Physicochemical assessment of urban wastewater of Cotonou (Benin)

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ABSTRACT

The present study aims to fill the data gap analysis in urban wastewaters characteristics in Benin and its statistical analysis. Physicochemical parameters such as pH, electrical conductivity (EC), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP) and UV Absorbance at 254 nm, were determined on domestic (greywater and blackwater) and industrial (hospital, pharmaceutical and commercial laundry) wastewater in Cotonou city. Analysis of variance showed a strong significant difference in the physico-chemistry of the various effluents. The pharmaceutical wastewater has the highest concentration of organic pollution (COD $= 5{,}912 \pm 1{,}026$ mg/L, Abs.UV254 $= 2.667 \pm 0.327$ cm^{-1}). The organic load of blackwater is mainly in particulate and biodegradable form. Besides, the correlation study showed the limits of pH and EC as an indicator of organic load. Furthermore, the choice of COD or BOD_5 as the main design parameter would be limited to blackwater treatment. Abs.UV254 was found to be the parameter having a strong relationship with other parameters of all effluents except blackwater. It then takes priority over COD for the treatment of greywater and industrial wastewater. For future wastewater treatment plant design, we recommend to consider Abs.UV254 as an important parameter.

Key words | organic pollution parameter, urban wastewater, UV absorbance 254

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HIGHLIGHTS

- First articl to fill a data gap for integrated wastewater management in Benin.
- Analysis of of industrial and domestic wastewater.
- Relationship between organic parameters according to wastewater characteristics.
- Main organic parameter according to effluent typology.
- Place of Absorbance 254 nm in wastewater characteristics.

INTRODUCTION

Urbanization is one of the major causes of the growing demand for energy and water. However, accelerating urbanization requires new approaches to wastewater management, the governance and data needs of which are the priority in sub-Saharan Africa (WWAP 2017). While its quantitative assessment can be deduced from the volume of water consumed (Tchobanoglous *et al.* 2003; Matos *et al.* 2013), the quality of wastewater deserves careful study because it varies depending on the country, source and practices (Kulabako *et al.* 2011; Popa *et al.* 2012; Antonopoulou *et al.* 2013; Edwin *et al.* 2014; Boutin *et al.* 2017). Urban wastewater can be domestic, industrial, commercial, or even runoff water depending on the urban collection system. In developing countries,

doi: 10.2166/wst.2021.073

centralized urban wastewater collection systems are usually absent (Hassidou *et al.* 2015; Nansubuga *et al.* 2016). When present, untreated industrial wastewater are mixed with domestic wastewater (Yan *et al.* 2020).

Benin, like most developing countries, has a highly decentralized system with sanitation facilities such as latrines, septic tanks and sumps whose by-products (sludge) are discharged into the environment via an increasingly inefficient stabilization pond plant (Hounkpe *et al.* 2014). Thus, the Cotonou lagoon and the Atlantic ocean are strongly threatened by the discharge of industrial effluents, the contribution of stormwater collectors and septic sludge (Onifadé *et al.* 2017; Adanlokonon *et al.* 2018).

Moreover, wastewater is a source of waterways pollution (Sikder *et al.* 2016; Igbinosa & Uwidia 2018; Sánchez-morales *et al.* 2018; Yotova *et al.* 2019). Apart from non-biodegradable pollutants and pathogenic elements, wastewater contains emerging pollutants that increased an environmental and health concern (Adefisoye & Okoh 2017; Bakare *et al.* 2017; Agoro *et al.* 2018; Aydin *et al.* 2019). According to Jiang *et al.* (2013) and Mailler *et al.* (2017), urban wastewater and treatment plants are the main vectors of the emergence of substances such as pharmaceutical residues, body care products, endocrine disruptors, etc. in natural water resources. Industries are one of the major sources of these pollutants found in urban wastewater (Odjadjare & Okoh 2010; Iloms *et al.* 2020). Thus, rivers near industrial zones are the most sensitive (Lokhande *et al.* 2012; Idris *et al.* 2013; Reda 2016; Leong *et al.* 2018). A study carried out on five effluents from five industries showed the limits of treatment method performance based on conventional parameters (Aniyikaiye *et al.* 2019). Thus, for several decades, conventional pollution parameters such as total suspended solids, chemical oxygen demand, biochemical oxygen demand, total nitrogen and total phosphorus have shown their inadequacies due to the use various products generating specific and variable pollutants (Boyjoo *et al.* 2013). The diversity of its specific emerging pollutants may prove to be a constraint to a comparative study of industrial effluents. However, the UV absorbance at 254 nm is now presented as real control parameter for evaluating the dissolved matter (organic micropollutants) of wastewater (Altmann *et al.* 2016; Wunderlin 2017). Coupled with conventional pollution parameters, UV absorbance at 254 nm, provides more information on the efficiency of treatment processes (Kamińska & Marszałek 2020). Therefore, this coupling would also make it possible to better appreciate the variance and the correlation between each parameter of the different types of wastewater generated.

