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Analysis of the characteristics of poultry slaughterhouse wastewater (PSW) and its treatability

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Abstract

The first step towards selecting a suitable treatment option for poultry slaughterhouse wastewater (PSW) treatment is to characterize it. Various parameters such as the pH, tCOD, BOD_5, TSS, FOG, turbidity, salinity or conductivity were analyzed in this study and provided values significantly higher than discharge limits imposed by various countries. Furthermore, the biodegradability index (BOD_5/COD) of PSW was determined and averaged a value of 0.61 for the samples collected during normal processing operations in the slaughterhouse and 0.72 for samples collected during the cleaning of equipment after broiler processing operations. This good biodegradability translated to a good biological decomposition potential, which can be a risk for the environment as a result of untreated effluent, and also highlights the suitability of biological treatment processes for the treatment of such wastewater. Moreover, to reduce the production of chemical waste from the toxic reagents used for some analyses, and to alleviate the cost and the time required for these analyses, linear regressions were used to correlate three water quality parameters (tCOD, BOD_5, and FOG), interchangeably. These linear regressions provided a good relationship between these parameters, with $R^2 > 0.9$ for the samples collected during normal operation periods; and weaker correlation for the FOG/BOD_5 and FOG/tCOD of samples collected during the cleaning of processing equipment. This was attributed to the high concentration of FOG (5,216 $\pm$ 2,534) in the samples collected during this period, from the collection of carcass debris and fats left on the equipment during the slaughtering.

Key words: biodegradability, BOD_5/COD, FOG/COD, FOG/BOD_5, poultry slaughterhouse wastewater characteristics, wastewater characterization

INTRODUCTION

Background

The increase of the global population aligns with the growing demand for food, including meat products. The United States Department of Agriculture (USDA) (2019) compared the total production of beef and veal, pork, and chicken meats in selected countries of the world (See Figure 1), including South Africa, from which it was observed that chicken meat is highly sought after (USDA 2019). This demand in poultry meat comes before beef and veal meat and shortly after pork meat. This trend has remained consistent over the last 4 years and is predicted to remain as such for the next years (USDA 2019).

The global production and consumption of poultry meat are further highlighted in Figures 2 and 3, respectively; from which the domination of United States in the production of poultry meat can be noticed, while South Africa fails to be ranked among the highest producers of poultry meat (USDA

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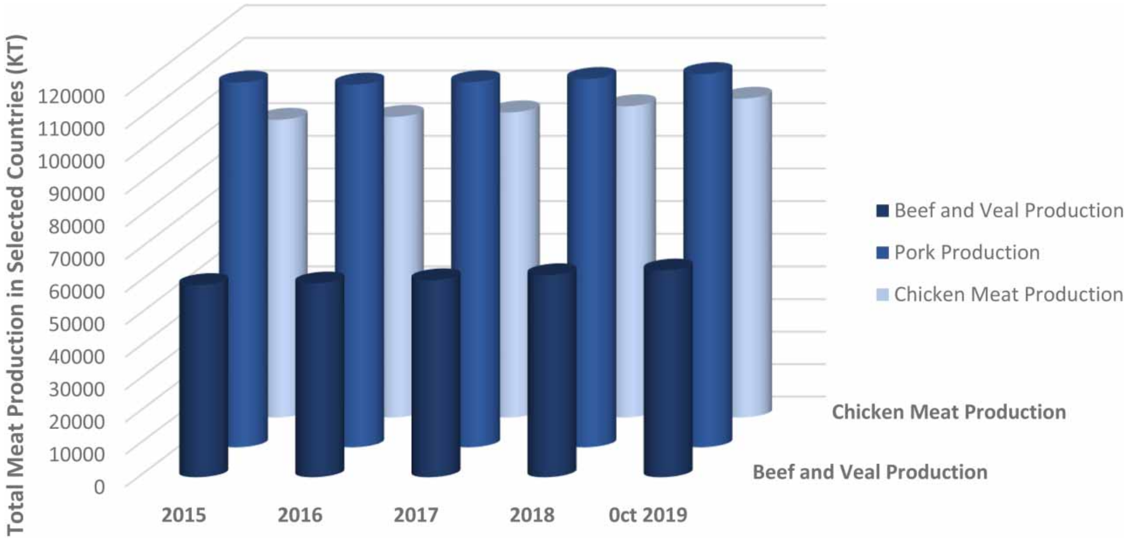

Figure 1 | Comparison of consumption of beef and veal, pork and chicken meat worldwide (Adapted from USDA 2019).

