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EFFECTS OF MUNICIPAL ABATTOIR WASTE ON WATER QUALITY OF WOJI RIVER IN TRANS-AMADI INDUSTRIAL AREA OF PORT HARCOURT, NIGERIA: IMPLICATION FOR SUSTAINABLE URBAN ENVIRONMENTAL MANAGEMENT

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ABSTRACT

This research provides a spatial analytical framework for sustainable urban environmental management. It examines the effects of abattoir wastes on water quality of the Woji River in the Trans-Amadi industrial area of Port Harcourt, Nigeria. The research was premised on the fact that untreated wastes from the Trans-Amadi abattoir are discharged directly into open drainage which flows into the river. Water samples were collected from nine points along the stream (upstream; 3 samples, downstream; 3 samples, fallout; 3 samples) and subjected to physico-chemical laboratory analysis for total dissolved solids (TDS), temperature, pH, turbidity, hardness, iron content, nitrate, sulphate, magnesium, nickel, copper as well as some biological parameters. The results obtained from these parameters were at variance with the allowable limits of WHO standards for human use and aquatic life. The result further showed that the abattoir effluent has lowered the quality of the receiving Woji River particularly at fallout point and downstream. There is, therefore, need to stop the discharge of effluents into the receiving Woji River by upgrading the wastewater and urban waste management techniques of the abattoir to international standard.

Contribution/Originality: This study contributes to the existing literature on the spatial analytical framework on abattoir wastes on water quality. This study uses a new estimation methodology of Peason's Coefficient to represent the relationship between microbiological and physico-chemical parameters of the river.

1. INTRODUCTION

According to the UNICEF (2013) 1,800 children under the age of five die every day from diseases associated with contaminated water. Obire and Wenedo (2003) in a related survey maintained that 11% of the UNICEF figure are Nigerians, yet water is viewed by some as an ordinary liquid made available and abundant by nature while others say natural water is relatively dilute aqueous solutions. On the contrary, water is a vital natural resource necessary for existence and so its quality should be strictly monitored and maintained. It is an essential component for human existence as it constitutes 65% of man's composition, 57% of the matter of earth's crust and necessary for the survival of vegetable matter, plants and animal life. In urban areas, the careless disposal of municipal abattoir waste, industrial effluents and other wastes may contribute greatly to the poor quality of the water (Chindah *et al.*, 2004; Nwankwoala *et al.*, 2018). Pollution of freshwater bodies (rivers, lakes, pond and streams) by nutrients is mostly experienced as a result of industrial discharge, municipal abattoir discharge, domestic sewage disposals, surface runoff from agricultural lands, underground water and salt-water intrusion and inundation (Asuquo, 2009). The disposal of effluent into drains and Woji River poses serious health and environmental hazard to urban dwellers downstream. Livestock waste spills from the abattoir can also introduce enteric pathogen and excess nutrient into surface waters (Meadows, 1995). Research has shown that pollution of water bodies leads to the destruction of primary producers due to alteration in levels of oxygen, CO_2, phosphate, etc. This, in turn, will bring about a decrease in fish yield. Sangodoyin (1992) reported that the groundwater quality in the vicinity of abattoir were adversely affected by seepage of abattoir effluent as well as water quality of receiving streams located away from abattoirs. More so, pathogen from cattle waste could be transmitted to human receiving and using such water. Potable water for domestic use should be free from pathogenic microorganisms, physicochemical and toxic substances such as heavy metals and hydrocarbons. Clean water resources used for drinking, sustaining aquatic and terrestrial ecology, industry and aesthetic values, along with breathable air should remain within a specific quality limit, and therefore require stringent and conservative protection measures. The protection of public health requires that people be supplied with water of adequate quality which satisfies the minimum quality standard (World Health Organisation, 2011). An effective programme to control drinking water quality requires the availability of adequate supportive legislation, the evolution of quality standards for the country and regular environmental surveillance of human activities due to urbanization and development. Indeed, there is an acute societal and global need to monitor the water quality characteristics of some rivers (Osibanjo *et al*., 2011).

In Nigeria and many developing nations, some abattoirs dispose of their waste directly into streams or rivers and also use water from the same source to wash slaughtered meat (Adelegan, 2002). The wastes from abattoir operations which are often separated into solid, liquid and fats could be highly organic. The solid part of the wastes consists of condensed meat, undigested ingest, bones, hairs, and aborted fetuses. The liquid aspect, on the other hand, consists of dissolved solids, blood, guts contents, urine, and water, while fat waste consists of fat and oil. The pollution of water resources often results in the destruction of primary producers, which in turn leads to an immediate diminishing impact on fish yields (Aina and Adedipe, 1991; Edwin, 2011; Magaji and Chup, 2012).

