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Toxic potential evaluation of liquids effluents discharged into nature by the university hospitals centers (UHC) and mixed wastewater treatment station (WWTS) at Ouagadougou-Burkina Faso

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Research Article

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Abstract

Introduction: In Burkina Faso, several investigations have raised suspicions that hospital liquid effluents are the source of contaminants in porbeagle-culture products and surface water in urban and peri-urban areas. This study aimed to evaluate the Hygienic quality of hospital liquid effluents discharged into nature by the UHC Bogodogo (UHC-BOG), Yalgado Ouédraogo (UHC-YO) and the WWTS of Kossodo (WWTS-KOS).

Methodology: 15 samples of liquid effluents (five per site) discharged into nature were collected. Within the physicochemical parameters, the COD, BOD₅, TSS, conductivity, copper, iron, hafnium, silver, mercury, lead and cadmium of these samples were determined using standards methods.

Results: The mean values of conductivity were 1956.80±81.30, 812.80 ±45.22 and 956.00 ±39.96 μ S/cm for WWTS-KOS, UHC-BOG and UHC-YO respectively. TSS were 338.20± 38.80, 45.00 ±5.79 and 187.80 ±27.58 mg/L respectively. COD were 274.80 ± 20.46, 35.00 ±5.52 and 139.80 ±25.53 mg/L respectively. BOD₅ were 186.40 ±68.68, 26.20 ±4.82 and 81.80 ±15.63 mg/L respectively. Mercury were 1.93±0.38, 4.04±0.38 and 14.37±1.65 μ g/L respectively. Lead were 434.70±202.42, 310.50±4.09 and 367.43±94.01 μ g/L respectively. Cadmium 79.59±19.48, 109.94±8.43 and 80.26±7.85 μ g/L respectively. Copper were 27.66±3.33, 30.84±1.65 and 28.32±2.36 mg/L respectively. Iron was detected only on the STEP-KOS with an average of 71.01±37.83 mg/L. Hafnium were 50.27±4.49 and 51.58±4.61 mg/L for WWTS-KOS and UHC-BOG respectively. Silver were 34.26±3.06 for WWTS-KOS.

Conclusion: Liquid hospital effluents from Ouagadougou discharged into nature on the whole do not respect the Burkinabè normative values for the discharge of wastewater into the environment. On the three sites, the differences found where significant (p<0.05)

Introduction

Hospital activities are anthropological and generate large quantities liquid effluent that can affect environmental hygiene quality (Emmanuel et al., 2009). Indeed, medical activities permanently require water for various cleanings in order to achieve adequate hygiene of premises, care materials, patients and caregivers in addition to the application of detergents, disinfectants and care products (El-Ogri et al., 2016). These waters could be very loaded with micro-pollutants, of which metallic trace elements and antibiotic residues would occupy the first ranks (Akin, 2016). As for metallic traces elements (MTE) such as mercury, copper, cadmium and lead, their presence in hospital liquid effluents has been reported by several investigations around the world (Kishor et al., 2021; Todedji et al., 2020). Thus, poor management of hospital liguid effluents before their discharge into nature, will make these effluents sources of contamination with MTEs in the receiving areas (Basturk et al., 2020). Indeed, some MTEs such as mercury or cadmium, even in low concentrations, would be very harmful substances for human or animal health and would impact the balance of biological diversity. However, in developing countries, very few measures are generally taken for effective treatment and micro-pollutants reduction in hospital liquid effluents. In addition, some hospitals directly discharge their liquid effluents into nature without any prior treatment (Emmanuel et al., 2009; Guessennd et al., 2013). In sub-Saharan Africa, the management and availability of fresh water are daily concerns in most countries (Laffite et al., 2016). The scarcity and the very high cost of drinking water have led to the choice to develop market gardening activities, less intensive fishing, livestock watering around wastewater generated by urban activities (Dao et al., 2018). However, poor management of the physicochemical and microbiological parameters of this wastewater before its disposal in nature, could generate serious consequences for users (Guessennd et al., 2013). Burkina Faso is a landlocked country in West Africa and its water management is handled by ONEA (National Office for Water and Sanitation). ONEA has a few wastewater WWTS in major cities. At these sites, certain parameters such as COD, BOD₅, pH, temperature and conductivity of liquid effluents are performed routinely before their release into nature. On the other hand, micro-pollutants such as MTE are not controlled in the landfills of these sites. The largest site is that of WWTS of Kossodo which receives liquid effluent from certain hospitals in Ouagadougou, the refrigerated slaughterhouse, breweries and certain households. In addition to ONEA sites, some hospitals care of the treatment of their own liquid effluents before discharging them into nature. Among these centers, the UHC of Bogodogo and UHC Yalgado Ouédraogo located in Ouagadougou, have the largest reception capacities of approximately 783 beds (Madougou, 2010). These two centers generate

