Evaluation of wastewater reuse and suitability for agricultural purpose in Akure, Nigeria

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Abstract: The suitability of six waste water sources for drinking and irrigation purposes in Akure, metropolis Nigeria was assessed. Waste water samples were collected from six sources (Tisco limited located at Akure North Local Government Area, FUTA Post-graduate Hotel, a Residential Quatre, State General Hospital Akure, Mandate Restaurant located at the South Gate of the Federal University of Technology, Akure and Mr Bigg Akure) in Akure, Nigeria. These were analysed for biochemical properties determination. The parameters determined include: pH, turbidity, alkalinity, electrical conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand (BOD_5) and total solids (TS). Others were chloride (CL-), total dissolved solids (TDS), total suspended solids (TSS), lead (Pb), nitrate (NO_3), sulphate (SO_4^{-2}), oil and grease (O/G), coliform count and heavy metals. The parameters were determined using APHA (2005) standard procedures and results obtained were subjected to statistical analysis. Also, parameters such as Sodium Absorption Ratio (SAR), Na percentage, Magnesium Hazard (MH), Kelley's index (KI), and soluble sodium percent (SSP). All the wastewater samples investigated contained a considerable degree of contamination which indicated the pollution of the wastewater. The results for the waste water indicated that the pH ranged from 5.37-7.60, EC ranged from 384.67-1656.7 μs cm^{-1}, TDS ranged from 2462-10604.00 mg L^{-1}, TS ranged from 16899.00-34438.00 mg L^{-1}, acidity ranged from 230.00-662.33mg L^{-1}, alkalinity ranged from 81.3-415.33 mg L^{-1}, chloride ranged from 82.77-457.08 mg L^{-1}, TH ranged from 24.30-89.00 mg L^{-1}, turbidity ranged from 7.93-188.55 NTU, Dissolved Oxygen ranged from 0.00-9.20 mg L^{-1}, BOD ranged from 0.00-1096.80 mg L^{-1}, Sulphate ranged from 51.27-190.09 mg L^{-1}, nitrate ranged from 4.08-17.27 mg L^{-1}, and O/G ranged from 0.64-15.32 mg L^{-1}. Statistical analyses showed significant (p<0.05) differences at specific confidence levels. Most of the values were above the maximum permissible levels of FAO, WHO and NSDWQ standards for drinking water and were mostly below or within the permissible range for irrigation according to FAO standard. Also, parameters such as SAR, SSP, KI, MH indicated the suitability of the waste water for irrigation. Results showed that the wastewater treatment is required to achieve minimum acceptable level for domestic reuse, public awareness on the dangers inherent in the possible re-use of the waste water for domestic purposes need be carried out.

Keywords: Wastewater, Irrigation, physico-chemical parameters, Heavy metals, Akure

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1 Introduction

Demands on water resources for household, commercial, industrial, and agricultural purposes are greatly increasing. The world population have grown 1.5 times over the second half of the twenty-first century, but the worldwide water usage has been growing at more than three times the population growth. In most countries, human populations are growing while water availability is not. Out of 100 countries surveyed by the World Resources Institute in 1986, more than half of them were assessed to have low to very low water availability, and quality of water has been the key issue for the low water availability. Given the rapid spread of water pollution and the growing concern about water availability, the links between quantity and quality of water supplies have become more apparent. In many parts of the world, there is already a widespread scarcity, gradual destruction and increased pollution of freshwater resources as reported by Vigneswaran and Sundaravadivel, (2004).

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Sewage is a water-carried waste in solution or suspension. This water can be obtained from domestic or commercial in form of grey water (all non-toilet wastewater from showers, baths, hand basins, washing machines, laundry troughs, dishwashers and kitchen sinks) and black water; water used to flush toilets combined with human waste (EPA, 2005). Municipal sewage contains both domestic and industrial wastewater which may differ from place to place depending upon the type of industries and industrial establishment. Domestic sewage comprises spent water from kitchen, bathroom, laundries, and lavatory. Typically, each person in a house provided with pipe-borne water generates about 150 to 200 litres of wastewater per day as reported by EPA (2005). Domestic sewage is also known as waste and wastewater from humans or household operations that is discharged to or otherwise enters a treatment works. Industrial waste streams differ from domestic wastewater in that they may contain relatively high levels of elements and compounds, which may be toxic to plants and animals. The factors which contribute to variations in characteristics of the domestic sewage are daily per capita use of water, quality of water supply and the type, condition and extent of sewerage system, and habits of the people. Discharge of untreated waste into surface waters, such as rivers, lakes and seas determine the contamination of waters for human and Agricultural purposes. Considering the harmful effects of discharged domestic waste water into water bodies on the environment, waste water can be stored and can be used for Agricultural purposes.