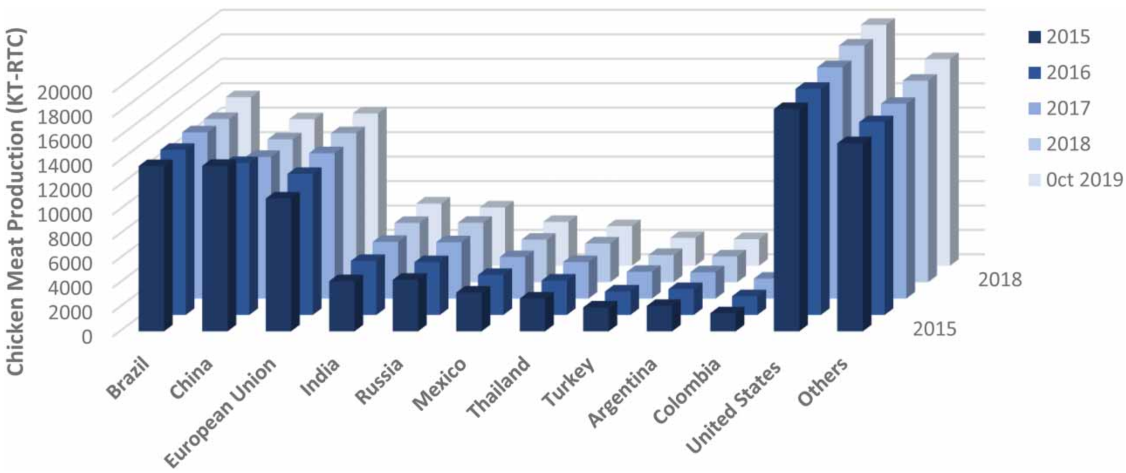

Figure 2 | Comparison of the production of poultry meat in selected countries (Adapted from USDA 2019).

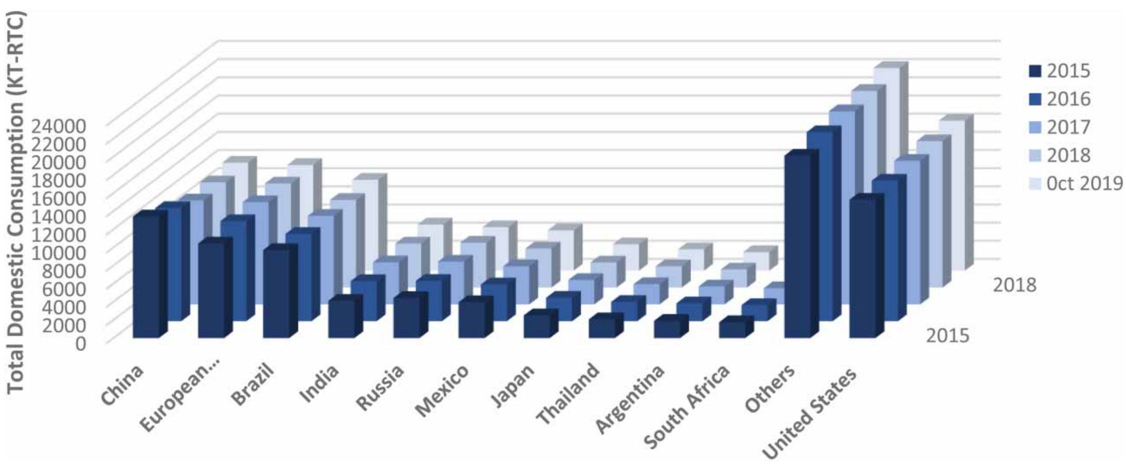

Figure 3 | Comparison of the consumption of poultry meat in selected countries (Adapted from USDA 2019).

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2019). However, this trend changes when it relates to the consumption of poultry meat (see Figure 3) with a noticeable consumption of poultry meat from South Africa, which has remained high over the last 4 years and is projected to increase in the future. Apart from the increase in the population, this demand for poultry meat is also driven by other factors, including its palatability and affordability, which is driven by an increased supply due to technological advances and the increase of the number of poultry farms in the country (Barbut 2015; Bolton 2015). This increase in the production of poultry meat is associated with an increased generation of poultry slaughterhouse waste (PSW), which results from an abundant use of potable water (approximately 26.5 L/bird) for the processing of birds.

Eutrophication and spreading of water-borne diseases are listed among the effects of the discharge of untreated poultry slaughterhouse wastewater (PSW) into water channels and surface waters (Basitere *et al.* 2017; Njoya *et al.* 2019a, 2019b). These effects may lead to serious environmental and health concerns that could be prevented by the treatment of PSW before its discharge. Moreover, the global challenge of water scarcity could be approached by promoting the treatment and recycling of the wastewater generated from various industries, including the poultry industry. In 2014, the average annual consumption of potable water by the poultry industry in South Africa was estimated at 32,564,576 m^3 (DEA & DP 2015). Certainly, this consumption is higher now when considering an annual growth of 7% in this sector. In poultry slaughterhouse facilities, potable water is usually required for various operations (stunning and slaughtering; de-feathering; evisceration; trimming and carcass washing; de-boning; chilling; cleaning and waste disposal, amongst others), which culminate in the generation of a reddish wastewater laden with nutrients, fats, oil and greases, faeces, carcass debris, blood, feathers and traces of heavy metals. The characterization of PSW is deemed important for the design of an efficient and cost-effective process for its treatment to address the challenges listed above. Therefore, various researchers have investigated PSW characteristics (Barbut 2015; Bustillo-Lecompte & Mehrvar 2017; Yaakob *et al.* 2018), which are provided in Table 1.

Table 1 | Characteristics of PSW from previous studies (adapted from Bustillo-Lecompte *et al.* 2016; Yaakob *et al.* 2018)

	Location	Parit Raja, Malaysia		Ontario, Canada	
Parameter	**Unit**	**Range**	**Average**	**Range**	**Average**
pH	–	7.3–8.6	8.2 ± 0.42	4.9–8.1	6.95
BOD_5	mg/L	1,341–1,821	1,602 ± 243	610–4,635	1,209
tCOD	mg/L	3,154–7,719	5,422 ± 2,282	1,250–15,900	4,221
TSS	mg/L	377–5,462	3,438 ± 2,696	300–2,800	1,164
TN	mg/L	162.6–564	361 ± 215	50–841	427
TOC	mg/L	195–651	419 ± 222	100–1,200	546
PO_4^{3-}	mg/L	7–17.1	12.3 ± 4.25	n.a.	n.a.
NO3	mg/L	1.64–3.3	2.24 ± 0.58	n.a.	n.a.

n.a.: Not applicable.

