University of Lomé:

Laboratory Analyzes

 Physico-chemical analysis

In order to determine the state of physico-chemical quality of the effluents of the Campus University Hospital, we focused on parameters such as pH, Temperature, Electrical Conductivity, Ammonium (NH4+), Nitrates (NO3-), Total Chlorine (Cl-), biological oxygen demand (BOD5), chemical oxygen demand (COD), total phosphate (P), and total nitrogen, suspended solids (MES) in the applied hydrology laboratory and environment and metals.

 Heavy metal analysis

The analysis of heavy metals concerned the dosage of Lead, arsenic, Cadmium, Zinc, Copper, mercury and chromium. Heavy metals were analyzed with a flame atomic absorption spectrophotometer using the spectrometric method at the geochemical and environmental analysis laboratory.

 Microbiological analysis

Fecal coliforms, fecal streptococci, E. coli, sulfito-reducing anaerobes, Salmonella were analyzed by inoculation in culture medium in the microbiology and food control laboratory for microbiological parameters.

Statistical analysis

The various statistical analyzes were carried out using STATA, Sphinx and Excel software. The average concentrations of the parameters and their standard deviation were calculated and compared to the guideline values of the World Health Organization (2014). From the principal component analysis (PCA), the correlation between the different parameters and the classification of the sampling points according to the physicochemical parameters were established at the significance threshold $\alpha = 0.05$.

3. Results

Physico-Chemical Characterization of Hospital Effluents

The average concentrations of the physicochemical parameters of the CHU compared to certain standards are presented in Table 1. The results of the analyzes were compared to the WHO standard. Apart from pH, nitrates, chlorides, and phosphorus which complied with standards, all other parameters present values higher than the standards for wastewater discharge into the environment.

Table 1

N °	Settings	units	1	2	3	4	5	6	average	Min	Max	threshold	n
1	pH		7,05	6,75	8,65	6,85	6,65	6,98	7,16	6,65	8,65	6-9	6
2	T°C	°C	30,1	30,2	30,5	29,7	30,4	30,7	30,27	29,7	30,7	< 30	6
3	Cond	µS/cm	1995	1956	2223	2030	2240	2200	2107,33	1956	2240	< 2000	6
4	Amm NH4+	mg/L	0,7	0,06	1,4	0	0	0,3	0,41	0	1,4	0,2	6
5	NoO3	mg/L	0,9	0,4	17,9	0,7	0,95	1,8	3,78	0,4	17,9	50	6
6	Cl total	mg/L	0	0	57,6	0	0	0	9,6	0	57,6	200	6
7	DBO5	mg/L	200	38	4,5	40	4	2	48,09	2	200	30	6
8	DCO	mg/L	250	80	200	80	80	280	161,67	80	280	125	6
9	P total	mg/L	6,8	5,5	0,6	8,3	10,9	11,5	7,27	0,6	11,5	< 10	6
10	MES	mg/L	160	17,5	82,5	60	22,5	294,9	106,23	17,5	294,9	20	6

Toxicological characterization of hospital effluents

The average concentrations of heavy metals at the University Hospital are presented in Table 2. The concentrations of lead and cadmium vary from one septic tank to another with an average concentration of **0.025 mg/L** for lead and **0.007 mg/L** for cadmium. The CHU has a very high average value of cadmium, arsenic and mercury compared to the standard**.**

Table 2

N °	Settings	units	1	2	3	4	5	6	average	Mini	Max	threshold	n
1	Cd	mg/L	0,005	0,006	0,009	0,009	0,005	0,006	0,007	0,005	0,009	0,001	6
2	Pb	mg/L	0,022	0,01	0,005	0,064	0,01	0,036	0,025	0,005	0,064	0,5	6