Agricultural wastewater reuse can be classified into direct and indirect wastewater reuses (Rutkowski et al., 2007). Direct wastewater reuse refers to the method whereby irrigation water is supplied directly from the wastewater treatment plant, while indirect wastewater reuse is a method where waste water from the wastewater treatment plant or untreated wastewater is collected downstream. In the case of direct wastewater reuse, the irrigation water quality is determined by the quality of wastewater effluent. Therefore, the target water quality can be easily achieved by controlling the quality of the effluent. In the case of indirect wastewater reuse, however, controlling the irrigation water quality is difficult because it is dependent on various factors such as treated wastewater effluent quality and the hydrological conditions of the stream which the effluent flows into (Jeong et al., 2016). The increase in the number of wastewater treatment plants due to rapid urbanization is intensifying the effect of indirect wastewater reuse on irrigation water (Jeong et al., 2016).

Previous studies suggest that the quality of irrigation water from streams fails to meet the agricultural water quality standards due to the effects of wastewater treatment plant effluent (Jeong et al., 2016; Kim et al., 2012). Thus, the water quality needs to be managed to ensure safe and sound crop production. Most of the currently suggested water quality standards Word Health Organization (WHO) and the United States Environmental Protection Agency (US EPA) are based on the direct wastewater reuse rather than the indirect wastewater reuse, which is a predominant means in agricultural wastewater reuse (Blumenthal et al., 2000). The direct wastewater reuse method in agriculture justify the need to collect the wastewater samples from the waste water sources and further analysed in the laboratory.

Therefore, considering the effects of sewage and contamination water on the environment and health, there is a need to assess the parametric evaluation/estimation of six sewage sources from the standpoint of accessing its re-use for irrigation purposes in Akure, Nigeria.

2 Materials and Methods

2.1 Description of the study area

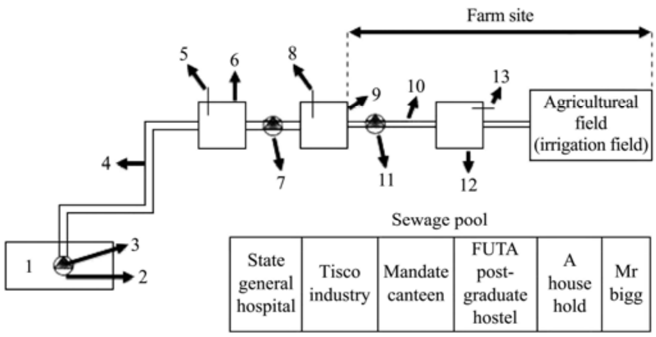
The study areas are located within Akure, Ondo State which is located in the South Western part of Nigeria. The study was conducted in Akure. The humid part of Nigeria (latitude 7°14'N and longitude 5°08'E), Akure lies in the rain forest zone with a mean annual rainfall of between 1300-1600 mm and with an average temperature of 27.5°C. The relative humidity ranges between 85% and 100% during the rainy season and less than 60% during the dry season period. Akure is about 351 m above the sea level. The area has a general elevation of between 300 and 700 m above the mean seas level and mean annual rainfall ranges between 1300 to 1500 mm (Fasinmirin and Olufayo, 2009).

The population strength of Akure has been increasing with time. The study conducted by Olanrewaju and Ilemobade (2009) showed that the population of Akure in 1992 and 2002 grew from 2 312 535 to 2 983 433 and the projected figures for 2012 and 2022 are 3 856 469 and 4 984 900 people respectively. Thus there is a need to properly manage the wastewater in Akure, so as to minimize the risk of outbreak of water related diseases such cholera, dysentry and cancer.

2.2 Sources of domestic wastewater

Three types of wastewaters were identified for this study. The first one was the Municipal wastewater from Tisco industry located in adjacent side of Akure North local government, FUTA Post graduate Hostel and a household; the second was Heath care sewage water from the State General Hospital Akure and the third one being domestic wastewater obtained at Mandate Restaurant located at the South Gate of the Federal University of Technology, Akure (FUTA) and Mr Bigg Alagbaka. All these locations were within Akure Metropolis. Tisco industry is located at the adjacent side of Akure North Local Government Area which produces detergent, table water and home care products like morning fresh. This company process semi-finished products into finished products which are then distributed amongst Akure metropolis and its environs.

