

Determination of the Physicochemical Properties of Singed Cowhide Meat Effluent from Akure Metropolis, Ondo State, Nigeria

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Abstract

Cowhide has been considered an alternative to meat for many years in Nigeria and other West-African countries. It is processed to be edible and deliciously inclusive in African recipes that call for assorted meats. The physicochemical properties assessed are pH, temperature, total suspended solids (TSS), total dissolved solids (TDS), total solids (TS), turbidity, salinity, biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity, dissolved oxygen (DO), electrical conductivity (EC) chloride, nitrate, sulphate, phosphate, color, and odor. The results of the assessment are as follows: electrical conductivity (1217 – 13732 $\mu\text{S}/\text{cm}$), pH (6.44 - 7.49), Temperature (28.58 - 33.61 $^{\circ}\text{C}$), total suspended solids (850 – 7640), total dissolved solids (632 - 10515), total solids (1482 - 18188), turbidity (48.67 NTU – 676 NTU), Salinity (0.73 PSU - 6.18 PSU), Alkalinity (560 mg/L – 5630 mg/L), BOD (0.34 mg/L - 1.26 mg/L), COD (432.40 mg/L - 4091.84 mg/L), DO (1.90 mg/L - 4.90 mg/L), Nitrate (6.04 mg/L – 13.08 mg/L), Phosphate (22.77 mg/L – 88.90 mg/L), Sulphate (30.41 mg/L – 95.66 mg/L) and chloride (747.19 mg/L – 2866.5 mg/L). The provision of an efficient waste disposal system is paramount to the public health safety and environmental sustainability. There is need to properly evaluate sources of waste water before its disposal and provide measures to curbing the burden on the society.

Keywords: Physicochemical; Cowhide; Waste Water; Akure Metropolis

Introduction

Water is a natural resource that is very essential to the existence and growth of life in the universe (Karikari and Ansa, 2006; Oketola et al., 2010; Arup *et al.*, 2020) [1,2,3]. Water covers about 71% of the earth surface and despite its abundance, the percentage of freshwater available for agricultural and domestic purposes is only about 5% (Usharani *et al.*, 2010; Zahidul, 2011) [4,5]. Over the past decades, many anthropogenic activities have altered the balance, credibility and stability of water flow by polluting several water channels (Ogbu *et al.*, 2016; Best, 2018) [6]. A great deal of these pollution generates from the dumping of plastics, PETs and other non-biodegradable substances in water bodies and these have a direct negative impact on the water quality and aquatic lives that inhabits the environment (Ogbu *et al.*, 2016; WHO, 1997) [6]. This phenomenon also creates a huge amount of stress on the receiving water bodies thus strain self-purification capabilities (Aniyikaiye *et al.*, 2019) [7]. These causes a disrupted balance between freshwater obtainability and consumption and therefore there will continue to be high demand for clean water due to the growing population, urbanization and changing weather patterns in populated areas (Ganoulis, 2009; Gorde and Jadhav, 2013) [8,9]. High water stress is another phenomenon affecting the availability of fresh water for human consumption (WHO & UNICEF, 2017) [10]. This has caused a six-fold increase in fresh water obtainability between 1900 to 1995 more than twice the rate of population growth leaving many countries battling with water scarcity (United Nations Environmental Programme, UNEP, 2002) [11]. This creates a situation whereby the population begins to opt for using untreated water for domestic purposes which is unhygienic (Ogbu *et al.*, 2016) [6].

Improper disposal of waste water is a major agent that alters the quality of water (Kaur *et al.*, 2010) [12]. Waste water should be treated (secondary or tertiary treatment) before it is discharged into the water streams as it is the practice in developed countries (Dhote *et al.*, 2012; Seow *et al.*, 2016; Agoro *et al.*, 2018) [13,14,15]. Since developing countries are still lacking in some social amenities which includes efficient waste disposal system and management, this can result in higher problems of environmental pollution in these regions (Naidoo and Olaniran, 2013) [16]. Eutrophication of rivers and streams is another problem of the persistence of untreated waste water in the environment, since waste water is rich in nutrients, it fosters the growth of aquatic plants and algal bloom likewise creating malodorous gases from the decomposition of organic matter present in the waste water (Topare *et al.*, 2011; Seow *et al.*, 2016) [14,17].

Cowhide which is originally meant for use in the leather industry for the making of bags, shoes, upholstery is daily consumed in Nigeria and other West African country as a subsidiary to beef (Obiri-Danso *et al.*, 2008; ICT, 2010) [18,19]. There are two (known) varieties of ponmo based on the mode of preparation and the resulting colour. One is usually white/cream/off-white in colour due to its dehairing using razors or sharp objects (Olukitibi *et al.*, 2017) [20], while the other is brown because of the singeing process it undergoes. The water used for softening 'ponmo' as well as to make it appealing to consumers results into the waste water as it is eventually disposed (Okiel *et al.*, 2009) [21]. For singed cowhide, Okiel *et al.* (2009) reported that highest levels of Pb (1.54 mg.kg⁻¹), Cr (0.79 mg.kg⁻¹) and As (2.85 mg.kg⁻¹) were found in singed hides processed with flame fueled by plastics mixed with refuse while Hg (6.74 mg.kg⁻¹) content was highest in singed hides processed with burning tyres. This residual elements and heavy metals deposited in the cowhide during singeing will also be found in the water. These waste water therefore contains toxic compounds that should not be carelessly discarded into run offs as they are liable to pollute the environment and could cause water pollution (Olorunfemi *et al.*, 2011; Olukitibi *et al.*, 2017) [21,22].