Urban environmental problems have increased in geometric proportion over the years with improper management practices being largely responsible for gross pollution of the urban aquatic environment resulting in a concomitant increase in water-borne diseases like typhoid, and dysentery. Abattoirs located in urban areas are generally known all over the world to pollute the urban environment either directly or indirectly from their various activities (Adelegan, 2002). Abattoirs are usually located near a flowing river especially in developing countries because of water scarcity, since there is high demand of water for washing of meat and cleaning the environment; therefore, the effluent from the washing is directly discharged into the nearby flowing river. These effluents contain high level of organic matter and waste like blood, fats, grease, heir, urine, grit, faeces and undigested feeds which have negative impact on the river water, particularly in large quantity and it can be hazardous to human beings and aquatic life (Kosamu *et al*., 2011).

Previous researches on abattoir in Port Harcourt city concentrated on perceived environmental profile of abattoirs, effect of abattoir waste water on physico-chemical characteristics of soil and sediment, impact of abattoir waste on air quality, perceived impact of abattoir on the livelihood of city dwellers (Egobueze *et al*., 2007; Onojake and Emereol, 2009; Ojesanmi and Ibe, 2010; Ogbonna and Ideriah, 2011) and none of them really emphasized on effects of municipal abattoir waste on water quality. This article therefore focused on the effects of municipal abattoir waste on water quality of Woji River in Trans-Amadi industrial area of Port Harcourt. To achieve this broad aim, a qualitative analysis of the Woji River was done and compared with the standard World Health Organization (WHO) limits for water quality and that of Federal Environmental Protection Agency (FEPA) (1991). More so, a water sample from upstream point of effluent discharge and downstream was also compared so as to determine the spatial trend.

1.1. The Study Area

The abattoir is located at the edge of the Trans- Amadi bridge linking Trans-Amadi Industrial layout to Woji town in Port Harcourt city. A river is located downhill of the abattoir where the slaughter wastes are dumped. Major activities around the river are dredging, boat building and fishing.

This river is called Woji River. It is an estuarine tidal water, a tributary of the upper Bonny River located between longitudes 7°00" E and 7°15" N and latitudes 4°28" E and 4°40" N Figure 1. It arises from the bifurcation to the left of the Okpoka River, which drains into Bonny River. The area has a mean water depth of 4.8m, which is tidal and gradually transits from fresh to salt water at the head.

It is joined by mini Apalugbo stream; this creek drains Rumuokurushi-Rumuogba-Woji axis of Port Harcourt. Woji River receives industrial effluent discharges from the Nigerian Bottling Company, Schlumberger, Halliburton and Rivers State Vegetable Oil Company and transverses through several communities among which include Azuabie, Woji, Okuru-ama, Abuloma, Kalio-ama and Oba-ama.