large quantities of wastewater in nature for which no official data is available according to our knowledge. However, several investigations carried out on market gardening products and piped water in Burkina Faso, have raised suspicions that contaminants of hospital origin are the bases of the contamination of these matrices (Kagambèga et *al.*, 2017; Traoré et al., 2015; Nitiema et al., 2013). The purpose of this investigation was to provide the first information on the diversity of metallic traces elements hosted by liquid discharges from UHC and WWTS-KOS generated in the nature of Ouagadougou city. Thus, the objective was to determine the physicochemical parameters of the liquid effluents of UHC-BOG, of UHC-YO and of WWTS-KOS by comparing the results with the data of the environmental code of Burkina Faso.

Materials And Method

Sampling

The samples were taken during two sampling campaigns with the support of the ONEA Paspanga sampling team. The first campaign took place between October 2019 and February 2020 and the second from June to October 2020. These samples took place on the UHC-YO, UHC-BOG and WWTS-KOS sites. Table I presents the geographic coordinates of the various sampling sites.

Table 1 Geographical coordinates of sampling sites						
Activities	Latitudes (North)	Longitude (West)				
Wastewater sampling	UHC-YO	12°22'57.6206"	-1°30'20.7072"			
	UHC-BOG	12°20'2.6901"	-1°29'39.7428"			
	WWTS-KOS	12°25'36.4220"	-1°28'51.3260"			

A total of fifteen samples of liquid effluents were collected on the three sites due to five samples per sampling site. The samples were packaged in one liter bottles before being transported in a cooler to the laboratory. The bottles were washed well beforehand, rinsed with 12% hydrochloric acid and distilled water then rolled up in aluminum foil before being autoclaved.

Determination Of Conductivity, Suspended Solids (Tss), Biochemical Oxygen Demand (Bod) And Chemical Oxygen Demand (Cod)

These analyzes were carried out at the ONEA wastewater analysis laboratory. The conductivity of the samples was determined using a thermo orion-star 322-premium portable conductivity meter. As for the content of suspended matter, it was determined according to the NF EN872 (2005) method. In addition to these physicochemical parameters, others such as BOD₅ and COD were determined according to ISO 5815-1 (2003) and ISO 15705 (2002) respectively. Thus, BOD₅ measurement was made by method based on the principle of the WARBURG respirometer during which the respiration of the biomass is directly measured by a device for five (5) days. The BOD₅ was determined by the expression BOD₅ = value read X factor. This factor was chosen from the reference table (Additional room). In this study the chosen factor was 5 with a test portion of 250 mL of the sample.

Determination Of Metallic Trace Elements

Copper, iron, silver and hafnium were measured by X-ray fluorescence spectrometry. The device used was the EDX-7000 type (SHIMADZU®). It is a Wavelength Dispersive X-ray Fluorescence Spectrometry (WD-XRF) spectrometer. It allows the analysis of chemical elements in concentration ranges from a few ppm to 100%. As for mercury, cadmium and lead, they were quantified by adapted method that used by (Pauwels et al., 1992). Thus cadmium and lead were assayed by titrimetry with a 0.02mol/L EDTA solution. The mass concentrations of the latter were determined by the following formula: $Cm(ETM) = [C_{EDTA} X V_{EDTA} / V (solution)] X M(ETM)$ where Cm(ETM) and M(EDTA) are respectively the mass concentration and the molar mass of the metallic trace element measured, C_{EDTA} and V_{EDTA} are concentration and volume of the EDTA solution respectively and V (solution) is the volume of the test portion of the solution to be titrated. On the other hand, Mercury was measured by visible UV spectrometry at a

wavelength of 420 nm using a calibration curve established using the function "Changer mode" by fixing the absorbance using the function "Fixer nm".