The provision of an efficient waste disposal system is very essential and is paramount to the public health and environmental sustainability (Olaniyi *et al.*, 2012) [23]. There is need to properly evaluate waste water sources before it is disposed off and eventually becomes a burden to the society. Therefore this manuscript aim at assessing the properties or features of waste water particularly the physicochemical properties which is an indicator of the level of pollution of a water source from singed cowhide ('ponmo') in Akure metropolis and suggest better disposal methods with treatment prior to its discharge.

Methodology

Description of Study Area

The study was conducted at ten (10) major places in Akure, Ondo state, Nigeria. Akure is the state capital of Ondo state and the largest city in Ondo State. Ondo State has a total land mass of approximately 991 km² (383 square kilometres), with inclusive water bodies. It located in the south-western region of Nigeria bordering Ekiti State to the north, Kogi State to the northeast, Edo State to the east, Delta State to the southeast, Ogun State to the southwest and Osun State northwest and Atlantic Ocean to the south. Akure is situated at Latitude 7°15'0"N and Longitude 5°11'42"E with an elevation of 350 meters (1, 150 ft) above sea level. Akure lies about 7° 25' north of the equator and 5° 19' east of the Meridian. It is about 700 km Southwest of Abuja, the country capital and 311 km north of Lagos State. The city is situated in the tropic rainforest zone in Nigeria and in a year, the rainfall measures about 1455 mm (57.3 inches). Akure experiences two major seasons yearly, which include wet season (April to October) and the dry season (November to March). Over the course of the year, the temperature typically varies from 66°F to 91°F and is rarely below 60°F or above 95°F. Based on 2006 census result, Akure had a population of 484,798 and the population of Ondo State was recorded to be 3,441,024 according to the National Population commission (NPC) (NPC, 2006).

Sample Collection

Wastewater samples of singed ready to eat cowhide meat (Ponmo) were obtained from ten (10) selected places in Akure, Ondo State, Nigeria. Three (3) out of which were collected directly from the processing sites while the remaining seven (7) were sampled from selling points in various market places. The samples were collected in clean 1 L plastic bottles which had been thoroughly washed and then rinsed with the respective wastewater samples prior collection and labelled appropriately in correlation with the site of collection. Onsite measurement of the pH and temperature was carried out using a pH meter and thermometer respectively. The samples were transported in ice chest to the laboratory and preserved in the refrigerator prior to analyses.

Chemical Oxygen Demand (COD)

Open reflux method was used to determine the amount of COD present in the waste water sample according to (Standard Analytical Procedures for Water Analysis, 1999). 50 mL of the waste water sample was add in a 500 mL refluxing flask, 1g HgSO₄, few glass beads, and 5 mL sulphuric acid reagent was added, mixed and allowed to cool. Thereafter, 25 mL of standard 0.0417M K₂Cr₂O₇ solution was added, mixed gently and the flask was connected to the condenser. The cooling water was turned on and an additional 70 mL of sulphuric acid reagent was added through the open end of the condenser with gentle swirling and mixing. Refluxing was done for 2 hours and thereafter was left to cool to room temperature, then the condenser was washed down with distilled water to double the volume of the contents and cooled. 2 drops of Ferroin indicator was added to the contents (potassium dichromate) and titrated with standard known volume of standard Ferrous Ammonium Sulphate (FAS) until a colour change from bluish green to reddish brown was observed and recorded. Likewise, a blank with all reagents added to 25 mL of distilled water was titrated.

Calculation

$$\text{COD, mgO/l} = \frac{(A - B) \times M \times 8000}{\text{mL of sample}} \dots \dots \dots \text{Equation 1}$$

Where:

A = FAS used for blank, mL

B = FAS used for sample, mL

M = Molarity of FAS

Biological Oxygen Demand

Sample dilution water was prepared by adding 1 mL each of phosphate buffer, magnesium sulphate, calcium chloride, ferric chloride, sodium sulphite and ammonium chloride solutions per litre distilled water. A known volume of wastewater sample was topped up with dilution water to 1 L mark of a standard flask. Two 300 mL amber bottle were completely filled with the diluted water. One of the bottles was incubated at 20°C for 5 days. MnSO₄ solution, alkali-iodide-azide reagent and concentrated sulphuric acid were added into the other amber bottle. DO in the wastewater sample was derived through iodometric titration. For dissolved oxygen at day zero (DO₀), 50 mL aliquot of the solution was titrated against sodium thiosulphate solution using starch solution as indicator, until a colourless end-point was attained. At the end of the 5 days, the sample in the incubator was brought out, dissolved oxygen at day five after incubation (DO₅) was determined by following the same procedure used for the determination of DO₀. A blank was prepared in a transparent bottle for DO₀. Another blank was prepared in an amber bottle and incubated with the sample for DO₅ (Owa, 2013) [24].

Calculation:

$$BOD_5 \text{ (mg L}^{-1}\text{)} = \frac{(DO_0 - DO_5) \times \text{Volume of BOD bottle}}{\text{Volume of sample}} \dots\dots\dots \text{Equation 2}$$

Dissolved Oxygen (DO) Measurement

DO in the collected wastewater samples were determined using the Winkler azide modification titrimetric. Standardisation was done by measuring 100 mL of distilled water in an Erlenmeyer flask, an approximately 2g KI was dissolved and added with 1 mL 6N H₂SO₄ or a few drops of concentrated H₂SO₄ and 20 mL bi-iodate solution. The solution was diluted to 200 mL and the liberated iodine was titrated with thiosulphate titrant to a pale straw colour. A few drops of starch indicator was added and the titration procedure went on until the first disappearance of blue colour. Molarity was calculated, M of thiosulphate as:

$$M = \frac{20 \times 0.0126}{V} \dots\dots\dots \text{Equation 3}$$

Where:

V = mL of thiosulphate used.