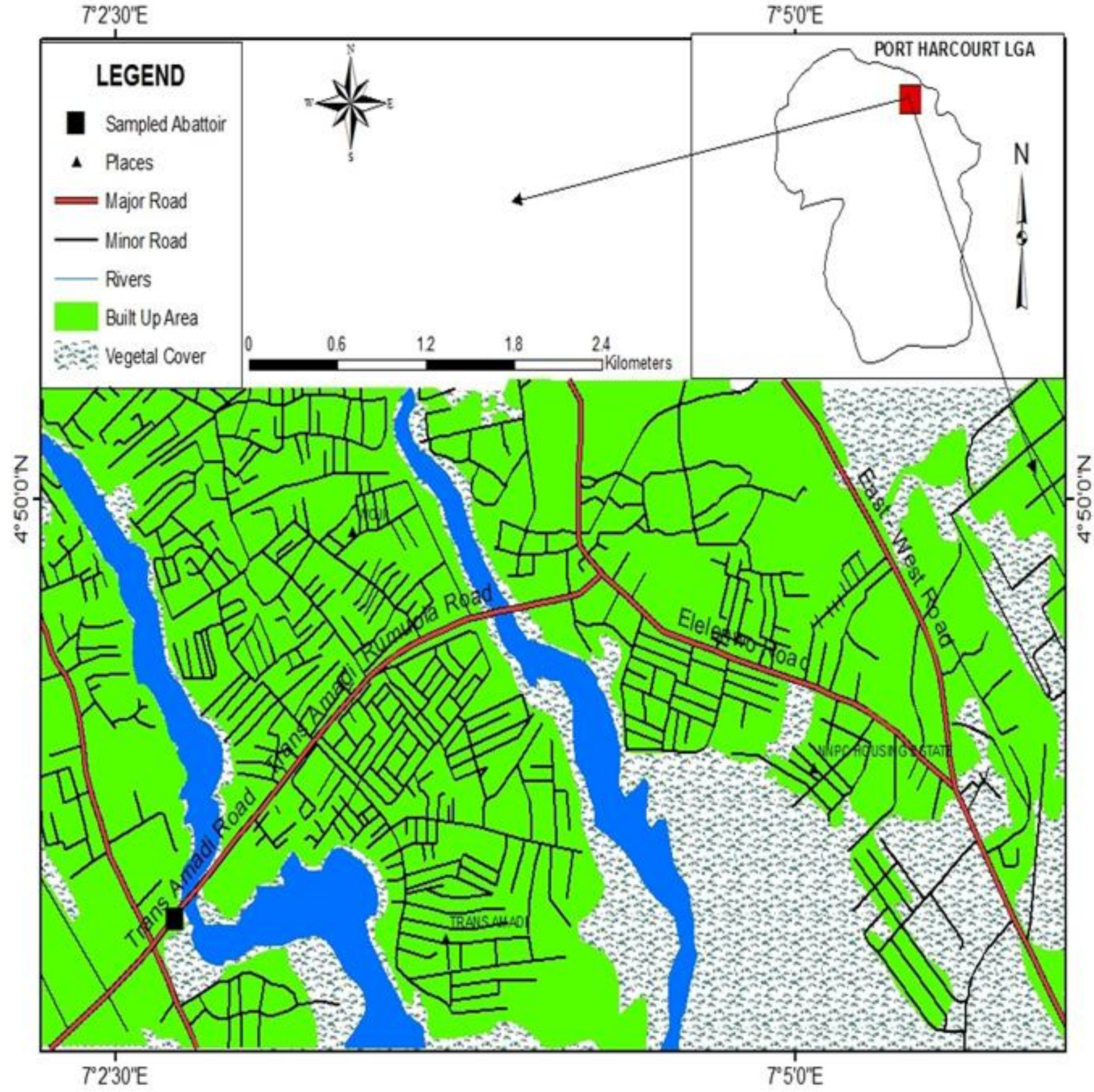


Figure-1. Drainage Map of study area.

Source: GIS Laboratory, Department of Geography and Environmental, University of Port Harcourt, Nigeria.

2. METHODOLOGY

This research was conducted at Woji River in Trans-Amadi industrial area of Port Harcourt, Nigeria from January to March 2018. Samples of water from the river in the vicinity of the abattoir were taken at nine (9) different points using well labeled sterile screw capped bottles at different sides respectively. The bottles were immediately covered to prevent contamination. The temperature and pH of water samples collected were immediately taken using mercury bulb thermometer and pH indicator strip. The sites were geo-referenced using a hand-held global positioning system GPS (Megallan GPS 315) which generated geographical coordinates of latitude and longitude of the river. The different samples were carried to the laboratory for analysis which was done within 8 hours of the collections.

The collected samples were designated as follows: -

(a) **Upstream (US):** 3 different Samples were collected at three different positions 70meters before the point where the abattoir waste meets the river.

Latitude $4^{0}48^{1}50.22^{11}$N

Longitude $7^{0}02^{1}36.8511$E and

(b) **Fallout point (FP):** 3 different Samples were collected at three different positions, at the point where the abattoir waste meets with the river.

Latitude $4^{0}48^{1}50.27^{11}$N

Longitude $7^{0}02^{1}47.^{11}11$E and

(b) **Downstream (DS):** 3 different Samples collected 60 meters away from the point where the abattoir waste meets with the river

Latitude $4^{0}48^{1}16{=}5.27^{11}$N

Longitude $7^{0}02^{1}45.^{11}11$E and

Laboratory Procedure: The H198194 Hanna Water Quality Instrument (a multi-parameter environmental laboratory system for water quality parameter measurement) was used for the physical and chemical parameters. Measurement was done immediately samples were collected and transported to the laboratory for analysis. The meter was equipped with probe/electrode that could be used for in-situ measurements and hence is particularly useful for field measurements as well as Bench Top Analysis.

The following steps were taken to ensure the validity of results: -

1. The instrument was standardized before use
2. The electrode was rinsed with distilled water then samples of interest taken before
   Measurements were made to avoid interference
3. The instrument was adjusted to the observed temperature for temperature dependent parameters such as pH, DO, conductivity, etc.

2.1. Turbidity

Turbidity was determined using UN spectrophotometer DR/2000 at wavelength of 45um. It is an already programmed instrument, thereby reading off the sample directly.

2.2. Heavy metal: Cu, Fe, Hardness, Alkalinity, Nitrate, etc.

Were determined using the American Standard Test and Method (ASTM) (2005)

2.3. Methods of Data Analysis

In line with the research objectives, appropriate statistical tools like tables and charts were employed. Standard deviation was used to ascertain significant variations of parameters within different sites of the Woji River.