3	Cr	mg/L	0,553	0,544	0,513	0,505	0,536	0,552	0,534	0,505	0,553	0,5	6
4	Cu	mg/L	0,02	0,001	0,011	0,005	0,017	0,054	0,018	0,001	0,054	0,5	6
5	Ni	mg/L	0,398	0,614	0,367	0,574	0,737	0,568	0,543	0,367	0,737	0,5	6
6	Zn	mg/L	0,214	0,116	0,094	0,121	0,058	0,325	0,155	0,058	0,325	2	6
7	As	µg/L	14,86	8,764	10,04	10,203	7,274	4,564	9,284	5	14,86	4	6
8	Hg	µg/L	0,588	0,05	0,05	0,05	0,411	0,05	0,200	0,05	0,588	0.03	6

Microbiological characterization

Apart from salmonella which does not exist in the center's effluents, the other parameters, Thermotolerant coliforms 44°, E. coli, Sulphite-reducing anaerobic, Fecal streptococci 37°c, Salmonella. Sp are beyond WHO recommendations.

Table 3

Settings	**units**	**1**	**2**	**3**	**4**	**5**	**average**	**Min**	**Max**	**threshold**	**n**
Thermotolerant coliforms 44°c	UFC/250	6000	8500	560000	110000	90000	154900	6000	560000	< 1	5
E. Coli	UFC/250	3600	1200	80000	60000	50000	38960	1200	80000	< 1	5
Anaerobic sulphite-reducing	UFC/50	4	2	1	1	1	1,8	1	4	< 1	5
Fecal streptococci 37°c	UFC/250	3200	3500	110000	5400	120000	48420	3200	120000	< 1	5
Salmonella. Sp	UFC/250	0	0	0	0	0	0	0	0	< 1	5

Analysis of health and microbiological risks.

For any ratio Cn/Nq<1 (Cn: concentration of pollutants in effluents; Nq: Discharge standard) and for any concentration of fecal coliforms NPP<1 per 100 mL, the danger (and therefore the risk) is considered negligible Conversely, for any Cn/Nq ratio > 1 and for any concentration of fecal coliforms NPP > 1 per 100 mL, the approach recommends moving on to the following stages of health risk assessment.

Settings	**units**	Max concentrations measured	**threshold**	ratio Cn/Nq
Toxicological				
Cd	mg/L	0,009	0,001	> 1
Pb	mg/L	0,064	0,5	< 1
Cr	mg/L	0,553	0,5	> 1
Ni	mg/L	0,737	0,5	> 1
As	µg/L	14,86	4	> 1
Hg	µg/L	0,588	0.03	> 1
Microbiological				
Thermotolerant coliforms 44°c	UFC/250	560000	< 1	> 1
E. Colis	UFC/250	80000	< 1	> 1
Anaerobic sulphitereducing	UFC/50	4	< 1	> 1
Fecal streptococci 37°c	UFC/250	120000	< 1	> 1

The effluents present health risks in relation to cadmium, chromium, Nikel, arsenic and mercury and also contain microorganisms which are illustrated by the fecal contamination indicators.

4. Discussion

Status report on the effluent management system at the Campus University Hospital

The current hospital liquid waste management system does not meet environmental and health protection standards. This system can be summarized as an autonomous/individual system: septic tanks-sumps (equipped in places with a submerged pump with direct discharge) which can be drained by spiro trucks and which is difficult to cure manually. Given the quantification estimates, the microbiological and physicochemical characterization of this water, the disadvantages linked to this type of management of hospital effluent within the Campus University Hospital are multiple:

- Nauseous odors;
- Proliferation of disease breeding grounds;
- Risks of clogging of the walls of septic tanks-sumps leading to the poor functioning of these structures

Analysis of physicochemical parameters

This study showed the physicochemical, toxicological and microbiological quality of the effluents produced by the University Hospital Campus of Lomé and the inherent effects that it can pose on the receiving environment. According to the physicochemical characteristics, the hospital effluents collected revealed that only pH, nitrates, total chlorine, and phosphorus had average values consistent with the standards for wastewater discharge into the environment. In certain septic tanks we note the existence of chlorine, proof of absence of treatment of the effluents dumped into its tanks.