Because of multiple efforts of sludge or wastewater treatment plants construction and regulatory pressure towards industries in Benin, it is appropriate to conduct a statistical study on the physicochemical characterization of urban wastewater for better consideration in decision-making tools for the regulation of the sanitation sector. This study focused on domestic, hospital, pharmaceutical and commercial laundry wastewater produced in Cotonou, the economic capital of Benin. This study focused on the physico-chemical characterization of some urban wastewaters produced in Cotonou the economic capital of Benin. It includes domestic, hospital, pharmaceutical and commercial laundry wastewater. Results were analyzed in order to assess the impact of their mixing on wastewater treatment plants and the most relevants parameters to be consider when designing a wastewater plant.

RESEARCH METHODOLOGY

Study area

The study was conducted at Cotonou city in the Littoral department, located in the South East of the Republic of Benin between 6° 20 and 6° 24 North latitude and 2° 20 and 2° 29 East longitude. It covers an area of 79 km^2, 70% of which is west of the channel. Since 1992, it is historically the most populous city in Benin with 679,012 inhabitants according to the general report of population and housing general census 2013 (INSAE 2016). Five types of wastewater were studied (Figure 1): domestic wastewater greywater (GW) and blackwater (BW) from the 1st and 13th Arrondissements, commercial laundry wastewater (CLW) from Pressing la Paix workshop, hospital wastewater (HW) from Centre National Hospitalier et Universitaire CNHU-HKM, and pharmaceutical wastewater (PW) from Pharmaquick Benin Industries.

Sampling

Domestic wastewater (GW and BW)

Random sampling was used to select 30 households (15 each from the 1st and 13th arrondissements of Cotonou). The criteria for choosing households were:

- The consent of the household leader
- Accessibility of sanitation facilities
- Separation of the drainage system from greywater and blackwater