Pearson's Coefficient (R) was used to represent the relationship between microbiological and physicochemical parameters of the river within different sites of the river. Probability was set at P = 0.5.

2.4. Statistical Procedure

The major technique was Pearson's Product Moment Correlation Statistical Technique. This was used to determine level of variation in the parameters between the different samples and WHO (2011) standards. Pearson's Product Moment correlation:

$$r_{xy} = \frac{\frac{1}{n}\sum (x-x)(y-y)}{(\partial x)(\partial x)} \quad (1)$$

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

3. RESULTS AND FINDINGS

Table 1: Results of Analysis of the physical parameters of the samples collected in relation to the WHO and FEPA standards. Figure 2 shows the physical parameters of the collected samples.

Table-1. Analytical Results of the Physico-chemical parameters.

Parameter	US	FP	DS	FEP*	WHO+
Electrical conductivity (μm cm^{-1})	100	180	150	N/A	N/A
Total dissolved solids	1050	990	700	2000	500
Temperature (^{0}C)	32.0	30.	27.0	35.40	29
pH	6.8	8.8	6.8	6.9	6.5-8.5
Odour	Odourless	Offensive	Little	Inoffensive	Inoffensive
Total suspended solids (mgL^{-1})	1030	915	712	30	N/A
Turbidity (FTU)	43	58	55	10	5

* Maximum Allowable Level (FEPA, 1991).
\+ Maximum Allowable Level (WHO, 2011).
UP = Upstream FP = Fallout Point DS = Downstream.

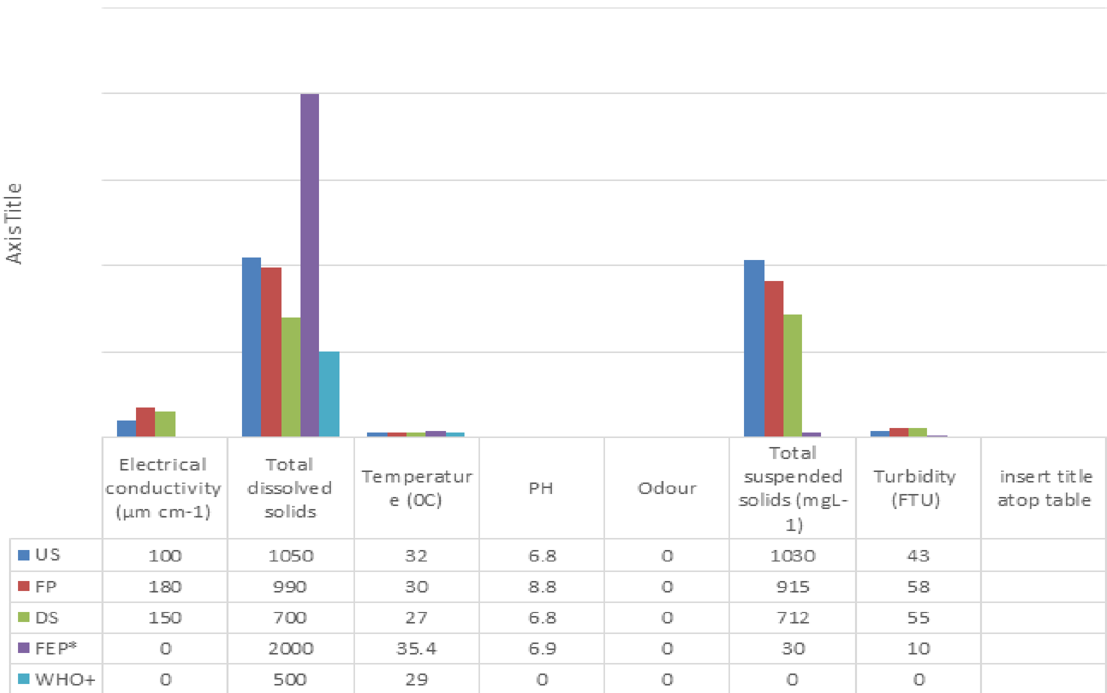


Figure-2. Physical parameters of Collected Samples.

Source: Authors Field Work, 2019.

The electrical conductivity of the samples ranged from 100 – 180 µm cm^{-1}. The average of the upstream sample (US) has the lowest value for electrical conductivity, the average of the fallout point samples (FP) where the abattoir waste meets with Woji River had the highest electrical conductivity of 180µm cm^{-1}. Sixty meters downstream, the average electrical conductivity of the three samples was 150µm cm^{-1}. This clearly indicates that there is a build-up of electrical conductivity at the point the waste enters the river. These values are well above the limits of 3.0µm cm^{-1} recommended by FAO for water used for agriculture purposes such as irrigation.

The total dissolved solids (TDS) of the samples, on the other hand, were quite high when compared to WHO maximum permissible value of 500 mgL^{-1}. However, the values are within the permissible limit of FEPA which is 2000mgL^{-1}.