Ammonia, a nitrogen compound found in its effluents above the standard with a maximum concentration of 1.4 mg/l, constitutes a significant threat. The discharge of these effluents with high levels of ammonia into the ecosystem can trigger eutrophication, a phenomenon characterized by an overabundance of nutrients that stimulates excessive growth of plants and algae. As a result, the oxygen level in the water decreases, endangering aquatic life, and disrupting the delicate balance of the ecosystem. The results are similar to works in the literature which also reported that liquid discharges from the hospital environment are very loaded with chemical pollutants and pathogenic germs and therefore constitute a threat to the environment and health (Berrada et al., 2014 ; Ike et al., 2017; El Mehdi et al., 2013; Aissi et al., 2013; 2014). Thus, the study carried out by Ike et al. (2017) in Nigeria showed that the values of measured physicochemical parameters are high in hospital effluent samples, and all values are above the Nigerian regulatory standards for wastewater discharge into the environment, except for the temperature which has a value below the standards. Conductivity makes it possible to assess the degree of mineralization of hospital effluents. These discharges have on average a fairly high degree of mineralization (2107.33 µS/cm).

The results showed that the effluents are very loaded with pollutants and constitute a threat to the environment and health. BOD5 is a parameter which makes it possible to evaluate the fraction of biodegradable organic matter. The ratio of 2.5 <COD/BOD<5 means that the effluents are not likely to undergo biological treatment or require prior acclimatization of the microorganisms involved. This COD/BOD5 ratio greater than 3 indicates the presence of toxic substances inhibiting the biological activity that can treat the effluents. According to a study (Boillot, 2008) the parameters are significantly higher than those observed at the treatment plant. This highlights significant organic pollution. In another study (Baurès et al. 2007), the low biodegradation capacity of hospital effluent (COD/BOD = 4-5) is highlighted, similar to our study. This is due to high COD values, explained by the use of specific products. The high conductivities show effluents rich in mineral matter.

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Analysis of Heavy Metals

Metals accumulate in the body and cause short- and/or long-term toxic effects. They can affect the nervous system, kidney, liver, respiratory, cardiovascular functions, etc. Lead is a well-known neurological toxicant responsible for lead poisoning. Hospital water can be contaminated by heavy metals (mercury, silver, chromium, nickel, cobalt, etc.) and by organic molecules (solvents, antibiotics, disinfectants, detergents, drugs, etc.). Our study presents pollution of all heavy metals (Mercury, Chromium, arsenic, cadmium, Nickel) analyzed except Lead.

The study presents high toxicity of mercury effluents with a contamination index of 19.6. The absence of treatment would constitute a real danger for health and the environment. Severe and prolonged methylmercury poisoning, such as that occurring in Minamata Bay, causes disruption of the central nervous system, causing joint atrophy, severe cognitive loss, blindness, paralysis and death (Olivier, 2009). For the fetus, or young children, the main effect of methylmercury contamination is impaired neurological development (USEPA, 2014a). Our results are above the results of a sampling campaign conducted in 2001 by the government of Nova Scotia on effluent from 17 hospitals in the province. This campaign demonstrated that total mercury concentrations in hospital wastewater ranged from 0.0064 to 1.6 µg/l with an average concentration of 0.10 µg/l and an average load per hospital of 65.3 g /year (Nova Scotia Environment and Labor (NSEL), 2014).