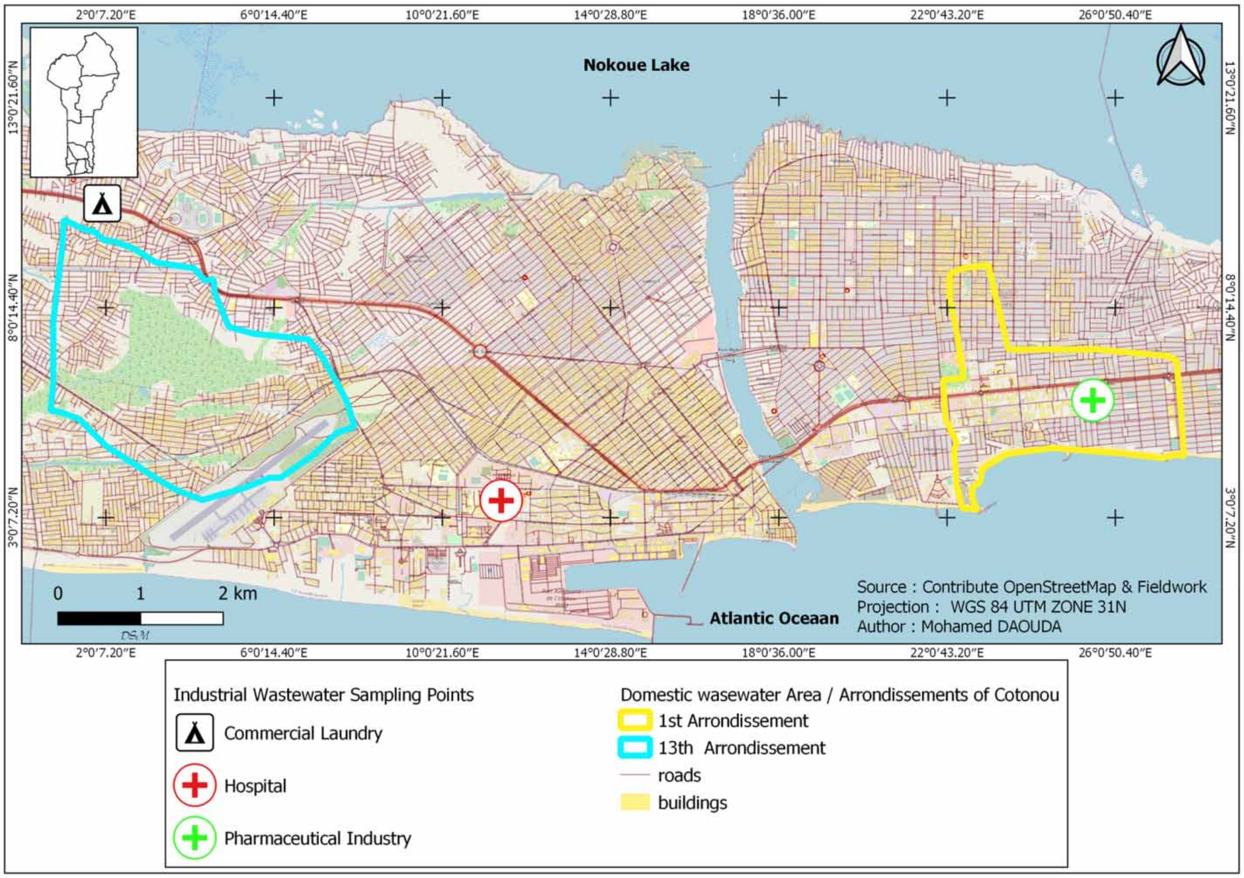

Figure 1 | Map showing the study sampling areas.

In each household, composite sampling was obtained from three samples taken between 06.00 am and 08.0 pm at 6 hours intervals. The time sample considered constitutes the peaks of the hourly output of domestic wastewater flow (Awuah *et al.* 2014). Greywater samples were taken mainly at the manhole receiving the drains of the kitchen and the bathroom. Blackwater samples were taken in the influent of the septic tanks.

Commercial Laundry Wastewater (CLW)

The washroom of the commercial laundry studied has a storage tank preceded by a manhole receiving the drains from the cleaning machines. Samples were taken at each emptying of cleaning machines throughout the day to obtain a composite sample. The sampling lasted two weeks except sunday what makes 12 composite samples.

Hospital Wastewater (HW)

Samples were taken at the entrance to the treatment plant of CNHU-HKM at the rate of 11 campaigns over a month at three days intervals. Each campaign represents a daily composite sampling of the samples taken at each automatic supply of the treatment plant.

Pharmaceutical Wastewater (PW)

Ten drug production campaigns were followed and samples were taken from the manhole receiving the wastewater from the cleaning of the manufacturing laboratory. For each campaign, composite sampling was a mixture of three samples taken according to the ratio: 1/4 sat the start of cleaning (maximum flow), 1/2 in the middle of cleaning (average flow) and ¼ at the end of cleaning (minimum flow).

Analytical techniques

All analyses were done in triplicate, according to the AFNOR standards (Rodier *et al.* 2009). pH and Electrical Conductivity (EC) were determined *in situ* through electrochemical methods with pH 3,110 SET WTW (NF T 90–008) and pH/EC/TDS waterproof Family (NF T 90–031) respectively. Total Suspended Solids (TSS) were determined according to the filtration method (NFT 90–105) with 1.2 μm glass microfiber filters 693 VWR. Chemical Oxygen Demand (COD) was evaluated through open reflux method (NFT 90–101). Manometric method (NFT 90–103) was used to determine Biochemical Oxygen Demand after 5 days (BOD5). Total Kjeldahl Nitrogen (TKN) and Total Phosphorus (TP) were measured following standard methods (NF EN 25,663 and NF EN ISO 6,878 respectively). On samples previously filtered with 1.2 μm, UV absorbance at 254 nm (Abs.UV.254) was measured using Shimadzu mini 1,240 UV spectrophotometer.

Statistical analysis

For the present study, the descriptive analysis has allowed generating mean, standard error and boxplots of the various parameters. Because of the non-normality of the variables, Spearman correlation test was used to know the relation between the parameters of each wastewater. In addition, to compare the characterizations of the different types of wastewater studied, nonparametric analysis of variance was used.

All statistical analysis were determined using R software version 4.0.1 with a significance level $p \leq 0.05$.