The temperature of the samples at UP (Upstream) and FP (Fallout point) sections were higher than WHO recommended standards but where within FEPA, values of 35-40^{o}c. High temperature causes thermal pollution and adversely affect aquatic life. One of the effects of rising temperatures is that it lowers the viscosity of water and so cause faster settling of solid particles; an increase in temperature also causes a decrease in the solubility of oxygen which is needed for oxidation of biodegradable wastes, at the same time the rate of oxidization is accelerated imposing a faster oxygen demand on the smaller supply and thereby depleting the oxygen content of the water further. Temperature also affects the lower organism in the aquatic food chain such as plankton and crustaceans, in general the higher the temperature the less desirable the types of algae in the water.

Results of the pH values of the samples ranged from 6.8 - 8.8. Upstream average pH was 6.8, the fallout was 8.8 and downstream 6.8. These are quite within the acceptable limits of FEPA (2011). However, the pH of 8.8 recorded for sample FP (Fallout point) was above WHO, maximum allowable levels. This could lead to eutrophication or nutrient enrichment with its attendant disastrous consequences. For example, the addition of inorganic or organic matter into these materials tend to have the same kind of oxygen-consuming effect on rivers, which limit penetration of sunlight and a consequent reduction in the growth of planktons.

Evidence from Table 1 above shows that the values for the total suspended solids TSS are 1030 mgL^{-1} , 915 mgL^{-1} and 712mgL^{-1} for the US (Upstream), FP (Fallout Point) and DS (Downstream) locations of the stream respectively. From this result, it is clear that the TSS for all the samples exceeds the value recommended by FEPA which is 30mgL^{-1}. However, this unacceptable condition may not be attributed to the abattoir waste directly since the TSS for the upstream location when the waste has not come in contact with the stream far exceeds that at the FP (Fallout Point) and DS (Downstream) locations. The waste itself appears to have a dilution effect since the TSS at the meeting point between waste and stream is less than that at the upstream locations and even further decreases at the downstream location. In general, suspended lead may be considered a pollutant when it exceeds natural concentration and has a detrimental effect on water in its biological and aesthetic sense. The total suspended solids for the effluent from the abattoir violate the permissible limit by FEPA.

Turbidity is an expression of the optical property of water that scatters light. Higher turbidity levels recorded in this study can lead to a high level of deposition downstream and silt problems in the water where the waste is discharged, which could cause blockage of drain passages and flooding. If the water is used for irrigation the suspended matter could block the soil pour spaces leading to poor drainage and increased runoff resulting to flooding and possible erosion problem. High turbidity also adversely affects the aquatic penetration of sunlight into bodies of water. Sunlight is needed by sea weeds for photosynthetic activities. In addition, visibility of aquatic lives is impaired at high turbidity levels and decreased turbidity beyond a certain level is also bad because it promotes the growth of algae.

3.1. Chemical Parameters of the Water Samples Analysed

Table 2 and chat below shows the result of the chemical parameters of the samples collected from the study area in relation to WHO and FEPA standards.

Table-2. Result of the Chemical Parameters of the Different Samples.

Parameter (mgL^{-1})	US	FP	DS	FEPA#	WHO (2011)
Total hardness	21	41	32	N/A	N/A
Total alkalinity	1664	104	90	N/A	N/A
Hardness (Ca)	8.4	16.1	12.8	200	500
Iron content	0.91	0.52	0.52	1	0.30
Nitrate (NO_3)	6.6	9.68	8.8	10	10
Sulphate	10	9	4	500	250
Phosphate 2.42	1.99	0.86	5	2	-
Calcium	233.36	86.56	55.12	200	100
Magnesium	333.06	255.98	214.67	200	30
Nitrate (NO_2)	0.073	0.205	0.512	1.5	1
Nickel	0.00	0.030	0.00	N/A	0.001
Copper	0.00	0.01	0.00	1.5	1.0

N/A = Not Available
* Maximum Allowable level (FEPA, 1991).
+ Maximum Allowable level (WHO, 2004; WHO, 2011).
UP = Upstream PS = Point source DS = Downstream.