Arsenic, a metal also whose concentration in the effluents analyzed was high, a concentration of 9.284 µg/L on average and up to more than 14 µg/L as a maximum. The use of arsenic for therapeutic purposes was gradually abandoned during the second half of the 20th century. Only the arsenic of thermal waters continued to be used for healing, and even today, the thermal water of La Bourboule, particularly rich in arsenic (6 to 7 mg/l), is still renowned for the treatment of ailments. Respiratory problems, particularly asthma in children and adults, and as such receives more than 8,000 spa guests per year (Boudène, 2001). An oral dose for humans of 110 mg of inorganic arsenic, present for example in contaminated drinking water, corresponding to a concentration of 1 to 2 mg/kg of body weight, is potentially fatal (Testud, 1998). Thus, the LD50 (lethal dose which causes 50% death in a population) of As (III) is 1 mg/kg in humans and places this substance in the "Super toxic" class of the scale of Gosselin et al. (1984). Arsine, very volatile, is considered the most toxic arsenic compound: concentrations above 250 mg/kg cause almost instantaneous death and even brief inhalation of 100 mg/kg causes death in the 30 minutes (Testud, 1998). The WHO (World Organization for Health) proposes a maximum admissible daily dose of inorganic arsenic of 2 µ/kg for humans, with a maximum of 150 µg/kg (Lenoble, 2003).

Extraordinary concentrations of Cadmium, Nikel and Chromium were observed according to our results obtained and can cause harmful effects on health and the environment.

Analysis of Microbial Parameters

On a microbiological level, the concentrations of control germs are lower in hospital effluents than in urban effluents, which is probably linked to higher concentrations of disinfectants and antibiotics. We find on average between 104 and 106 germs/mL. Our results show similar concentrations ranging from 120,000 to 560,000 microbial pollution indicators.

To properly assess the microbial quality of hospital effluent, let us first assess the hospital flora: it is made up of the flora of patients and germs from the environment (soils, surfaces, materials, water (legionella), air, etc.) .Thus, the pathogenic germs found in hospital wastewater can be: bacteria present in stools or urine (Salmonella, Shigella, Coliforms, Vibrios, Streptococci, Enterobacteria, etc.) or bacteria responsible for nosocomial infections (Staphylococci, Streptococci, Pseudomonas, etc.). All of these bacteria are dangerous because they acquire resistance to antibiotics.

Strictly pathogenic infectious agents are responsible for contagious infections. They come from patients with tuberculosis, chickenpox, meningococcal infections, salmonellosis or AIDS, etc. The commensal flora exists in all individuals and is composed of bacteria that can be responsible for opportunistic, community or nosocomial infections that are not contagious but transmissible (Staphylococcus). It is subject to a certain variability, notably through the acquisition of resistance to antibiotics. Saprophytic agents (living in a host without causing disease) are mainly bacteria or fungi responsible for almost exclusively nosocomial opportunistic infections. Certain bacteria have been identified as being more concentrated in hospital water (Schlosser, 1999): Pseudomonas aeruginosa (more than 10 times higher in hospital effluent) and pathogenic staphylococci.

Pathogenic varieties of Salmonella are dangerous because they are very resistant to antibiotics, but they are generally more common in urban wastewater

5. Conclusion

Most physicochemical parameters exceed accepted standards. This shows that these effluents pose enormous risks to living organisms in natural water reserves. This result can be explained by the strong medical activity which is carried out at the university hospital level and by the absence of correct treatment of these effluents produced by this hospital center. This wastewater is therefore characterized by high organic loads resulting from the series of hospital practices. Hospital wastewater is not treated before disposal into the environment, thereby posing serious health risks and other environmental threats among surrounding residents.

Ultimately, it is within the hospital itself that the fate of liquid waste must be taken care of, in particular by raising staff awareness of the impact of its discharges and by organizing the sorting and collection at the source of waste presenting the highest risks.

However, it is certainly at the level of direct discharge to the sink that the majority of problems can be solved. An independent wastewater treatment plant specific to the hospital establishment is therefore justified given the nature of the effluent to be treated. It then appears more than necessary to develop methods for treating these effluents before their discharge into the natural environment while awaiting the establishment of a WWTP.

6. Contribution of Authors

Role of the contributor	Author names
Conceptualization	Laounwi LAKMON
Data management	Laounwi LAKMON
Formal analysis	Daouda SAMA
Investigations	Laounwi LAKMON
Methodology	Laounwi LAKMON
Supervision and validation	Kissao GNANDI
Writing -Preparation	Laounwi LAKMON
Writing-Revision	Daouda SAMA

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