RESULTS AND DISCUSSION

Urban wastewater physicochemical characteristics

The results were compared with urban effluent characterization in Africa (Table 1). According to Boyjoo *et al.* (2013) and Gheethi *et al.* (2019), greywater studied can be considered as low-load greywater with neutral or basic pH. This low-load can be explained by the fact that in most of the households surveyed, the collection system of domestic wastewater excluding an important part of kitchen and laundry. On the other hand, Dwumfour-Asare *et al.* (2017) are reported a high-load greywater due to including kitchen and laundry. Concerning black water, similar results reported by others studied in west Africa (Alemneh 2014; Awuah *et al.* 2014; Kuwornu 2014) while Abdel-Shafy *et al.* (2017) were observed a low-load in Egypt blackwater. However, the geographic position and lifestyles influence the quality of wastewater.

As for commercial laundry wastewater which is alkaline, COD levels being lower than domestic and manual laundry wastewater. Indeed, Ghunmi (2009) and Yaseen *et al.* (2019) revealed that the average COD of greywater from a domestic laundry is 1,545 and 4,659 mg/L respectively. However, there is a significant difference between the phosphorus contents. The maximum total phosphorus content (10.15 mg/L) recorded in Nigeria (Adesoye *et al.* 2014) is lower than the minimum value (32.00 mg/L) of the present study (Benin). This could be due to the specificity of the commercialized detergents in each country.

Hospital and pharmaceutical wastewater can be acid (James *et al.* 2014; Placide *et al.* 2016), alkaline (Elmountassir *et al.* 2019) or around neutrality (Kermet-said & Moulai-mostefa 2015; Messrouk *et al.* 2015). Therefore, there is a significant difference depending on the country, which confirms the specificity of these effluents.

Table 1 also shows selectivity in the choice of physicochemical and global pollution parameters according to the effluent type. In general, pH, TSS, COD and BOD_5 are always done. The choice of nitrogen and phosphorus is often induced by the effluent type. Thus, it is compulsory to analyse total phosphorus on greywater and laundry wastewater. It is only on domestic wastewater, organic nitrogen was measured. The determination of organic nitrogen was determined only in domestic wastewater. Consequently, water uses are an indicator of the choice of the determined parameters. In addition, wastewater management need to be done with the specific characterization values of each country.

Difference between physicochemical characterization of urban wastewaters

The boxplot (Figure 2) shows differences in physicochemical parameters values among the five urban wastewater. In general, the measure distribution is asymmetric. Comparing the median values, blackwater is characterized by a pH close to neutrality with high particulate pollution (TSS), nitrogenous (NTK) and biodegradable organic matter (BOD_5). The most important total organic load (COD) and dissolved fraction (UV Abs. 254 nm) are those of pharmaceutical wastewater which is mostly acid. As for commercial laundry wastewater, it is very alkaline and has high phosphorus content. The lowest concentrations were recorded on greywater aside from total phosphorus.

It also used an analysis of variance to assess the difference between these urban wastewaters (Table 2). This analysis showed that there was a very high significant difference between the various parameters of the urban wastewaters (rAnova, $p < 0{,}001$). So, prior the discharge of industrial wastewater in an urban sewer system, the load compatibility should be assessed. Indeed, the very high