Another site where sewage water was obtained was FUTA Postgraduate Hostel where both male and female Students reside and it is located along Animal Production and Health farm within FUTA. Mr Bigg is a restaurant which is located at Alagbaka, this is a where fast food is being prepared while Mandate Restaurant is located at about 1000 m north of South Gate also at FUTA. The state General Hospital comprises of several wards with various activities. Wastewater from Health-Care establishments is of a similar quality to urban wastewater which may also contain various hazardous components viz: *Microbiological pathogens, Hazardous chemicals* from cleaning and disinfection operations and *Pharmaceuticals* from hospital pharmacies. This is the State General Hospital located in Ijoka Street, Akure, where activities such as washing, disinfecting and general cleaning are carried out using various chemicals. Figure 1 showed the designed diagram for the direct/indirect waste water possible reuse



1. Sewage pool (source) 2. Filter 3. Sewage immersion pump 4. Connecting steel pipe 5. Thermometer 6. Sewage storage tank 7. Surface pump 8. Thermometer 9. Sewage treatment tank 10. Experimental pipe 11. Surface pump 12. Farm storage tank 13. Control valve

Figure 1 The designed diagram for possible reuse of wastewater obtained from different sources

2.3 Sampling and analysis

Sewage water samples were collected from Tisco industry, Mr. Bigg, Mandate canteen, a household, State General Hospital and FUTA Postgraduate Hostel within Akure and were represented as samples A, B, C, D, E and F, respectively. Sewage water samples were collected using sterilized bottles; washed with liquid soap, rinsed with distilled water and then soaked in 10% HNO_3 solution for 24 h and stored in refrigeration at 4°C in accordance with standard procedures as reported by APHA (2005). They were transferred to the laboratory for physical, chemical and microbial tests. Each bottle contained two litres by volume which was used to collect sample from each site in triplicates.

They were transferred to the laboratory for physical, chemical and microbial tests. Three samples were collected from each source. The physical and chemical parameters tested for include; pH, electrical conductivity (EC), biological oxygen demand (BOD), total suspended solids (TSS), dissolved oxygen (DO) and nutrients (nitrates and phosphates), acidity, turbidity, alkalinity, hardness, chloride content, total solid, oil and grease; Heavy metals and the microbial viz: total viable counts and coliform counts. The electrical conductivity determination was carried out using conductivity meter (WINLAB model) while the pH was determined.

The sewage samples also analyzed at the University Central Laboratory and include; total dissolved solids (TDS), TSS, BOD, DO, turbidity, acidity, alkalinity, NO_3, NO_2, SO_4^{2-}, Cl^-, oil and grease using standard methods for the examination of water (APHA 2005). The concentration of heavy metals (Pb cd, Cu, Fe, Mn, Zn, Ni and Cr) were determined with flame atomic absorption spectrophotometer while Na^+ and K^+ were determined using flame photometer. Also, microbial analysis was carried out in the laboratory using APHA, 2005 standards. All the results were compared with the World Health Organization (WHO 2004), Food and Agricultural organization (FAO 2007) and the Nigerian Standard for Drinking Water Quality (NSDWQ 2007) values.

3 Results and discussion

3.1 Sewage water analysis

The results of the sewage water analysis of the samples collected, FAO, NSDWG, WHO standard for drinking water and irrigation water quality standard according to FAO are presented in Tables 1 and 2, respectively.

Table 1 The results and ANOVA of the sewage physical and chemical properties obtained from the six sampling sites (mg L^{-1})