From Table 1, it is noticeable that the parameters investigated by the researchers, i.e. Bustillo-Lecompte *et al.* (2016) in Ontario, Canada, and Yaakob *et al.* (2018) in Parit Raja, Malaysia, differ from one study to another. This could be related to various factors including the prevailing slaughterhouse operation during the wastewater sampling, the quantity of potable water used for processing a single bird, or the difference in the nutritional quality of the birds slaughtered (Avula *et al.* 2009). These factors could be driven by various socio-economic factors related to the location of the poultry slaughterhouse in the world (Barbut 2015; Yaakob *et al.* 2018; Njoya *et al.* 2019a, 2019b). Therefore, it appears legitimate to provide a local characterization of PSW. Moreover, the development of correlations between relatable parameters of PSW can also serve to circumvent the requirement for

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running all the analyses to characterize PSW. One of these tests is the BOD_5 takes up to 5 days to provide results while the tCOD could be tested in a couple of hours (3–4 hours).

Objectives

This study aims at characterizing PSW and providing a solution towards the reduction of number analysis tests performed to assess the quality of such an effluent. To this end, the following objectives should be achieved:

- Provide a local characterization of PSW to enable the selection or design of suitable treatment processes,
- Correlate the concentration of COD, BOD_5, and FOG using linear regressions to further characterize PSW and minimize the number of required analysis tests,
- Use the correlation equations to provide a means to reduce PSW analysis cost, and the minimization of chemical wastes generated from these analyses, and
- Determine PSW biodegradability to assess its inclination towards environmental pollution when discharged untreated, and its biological treatability.

MATERIALS AND METHODS

Background

The PSW used in this study was collected from a poultry slaughterhouse located in the Western Cape, South Africa, at different stages of the poultry processing process. To factor in prevailing operations at various stages of the poultry processing, the samples were collected at different periods of the day. Samples from group 1 were collected in the morning, while samples of group 2 were collected in the afternoon, and the samples from the third group were collected around noon. The distribution of the samples is provided in Figure 4. The poultry slaughterhouse from which samples were collected had a weekly throughput of a million birds averaging a weight of 2.2 kgs/bird. The samples were collected from a wastewater stream to a clarification tank with a 1 L bucket that was used to fill up a 20 L polystyrene container during the processing of chickens. The 20 L container was stored in the refrigerator at a temperature below or equal to 4 °C after getting a representative sample from agitating the container's content before sampling in the laboratory.

PSW analysis

After collection, the samples were analyzed every week to determine the concentration of water quality assessment parameters, including the total suspended solids (TSS), total chemical oxygen demand

(a)

Number of samples		
Group 1	**Group 2**	**Group 3**
20	25	15

(b)

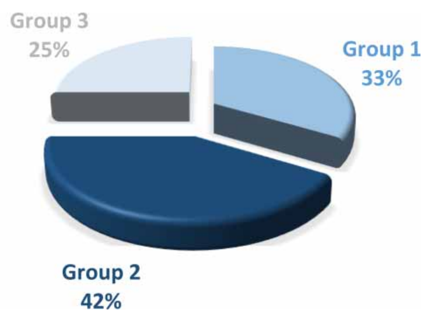

Figure 4 | Grouping of samples.

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(tCOD), biological oxygen demand (BOD_5), volatile fatty acids (VFA), alkalinity, and fats, oil and grease (FOG), as per the methods illustrated in Table 2. Other tests, including pH, total dissolved solids, salinity, temperature, and turbidity, were performed daily. All analyses were performed in triplicate. As per Figure 4, a total of 60 samples regrouped into three groups were analyzed.

The analysis methods of FOG, tCOD, and BOD_5 are described subsequently.

Table 2 | PSW analysis methods

Parameter	Method
pH	EPA Method 9040C
Total dissolved solids (TDS)	EPA method 160.1
Salinity	EPA method 320
Temperature	EPA Method 9040C
Turbidity	EPA method 180.1
Total suspended solids (TSS)	EPA method 160.2
Total chemical oxygen demand (TCOD)	EPA method 410.4
Biological oxygen demand (BOD5)	EPA method 5210 B
Volatile fatty acids (VFAs) as acetic acid	Potentiometric titration
Alkalinity as $CaCO_3$	Titration method 2320 B
Fats, oils, and grease (FOG)	EPA method 10056

FOG analysis (EPA method 10056)

FOG analysis consisted of determining the concentration of fats, oils, waxes and other related constituents found in the PSW. The release of untreated wastewater with a high FOG concentration to surface waters can interfere with biological life in such an environment and promote the creation of hideous films at its surface.