Table 1 | Physicochemical characterization of urban wastewater in Africa

Parameters	Statistical terms	pH	EC (μS/cm)	TSS (mg/L)	COD (mg/L)	BOD_5 (mg/L)	TKN (mg/L)	TP (mg/L)	References
Greywater	*Min – Max*	6.75–8.71	173–2,130	50–410	66–559	35–205	3.60–51.33	1.22–21.23	This study
	Mean ± SE	7.7 ± 0.35		633.2 ± 189.8	67.6 ± 57.1	60.2 ± 27.3			Nigeria (Nnaji *et al.* 2013)
	Min – Max	6.4–9.7	351–3,530	372–4,720	400–2,210	132.5–269	15.2 ± 4.5	10.8–23.2	Ghana (Dwumfour-Asare *et al.* 2017)
	Mean ± SE	7.5 ± 0.2		212.0 ± 20.8	399 ± 108.4	198.3 ± 33.3		11.8 ± 4.0	Ghana (Awuah *et al.* 2014)
	Mean ± SE	7.6 ± 0.4	645 ± 67		109 ± 33	59 ± 13		1.6 ± 0.5	Morocco (Merz *et al.* 2007)
Blackwater	*Min – Max*	7.08–8.24	165–3,680	375–5,400	460–5,490	290–3,480	9.55–142.88	2.36–40.33	This study
	Mean ± SE	8 ± 0.0		1,151.67 ± 345	2,540 ± 640.9	1,006.7 ± 377.5		17.0 ± 9.9	Ghana (Awuah *et al.* 2014)
	Mean ± SE	6.83 ± 0.41	660.5 ± 340.9	3,954 ± 500	5,729 ± 3,378	360 ± 27	512 ± 166	68.1 ± 66.3	Ghana (Kuwornu 2014)
	Mean	6.8		5,700	1,814	870			Ghana (Alemneh 2014)
	Min – Max	7.16 –8.1		212–486	835–1,680	420–1,420	117–178	17.9–35.4	Egypt (Abdel-Shafy *et al.* 2017)
Commercial laundry wastewater	*Min – Max*	7.67–9.10	320–1,680	40–340	31–884	9–270	5.60–68.64	32–135	This study
	Min – Max	7–10.2	360–2,200	18–107	88–648			0–45.8	South Africa (Natsurv 8 2017)
	Min – Max	9.1–10.2		200–400	664–716	134–276.7		0.9–10.15	Nigeria (Adesoye *et al.* 2014)
Hospital wastewater	*Min – Max*	6.50–8.75	250–1,688	30–1,140	151–810	60–690	3.75–54.88	1.12–17.50	This study
	Min – Max	6.65–7.86	3,980–4,550	29	223.01–691.2	100–150			Algeria (Messrouk *et al.* 2015)
	Min – Max	5.80–8.60	343–660	0.23–1.80	83–213	65–125			Ivory Cost (Sadia *et al.* 2016)
	Mean	8.28	230,000		1,593.6	131.28			Morocco (Elmountassir *et al.* 2019)
Pharmaceutical wastewater	*Min – Max*	5.62–8.79	356–1,275	370–2,370	1,080–9,504	180–1,700	3.05–20.32	0.77–8.75	This study
	Min – Max	4.7–7.2	199–413	30–70	80–110	20–60		0.08–0.16	Nigeria (James *et al.* 2014)
	Mean	6.46	784		525.51				Algeria (Kermet-said & Moulai-mostefa 2015)

Min, Minimum; Max, Maximum; SD, Standard error.