Parameters	A	B	C	D	E	F	Standards		
							WHO	NSDWG	FAO
pH	7.40^{ab}±0.10	5.37^{d}±0.15	6.60^{c}±0.10	7.30^{b}±0.10	7.60^{a}±0.20	7.60^{a}±0.10	6-8.5	6.5-8.6	6.5-8.5
EC (μs cm^{-1})	426.67^{e}±1.95	810.98^{b}±6.50	1656.7^{a}±2.00	618.33^{d}±1.53	661.33^{c}±11.37	384.67^{f}±1.95	300	1400	3
Turbidity	9.95^{c}±0.04	188.55^{a}±1.05	188.00^{a}±4.00	188.38^{a}±1.53	7.93^{c}±0.15	50.47^{b}±0.83	0.5-5	5	5
Acidity	230.33^{d}±4.51	510.00^{b}±2.00	660.67^{a}±0.58	662.33^{a}±2.08	300.00^{c}±0.00	230.00^{d}±10.00			
Alkalinity	81.33^{d}±2.31	108.00^{c}±2.00	255.33^{b}±3.06	415.33^{a}±3.06	104.67^{c}±3.06	108.00^{c}±2.00	100		200
TDS	2735.40^{e}±5.32	5194.80^{b}±8.56	10604.00^{a}±4.13	3957.00^{d}±3.80	4211.20^{c}±3.15	2462.40^{f}±4.58	0.5	500	40
TSS	14164.00^{e}±1.96	28688.00^{d}±5.73	6355.70^{f}±2.52	30481.00^{b}±4.49	30129.00^{c}±2.83	31391.00^{a}±1.83	250	500	100
TS	16899.00^{f}±6.75	33883.00^{c}±2.84	16959.00^{e}±6.61	34438.00^{a}±2.26	34340.00^{b}±2.86	33854.00^{d}±4.21	500		2
Chloride	82.77^{f}±0.17	314.06^{b}±0.04	457.08^{a}±4.32	276.59^{c}±2.29	167.32^{d}±2.02	119.46^{e}±1.93	250	500	100
BOD	566.40^{b}±4.00	1096.80^{a}±2.00	0.00^{e}±0.00	0.00^{e}±0.00	543.60^{c}±2.00	81.60^{d}±1.20	5	5	
DO	9.20^{a}±0.20	2.33^{d}±0.15	0.00^{e}±0.00	0.00^{e}±0.00	8.67^{b}±0.25	4.33^{c}±0.58	0.3	0.3	2
Hardness	86.67^{a}±2.52	24.30^{e}±0.20	56.67^{c}±2.52	83.00^{b}±1.28	89.00^{a}±1.95	40.00^{d}±1.00	500	200	
Ca hardness	114.00^{b}±3.00	84.60^{c}±0.36	32.33^{f}±1.53	79.80^{d}±1.45	75.73^{e}±2.45	132.67^{a}±2.52	500	200	
Mg hardness	200.67^{a}±0.58	108.90^{d}±0.17	89.00^{e}±1.00	162.80^{c}±0.26	164.73^{c}±0.87	172.67^{b}±2.31	500		
Phosphate	1.28^{d}±0.02	3.02^{a}±0.03	2.33^{b}±0.02	1.94^{c}±0.03	0.94^{f}±0.02	1.02^{e}±0.01	0.4		
Sulphate	62.42^{d}±0.03	190.09^{a}±0.07	147.68^{b}±0.88	74.40^{c}±0.86	51.27^{f}±0.19	57.34^{e}±1.03	150	100	20
Nitrate	6.70^{d}±0.13	17.27^{a}±0.27	13.70^{b}±0.18	11.08^{c}±0.06	4.08^{f}±0.03	5.31^{e}±0.04	5	50	30
O/G	2.18^{c}±0.02	0.85^{e}±0.02	15.32^{a}±0.33	3.03^{b}±0.06	0.64^{e}±0.03	1.15^{d}±0.02	20-Oct	20	10

Note: A = Tisco Industry B = Mr Bigg C = Mandate Canteen D = A Household E = State General Hospital F = FUTA Postgraduate Hostel.
Means with different letters are significantly different at 5% level of significance.

Table 2 FAO guidelines for interpretation of water quality for irrigation

Potential irrigation problem	Units	Degree of restriction on Use		
Salinity (affects crop water availability)		None	Slight to Moderate	Severe
EC_w	μS m^{-1}	<0.7	0.7-3.0	>3.0
TDS	mg L^{-1}	<450	450-2000	>2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using ECw and SAR together)				
SAR = 0–3 and EC_w =		>0.7	0.7-0.2	<0.2
= 3–6 =		>1.2	1.2-0.3	<0.3
= 6–12 =		>1.9	1.9-0.5	<0.5
= 12–20 =		>2.9	2.9-1.3	<1.3
= 20–40 =		>5.0	5.0-2.9	<2.9
Specific ion toxicity (affects sensitive crops)				
Na	SAR	<3.0	3.0-9.0	>9.0
Surface irrigation	mg L^{-1}	<69.0	>69.0	-
Sprinkler irrigation				
Cl	mg L^{-1}	<142.0	142.0-355.0	>355.0
Surface irrigation	mg L^{-1}	<106.5	>106.5	-
Sprinkler irrigation	mg L^{-1}	<0.7	0.7-3.0	>3.0
pH		6-8.5		

Note: Sources: Food and Agriculture Organization (Ayers and Westcot, 1985).

3.1.1 pH

There is a significant difference among the pH of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The pH values of sewage samples ranged from 5.37 to 7.60 for samples A, B, C, D, E, F the lowest values were recorded for sample B while highest value was recorded for samples E and F. These values fall within the permissible safe limit of both FAO, NSDWQ and WHO of 6.5-8.5, 6.5-8.6 and 6-8.5 respectively except for sample B which fell below. However, sample B has a pH value of 5.37 which is acidic and did not conform to normal standard of international limit. Most of pH value less than 6.5 are considered too acidic for human consumption and can cause health problems such as acidosis (Ackah et al., 2011). The pH values recorded in the study areas were lower than the range (7.38-7.81) reported by Das and Acharya (2003) and the range (8.94 -10.34) reported by Akan et al. (2008) for waste water. The pH values obtained in all the sewage sources are suitable for irrigation purpose. They fall below and within the permissible range for irrigation.