In this study, the analysis of FOG was done externally in the City of Cape Town Wastewater Treatment Plant Laboratory, as per EPA method 10056. The EPA method 10056 relies on N-hexane for the extraction of animal fats, waxes, greases, soaps, non-volatile hydrocarbons and related lipids (Down & Lehr 2005). FOGs are hydrophobic compounds; therefore, their analysis requires glassware that is pre-rinsed with the sample of PSW before collection (Down & Lehr 2005; Kaur 2007). To avoid the contamination of the sample before the analysis, it was conserved at a temperature below 4 °C for a maximum of 28 days. Additionally, in the beginning, the sample was conserved at $pH < 2$ using sulfuric (H_2SO_4) or hydrochloric (HCl) acid. The sample was then transferred to a separatory funnel, 20 mL of N-hexane was added to it, the content of the funnel was agitated energetically and then allowed to settle to enable the separation of the FOG from the solution. The denser layer (aqueous solution) was drained into a different container to separate it from the hexane layer, which was then transferred to a funnel containing anhydrous sodium sulfate to minimize the concentration of water from the extract. The extract was kept in a pre-weighed flask. This procedure was repeated three times to ensure the collection of all grease and oil compounds from the sample. Thereafter, the solvent was evaporated, and the pre-weighed flask was weighed once again. The difference in mass provided the concentration of fats, oil, and grease in the sample.

Total chemical oxygen demand (tCOD) analysis (EPA method 410.4)

The total chemical oxygen demand serves as a method to determine the quantity of oxygen that would be used by a body of receiving water to process the nutrients contained in the wastewater. This differs

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from soluble chemical oxygen demand (sCOD), which is deprived of suspended solids before the analysis and therefore has a lower oxygen requirement (Kaur 2007). The tCOD reflects the energy content of a feedstock by indicating the concentration of total oxidizable material in a sample of wastewater (Down & Lehr 2005; Kaur 2007). The results of the tCOD test are provided in mg/L COD. This translates to milligrams of oxygen-depleted per liter of sample. The tCOD analysis consisted of heating a sample of PSW at 148 °C for 2 hours with sulfuric acid (H_2SO_4) and a strong oxidizing agent such as potassium dichromate ($K_2Cr_2O_7$). For improved oxidation performance, a silver sulfate catalyst can be added to the solution. While being heated, the oxidizable organic compounds reduced the yellow dichromate ion ($Cr_2O_7^{2-}$) to green chromic ion (Cr^{3+}) during the reaction. It should be noted that 1 mol of $K_2Cr_2O_7$ is equivalent to 1.5 mol of O_2. The reduction of dichromate ions was quantified spectrophotometrically at 445 nm and directly related to the mass of oxygen consumed per liter of solution (mg/l COD is proportional to mg/L of oxygen).

The tCOD of PSW can be evaluated at different ranges (low and high range), as illustrated in Tables 3 and 4. These tables provide the volume of reagents and samples mixed and shaken in glass cell tubes, before being heated at 148 °C for two hours in a thermo-reactor. After two hours, the cell tubes were removed and allowed to cool down in cell tube trays. Half an hour later, the content of the glass cell tube was mixed on a shaker, and then the COD concentration in each sample was measured using a NOVA 60 photometer, which was calibrated as per the range investigated.

Table 3 | Parameters of the measurement of COD in a high range

	Range (mg/L)	
	500–10,000	
HIGH RANGE	**Volume (mL)**	**Content**
Solution A	2.2	Sulfuric acid, Mercury (III) Sulphate
Solution B	1.8	Sulfuric acid, Potassium dichromate
Sample	1	PSW
Total	**5**	

Table 4 | Parameters of the measurement of COD in low range

	Range (mg/L)	
	100–1,500	
LOW RANGE	**Volume (mL)**	**Content**
Solution A	0.3	Mercury (II) Sulphate
Solution B	2.3	Sulfuric acid, Potassium dichromate
Sample	3	PSW
Total	**5.6**	

BOD_5 analysis (EPA method 5210 B)

The BOD_5 and tCOD both measure the quantity of organic matter in a sample of wastewater. However, the BOD_5 differs from the tCOD because it quantifies biologically oxidized organic matter, while the tCOD quantifies materials that can be chemically oxidized.

The EPA method 5210 B is based on the determination of the quantity of dissolved oxygen consumed by a sample of PSW in 5 days. To this end, an airtight 300 mL incubation bottle was filled

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with PSW sample and incubated at 20 °C for five days. It was important to maintain the incubator dark to prevent the formation of dissolved oxygen in the sample through photosynthesis. In this analysis, the concentration of dissolved oxygen in the samples was measured before and after the incubation. The dissolved oxygen concentration in the samples was measured using a dissolved oxygen sensor. Before the measurement, the sample was vigorously manually agitated to promote the accuracy of the measurement through the dispersion of floatable and settleable solids, and the homogeneity of the sample.

RESULTS AND DISCUSSION

Characteristics of PSW

Table 5 provides a summary of the results of the PSW analysis. The PSW of the three sampling groups analyzed present fairly similar results, with tCOD average concentrations of 4,981 ± 1,832, 5,216 ± 2,534, 5,354 ± 1,810, for groups 1, 2 and 3, respectively. This similarity is further illustrated for the concentration of TSS, BOD_5, salinity, conductivity, total dissolved solids (TDS), alkalinity and VFA in the three groups. The turbidity level of each group appears to be following the same trend, with average turbidity values falling into the same range (~730 NTU). For the FOG, the concentration in the second group (5,216 ± 2,534) is significantly higher than that of groups 1 and 3 (795 ± 367 and 738 ± 374). This difference reflects a higher concentration of FOG in the wastewater during the sample collection period of group 2, which might be related to nutrition and/or size of the birds during that period. The FOG concentration of such wastewaters usually originates from a fatty carcass that gets collected in the PSW during operations such as evisceration or carcass washing. This high FOG content in the second group reflects also a challenge associated with the treatment of PSW, which is known for its high FOG concentration (Kiepper 2003; Avula *et al.* 2009), and suggests the requirement of a pre-treatment unit such as filtration to reduce the FOG concentration prior to a biological treatment like anaerobic digestion (Basitere *et al.* 2017; Williams *et al.* 2018; Njoya *et al.* 2019a, 2019b).