Statistical Analyzes

Sphinx V5 software was used for data processing. Means and standard deviations were compared by Student's t-test with a risk p < 0.05. Principal component analysis was performed using the correlation matrix.

Results

Results of Analysis of Conductivity, TSS, COD and \mbox{BOD}_5 of Liquid Effluents

During the two sampling campaigns, fifteen samples were collected, including five per site for chemical analysis. The conductivity values in μ S/cm (Table II) of the liquid effluents had means 1956.80 ± 81.30 μ S/cm, 812.80 ± 45.22 μ S/cm and 956.00 ± 39.96 μ S/cm for WWTS-KOS, UHC-BOG and UHC-YO respectively. The mean conductivities of UHC-BOG and UHC-YO showed no significant difference. However, they were different from the mean conductivity of WWTS-KOS (p < 0.05). High correlation rates were observed between the conductivities of the different sites and the other parameters (Table III). The suspended solids means were 338.20 ± 37.80 mg/L, 33.80 ± 5.79 mg/L and 187.80 ± 27.53 mg/L respectively at WWTS-KOS, at UHC-BOG and UHC-YO. The averages of TSS measured in the three sites were significantly different (p < 0.05). The variation of TSS values showed high correlation rates (98%) with COD and BOD₅ values (Table III). For COD, the mean values determined were 274.80 ± 20.46 mg/L, 35 ± 5.52 mg/L and 139.80 ± 25.53 mg/L respectively in the liquid effluents of the WWTS-KOS, UHC-BOG and UHC-YO. Statistical analyzes showed that the COD means of the three sites were significantly different (Table II) with p < 0.05. The COD variations on the different sites presented high correlation rates of 89–99% with the other parameters studied (Table III). As for BOD₅ measurements, the means were 186.40 ± 68.68 mg/L, 26.20 ± 4.82 mg/L and 81.80 ± 15.63 mg/L respectively at WWTS-KOS, at UHC-BOG and UHC-YO. However, the COD/BOD₅ ratios were 1.47, 1.33 and 1.70 respectively at WWTS-KOS, at the UHC-BOG site and at the UHC-YO site.

Sites Samples code		Conductivity		TSS (mg/L)		COD (mg/L)		BOD ₅ (mg/L)	
		(μS/cm)							
		Measured values	Averages generated	Measured values	Averages generated	Measured values	Averages generated	Measured values	Averages generated
STEP- KOG	KOS 1	2050	1956.80 ± 81.30 ^a	350	338.20 ± 38.80 ^a	303	274.80 ± 20.46 ^a	302	186.40 ± 68.68 ^a
	KOS 2	1890		310		290		188	
	KOS 3	1908		309		258		169	
	KOS 4	1895		299		264		126	
	KOS 5	2041		323		259		147	
CHU- BOG	BOG 1	789	812.80 ± 45.22 ^b	48	45.00 ± 5.79 ^b	38	35.00 ± 5.52 ^b	48	26.20 ± 4.82 ^b
	BOG 2	850		45		39		45	
	BOG 3	754		49		29		49	
	BOG 4	806		35		29		35	
	BOG 5	865		48		40		48	
CHU-	YO 1	939	956.00 ± 39.96 ^b	180	187.80 ± 27.58 ^c	151	139.80 ± 25.53 ^c	98	81.80 ± 15.63°
YU	YO 2	1002		195		139		76	
_	YO 3	900		201		123		92	
	YO 4	954		145		110		58	
	YO 5	985		218		176		85	

Table 2 Parameters Conductivity, TSS, COD and BOD₅

Legend

The values in the table are the directly measured values, the means generated and the standard deviations calculated without taking non-responses into account. The letters a, b and c correspond to means by category that are significantly different (t-test) from the entire sample (at the risk of 95%).