3.1.2 Electrical conductivity

There is a significant difference among EC of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The conductivity of the effluents ranged from 384.67 to 1656.7 μs cm^{-1}. Although there is no Federal Environment Protection Agency (FEPA) limit on conductivity, however sample C value fell above WHO limit of 1400 μs cm^{-1} for drinking water while the values of other sewage samples fell below WHO limit. With the value observed, all the water samples are not saved for consumption for both human beings and livestocks. If the EC of irrigation water is below 700 μs cm^{-1}, it does not affect crop growth; when above 3000 μs cm^{-1}, it can cause severe damage (Ayers and Westcot, 1985). From the result of the water analysis, the wastewater are suitable for irrigation ranging from no restriction to slight restriction (Table 2) EC in water sample is an indication of dissolve ion.

3.1.3 Turbidity

The turbidity of the samples ranged between 7.93 and 188.55 NTU with sample B having the highest value and sample E having the lowest. Sewage samples had their turbidity values higher than the WHO limit. A high level of turbidity can affect the performance of the irrigation facility, and can lower the hydraulic conductivity of the soil and in turn pollute the soil surface through surface flow. In addition, since various viruses and bacteria can be attached to and migrate along with the solid particles, the elimination of suspended solids is related to the elimination of germs (EPA, 2012).

3.1.4 Total dissolved solid

There is a significant difference among the TSS of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). Total dissolve solid is defined as the concentration of all dissolve minerals in the water (Tahlawi et al., 2014). The TSS of the sewage samples ranged from 2462 mg L^{-1} to 10604.00 mg L^{-1}. Accordingly, all the sample's values fell above the WHO, NSDWQ and FAO permissible limit of 250, 500 and 100, respectively which show a High level of dissolved minerals in the water samples. The values are similar to the ones obtained by (Okoye, 2011) untreated effluents of soap factories in Aba. Dissolved mineral, gases and organic constituent may result to displeasing colour, odour and taste. High level of dissolved organic chemicals may deplete the dissolved oxygen in the water. The high values of TDS recorded in this study are above the range recommended for irrigation water according to FAO (Table 2).

3.1.5 Total solid

There is a significant difference among the Total Solid (TS) of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The values ranged between 16899.00-34438.00 mg L^{-1}. The total solid values recorded for the sewage water showed that all the samples A, B, C, D, E, F, G were higher than the WHO recommended safe limit of 1000. These values are higher than those reported by Siyanbola et al. (2011) for some industrial effluents in Lagos.

3.1.6 Acidity

There is a significant difference among the acidity of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The acidity of effluents ranged from 230.00 to 662.33 mg L^{-1}

with sewage sample D having the highest acidity while sample F has the lowest, but here is no FEPA nor WHO acidity limit for discharge into surface water.

3.1.7 Alkalinity

There is a significant difference among the Alkalinity of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). Alkalinity of the sewage water sample ranged between 81.33-415.33 mg L^{-1} CaCO3. Sample D recorded the highest value while sample A has lowest value. Although there is no FEPA limit, but samples A, B, C, D, E and F fell within the WHO limit of 30-500. However, excessive alkalinity in water is not good for irrigation which may lead to damage of the soil and consequently leads to reduction in crop yield (Gyamfi et al., 2012).

3.1.8 Dissolved oxygen

There is a significant difference among the Dissolved Oxygen of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The DO levels obtained in the sewage water samples ranged between 0.00 and 9.20 mg L^{-1}. The values obtained for samples A, B, E and F fell above the safe limit of 2 mg L^{-1} of WHO while the DO values of samples C and D fell below the recommended limit. This result is similar to 2.00-4.60 mg L^{-1} obtained by Okoye et al. (2011) for effluents discharged by soap factories in Aba.

3.1.9 Biochemical oxygen demand

There is a significant difference among the BOD of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The biochemical oxygen demand for the sewage water samples ranged between 0.00 to 1096.80 mg L^{-1}. The result showed that the BOD of sewage water samples C and D fell below the standard limit while samples A, B, E and F exceeded the standard limit of 50 mg L^{-1} given by FEPA (1991). This can deplete dissolved oxygen from streams, lakes and oceans; may cause death of aerobic organisms; increases anaerobic properties of water. This result is higher than 7.6-12.4 mg L^{-1} for soap factories in Aba by Okoye et al. (2011) but close to 340.0-560.0 obtained by Siyanbola (2011) for effluent analysis of selected industries in Lagos state.

3.1.10 Phosphate

There is a significant difference among the Phosphorus of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The phosphate level in the sewage water samples ranged between 0.94-3.02 mg L^{-1}. all the sewage water samples A, B, C, D, E and F fell above the recommended limit of 0.1 and 0.4 mg L^{-1} by FEPA and WHO respectively.

3.1.11 Nitrate

There is a significant difference among the Nitrate of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). Nitrate concentrations of the sewage water samples ranged between 4.08-17.27 mg L^{-1}. All values of the sewage water samples fell below the WHO standard which is 50 mg L^{-1} while all the samples A, B, C, D, F exceed FEPA standard limit of 5 mg L^{-1} except sample E which fell below FEPA standard limit . High concentration of nitrate in water might contribute to illness of infant called methemoglobinemia. These values are above 0.3-1.0 mg L^{-1} obtained by Okoye (2011) and 0.32-0.71 mg L^{-1} as reported by Adegbite (2010).