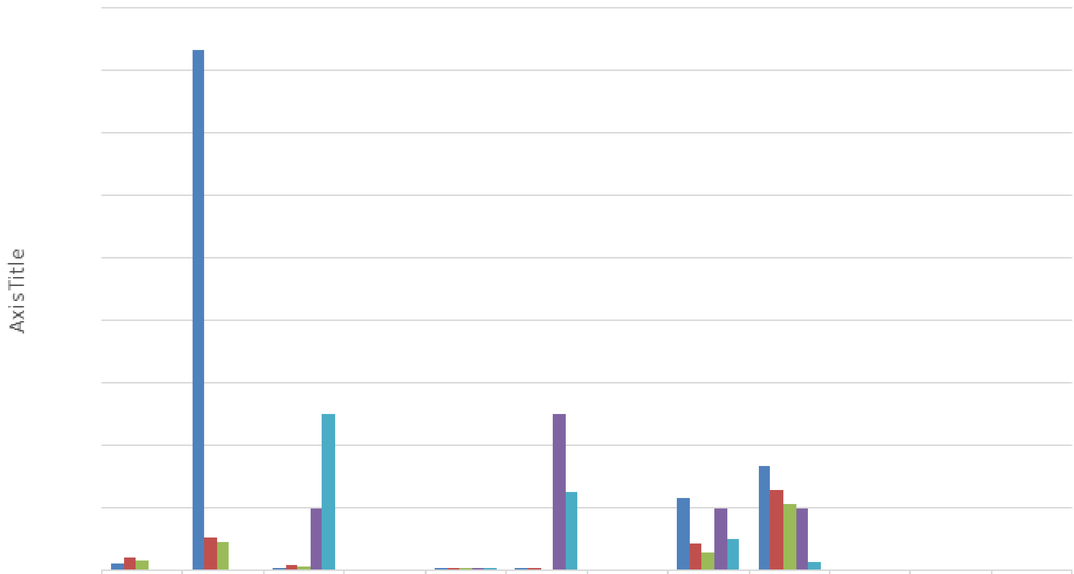
3.2. Total Hardness

The hardening of water is usually as a result of the presence of certain minerals and salts like calcium salts ($CaCO_3$) and magnesium salts ($MgCO_3$).

From the result of the study, it was observed that the total hardness of the samples collected was highest (41 mgL^{-1}) for the fallout point, the least (21 mgL^{-1}) for the upstream and (32 mgL^{-1}) for the downstream sample.

3.3. Total Alkalinity

The normal pH for drinking water ranges from 7–8, thus alkaline level for safe drinking water should normally not exceed 8. There is no FEPA and WHO allowable limit for this chemical parameter.



	Total hardness	Total alkalinity	Hardness Ca	Iron content	Nitrate (NO3)	Sulphate	Phosphate 2.42	Calcium	Magnesium	Nitrate (NO2)	Nickel	Copper
US	21	1664	8.4	0.91	6.6	10	1.99	233.36	333.06	0.073	0	0
FP	41	104	16.1	0.52	9.68	9	0.86	86.56	255.98	0.205	0.03	0.01
DS	32	90	12.8	0.52	8.8	4	5	55.12	214.67	0.512	0	0
FEPA#	0	0	200	1	10	500	2	200	200	1.5	0	1.5
WHO+	0	0	500	0.3	10	250	0	100	30	1	0.001	1

Figure-3. Chemical Parameters of Different Samples.

Source: Authors Field work, 2019.

3.4. Hardness

The samples from fallout point are highest (16.1 mgL^{-1}), next to downstream (12.8 mgL^{-1}) and upstream is the least (8.4 mgL^{-1}). But all of them are below the FEPA and WHO standards of 200 mgL^{-1} and 500 mgL^{-1} respectively.

3.5. Iron

The result of the research shows that all the samples fall within the acceptable limits of FEPA but they all exceed the acceptable limits for WHO (2011). Thus, the Iron content of the samples is acceptable within the Nigerian Standard.

3.6. Nitrate

Table 2 above shows that the Nitrate samples from fallout point is highest (9.68 mgL^{-1}), next is downstream (8.8 mgL^{-1}) and upstream is the least (6.6 mgL^{-1});but all of them are below the FEPA and WHO standards of 10 mgL^{-1} and 10 mgL^{-1} respectively.

3.7. Sulphate

The result of the research shows that all the samples are much below the acceptable limits of FEPA and WHO standards of (500 mgL^{-1}) and (250 mgL^{-1}) respectively.

3.8. Phosphate

From the result of the research, the Phosphate samples from Upstream (US) and Fallout Point (FP) are below the acceptable limits of FEPA but samples from Downstream (DS) are above the limits of FEPA. It is important to state that there is no known limit of Phosphate content for WHO.

3.9. Calcium

The analysis of the collected samples shows that the Calcium samples from fallout point (86.56 mgL^{-1}) and downstream (55.12 mgL^{-1}) are below the acceptable limits of FEPA and WHO standards of (200 mgL^{-1}) and (100 mgL^{-1}) respectively while samples from upstream (233.36 mgL^{-1}) are above the WHO acceptable limits and slightly above that of FEPA.

The increased level of Calcium in the upstream sample as shown in Figure 3 above, suggests that the River Upstream may be contaminated by substances from another source. As the River flows to the Fallout Point, reactions take place that reduce the Calcium content resulting in the observed reduction in Calcium content of the Fallout point sample and Downstream samples.