Table 3
Correlation coefficients between the averages of
conductivity, suspended solids, COD and BOD ₅
parameters of the sites

	Conductivity	TSS	COD	BOD_5
Conductivity	1.00			
TSS	0.91	1.00		
COD	0.89	0.98	1.00	
BOD ₅	0.91	0.98	0.99	1.00

Results Of Metallic Trace Elements Determination

Analyzes of the 15 samples revealed several MTE including copper, iron, silver, hafnium, mercury, cadmium and lead. However, copper, mercury, lead and cadmium were the most frequently detected in the samples, followed by iron, hafnium and silver. Table IV represents the mean assay values of the various MTE characterized in the 15 samples. As for table V, it shows the limit values of the MTE not to be exceeded in the liquid landfills intended to be evacuated in nature according to the decree N°2015/1205/PRES/TRANS/PM/MERH/MEF/MARHASA/MS/MRA/MICA/MME/MIDT/MATD. Copper was detected at 8.02 keV whose copper contents varied from 24.29 mg/L to 32.85 mg/L at WWTS-KOS site, from 28.46 mg/L to 32.65 mg/L at UHC-BOG site and from 26.38 mg/L to 31.76 mg/L at UHC-YO effluents. As for iron, it was detected at 6.40 keV and only at the WWTS-KOS site (Fig. 1C). Its contents varied from 23.68 mg/L to 166.82 mg/L. Hafnium was detected at 7.88 keV in two samples, one sample from the WWTS-KOS site and the other from the UHC-BOG (Fig. 1D) with respective values of 50. 27 mg/L and 51.58 mg/L. As for silver, it was detected at 22.10 keV in a single sample from WWTS-KOS (Fig. 1E) with a content of 34.29 mg/L. Images 1A and 1B represent the detection spectra of the standards used in the EDX-7000 device.

Table 4							
Sites	Hg (µg/L)	Cd (µg/L)	Pb (µg/L)	Cu (mg/L)	Fe (mg/L)	Ag (mg/L)	Hf (mg/L)
WWTS- KOS	1.93 ± 0.38ª	79.59 ± 19.48 ^a	434.70 ± 202.42 ^a	27.66 ± 3.33ª	71.01 ± 37.83	34.26 ± 3.06	50.27 ± 4.49 ^a
UHC-BOG	4.04 ± 0.38 ^b	109.94 ± 8.43 ^b	310.50 ± 40.91ª	30.84 ± 1.65 ^a	-	-	51.58 ± 4.61 ^a
UHC-YO	14.37 ± 1.65 ^c	80.26 ± 7.85 ^a	367.43 ± 94.01 ^a	28.32 ± 2.36 a	-	-	-

Legend:

- The values in the table are the means and the standard deviations calculated without taking into account non-responses.
- The names of the discriminating criteria are framed.
- The letters **a**, **b** and **c** correspond to means by category that are significantly different (t-test) from the entire sample (at 95% risk).

In Burkina Faso, the ministry in charge of water and the environment has determined normative levels for MTE in the different types of liquid discharges in nature. Thus, table V presents the limit contents decreed by the decree.

Table 5

Burkinabè Normative Values on MTE in wastewater intended to be discharged into nature set by the decree N°2015/1205/PRES/TRANS/PM/MERH/MEF/MARHASA/MS/MRA/MICA/MME/MIDT/MATD

Metallic trace elements	Limit values
Mercury (Hg)	0,05 mg/L
Cadmium (Cd)	1 mg/L
Lead (Pb)	2 mg/L
Copper (Cu)	2 mg/L
Iron (Fe)	20 mg/L
Silver (Ag)	Not mentioned
Hafnium (Hf)	Not mentioned