Following standardization, the flared lip of the BOD bottle was drained for any liquid containing the sample, the stopper was removed and 1 mL of MnSO₄ was added followed by 1 mL alkali-iodide-azide reagent. The pipette tip was held carefully just below the liquid surface touching the side of the bottle. Air bubbles were excluded by adjusting the stopper and the bottles were inverted a few times to allow for mixing. The brown manganese hydroxide floc (white floc indicated absence of DO) was left to settle approximately to half the bottle volume and 1.0 mL concentrated H₂SO₄ was added and re-stopper. The solution was mixed several times by inverting the bottles until dissolution was completely achieved. 201 mL of the solution was titrated with standard Na₂S₂O₂ as for standardization procedure described above (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\text{Mg DO/L} = \frac{V \times M}{0.025} \dots\dots\dots \text{Equation 4}$$

Where:

V = mL thiosulphate solution used

M = molarity of thiosulphate titrant

Electrical conductivity

This was achieved using the conductivity cell potentiometric method. The conductivity cell was rinsed thoroughly with 3 portions of 0.01M KCl solution and the resistance of the fourth portion was measured and the temperature was noted. The cell was rinsed again with one more portion of the sample, the temperature of the sample was adjusted to about 25°C. The sample conductivity was observed and recorded and the temperature was noted to the nearest 0.1°C. Finally, the cell was rinsed thoroughly with distilled water and kept in distilled water till further usage (Standard Analytical Procedures for Water Analysis, 1999).

Calculations:

Conductivity at 25°C is

$$\text{Electrical conductivity (mS/cm)} = \frac{C_m \times K_c}{0.0191 (t - 25) + 1} \quad \dots\dots\dots\text{Equation 5}$$

Where:

- K_c = the cell constant, 1/cm
- C_m = measured conductance of the sample
- T = observed temperature of sample

The meter reading, unit of measurement and the temperature of the sample was measured and recorded at the time of reading, the electrical conductivity was reported at 25°C in mS/m.

Determination of Total Suspended Solids (TSS)

Gravimetric after filtration method was used for this procedure. Washing the filter paper was achieved by putting it on filtration assembly and filtering 3 successive 20 mL portions of distilled water through it. The filter was placed in an aluminum dish to dry in an oven at $104 \pm 1^\circ\text{C}$ for 1 hour. The filtration apparatus was assembled with the washed, dried and weighed filter paper. Filter paper was soaked a little with small amount of distilled water to seat it. The waste water sample was stirred with a magnetic stirrer and while stirring, a pipette was used to measure a known volume unto the filter using a wide bore pipette. Sample volumes were chosen to yield between 10 and 200 mg dried solids. The filter was carefully removed and transferred to the aluminium-weighing dish to dry and the weighed was measured (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\text{Total Suspended Solids mg/L} = \frac{(A - B) \times 1000}{\text{mL of sample}} \quad \dots\dots\dots\text{Equation 6}$$

Where:

- A = weight of filter + dried residue, mg, and
- B = weight of filter, mg

Determination of Total Solids (TS)

Determination of total solids was done using Gravimetric method. Evaporating dish was dried at $104 \pm 1^\circ\text{C}$ for 1 hour, left to cool and stored in a desiccator. The waste water sample was stirred with a magnetic stirrer and while stirring, a measured volume was pipetted out into a pre-weighed evaporating dish using a wide bore pipette. Sample volumes were chosen to yield between 10 and 200 mg dried residue. The samples were evaporated to dryness in an oven at $104 \pm 10^\circ\text{C}$. To prevent splattering, the oven temperature

was lowered initially by 2°C below boiling point and raised to 104°C after evaporation for 1 hour, then cooled in a desiccator and thereafter the weight was measured (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\text{Total Solids mg/L} = \frac{(A - B) \times 1000}{\text{mL of sample}} \dots\dots\dots\text{Equation 7}$$

Where:

A = weight of dish + residue, mg

B = weight of dish, mg

Determination of Total Dissolved Solids (TDS)

Determination of Total Dissolved Solids (TDS) using Gravimetric after filtration method. The filter paper was washed by inserting it in the filtration assembly and filtering it through 3 successive 20 mL portions of distilled water. The suctioning process went on to remove all traces of water and the washings were discarded. Evaporating dish was dried at 104 ±10°C for 1 h followed by cooling and storage in a desiccator and was weighed immediately before use. The waste water samples was stirred with magnetic stirrer and while stirring, a pipette was used to measure a known volume on to the filter using a wide bore pipette. Sample volumes were chosen to yield between 10 and 200 mg dried residue and it was then washed with three successive 10 mL volumes of distilled water. The suctioning process proceeded for about 3 mins after filtration was completed. Total filtrate was transferred with washings to a weighed evaporating dish and was evaporated to dryness in an oven at 104 ±10°C. As necessary, an addition of successive portions were made on same dish after evaporation in order to yield between 10 and 200 mg dried residue. Cool in a desiccator and weigh. The residue was then cooled in a desiccator and the weight was measured (Standard Analytical Procedures for Water Analysis, 1999).