3.10. Magnesium

Evidence from Table 2 shows that all the Samples have Magnesium content above FEPA (200 mgL^{-1}) and WHO (30 mgL^{-1}) acceptable limits. With Upstream sample having the highest value, this suggests that there may be contamination of the Upstream from another source that is increasing the Magnesium content of the upstream sample.

Further evidence from the research as shown by the result of the analysis in Table 2 clearly reveals that the values for most of the chemical parameters were relatively low when compared with the tolerance limits allowed by both FEPA and WHO. The iron contents were higher than the WHO, 2004 recommended level of 0.30mgL^{-1}. The magnesium contents at the three locations all exceeded the recommended limits by both FEPA and WHO. Nickel content at the point where the abattoir waste enters the stream is higher than the recommended limit by WHO (2011).

In the case of sulphates, effluents are allowed by FEPA to be used for irrigation purposes if the sulphate content is equal to 500mgL^{-1}. The result satisfies the criterion for use of the effluent from the abattoir as irrigation water. Furthermore, sulphur is quite important to plants as it helps in the formation of certain proteins in the protoplasm and it is always found in the sulphates.

Reactive phosphates in the effluent has values that range between 0.83 mgL^{-1} and 2.4mgL^{-1} . The values are within the maximum allowable levels by FEPA which is 5mgL^{-1}, However, they do not satisfy the desirable level of 0.5mgL^{-1} for drinking water as recommended by WHO. The effluent from the abattoir does not satisfy any of the above standards.

Total iron from the effluent is between 0.52 mgL^{-1} and 0.91mgL^{-1}, which is above the WHO 0.30 mgL^{-1} acceptable limit. The implication therefore is that if the abattoir discharges its waste water into other bodies of water used for drinking purposes downstream, it could be contaminated and hence hazardous to human health. The presence of excess iron in water also impacts taste and colour of rivers.

Copper concentration at the discharge point was found to be between 0.0 and 0.014mgL^{-1}, which is within the limit specified by FEPA (1.5mgL^{-1}). Copper, in excess, could lead to a bitter taste of water and is toxic to fish. It also promotes the corrosion of galvanized iron and steel fittings.

Nitrate level of the effluent ranges between 6.60 mgL^{-1} and 9.68mgL^{-1} which is within the acceptable levels of FEPA (10mgL^{-1}) and WHO (10mgL^{-1}). The value of 9.68mgL^{-1} was recorded at the point where the abattoir waste discharges into the river. A value of Nitrate above 0.001mgL^{-1} is of sanitary significance and any value above 10mgL^{-1} is hazardous in drinking water particularly for infants.

3.11. Biological Parameters

This section deals on the presentation of the biological parameters of the samples collected from the study area (Woji River). The biological parameters include the quality of the living things in the River i.e. Fish, planktons etc. In this study, bacterial count and fungal count were investigated Table 3.

Table-3. Result of Analysis of Heterotrophic Plate Count of Primary Culture of Water Samples of Woji River.

Source	Bacterial Count (CFU/1)	Fungal Count (CFU/1)	Coliform Count CFU/100ml
Upstream	$3.4\times10^3\pm50$	6.00 ± 0.10	7
Down Stream	$3.2\times10^2\pm0.1$	4.00 ± 0.10	10.5
Fallout	$2.6\times10^3\pm52$	115.00 ± 15.60	17
Who	N/A	N/A	10

Source: Authors Results, 2019.

An isolated plate count is rarely of value from raw surface waters, even series of plate counts is of little value, because of the wide variation which occur, due to change in climate conditions for instance. The organism most commonly employed as indicators of pollution are *Escherichia coli* and coliform group which are of faecal origin.

The coliform content of Fallout Point sample (17) and downstream sample (10.5) are above the WHO acceptable limits. This is an indication of high levels of faecal contamination.

3.12. Hypotheses Testing

To test hypothesis 1, the average of the three-sample parameter at Woji River and permissible WHO (2011) water quality standards was gotten. To test hypothesis 2, the average of the three samples collected upstream and the average of the three samples collected downstream was also gotten. Pearson Product Moment Correlation Statistical Techniques was used to test the two hypotheses. Equation 2 is the Pearson's product moment correlation statistical formula for hypothesis 1.

Hypothesis 1: There is no significant relationship between Trans-Amadi abattoir waste and the deteriorating water quality of Woji River.

Hypothesis 2: There is no significant difference between upstream water quality and downstream water quality of Woji River.