3.1.12 Sulphate

There is a significant difference among the Sulphate of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The concentration of sulphate in the sewage water samples ranged from 51.27-190.09 mg L^{-1}. All the sewage water samples A, B, C, D, E and F values fell below the maximum permissible limit of 400 mg L^{-1} and 250 mg L^{-1} as recommended by FEPA and WHO respectively. The values are lower than 36.65-163.9 mg L^{-1} reported by Adegbite (2010) for brewery industry effluents in Benin. High level of sulphate in water may enhance corrosion of distribution system. It gives water a bad taste.

3.1.13 Chloride

There is a significant difference among the Chloride of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The chloride content of sewage water samples ranged from 82.77-457.08. sewage water samples A, E, F fell below standard permissible limit of WHO while samples B, C, D exceed the standard permissible limit of WHO recommended as 250 mg L^{-1} but all the samples A, B, C, D, E and F fell below the standard permissible limit of 500 mg L^{-1} as prescribed by FEPA. Chloride ions is one of the major inorganic anions in water which its high content may harm metallic pipes and structures. In water, salty taste is produced by high chloride concentration. High concentration of chloride is injurious to people suffering due to heart and kidney diseases. Aturamu (2012) reported chloride concentration values range between 4.5 mg L^{-1} and 69 mg L^{-1} which also indicate a low chloride concentration. The chloride values recorded for all the wastewater are above the permissible limit for irrigation according to FAO (Table 2).

3.1.14 Oil and grease

There is a significant difference among the Oil and Grease of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). The oil and grease level in the sewage water samples ranged between 0.64-15.32 mg L^{-1}. all the sewage water samples A, B, C, D, E and F fell below the FEPA standard limit of 20 mg L^{-1} and below 5.60-8.50 mg L^{-1} reported for food processing effluents in Lagos by Ogbonaya (2008).

3.1.15 Total hardness

There is a significant difference among the Total Hardness of the sewage from the different sources A, B, C, D, E and F, respectively at 5% level of significance (Table 1). Hardness of water (mg L^{-1}) is an important measure of pollution. It is the measure of capacity of water to react with soap. The higher the water hardness the more soap is required to foam. The hardness concentration of the samples ranged between 24.3 mg L^{-1} and 89 mg L^{-1} which all fall below WHO permissible limit (500 mg L^{-1}). Calcium hardness and magnesium hardness in all the water samples fell below WHO permissible limit. The samples are observed to be safe for consumption for both human and livestock. These values are higher than that of Aturamu (2012) who observed values ranged between 67 mg L^{-1} and 300 mg L^{-1}.

3.2 Heavy metal composition of wastewater from the six sampling sites

Table 3 presents the concentration of some heavy/toxic metals determined from the sewage water from the six locations analysed.

Copper (Cu) concentration in sewage water ranged between 0.603-0.800 mg L^{-1} which was greater than 0.5 mg L^{-1} the standard limit for FEPA. The metal concentration of zinc (Zn), chromium (Cr), iron (Fe), manganese (Mn), lead (Pb), cadmium (Cd) in the sewage water ranged between 32.831-69.321 mg L^{-1}, 0.013-0.051 mg L^{-1}, 0.062-0.834 mg L^{-1}, 1.493-4.927 mg L^{-1}, 13.60-120.00 mg L^{-1}, 0.137-0.893 mg L^{-1}, 0.000-0.021 mg L^{-1} and 0.000-0.072 mg L^{-1} respectively. The values of Fe, Mn, Zn and Cd were lower compared to Fe 3.8-11.9 mg L^{-1}, Mn 2.7-5.0 mg L^{-1}, Cd 0.2-0.9 mg L^{-1} as obtained by Ayeni (2013) for raw effluents discharged from an industrial estate in Lagos. A high concentration of Mn is toxic and usually bad in terms of taste, odor and discoloration of food (Tahlawi et al., 2014). Tahlawi et al. (2014) reported similar results ranged between 0.001 mg L^{-1} and 2.6 mg L^{-1}. The Mn reported in this study is within the permissible range for irrigation. Zinc is an essential and beneficial element in body growth (Gyamfi et al., 2012). Also, Zn and Pb values are below the permissible limit reported by FAO for irrigation.

Table 4 shows some parameters (MH, KI, SAR, Na and SSP) results analysed for the suitability of waste water for irrigation as compared with the FAO standard in Table 5.