Determination of Nitrate Concentration

Determination of Nitrate Concentration was achieved using Sodium Salicylate (Colorimetric) Method. Mercury (II) chloride was added into the waste water samples to give a concentration of 1000 mg/l, then thoroughly mixed. A known amount of the samples were taken and its pH was adjusted to 11 with 50% NaOH. The resulting solution was stirred for a few minutes using a magnetic stirrer and left to stand for 5 minutes so that the flocculated particles may settle and be discarded. 2 ml of the filtrate was transferred into a 50 ml cooperating dish and added with 1 ml of 1% sodium salicylate solution then evaporated to dryness. The residue was dried for at least 30 minutes in a drying oven at 105° C. Afterwards, the residue was removed and allowed to cool then added with 2ml conc. H₂SO₄. Immediately the mixture was mixed well by stirring continuously for 15 minutes to totally dissolve the solids. When cold, 15ml nitrate-free distilled water was pipetted into the residue and swirled. 15ml sodium-hydroxide-potassium-sodium nitrate solution was added and the colour development was observed and recorded. A blank solution with an addition of sodium salicylate was also prepared in likewise manner. The absorbance was read in a spectrophometer at 420 nm. The values of nitrate was determined by exploration from a calibration curve after making necessary dilution (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\frac{\text{NO}_3 - \text{N (mg/l)}}{\text{mL of sample}} = \frac{\mu\text{g N read from curve} \times \text{D}}{\dots\dots\dots\text{Equation 8}}$$

Determination of Phosphate level Concentration

Determination of phosphate level concentration was done using Ascorbic acid spectrophotometric. The waste water sample was treated by taking 50 mL into a 125 mL conical flask and adding 1 drop of phenolphthalein indicator. Red colour formation was discarded by adding 5N H₂SO₄ then added with 8 mL of combined reagent and mixed. The solution was left to stand for 10 minutes and the absorbance was measured at 880 nm. Blank reagent was prepared by adding all reagents except ascorbic acid and potassium antimonyl tartrate to the sample. Then the blank absorbance was subtracted from sample absorbance reading and the calibration curve was prepared from a series of standards between 0.15-1.30 mgP/L range (for a 1 cm light path). Distilled water was used as blank with the combined reagent and a graph was plotted with absorbance versus phosphate concentration to give a straight line (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$O - PO_4 \text{ mgP/L} = \frac{\text{mg P}_{\text{from calibration curve}} \times 1000}{\text{mL of sample}} \quad \dots\dots\dots \text{Equation 9}$$

Determination of Sulphate level Concentration

Determination of phosphate level concentration was done using Turbidimetric method. Barium sulphate turbidity was formed by placing 100 mL of waste water sample into a 250 mL Erlenmeyer flask and added with 5.0 mL of conditioning reagent then mixed using a magnetic stirrer. While the solution is being mixed, a measured spoonful of PO₄ crystals was added and stirred for exactly 1.0 min at constant speed. Immediately after this, the solution was poured into an absorbance cell and turbidity was measured at 30 sec intervals for 4 mins. Calibration curve was prepared using standard sulphate solution with a spacing of 5 mg/L increments in the 0 – 40 mg/L sulphate range. A sample blank using the above steps without the addition of BaCl₂ was used for correction for sample color and turbidity (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\frac{\text{Mg SO}_4^{-2} \times 1000}{\text{mL of sample}} \quad \dots\dots\dots \text{Equation 10}$$

Determination of Chloride level Concentration

Determination of chloride level concentration was done using Argentometric method. A 100 mL of waste water was added with 3 mL Al (OH)₃ titrate with AgNO₃ suspension, mixed and allowed to settle before filtering. 1 mL K₂CrO₄ indicator solution was added and titrated with AgNO₃ to a pinkish yellow end point. The titration process was repeated with distilled water as blank (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\text{Mg Cl/L} = \frac{(A - B) \times N \times 35 \times 450}{\text{mL of sample}} \quad \dots\dots\dots \text{Equation 11}$$

Where:

A = mL titration for sample

B = mL titration for blank

N = normality of AgNO₃

Determination of Total Hardness

Determination of total hardness was done using EDTA titrimetric method. 25 mL of waste water sample was diluted to 50 mL with distilled water and added with 1 to 2 mL buffer to give a pH of 10.0 to 10.1. This was followed by an addition of 1 to 2 drops of indicator solution and titrated with EDTA titrant to change in colour from reddish tinge to blue. Sample volume that requires less than 15 mL EDTA titrant was selected and the titration was completed within 5 min after an addition of a buffer. The EDTA was also standardized against standard calcium solution using the above procedure (Standard Analytical Procedures for Water Analysis, 1999).

Calculation:

$$\text{Total Hardness (EDTA), mg CaCO}_3\text{/L} = \frac{A \times B \times 1000}{\text{mL of sample}} \quad \dots\dots\text{Equation 12}$$

Where:

A = mL EDTA titrated for sample

B = mg CaCO₃ equivalent to 1.00 mL EDTA titrant

Alkalinity Test

Determination of alkalinity was done using titrimetric method. 50 ml of sample was added into a conical flask and added with 2 drops of Phenolphthalein indicator, colour changes were observed then titrated with standard H₂SO₄ titrant until the colour disappeared. To the same solution, 2 drops of mixed indicator was added and titrated with standard H₂SO₄ solution until the color changed which was marked as the end point.

Calculation:

$$\text{Alkalinity mg/L} = \frac{T \times 0.05 \times 50 \times 1000}{\text{mL of sample}} \quad \dots\dots\dots\text{Equation 13}$$

Where:

T = mL of titrant for sample

Turbidity Test

Determination of alkalinity was done using nephelometric method. The nephelometer was calibrated according to manufacturer's operating instructions. One standard in each instrument range to be used was ran. The waste water sample was gently agitated and allowed to settle to exclude air bubbles. The sample was poured into the cell and the turbidity was read from instrument display.

Results

Table 1 shows the physicochemical properties of cowhide waste water collected from 10 sampling locations in Akure metropolis. pH value is an important parameter in waste water which has a direct influence on the waste water purification (Dirican, 2015) [25]. The pH of drinking water needs to be at the neutral level of 7 while waste water pH needs to be between 6 to 8 which is an ideal pH level suitable for biological life (Wijaya and Soedjono, 2018) [26]. The pH result obtained in this study ranged from 6.44 to 7.49 and these values conforms to the set standards and guidelines limits for discharged effluents into a receiving water body by NESREA and WHO. Principal factors influencing the level of pH in natural or waste water are the carbonates (CO₂, H₂CO₃ and HCO₃) and presence of impurities (Benit and Roslin, 2005; Agoro *et al.*, 2018) [15,27]. These factors might be considered responsible for the non-conformity of waste water pH to a neutral level of 7. The pH values obtained in this current study proves similar to the research of Wijaya and Soedjono (2018) [26].