Discussion

The averages of effluents conductivity of two UHC complied with the Burkinabe standards which set the values of the maximum conductivity at 1000 µS/cm of the wastewater authorized to be discharged into the environment (Gouvernement BF, 2015). However, this limit value of 1000 µS/cm was largely exceeded by the WWTS-KOS conductivities. Kakou (2021) had reported an average of 1855.71 µS/cm of the conductivities of the WWTS-KOS site, which is close to the average of the conductivities found in this study (Kakou, 2021). These high conductivity values at the WWTS-KOS could be explained by the reception of other discharges such as those from the breweries and the slaughterhouse in addition to the liquid effluents from certain hospitals in Ouagadougou. Indeed, the discharges from the breweries and the slaughterhouse would be highly charged with a variety of ions which would increase the electrolyte power of the liquid effluents from Kossodo. Thus, the high dissolved ionic load (calcium, chlorine, nitrate, etc.) of a liquid effluent would be a limit to certain metabolic reactions of the aquatic population and would have a negative impact on the biodiversity of the areas receiving this effluent (Almakki et al., 2019). In addition, a correlation of 91% between the averages of the conductivities and the TSS of the various sites was noticed and would be explained by the induction of the conductivity largely by mineralizable contaminants in suspension such as phosphate, ammonia, nitrite, nitrate, total nitrogen, chloride, sulfate(Almakki et al., 2019). An average of 45.00 ± 5.79 mg/L of the TSS of the UHC-BOG liquid effluents was also recorded. This average complied with the TSS values < 150mg/L of the Burkinabé recommendations of the decree (Gouvernement BF, 2015). This was not the case for the liquid effluents from the WWTS-KOS and the UHC-YO where the TSS averages were respectively 338.20 ± 38.80mg/L and 187.80 ± 27.58mg/L. These values which exceeded the maximum value set by Burkinabe standards. At WWTS-KOS site, Kakou (2021) had reported that the average TSS was 255.71 mg/L. Elsewhere in India, Bhatt et al. (2020) reported TSS values for hospital effluents and mixed WWTS effluents, the averages of which were respectively 101, 67 ± 26.54 mg/l and 420 ± 12.77 mg/L. The high load of TSS from mixed WWTS would be more impacted by domestic landfills rich in insoluble and non-volatile food residues, also by landfills from other structures such as slaughterhouses where most of the faeces, hair or bones remain in suspense (Bhatt et al., 2020). As for the high average discharges of the UHC-YO, it would be explained by the lack of treatment device as at the UHC-BOG. Moreover, TSS variation would strongly impact COD and BOD₅ parameters. Statistical analyzes of the results of this study showed correlations of 99% between the average TSS and COD on the one hand and that of BOD_5 on the other hand (p < 0.05). Indeed, the sedimentation of suspended solids leads to residues that can be oxidized by the chemical route (COD) or by the biological route (BOD₅) (Gholamreza et al., 2021). However, the increase in the TSS load of liquid effluents promotes the proliferation of pathogenic bacteria and/or bacteria that are indicators of water pollution (Fawaz et al., 2014). The determination of the COD of the liquid effluents of the UHC-BOG and the UHC-YO showed averages of 35.00 ± 5.52 mg/L and 139.80 ± 25.53 mg/L respectively. These values were lower than the maximum COD value recommended by the decree

N°2015/1205/PRES/TRANS/PM/MERH/MEF/MARHASA/MS/MRA/MICA/MME/MIDT/MATD. On the other hand, the average COD of liquid effluents from the STEP-KOS was well above the value recommended by the same decree. On this last site, Karou (2021) had reported an average of 744.83 mg/L of COD measured. Somewhere else, Sarizadeh et *al.* (2021) and Sarafraz et al.