Table 3 Elemental composition (ppm) of sewage water samples in comparison with water standard Irrigation

Elements (ppm)	A	B	C	D	E	F	Standard FAO
Pb	ND	0.016	0.021	0.009	ND	0.013	5
Cd	0.001	ND	0.072	0.033	0.016	0.022	0.01
Cu	0.800	0.663	0.64	0.69	0.62	0.603	0.2
Fe	1.493	2.403	4.927	2.313	2.537	2.134	5
Mn	0.137	0.328	0.893	0.284	0.517	0.373	2
Zn	0.043	0.04	0.013	0.033	0.042	0.051	2
Ni	0.024	ND	0.061	0.233	0.031	0.008	0.2
Cr	0.377	0.834	0.343	0.062	0.091	0.484	0.1

Note: A = Tisco industry B = Mr Bigg C = Mandate canteen D = A household E = State general Hospital F = FUTA Postgraduate Hostel ND=Not found.

Table 4 Values of MH, KI, SAR, Na%, and SSP respectively for each sample Irrigation

SAMPLES	MH	KI	SAR	Na%	SSP
A	63.77	0.04	1.08	9.83	4.14
B	56.28	0.17	3.25	22.20	14.19
C	73.35	0.99	15.41	54.43	49.72
D	67.11	0.43	9.53	36.94	30.21
E	68.51	0.17	3.63	18.86	14.20
F	56.55	0.10	2.58	13.95	9.46

Note: A = Tisco industry B = Mr Bigg C = Mandate canteen D = A household E = State general Hospital F = FUTA postgraduate hostel.

Table 5 Classification of water to evaluate its suitability for irrigation according to FAO

Classification pattern	Categories	Ranges
Percentage sodium (Na%)	Excellent	0-20
	Good	20-40
	Permissible	40-60
	Doubtful	60-80
	Unsuitable	>80
Sodium absorption ratio (SAR)	Excellent	0-10
	Good	10-18
	Doubtful	18-26
	Unsuitable	>26
Magnesium hazard (MH)	Suitable	<50
	Unsuitable	>50
Kelley's ratio (KI)	Suitable	<1
	Unsuitable	≥1
Soluble sodium per cent (SSP)	Suitable	≤50
	Unsuitable	>50

3.2.1 Sodium adsorption ratio

The sodium adsorption ratio indicates the effect of relative cation concentration on sodium accumulation in soil. The potential for sodium hazard increases with high sodium adsorption ratio. The SAR of content of the studied area water samples as shown in Table 4, range between 1.08 and 15.41 with a mean value 8.245. All the water samples fall within the water class grade "excellent" as shown in Table 4 except for sample C which falls in class grade ''good'' hence the water samples are fit for irrigation purpose according to SAR water class grade. (Hakim et al., 2009) got a similar result range between 0.27 and 0.54.

3.2.2 Percentage sodium (Na%)

Excess concentration of sodium in water produces an undesirable effect, changing soil property thereby reducing soil permeability. The Na% of water samples in the study areas as shown in Table 4, ranged between 9.83-54.43 with a mean value 32.13 which indicate that 50% of the water samples fell within the water class grade "Excellent" and 40% fell within the class grade "good'' and 10% fell within permissible as shown in Table 4, hence the water samples are fit for irrigation purpose according to Na% water class grade.

3.2.3 Magnesium hazard

Calcium and magnesium maintain a state of equilibrium in groundwater. More magnesium in water will affect the soil quality and reduce crop yield (Tahlawi et al., 2014). The calculated MH values ranged between 56.28 and 73.35 with a mean value 64.815. According to MH class grade 100%, the waste water samples are unsuitable for irrigation.

3.2.4 Kelley's ratio

Kelley's ratio has been used to evaluate water based on level of sodium measured against calcium and magnesium. The calculated KI values ranged between 0.04 and 0.99 with a mean value 0.317 which indicate that all the water samples fell within the suitable grade class of KI. This implies that all the waste water samples are good for irrigation purpose.

3.2.5 Soluble sodium percent

The percentage soluble sodium calculated range between 4.14 and 49.72 with a mean value 20.32 which indicates that all the waste water samples fell below 50. This showed that all the water samples are suitable for irrigation purpose. Hakim et al. (2009) also reported a value ranged between 8.135 and 24.28 which also shows suitability of the waste water sample for irrigation purpose.

3.3 Significance of correlation coefficients

The significance of the observed correlation coefficients showed in Table 6 revealed that out of the total 151 correlations found between two parameters, two were found to be significant at the 0.001 level, 10 were found to be significant at the 0.01 level and 19 were found to be significant at the 0.05 level, respectively and the rest were interwoven between negative and positive correlations.