PARAMETER	STANDARDS		SAMPLE LOCATION									
	WHO	NESREA	FSG	ORT	FNG	OKE	OO	KJ	OJ	IJ	ONB	NM
Conductivity (µS/cm)	400	NS	5465±0.47	6242±2.65	3980±1.15	2331±10.21	13732±7.62	1217±6.43	3804±5.13	4457±7.0	4415±7.57	1731±10.07
Total Alkalinity (mg/L)	150	NS	1840±3.09	1985±2.05	1215±2.21	857±3.13	5630±2.53	560±3.45	1200±4.5	1460±3.62	1360±3.24	789±4.07
Chloride (mg/L)	250	NS	1081.23±0.12	1222.84±0.98	1019±0.87	1004.93±1.21	2866.5±2.13	747.19±1.82	1016.06±2.16	1049.68±1.69	1023.4±1.34	930±1.56
Nitrate (mg/L)	5.0	NS	8.80±0.05	9.41±0.23	7.87±0.56	6.25±0.65	13.08±0.04	6.04±0.53	7.14±0.07	8.05±0.09	7.85±0.43	6.59±0.23
Sulphate (mg/L)	400	NS	75.21±0.56	46.71±0.23	85.02±0.43	58±0.05	95.66±0.42	30.41±0.34	81.22±0.52	50.67±0.45	59.08±0.26	42.29±0.97
Phosphate (mg/L)	6.5	NS	42.26±2.46	60.09±0.17	39.44±2.01	30.21±3.67	88.90±0.15	22.77±0.96	34.52±0.87	51.59±0.92	46.71±0.45	26.86±1.21
Total Dissolved Solids (TDS)	1,000	500	3643±35.1	4478±2.08	2304±5.03	1340±20.0	10515±13.23	632±2.65	2583±3.51	2653±15.53	2642±13.65	1438±2.87
Total Suspended Solids (TSS)	NS	25	2063±56.86	1962±2.08	2013±5.78	2423±25.17	7640±52.92	850±52.92	2164±10.0	3618±15.87	1217±20.28	2830±30.00
Total Solids (TS)	1,000	NS	5713±30.55	6447 ±9.29	2508±10.58	3440±91.65	18188±97.51	1482±10.82	4747±9.87	6271±27.74	1217±20.82	4291±32.97
Salinity (PSU)	NS	NS	1.96±0.04	1.79±0.07	1.35±0.04	1.64±0.03	6.18±0.02	0.76±0.05	1.32±0.03	1.33±0.03	0.96±0.11	0.73±0.03
DO (mg/L)	7.5	NS	1.90±0.04	2.34±0.03	1.92±0.02	1.75±0.05	1.67±0.04	4.45±0.02	3.67±0.21	3.91±0.01	4.55±0.04	4.90±0.02
BOD (mg/L)	40	30	0.34 ± 0.02	0.55±0.30	0.45±0.30	0.31±0.04	1.26±0.02	1.21±0.05	1.26±0.04	0.82±0.03	0.71±0.02	1.11±0.06
COD (Mg/L)	80	60	1998.07±0.65	2019.15±0.46	988.35±0.49	1258.24±0.45	4091.84±0.62	699.51±0.09	1499.91±0.76	2002.01±1.26	432.40±0.76	1477.33±0.23

PHYSICAL (UNIT)	WHO	NESREA	FSG	ORT	FNG	OKE	OO	KJ	OJ	IJ	ONB	NM
Odour (Threshold Odor No.)	Odourless	Odourless	Offensive	Offensive	Offensive	Offensive	Very offensive	Less offensive	Offensive	Offensive	Offensive	Less offensive
Ph	6.5 - 8.9	6 - 9	6.44±0.15	6.64±0.16	6.65±0.14	7.49±0.32	7.24±0.16	7.48±0.13	7.15±0.95	7.11±0.12	6.94±0.47	7.44±0.33
Temperature (°C)	30	40	30.65±0.44	30.63±1.61	31.40±1.12	33.61±0.96	28.91±0.26	31.70±0.21	29.17±0.30	29.55±0.43	28.58±0.42	30.44±0.41
Turbidity (NTU)	5	5	249±3.61	265±3.0	48.67±0.76	322±2.52	484±3.61	130±2.52	667±3.06	59.4±3.51	676±3.51	175±4.36
Colour (TCU)	Colourless	Colourless	Brownish-yellow	Brownish-yellow	Brownish-yellow	Brownish-yellow	light brown	light yellow	Brownish-yellow	Dark brown	Brownish-yellow	light yellow
Taste (Dilution No.)	Unobjectionable	Unobjectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable

W.H.O – World Health Organization, NESREA- National Environmental Standards and Regulations Enforcement Agency, OYG – Onyearugbulem, OJ – Oke-Ijebu, IJ – Ijoka, FNG – Futa Northgate, FSG – Futa Southgate, OO – Oja-Oba, KJ – Kajola, NM – Nepa Market, ORT – Orita-Obele, OKE – Oke-Aro.