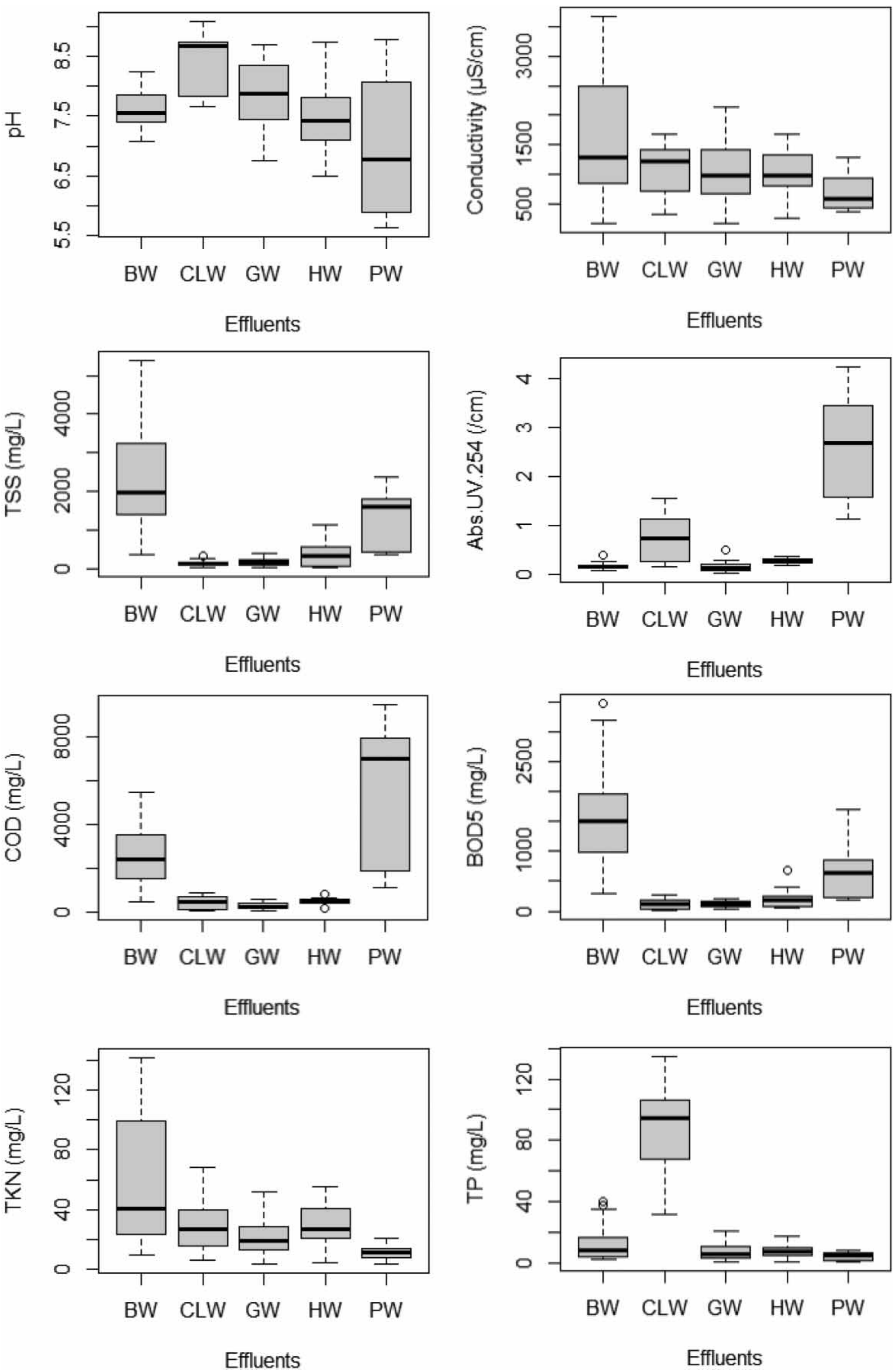

Figure 2 | Distribution of the values of physicochemical parameters of different effluents. BW: Blackwater, CLW: Commercial Laundry Wastewater, GW: Greywater, HW: Hospital Wastewater, PW: Pharmaceutical Wastewater.

Table 2 | Variance analysis of urban wastewater characteristics

Parameters	pH	EC	TSS	COD	BOD_5	TKN	TP	Abs. UV 254 nm
Greywater	7.85 ± 0.11^{ab}	$1{,}071 \pm 91^{ab}$	176 ± 17^{b}	265 ± 24^{c}	122 ± 9^{c}	20.73 ± 2.06^{bc}	7.74 ± 0.95^{b}	0.141 ± 0.019^{c}
Blackwater	7.63 ± 0.06^{bc}	$1{,}596 \pm 180^{a}$	$2{,}404 \pm 237^{a}$	$2{,}513 \pm 225^{a}$	$1{,}520 \pm 138^{a}$	58.24 ± 7.68^{a}	12.60 ± 2.12^{b}	0.168 ± 0.013^{c}
Commercial Laundry Wastewater	8.42 ± 0.15^{a}	$1{,}099 \pm 130^{ab}$	156 ± 23^{b}	419 ± 86^{bc}	120 ± 24^{c}	29.87 ± 5.42^{ab}	88.64 ± 8.60^{a}	0.766 ± 0.143^{ab}
Hospital Wastewater	7.48 ± 0.19^{bc}	$1{,}025 \pm 133^{ab}$	387 ± 106^{b}	486 ± 49^{b}	223 ± 56^{c}	29.58 ± 4.68^{ab}	8.55 ± 1.55^{b}	0.275 ± 0.018^{b}
Pharmaceutical Wastewater	6.90 ± 0.35^{c}	680 ± 100^{b}	$1{,}322 \pm 223^{a}$	$5{,}912 \pm 1{,}026^{a}$	718 ± 168^{b}	11.32 ± 1.72^{c}	5.00 ± 0.82^{b}	2.667 ± 0.327^{a}
***p* value**	***	***	***	***	***	***	***	***

levels of pH and total phosphorus of commercial laundry wastewater confirmed its alkalinity and the use of detergents and surfactants (Sheth *et al.* 2017; Bhagat *et al.* 2018). The significant difference noted on the electrical conductivity reveals the low mineralization of pharmaceutical wastewater compared to blackwater. Concerning the particulate matter, pharmaceutical wastewater and blackwater had an appreciable high level of TSS compared to other urban wastewaters. On the other hand, COD results showed that the organic load of industrial wastewater is not always higher than that of domestic wastewater. Several studies also reported that wastewater composition depends mainly on the type of industries and the activities process (Iloms *et al.* 2020). This confirms the significant difference of commercial laundry wastewater compared to others in terms of total phosphorus. The variance analysis of UV absorbance at 254 nm shows that the micropollutant content of domestic wastewater is lower than that of industrial wastewater. In addition, the micropollutant content through UV absorbance at 254 nm is specific to each industrial effluent.