Table 5 | Characteristics of PSW in this study

Parameters		Group 1		Group 2		Group 3	
	Unit	Range	Average (±SD)	Range	Average (±SD)	Range	Average (±SD)
pH	–	6–8	–	6.13–7.24	–	6.29–7.13	–
Conductivity	µs/cm	798–2,360	1,479 ± 412	973–2,405	1,604 ± 414	899–2,450	1,769 ± 425.96
TDS	ppm	567–2,145	1,059 ± 303	691–1,693	1,138 ± 294	639–1,740	1,250 ± 302.09
Salinity	ppm	390–926	772 ± 178	529–1,413	916 ± 179	451–1,240	880 ± 189.80
Turbidity	NTU	99–1,847	749 ± 342	237–997	719 ± 201	328.5–864.5	758 ± 158.50
tCOD	mg/L	1,423–11,068	4,981 ± 1,832	2,517–12,490	5,216 ± 2,534	2,280–11,425	5,354.50 ± 1,810
TSS	mg/L	60–5,165	1,399 ± 1,213	313–8,200	1,654 ± 1,695	291–5,044	1,750.16 ± 1,125
FOG	mg/L	312–1,542	795 ± 367	2,517–12,490	5,216 ± 2,534	280–1,668	738.00 ± 374
BOD_5	mg/L	850–6,125	3,090 ± 1,453	925–5,000	2,477 ± 1,347	850–4,250	3,000 ± 958
VFA	mg/L	71–721	383 ± 230	105–898	375 ± 213	74–548	350 ± 167.64
Alkalinity	mg/L	415–1,022	520.8 ± 145	322–923	499 ± 158	360–926	602 ± 208.68

The tCOD, BOD_5, and TSS values determined from this study (Table 5) were compared to those provided by previous studies (Table 1) (Bustillo-Lecompte *et al.* 2016; Yaakob *et al.* 2018). While the tCOD and TSS of this study's concentrations values are close to those of previous studies

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(Table 1), the BOD_5 of this study looks higher than that of previous studies. This suggests a difference in the characteristics of PSW with the location, as a result of different operational requirements and techniques.

Table 6 provides the discharge standards for industrial effluent to water bodies in different parts of the world (DWAF 1998; Bustillo-Lecompte & Mehrvar 2017). A comparison of the results of this study to these discharge standards stresses the requirement for treatment of PSW, as it has a BOD_5 concentration at least 50 times higher than the limit imposed by regulations. Excess BOD_5 may lead to the depletion of dissolved oxygen of receiving water bodies, culminating in the death of the aquatic fauna and anaerobiosis (Abdel-Raouf *et al.* 2012). Low levels of dissolved oxygen can be detrimental to aquatic life, while high levels can induce the corrosion of metal pipes. This excess concentration is also noticed for the tCOD and TSS, which should be significantly reduced before discharge.

Table 6 | Regulations and discharge limits in different areas of the world (adapted from DWAF 1998; Bustillo-Lecompte & Mehrvar 2017)

Parameter	Unit	World Bank	EU	USA	Australia	Colombia	South Africa	China	India	Canada
BOD_5	mg/L	30	25	16–26	5–20	50	–	20–100	30–100	5–30
tCOD	mg/L	125	125	-	40	150	75	100–300	250	–
TN	mg/L	10	10–15	4–8	10–20	10	15	15–20	10–50	1.25
TOC	mg/L	–	–	–	10	–	–	20–60	–	–
TP	mg/L	2	1–2	–	2	–	10	0.1–1	5	1
TSS	mg/L	5	35–60	20–30	5–20	50	25	20–30	100	5–30
pH	–	6–9	–	6–9	5–9	6–9	5.5–9.5	6–9	5.5–9	6–9
Temperature	°C	–	–	–	<2	–	25	–	<5	<1

Biodegradability index of PSW and correlation between FOG and tCOD

The study of the biodegradability index of various types of wastewater has been approached by different researchers (Esener *et al.* 1981; Papadopoulos *et al.* 2001; Abdalla & Hammam 2014) to improve the design and operations of wastewater treatment systems. The biodegradability index of wastewater translates to its ability to be biologically decomposed (Abdalla & Hammam 2014). Furthermore, this correlation (BOD_5/COD) can be used to determine the BOD_5 of PSW without running a test, which requires 5 days. The tCOD of analyzed samples of the three groups was plotted against their corresponding BOD_5, as illustrated in Figure 5(a)–5(c). It can be noticed that the correlation coefficients R^2 are 0.96 for groups 1 and 3, which translates to a BOD_5 concentration equivalent to 0.61 times the tCOD concentration during normal operational hours (morning and noon, respectively). This ratio also suggests a