Table 6 Correlation between water sample physical and chemical parameters

	pH	EC	Turbidity	Acidity	Alkalinity	TDS
EC	–0.444					
Turbidity	–0.683	0.600				
Acidity	–0.483	0.695	0.930**			
Alkalinity	0.052	0.318	0.668	0.815*		
TDS	–0.446	1.000***	0.601	0.695	0.319	
TSS	0.119	–0.671	–0.122	–0.229	–0.024	–0.672
TS	–0.008	–0.465	0.057	–0.040	0.078	–0.466
Chloride	–0.616	0.911*	0.866*	0.900*	0.533	0.911*
BOD_5	–0.598	–0.213	–0.103	–0.262	–0.622	–0.213
DO	0.462	–0.568	–0.942**	– 0.881*	–0.746	–0.569
Hardness	0.701	–0.194	–0.449	–0.123	0.244	–0.195
Ca hardness	0.365	–0.906*	–0.585	–0.776	–0.471	–0.905*
Mg hardness	0.753	–0.870*	–0.770	–0.716	–0.229	–0.870*
Phosphate	–0.936**	0.556	0.880*	0.739	0.289	0.557
Sulphate	–0.973**	0.627	0.755	0.587	0.040	0.629
Nitrate	–0.917*	0.576	0.900*	0.761	0.326	0.577
O/G	–0.168	0.915*	0.479	0.601	0.397	0.915*

Note: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level. *** Correlation is significant at the 0.001 level.

	TSS	TS	Chloride	BOD_5	DO	Hardness
TS	0.968**					
Chloride	–0.409	–0.183				
BOD_5	0.197	0.164	–0.158			
DO	0.078	–0.098	–0.813*	0.389		
Hardness	–0.127	–0.217	–0.332	–0.293	0.443	
Ca hardness	0.495	0.287	–0.876*	0.150	0.501	–0.087
Mg hardness	0.325	0.095	–0.934**	–0.066	0.698	0.575
Phosphate	–0.201	–0.052	0.775	0.342	–0.692	–0.575
Sulphate	–0.274	–0.116	0.757	0.429	–0.572	–0.698
Nitrate	–0.230	–0.081	0.792	0.283	–0.728	–0.575
O/G	–0.812*	–0.662	0.767	–0.502	–0.534	–0.044

Note: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level. *** Correlation is significant at the 0.001 level.

	Ca hardness	Mg hardness	Phosphate	Sulphate	Nitrate
Mg hardness	0.765				
Phosphate	–0.512	–0.792			
Sulphate	–0.508	–0.868*	0.950**		
Nitrate	–0.517	–0.796	0.998***	0.942**	
O/G	–0.759	–0.651	0.343	0.386	0.385

Note: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level. *** Correlation is significant at the 0.001 level.

Strong correlations were found between pH and turbidity, pH and Hardness, pH and sulphate between TSS and oil and grease, between TDS and SO_4 to mention but few.

There were strong positive correlations significant at 0.01significant level between EC and oil and grease (R=0.915), oil and grease and TDS (R=0.915) and between turbidity and sulphate, phosphate and nitrate. The correlation (R value) between turbidity and alkalinity wasn't good. These results are similar to the report of Akinbile et al. (2015) who reported that leachate contained suspended solid matter consisting of particles of many different sizes which were relatively small solid particles that caused the leachate to appear turbid. Higher rate of turbidity in the water may constitute dissolution of polluting materials. Also, positive correlations were observed between Cl and SO_4 (R=0.757), SO_4 and TDS (R=0.629). Positive correlations significant at 0.01 was observed turbidity and acidity (0.930), between TS and TSS (R=0.968). All these indicated that an increase in one of the parameters favoured increase in another due to the inter-relative significance in–between them. Consequently, strong negative correlation significant at 0.05 in dry season were found between pH and turbidity (R=–0.683) (decrease in value of pH will consequently cause a decline in turbidity value at 0.05 significant level). Also, in dry season there were strong positive correlation significant at 0.05 significant level between acidity and alkalinity, chloride and acidity (R=0.953), chloride and turbidity (R=0.866), chloride and acidity (0.900). Negative correlations significant at 0.05 level were found between DO and acidity (R=0.881), DO and Chloride (R=0.813). The trend was an indication that the pollutants presence in the test parameters was strongly interrelated and interdependence on one another with the co variability values observed. For instance, DO dependence on NO_3, oil and grease and Cl indicated that the effect of oxygen depletion will be significantly felt on all the aforementioned parameters considerably. This is also true with all other parameters of high correlation values in all other constituents analysed in the study. This is in agreement with the report of Akinbile (2015).

4 Conclusion

This study considered wastewater obtained from Akure metropolis (FUTA post graduate hostel, Tisco, Mandate canteen, Mr Bigg, Hospital, and a Resident) and the suitability of the wastewater for possible domestic reuse and irrigation were evaluated. Based on the results obtained from the study, the waste water obtained from the Akure metropolis were polluted and not suitable for reuse for domestic purposes but suitable for irrigation. Also, the water qualities from the six sources were affected and significantly different at 5% level of significance. The unsuitability of the wastewater quality accessed for drinking purpose in this study presents a treatment options available for the waste water reclamation.

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