The ratios of biodegradability ($COD{:}BOD_5$) and organics to nutrients (COD:N:P) can be used for the appreciation of wastewater pollutant load (Table 3). Conventionally, the biodegradability of an effluent ($COD{:}BOD_5$ less than 3) with sufficient nutrients, could make easy its biological treatment (Rodier *et al.* 2009). Hamza *et al.* (2019) found that a conventional organics to nutrients ratio (100:5:1) is not essential and proved that the optimum nutrients needs correspond to 100:2.8:0.4 for an effective biological treatment of wastewater. With the high biodegradability and near optimal organics to nutrients ratio, biological treatment is mainly required for blackwater (Abdel-Shafy *et al.* 2017). The average biodegradability ($2 < COD{:}BOD_5 < 3$) of hospital wastewater explains the implementation of activated sludge treatment at CNHU-HKM. It should be noted that the very low COD:N:P ratio recorded for commercial laundry wastewater and greywater reflects their excess nutrients (Al-Gheethi *et al.* 2019). Despite their average biodegradability ($2 < COD{:}BOD_5 < 3$),

Table 3 | Biodegradability and organics to nutrients ratios of urban wastewaters

Effluents	$COD{:}BOD_5$	COD:N:P
Greywater	2.17	100/7.82/2.92
Blackwater	1.65	100/2.32/0.50
Commercial Laundry Wastewater	3.50	100/7.13/21.15
Hospital Wastewater	2.18	100/6.09/1.76
Pharmaceutical Wastewater	8.24	100/0.19/0.08

excess nutrients in greywater may then require physicochemical treatments (Pidou *et al.* 2008; Antonopoulou *et al.* 2013). Indeed, Kaminska & Marszalek (2020) have coupled Sequential Biological Reactor (SBR) and ultrafiltration to efficiently treat greywater whose characteristics are similar to those of this study. These excess nutrients, especially phosphorus correlated with the surfactant content, are the limits of activated sludge performance on laundry wastewater (Pandey *et al.* 2020). Pharmaceutical wastewater is the most non-biodegradable (COD:BOD_5>5) with a high nutrient deficiency. This recalcitrant nature of organic matter guides the choice of treatment methods towards bioremediation (Rana *et al.* 2017) and advanced oxidation processes (Gadipelly *et al.* 2014; Kermet-said & Moulai-mostefa 2015). Consequently, the specificity of each type of urban wastewater and the increasing presence of emerging pollutants make tertiary treatment of effluents before discharge into the natural environment indispensable.

Relation between physicochemical parameters of urban wastewaters

The results of the correlations test are presented in Table 4. It was showed that pH variation informs very little about the evolution of organic pollution parameters (like TSS, COD, BOD_5, TKN, TP and Abs UV 254 nm). The correlation of pH with the other parameters was only observed in hospital wastewater. As EC is the overall aspect of the mineralization in an aqueous medium, it could only be strongly correlated with total dissolved solids (Tanyol & Demir 2016; Adefisoye & Okoh 2017), correlation between EC and other parameters is mainly recorded from hospital wastewater only. This specificity of pH and EC relationship with organic parameters reflects the complexity of hospital wastewater (García-Muñoz *et al.* 2017). On the other hand, this test reported the existence of a significant positive correlation among organic parameters of all effluents. Except for hospital wastewater, the significant correlation between TSS and COD shows that particulate pollution is taken into account in the COD measured. In general, there was a moderate significant correlation between COD and BOD_5 whatever the effluent type. This could explain why it considers the biodegradability ratio as an indicator of wastewater characterization. Among the five effluents studied, only the UV Absorbance 254 nm of blackwater is not correlated with any of other organics parameters. It can be deduced that the dissolved pollution of blackwater is random while particulate pollution is strongly correlated with the organic matter. This organic matter speciation blackwater is characteristic of the high particulate fraction whose progressive digestion generates the dissolved matter (Moges *et al.* 2018). In addition, the most stable relationship between UV abs at 254 nm and some organics parameters of other effluents, showed that UV absorbance 254 nm is an excellent indicator of the dissolved pollution of wastewater. Consequently, except for blackwater, UV absorbance at 254 nm