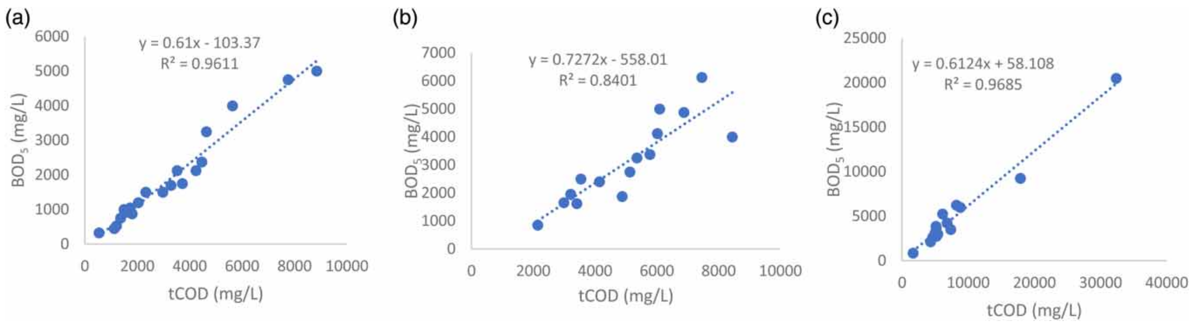

Figure 5 | Biodegradability of the samples of group1 (a), group 2 (b), and group 3 (c).

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good biodegradability potential of PSW. The evaluation of the biodegradability of PSW provides a means to assess the degree of potential pollution it may induce when discharged untreated and determines the efficacy of biological treatment to minimize the endangerment of the environment. tCOD measures the concentration of organic matter in wastewater, while BOD_5 provides the concentration of biodegradable matter in the same sample (Vollertsen & Hvitved-Jacobsen 2002). Therefore, a slope 0.61 from a linear regression between BOD_5 and tCOD suggests that roughly more than 60% of the organic matter represented by tCOD could be biologically processed.

Furthermore, this slope also provides a means to relate the concentration of the tCOD to that of BOD_5 for PSW. A higher slope (0.73 with an R^2 of 0.84) was noticed from the second, which was collected in the afternoon when the operations were winding down in the poultry slaughterhouse. This higher slope from the ratio between tCOD and BOD_5 in samples of group 2 suggests the presence of even more biodegradable organic matter in the PSW collected during that time of the day, as illustrated by Figure 6(a) and 6(b), from which it can be noticed than the average concentration of BOD_5 is slightly higher than the average concentration of BOD_5 in samples from the groups 1 and 3, as illustrated by Figures 7(a), 7(b), 8(a) and 8(b). This difference between the slope of the linear regression of samples of group 2 to samples of group 1 and 3 may be attributed to the prevailing operation during that time of the day in the poultry slaughterhouse operated routinely, when operations cease and the equipment is cleaned to maintain hygienic standards in facilities. Products collected during the cleaning of the slaughtering equipment may include feces, carcass debris, feathers, and blood from the carcass broilers, which get collected in the effluent and contribute to increasing the organic content of PSW, as demonstrated by the slope of BOD_5 to tCOD for the samples collected during this period of the day.

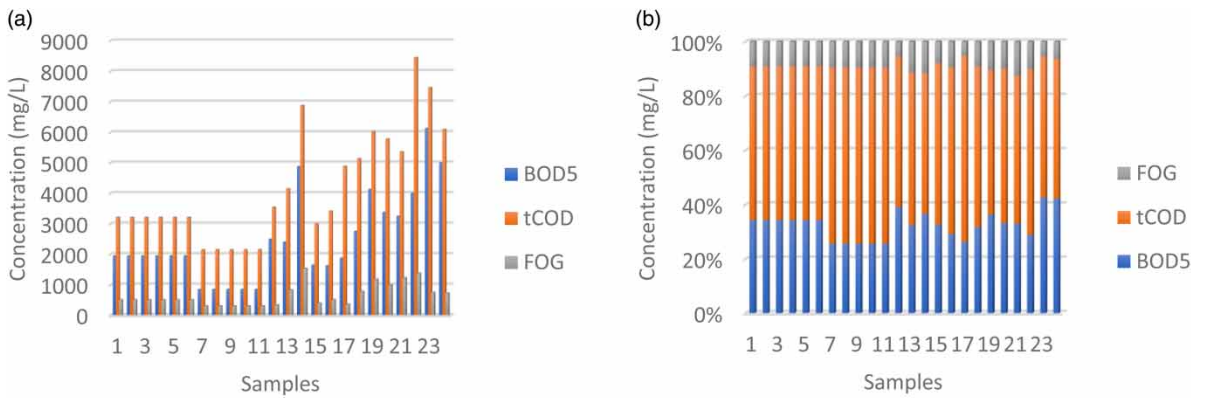

Figure 6 | (a) Concentration of tCOD, FOG and BOD_5 in PSW, and (b) concentration percentage of BOD_5, FOG, and tCOD in group 2.