(2007) reported averages of 521 mg/L and 628.10 ± 244.7 mg/L of COD in Iranian hospitals liquid effluents, respectively, which were significantly higher than the averages found in this study (Sarafraz et al., 2007). Indeed, the high COD values of a liquid effluent would contribute to anoxia phenomenon in environment and in receiving zones(Emmanuel et al., 2009). Thus, anoxia would promote the establishment of fermenting respiration, the development of sulphur-reducing organisms and limit the growth of aerobic organisms (Álamo et al., 2020). The excessive COD values of the WWTS-KOS are largely explained by the contribution of sediments from landfills of animal slaughtering units, breweries and households in the city of Ouagadougou. In hospital effluents, the sediments resulting from the discharges of the canteens and the activities of the accompanying patients, would have the large contribution to increase the values of the COD, the BOD₅ or the TSS (Gholamreza et al., 2021). In this study, the low COD values of the effluents of the UHC-BOG would also be due to the pre-treatment device that this center has but which operated at around 60% according to the managers of the hygiene service of the UHC-BOG (2019-2020). The ratios of the COD by the BOD₅ showed values lower than 2. This explains why the large part of the residual contaminants of the liquid effluents would be biodegradable (Basturk et al., 2020). Metallic trace elements including mercury, lead, cadmium, iron, copper, hafnium and silver were also detected in the same liquid effluents. Overall, levels of MTE were less those set by the Burkinabè standards for the discharge of wastewater into nature except those copper and iron. Like our study, some authors including Todedji et al. (2020), Touré et al. (2016), Beyene & Redaie (2011) had highlighted also the MTE in hospital liquid effluents. However, similar findings on the identification frequencies of MTE including lead, cadmium, mercury and copper have been observed. Indeed, MTE in hospital effluents can have several sources, including the equipment or care products used, the pathology products of patients and even hospital staff, certain household appliances in the various departments and the pipes within the structures hospital (Khan et al., 2020; Garnier, 2005). However, modern antimicrobials have largely replaced therapeutic products based on trace metals in the treatment of infections, the use of therapeutic complexes containing MTE such as platinum, copper, zinc or silver in the hospital setting is still topical. Thereby, Navarro et al. (2010) have reported pharmaceutical products including cisplatin, auranofin, pentostam, metallointercalator, ruthenium chloroquine or ferroquine which are complexes with MTE and used for the fight against malaria, leishmaniasis, cancers, rheumatoid arthritis (Navarro et al., 2010). Humans, like other animals, are placed at the top of the food chain so they are large accumulators of MTE such as mercury, cadmium or lead, which they can also eliminate on a small scale through urine or stool or even blood during operation sessions (Hu et al., 2018; Steckling et al., 2017). In hospitals, these pathological products are easily found in often very high quantities in hospital liquid effluents and also contribute to increasing the levels of MTE in these effluents (Toure et al., 2016; Liu et al., 2019). In addition, cleaning solutions such as disinfectants or detergents and also dyes can be sources of MTE including lead, cadmium. Mercury could come from amalgam fillings, dental plates, mercury thermometers and certain alloys such as light bulbs. As for copper, its antiviral, antibacterial and antifungal properties have made it one of the most used MTE to limit nosocomial infections. However, its presence in the effluents could be explained first by the discharge of copper residues used to impregnate latex gloves (concentration that can reach 3%) or protective masks against the influenza virus or applied to certain materials of blood transfusion or socks against plantar mycosis (Borkow et al., 2010; Borkow & Gabbay 2004). Despite the levels of MTE in hospital effluents often seem low, it should be noted that these effluents are discharged daily in urban and peri-urban areas. Indeed, hospitals would be sources of contamination of large urban centers with MTE. However, the discharge into nature of liquid effluents contaminated by MTE could have serious consequences on biodiversity of receiving environments and on users of these effluents (Gomaa et al., 2021; Lutterbeck et al., 2020). These consequences occur following long periods of exposure and accumulation to MTE. For example, prolonged exposure of bacteria to non-bactericidal concentrations of MTE would cause the acquisition of genetic materials such as the staphylococcal cassette chromosome, plasmids or integrons that can harbor both MTE and antibiotic resistance genes (Liu et al., 2019; Lutterbeck et al., 2020; Gao et al., 2015; Alam et al., 2020; Funaki et al., 2019). Wang et al. (2020) reported the particular case of copper in China. They demonstrated that exposure of bacteria in an aquatic environment would be an accelerating factor in conjugation in these strains for exchanges of both resistance genes to MTE and to antibiotics. In addition, MTE would affect the nervous system, renal, hepatic and respiratory functions in humans (Hu et al. 2018; Cai et al., 2020; Yazbeck et al., 2007; Nourdine et al., 2020; Yehouenou et al., 2020). Even at low concentrations, some MTE including Hg, Cd, Pb and Cu inhibit photosynthesis and phytoplankton growth (Yehouenou et al., 2020). They would cause a delay in the development of embryos, malformations and poorer growth of adults in fish, molluscs and crustaceans copper (Rodrigues et al., 2022; Janani et al., 2020; Luo et al., 2020). However, incidences to copper in particular rarely occur because its redox potential allows it to play an important role in reactions with electron transfer in the body where a copper deficiency would cause alterations in energy production, changes in the glucose and cholesterol metabolism(Uriu-Adams & Keen 2005) (45).