Table 4 | Correlation matrix of physicochemical parameters of urban wastewaters

	pH	EC	TSS	COD	BOD5	TKN	TP	Abs.UV.254
Greywater								
pH	1							
EC	0.23	1						
TSS	0.05	0.17	1					
COD	−0.03	0.18	**0.79*****	1				
BOD5	−0.04	0.24	**0.69*****	**0.94*****	1			
TKN	0.21	0.17	−0.09	0.15	0.23	1		
TP	0.15	0.30	0.04	0.18	0.30	**0.85*****	1	
Abs.UV.254	0.18	**0.46***	0.23	**0.49*****	**0.55****	**0.75*****	**0.75*****	1
Blackwater								
pH	1							
EC	−0.01	1						
TSS	−0.17	0.34	1					
COD	−0.05	**0.36***	**0.68*****	1				

(*continued*)

Table 4 | continued

	pH	EC	TSS	COD	BOD5	TKN	TP	Abs.UV.254
BOD5	−0.08	0.31	**0.62*****	**0.95*****	1			
TKN	0.05	0.1	0.11	**0.39***	**0.38***	1		
TP	0.04	0.05	0.11	0.28	0.26	**0.90*****	1	
Abs.UV.254	0.01	0.01	−0.14	−0.27	−0.21	0.12	0.14	1
Commercial Laundry wastewater								
pH	1							
EC	0.35	1						
TSS	0.22	0.47	1					
COD	−0.01	0.30	**0.52***	1				
BOD5	−0.16	0.22	**0.64***	**0.91*****	1			
TKN	−0.33	0.08	**0.62***	**0.81****	**0.96*****	1		
TP	0.05	0.16	**0.53***	0.42	0.44	**0.46***	1	
Abs.UV.254	0.08	0.10	0.17	−0.04	−0.05	0.10	**0.52***	1
Hospital wastewater								
pH	1							
EC	**− 0.78****	1						
TSS	0.34	−0.16	1					
COD	**0.70***	**− 0.65***	0.45	1				
BOD5	0.44	**− 0.58**	0.41	**0.85****	1			
TKN	0.25	−0.03	−0.18	0.04	−0.13	1		
TP	**0.83****	**− 0.63***	0.24	0.56	0.20	0.36	1	
Abs.UV.254	**0.71***	**− 0.55**	0.26	**0.82****	0.53	0.21	0.55	1
Pharmaceutical wastewater								
pH	1							
EC	−0.07	1						
TSS	−0.33	0.42	1					
COD	−0.20	0.18	**0.83*****	1				
BOD5	−0.30	0.41	**0.67***	**0.71***	1			
TKN	0.35	−0.42	0.27	0.33	0.10	1		
TP	−0.62	0.21	**0.66***	**0.70***	**0.74***	0.09	1	
Abs.UV.254	−0.20	0.18	**0.83****	**0.99*****	**0.71***	0.33	**0.70***	1

could be the main parameter for dimensioning wastewater treatment plant.

CONCLUSIONS

The physicochemical parameters of five various urban wastewater in the Cotonou city were assessed to serve as a decision-making tool for integrated wastewater management in Benin republic. The results showed that the physicochemical characterization of wastewater depends mainly on its typology, source and geographical position. Statistical analysis of data showed that there was a significant difference according to the typology of the effluent and a moderate correlation between the organic pollution parameters of each effluent. Indeed, a high particulate and biodegradable organic load characterized a blackwater while greywater would be the source of excess nutrients in domestic wastewater. As for the industrial wastewaters studied, alkalinity and phosphorus content on the one hand and the high dissolved and non-biodegradable organic load on the other hand, are the specificities of commercial laundry and pharmaceutical wastewaters respectively. It was noticed that hospital wastewater can be comparable to domestic wastewater, but it is a very complex effluent. Consequently, it is important to ensure the quality of industrial wastewater before its discharging into urban wastewater treatment plants, especially for pharmaceutical wastewater.

Moreover, the results of the correlation test confirmed the evidence of the relationship between organic parameters. It was proved that UV absorbance at 254 nm could be the overall parameter on the organic quality of wastewater except for blackwater. It can be concluded that UV absorbance at 254 nm coupled with the COD would allow better dimensioning of wastewater treatment plants. For future studies, it is recommended to assess the relation between UV absorbance at 254 nm and specific parameters such as pharmaceutical residues and surfactants.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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First received 27 October 2020; accepted in revised form 5 February 2021. Available online 17 February 2021