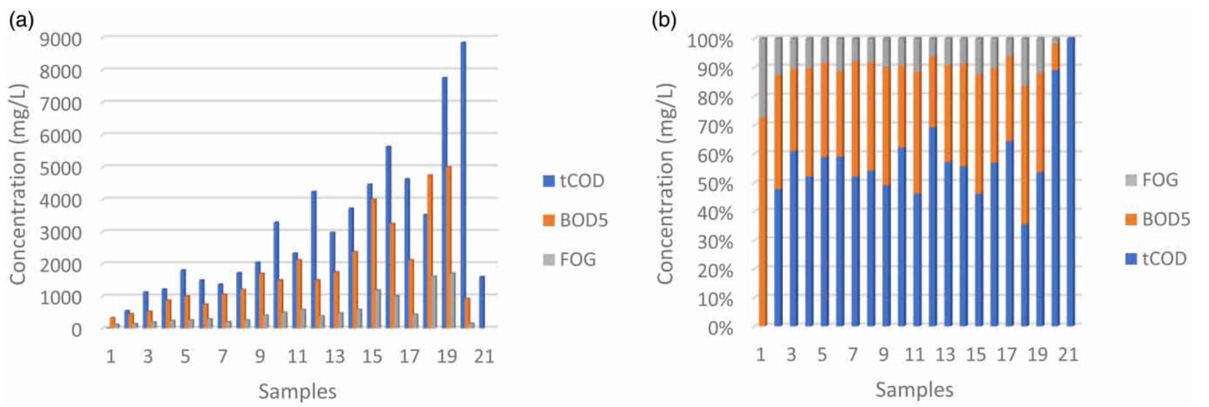

Figure 7 | (a) Concentration of tCOD, FOG and BOD_5 in PSW, and (b) concentration percentage of BOD_5, FOG, and tCOD in group 1.

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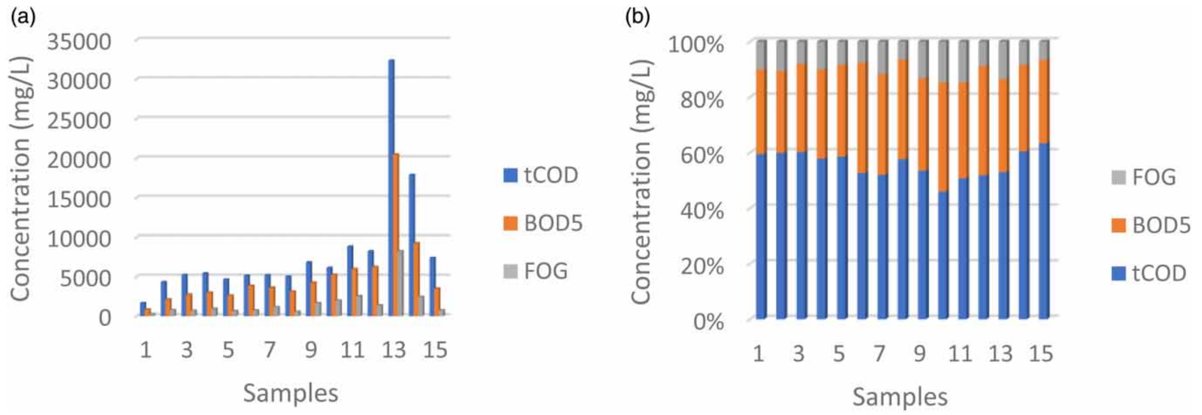

Figure 8 | (a) Concentration of tCOD, FOG and BOD_5 in PSW, and (b) concentration percentage of BOD_5, FOG, and tCOD in group 3.

In the Figures 6(a), 6(b), 7(a), 7(b), 8(a) and 8(b), despite some fluctuations probably related to the density of organic matter in the PSW, the tCOD concentration consistently remains higher than the BOD_5 and FOG concentrations in the samples of the three groups. Then follows the concentration of BOD_5, which also consistently remains higher than that of FOG for all the samples analyzed. This consolidation of results confirms the uniformity of PSW and leads the path towards the development of correlations that could be used to determine the other characterization parameters, such as the FOG.

Linear regressions between tCOD, FOG, and BOD_5, in the three groups of samples

Figures 9–11 provide the linear regressions between FOG, BOD_5, and tCOD for each group of samples. These results are summarized in Table 7. The correlations provide good R^2 values for the first and second group (see Table 7), but a lower R^2 value for the second group. This could be explained by the deviation of the FOG concentration of the second group of samples noticed in Table 5, when compared to those of the first and third group of samples. This suggests that the concentration of FOG is significantly higher in the PSW collected from the treatment of equipment; probably related to the fats and meat trimmings from the chicken carcasses. This high concentration of FOG in this sample leads to the slope between FOG/BOD_5, as opposed to those of groups 1 and 3. This difference is further illustrated by a low coefficient of determination (R^2) of 0.56 for the linear regression between FOG and BOD_5. This suggests that the average FOG concentration for the second group does not perfectly reflect the characteristics of PSW. This difference in FOG concentration of samples from group 2 is further illustrated in the correlation between tCOD/FOG in group, with an R^2 of 0.71. However, in this case, the value of the slope (0.17) is close to those of group 1 (0.21) and group 3 (0.24).

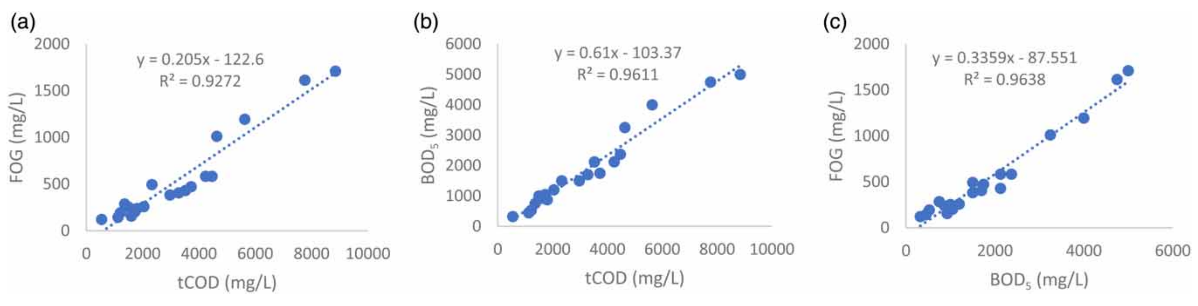

Figure 9 | (a) FOG/tCOD, (b) BOD_5/tCOD, and (c) FOG/BOD_5 in group 1.