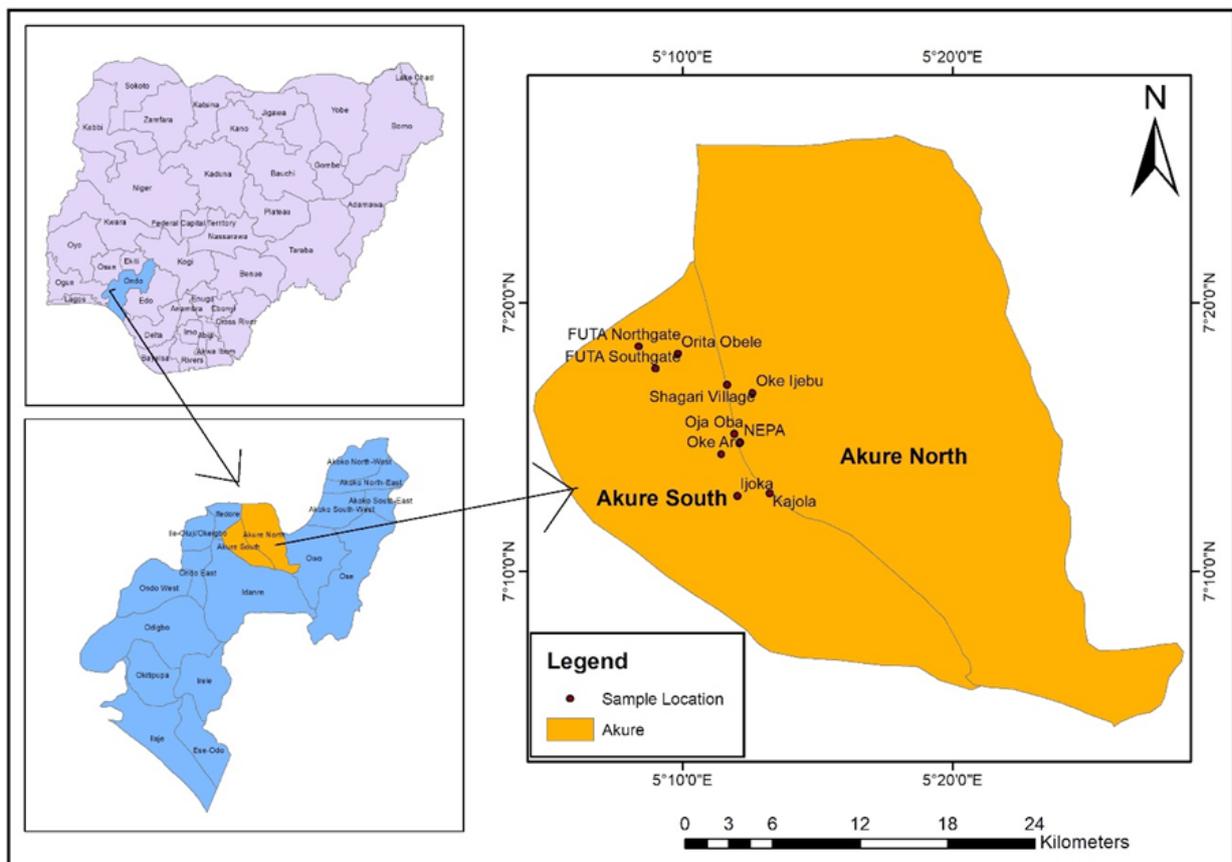


Plate 1: Map of study area

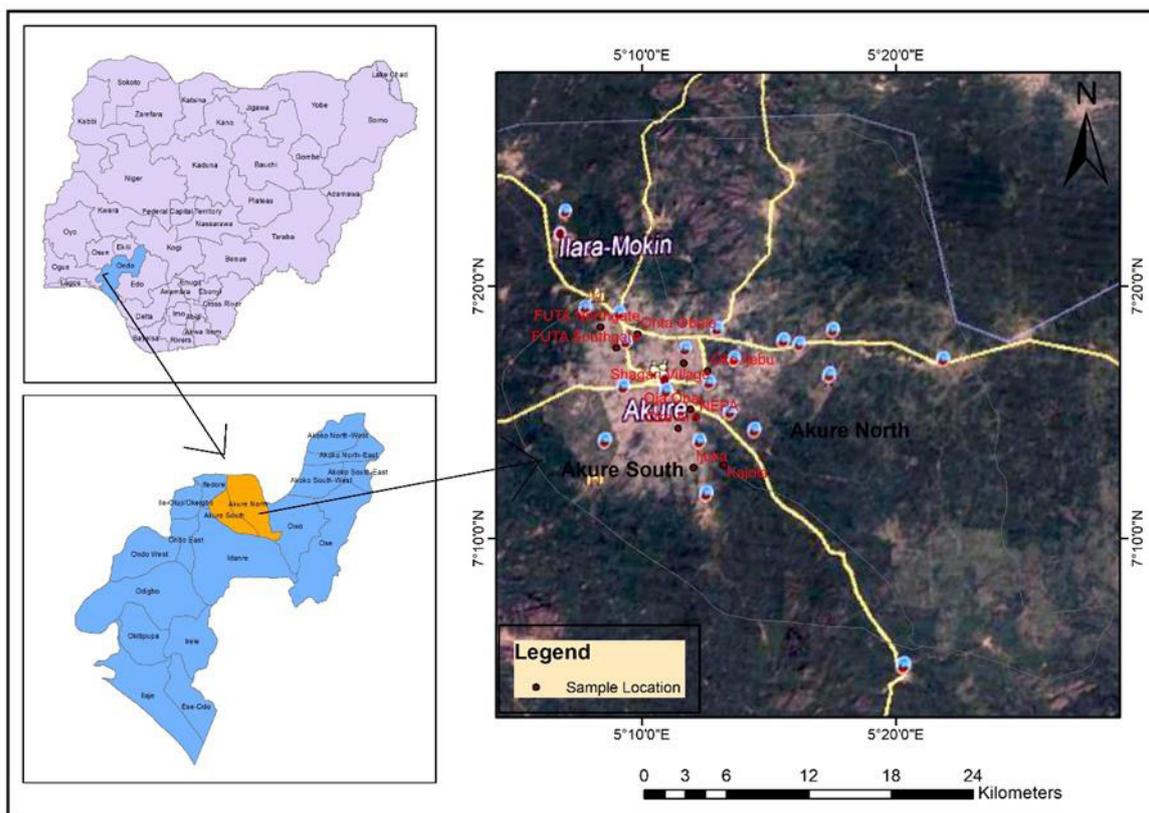


Plate 2: Area photograph of study area

Temperature is important in monitoring the biological metabolism and activities of waste water treatment system (Adeyemi et al., 2017) [28] and since bacteria in waste water treatment system function optimally at a certain temperature range, this can help to determine the rate of degradation of certain impurities and therefore the measure of the waste water treatability in a waste water treatment system (Faiza et al., 2018) [29]. Temperature values obtained in this present study conforms to the guideline limits of NESREA and WHO except for the location of Oja-Oba (OO), Oke-Ijebu (OJ), Ijoka (IJ) and Oyearugbulem (OYB) which had temperature values of 28.91°C, 29.17°C, 29.55°C and 28.5°C respectively as opposed to the guidelines limit of WHO which stated a temperature of 30°C for waste water. Ogbu *et al.* (2016) [6] in their research recorded similar drop in temperature and attributed this to the effect of dilution when the effluent mixes with the receiving water body.

Electrical conductivity is used in measuring of the amount of electrical current or charge a solution can convey and efficiently transmit (Helmenstine, 2020) [30]. This ability of a material or solution to conduct electric current is largely dependent on the availability of ions in the solution (Julian *et al.*, 2018) [31]. The presence of high values of inorganic ions such as chloride ions indicates high potential for the solution to conduct electrical current (Aniyikaiye *et al.*, 2019) [7] and these therefore is directly proportional to the concentration of Total Dissolved Solids (TDS) in the solution. The values of electrical conductivity in the current study were higher than the standards of WHO and NESREA. This non-conformity to the set guideline limit could be as a result of singeing effect of the cowhide which could result in great amount of inorganic ions to be deposited in the cowhide wastewater during soaking of the hides. Discharging waste water of this kind into a receiving water body could result in high amount dissolved inorganic substances in ionized form (Avalon Global Research, 2012) [32]. The effect of high inorganic ions in a water body could result in corrosion of pipes, boilers and heaters (WHO, 2017) and can pose a threat to aquatic lives as there would be reduction in the available dissolved oxygen which directly results in high Biological Oxygen Demand (BOD) (DWAF, 2002) [33].

Total Dissolved Solids (TDS) is a measure of all dissolved materials in a water (Mohammad et al., 2016) [34]. In a water body, TDS comprises of bicarbonates, chlorides, carbonates, phosphates, and nitrates of calcium, magnesium, sodium, and potassium;