Conclusion

This study focused on determining the physico-chemical quality of liquid effluents directly discharged into the city of Ouagadougou by WWTS-KOS, UHC-BOG and UHC-YO. The analyzes revealed values of the conductivity, the COD, the BOD5 and the MES from WWTS-KOS exceeding those recommended by the Burkinabe standards on the discharge of wastewater into nature. As for the UHC-BOG and UHC-YO sites, the average values of these latter parameters complied with the recommendations of Burkinabe standards. However, the samples were contaminated with metals trace elements including mercury, cadmium, lead and copper were identified in each of the samples. In addition, the MTE contents of the samples greatly less regarding maximum values set by the normative recommendations of Burkina Faso except copper and iron contents. In the light of the hygienic results of the different samples, the liquid effluents from the UHC-BOG and the UHC-YO and the WWTS-KOS represent toxicity risks for aquatic populations and users of effluents in receiving areas.

Declarations

Author Contributions: Conceptualization, Ouédraogo Gamamé Abasse, Savadogo Aly and Tchoumbougnang François; methodology, Ouédraogo Gamamé Abasse, Zongo Omarou and Djopnang Djimbie Justin; software, Ouédraogo Gamamé Abasse, Badé Farid Toyigbenan and Kaboré Boukaré; validation, Tchoumbougnang François, Ouédraogo Arouna, Cissé Hama and Traoré Yves; formal analysis, Ouédraogo Gamamé Abasse and Djopnang Djimbie Justin; investigation; resources, Ouédraogo Gamamé Abasse, Tchoumbougnang François and Savadogo Aly; writing—review and editing, Ouédraogo Gamamé Abasse, Cissé Hama and Zongo Omarou; visualization, Badé Farid Toyigbenan, Djopnang Djimbie Justin, and Ismael Henri Nestor Bassolé; supervision, Traoré Yves, Ismael Henri Nestor Bassolé, Tchoumbougnang François, and Savadogo Aly; project administration, University Joseph KI-ZERBO and University of Douala; funding acquisition, AFRIDI.

Declaration of data: all the detailed data of this manuscript are available from the authors Ouédraogo Ganamé Abasse and Savadogo Aly. For the needs, these data can be provided with the agreement of all the actors of the manuscit to the following Emails: ganamabasse@gmail.com or alysavadogo@gmail.com

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Conflicts of Interest: "The authors declare no conflict of interest."

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Figures



Figure 1

Spectra of metallic trace elements by X-ray fluorescence spectrometry **Legend**: **a**: batch 1 of the standards; **b**: batch 2 of the standards; **c**: E1 WWTS-KOS characteristics Sample; **d**: E5 UHC-BOG sample characteristics and **e**: E3 UHC-KOS sample characteristics.

The titrimetric analyzes of 15 samples showed different cadmium and lead contents. Thus, the cadmium contents were from 46.09 to 96.67 μ g/L; from 101.17 to 122.53 μ g/L and from 70.82 to 91.05 μ g/L for WWTS-KOS, UHC-BOG and UHC-YO respectively. Those of lead were from 232.88 to 646.88 μ g/L, from 258.75 to 362.25 μ g/L and from 232.88 to 491.13 μ g/L for WWTS-KOS and UHC-BOG and UHC-YO respectively. As for visible UV spectrometry, it allowed the determination of mercury. The mercury contents in liquid effluents from WWTS-KOS, from UHC-BOG and from UHC-YO vary from 1.48 to 2.41 μ g/L, from 3.71 to 4.64 μ g/L and from 12.25 to 16.34 μ g/L respectively. Table 4 presents the different averages of the dosed MTE.



Figure 2

Distribution of Elemental Contaminants per Sample.