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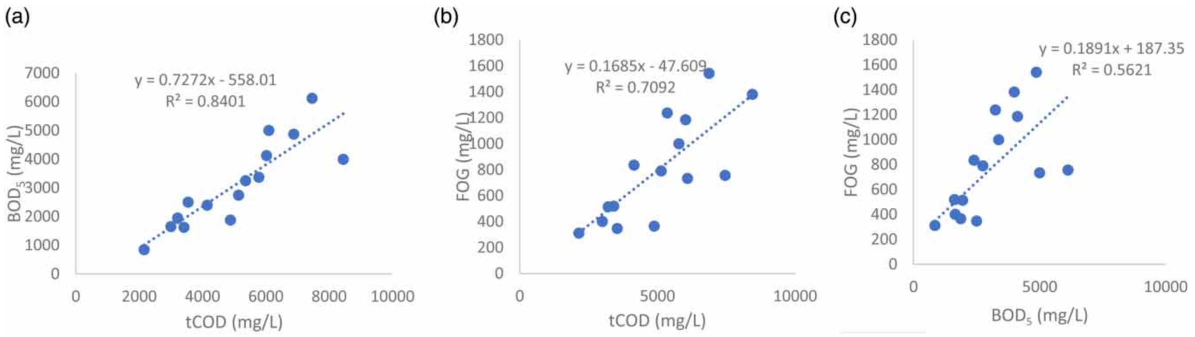

Figure 10 | (a) BOD_5/tCOD, (b) FOG/tCOD, and (c) FOG/BOD_5 in group 2.

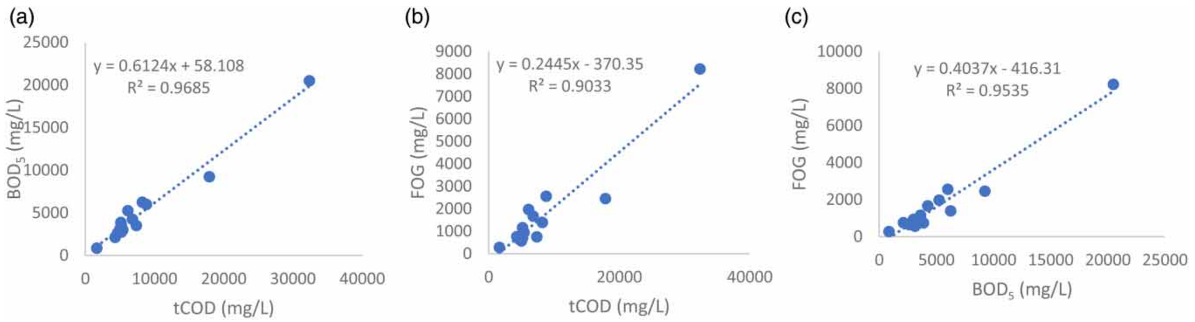

Figure 11 | (a) BOD_5/tCOD, (b) FOG/tCOD, and (c) FOG/BOD_5 in group 3.

Table 7 | Summary of the linear regressions results

	Group 1		Group 2		Group 3	
	Slope	**R^2**	**Slope**	**R^2**	**Slope**	**R^2**
tCOD/BOD_5	0.61	0.96	0.73	0.84	0.61	0.96
tCOD/FOG	0.21	0.93	0.17	0.71	0.24	0.90
FOG/BOD_5	0.34	0.96	0.19	0.56	0.4	0.93

Overall, with $R^2 > 0.75$, good correlations were found to relate BOD_5, tCOD, and FOG, which can allow the determination of one of these parameters from a single water quality assessment parameter. This can enable the reduction of the time taken to perform the analysis of BOD_5, which takes up to five days, or the determination of the tCOD from FOG, interchangeably. This approach also generates savings from the reduction of analysis tests, which represent an essential step in wastewater processing.

CONCLUSION

The characterization of PSW provides better clarity on the operations required for its treatment and therefore contributes to the design of appropriate treatment systems. PSW fails to be characterized universally as its characteristics depend on several factors, such as the hygienic standards imposed on poultry slaughterhouses, the nutrition of the broilers or the prevailing operation during the collection of the sample. This was demonstrated in this study, with a noted variation of the characteristics and the slope of linear regressions correlating the FOG, BOD_5, and tCOD of the samples analyzed. It

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was also found that PSW has a good biodegradability, which also varies with the prevailing operation in the poultry slaughterhouse. This good biodegradability translates to a potential risk for the environment if the PSW is discharged untreated, and the suitability of biological processes for the treatment of such wastewater. The development of such correlations between key water quality parameters can reduce the costs associated with the analysis of PSW, and reduce the time required to gain a good insight into the characteristics of the effluent. Furthermore, the limitation of analysis may contribute to reducing the quantity of chemical waste generated from the accumulation of analysis waste.

Following the method used in this study, the correlation between the water quality assessment parameters of other types of wastewater could be investigated to reduce the number of analyses required to characterize PSW or a different type of wastewater.

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