manganese; salt; and other particles (Mahananda *et al.*, 2010) [35]. The values for TDS in the current study ranged from 1438 to 10515 across the ten sampling location. This values reported are in non-conformance to the guideline limits of WHO and NESREA of 1000 and 500 respectively. The non-conformity of cowhide waste water to the standards of WHO and NESREA is not surprising since during processing and at point of sale, salt is added to the water used for soaking the hides to preserve the hides from being slimy- which is caused by the activities of microorganisms and maintain the appealing appearance of the cowhide in the market.

Total Suspended Solids (TSS) serves as a good indicator for the turbidity of water as it is used to measure the extent of particulate matter suspended in a water body, and the level of water pollution (Sulaiman *et al.*, 2016; Aniyikaiye *et al.*, 2019) [7,36]. The values of TSS for this study ranged from 850 to 7460. The high values for TSS indicates the high level of the extent of pollution in cowhide waste water. Particulate matter contained in the hide consists of bits of cowhide, the singed scale of cowhide, ting foams, sands, stones, hair, leaves and bits of shredded ropes used in folding the hide. All of these can be said to have contributed to the high values recorded for TSS. Kaur *et al.* (2010) [12] in reported that individuals constantly exposed to waters containing high levels TSS and TDS are at risk of having cancer. Furthermore, Total solids is the summation of total dissolved solids and total suspended solids in a water body. It consists of inorganic and organic particulate matter and likewise the settleable solids (Shah *et al.*, 2014) [37]. The values obtained for total solids ranged for 1217 to, 18188 as this is as a result of the already high levels of TSS and TDS in the cowhide waste water which has been in non-conformity to the standards of WHO and NESREA.

Dissolved oxygen is a very important indicator aquatic ecosystem condition as it ensures the survival of aquatic lives (Kibria, 2004) [38]. Factors influencing the availability of dissolved oxygen in water consists chemical, physical and biochemical activities occurring in the water (Prasad *et al.*, 2014) [39]. Photosynthesis likewise play a major role in the availability of dissolved oxygen as it helps to generate the needed oxygen required by bacteria and other aquatic microorganisms for consumption and degradation of organic matter (Dick *et al.*, 2016) [40]. The values for dissolved oxygen for cowhide waste water ranged from 1.67 mg/L to 4.90 mg/L as against the standards of 5 mg/L set by WHO. Low DO concentration in effluent is an indication of high microbial activities in the water due to presence of biodegradable organic compounds (Joos *et al.*, 2003) [41]. The effect of high BOD are the same as those for low DO since these parameters are directly proportional. DO therefore estimates the degree of pollution by organic matter, the destruction of organic substances, and the self-purification capacity of the water body (Prasad, *et al.*, 2014) [39]. This therefore proves that waste water generated from soaking cowhide are unsafe for discharge into water bodies.

Biological Oxygen Demand is the measure of the amount of oxygen used up by aerobic microorganisms to degrade oxidizable organic matter present in the water body (Ogbu *et al.*, 2016) [6]. It is measured over a period of 5 days and it is used widely as a parameter for evaluating the extent of organic pollution in surface waters (Mohammed *et al.*, 2020) [42]. The biological oxygen demand for cowhide waste water ranged from 0.31 mg/L to 1.26 mg/L. These values obtained are way lesser than the standard of WHO and NESREA of 30 mg/L and 40 mg/L respectively. The observed non-conformity of cowhide waste water BOD to the set guidelines proves that the waste water is to be considered hazardous to aquatic lives and receiving water body. A reduced BOD means that there are little to no dissolved oxygen present in the water and the effect could cause suffocation of aquatic lives (Rachna and Disha, 2016) [43] if an anaerobic condition is created as a result of the effect present in the receiving water body except there is room for enough dilution when the water mixes with other sources thereby increasing the BOD as there would be enough dissolved oxygen for aerobic microorganisms and species in the water to degrade organic matter. The cause of a reduced BOD could be though to have arose from the high TDS, TSS and TS in the cowhide waste water as explained earlier. The suspended organic and inorganic matter causes decreasing light penetration, leading to a decrease in photosynthesis and the resultant primary production reduces food availability for aquatic organisms higher up in the food chain (Jouanneau *et al.*, 2014) [44].

Chemical Oxygen Demand or COD is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water (Jain and Singh, 2003) [45]. COD is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant. It is an important and rapidly measured variable for characterizing water bodies, sewage, industrial wastes, and treatment plant effluents (Khan and Ali, 2018) [46]. The COD values were not within the recommended limits as the values ranged from 432.40 mg/L– 4091.84 mg/L. The implication of a high COD value in water mean a

greater amount of oxidizable organic material in the waste water, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms (Real Tech Inc. 2017) [47]. Oxygen demand value is useful in specifying toxic condition and presence of biologically resistant substances. The COD and BOD values are a measure of the relative oxygen-depletion effect of a waste contaminant nevertheless, COD will always be higher in value than BOD as COD measures substances that are both chemically and biologically oxidized (Benit and Roslin, 2015; Wijaya and Soedjono, 2018) [26,27], thence both parameters are useful for estimating the effect of pollution in water bodies.

The highest value for nitrate was 13.08 mg/L while the least value was 6.04 mg/L across the ten sampling point according to the result shown in table 1. The presence of nitrates in the water samples is suggestive of some microbial activities and metabolism (Leimer *et al.*, 2014) [48], however some anthropogenic activities could contribute to the presence of nitrate in water samples as well. These man-made actions could result in increasing the nitrate content of water samples to dangerous levels as observed in this study where the nitrate values of cowhide waste water did not conform to the recommended limit. High values of nitrate in the waste water could be attributed to the type of water used in soaking the cowhide as many household water sources have been impacted upon with fertilizers, food waste and urea (Sotirakou *et al.*, 1998) [49] especially in remote environment typical of where the cowhides and its waste water were sampled. The implication of excessive amounts of nitrogen in waste water would be more significant in receiving water bodies especially on dissolved oxygen concentration which may become super saturated during the daylight due to plant photosynthesis but then drop to very low levels during darkness as plant respiration uses up the dissolved oxygen (Arimoro *et al.*, 2015) [50]. High levels of nitrogenous compounds in water bodies also is a major contributing factor to eutrophication with extreme variations in parameters which in turn can substantially degrade the ecological worth of the watercourse (Arimoro *et al.*, 2015) [50].

Phosphorus appears in wastewater as orthophosphate, polyphosphate and organically bound phosphorus (Sotirakou *et al.*, 1998) [49]. The phosphate level of the current study ranged from 22.77 mg/L to 88.90 mg/L in non-conformity to the recommended limit. The main sources of phosphorus in waste water are leakages of human excreta, phosphorus containing household detergents and some industrial and trade effluents (Kroiss *et al.*, 2011) [51]. High level of phosphorous can result in eutrophication, a condition characterized with increased growth of aquatic plants and algae which in turn can cause decrease in the levels of dissolved oxygen. High levels of phosphorus can also lead to algae blooms that produce algal toxins which can be harmful to human and animal health (Environmental Protection Agency, 2017) [52].

The values for Sulphur contained in the cowhide waste water ranged from 30.41 mg/L – 95.66 mg/L which was within the recommended limits of WHO of 400mg/L. This is to suggest the minimal contact of Sulphur in the cowhide waste water. Sulphate is present in the environment as part of the Sulphur cycle (Sievert *et al.*, 2007) [53]. The Sulphur cycle contains both atmospheric and terrestrial processes. Sulphur enters the atmosphere primarily through the burning of fossil fuels, incineration of refuse, and the processing of minerals and metals.

Turbidity values ranged from 48.67 NTU – 667 NTU. It has been reported by Sulieman *et al.* (2010) [54] that the turbidity of the samples depends up on the strength of waste water. The denser or more concentrated the waste water, the higher its turbidity value. The cowhide waste water samples were observed to be turbid as substances like sand, leaves, ropes, cowhide bits were found in the waste water [55-63].

Conclusion

The pH, sulphur content and the temperature recorded for some location assessed conforms with the set guidelines of physicochemical parameters. The physicochemical parameters measured indicated that cowhide waste water is poorly polluted therefore, cowhide processors should be educated on safe means of managing the waste water from the production process. Aquatic farming activities should not be sited at locations close to cowhide processing points as fertility in the nutrients contained in the waste water can seep into surrounding ponds causing cultural eutrophication.

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