Table-4. Hypothesis Testing

Parameters	FS	DS (x)	US (y)	Average of the three samples parameters at Woji river (χ)	Permissible WHO (2011) Water quality standards (ß)
TDS	990	700	1050	1370	500
Temperature	30.0	27.0	32.0	44	29
pH	8.8	6.8	6.8	11.2	8.5
Turbidity	58	55	43	78	5
Hardness	16.1	12.8	8.4	18.8	500
Iron content	0.52	0.52	0.91	0.97	0.30
Nitrate (NO_3)	9.68	8.8	6.6	12.5	10
Sulphate	9	4	10	11.5	250
Magnesium	255.98	214.67	333.06	401.86	30
Nitrate (NO_2)	0.205	0.512	0.073	0.40	1
Nickel	0.030	0.00	0.00	0.015	0.001
Copper	0.01	0.00	0.00	0.005	1.0

Using Pearson's Product Moment Correlation Statistical Technique:

Hypothesis 1:

$$rxy = \frac{\frac{1}{n}\sum (x-\mathbf{x})(y-y)}{(\partial x)\,(\partial x)} \quad (2)$$

n =12

(x – x) (y – y) = 675850.1

∂x = 377.28

∂y = 186.18

$$rxy = \frac{\frac{1}{12}\sum 675850.1}{377.28 \text{ x } 186.18}$$

$$rxy = \frac{\frac{1}{12}\sum 675850.1}{70241.99}$$

$$rxy = \frac{56320.84}{70241.99}$$

rxy = 0.80

To test the significance, we use the student t statistical technique. (t test)

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

$$t = 0.80\sqrt{\frac{12-2}{1-0.8^2}}$$

$$t = 0.80\sqrt{\frac{10}{0.36}} \qquad t = 0.80 \times 5.27$$

t cal = 4.22

Degree of freedom = n-1

= 12-1

= 11

Degree of freedom for 11 in a two-tail test at 0.05 = 2.23

Since the t calculated value of 4.22 is greater than the critical table value of 2.23 @ 0.50 confidence level, we accept the alternate hypothesis and reject the null hypothesis which holds that there is no significant relationship between the Trans-Amadi abattoir waste and the deteriorated water quality of Woji River. Therefore, it can be concluded that there is significant relationship between the Trans-Amadi abattoir waste and the deteriorated water quality of Woji River, Port Harcourt.

Hypothesis 2:

$$rxy = \frac{\frac{1}{n}\sum (x-\mathbf{x})(y-y)}{(\partial x)\,(\partial x)} \qquad (3)$$

n =12

(x – x) (y – y) = 651041.012

∂x = 190

∂y = 286.81

$$rxy = \frac{\frac{1}{12}\sum 651041.012}{190 \text{ x } 286.81}$$

$$rxy = \frac{\frac{1}{12}\sum 651041.012}{54493.9}$$

$$rxy = \frac{54253.418}{54493.9}$$

rxy = 0.9

To test the significance, we use the student t statistical technique. (t test)

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

$$t = 0.9\sqrt{\frac{12-2}{1-0.9^2}}$$

$$t = 0.9\sqrt{\frac{10}{0.19}} \qquad t = 0.9 \times 7.255$$

t cal = 6.53

Degree of freedom = n-1

= 12-1

= 11

Degree of freedom for 11 in a two-tail test at 0.05 = 2.23

Since the t calculated value of 6.53 is greater than the critical table value of 2.23 @ 0.50 confidence level, we therefore reject the null hypothesis and accept the alternate hypothesis. Hence it can be concluded that there is significant difference between upstream water quality and downstream water quality of Woji River, Port Harcourt.

3.13. Implications for Sustainable Urban Environmental Management

The implications of the above results are enormous. There is a high degree of pollution to the adjoining Woji River. The pollution of the River by waste from this urban abattoir has distorted the physicochemical composition of the River and the biological characteristics of the river. There is also the serious issue on the appearance of the area and health concern for urban inhabitants of the area, those carrying out activities in the river and even downstream.

Interestingly, there is no doubt that, the pollutants generated by the abattoir effluent negatively affects both the water quality and the entire urban environment, both the fauna and flora of the ecosystem. This is expected to affect the health of most urban dwellers who directly and indirectly depend on the fish and other aquatic organisms from the polluted river for their livelihood and source of protein. Aina and Adedipe (1991) clearly asserted in their study that the pollution of water resources often results in the destruction of primary producers, which in turn leads to an immediate diminishing impact on fish yields, with the resultant consequence of decrease in diet. This is also consistent with the study of Chindah *et al.* (2004) which insist that in urban areas, the careless disposal of municipal abattoir waste, industrial effluents and other wastes contributes greatly to the poor quality of the water. Asuquo (2009) further affirms that Pollution of freshwater bodies (rivers, lakes, pond and streams) by nutrients is mostly experienced as a result of industrial discharge, municipal abattoir discharge, domestic sewage disposals, surface runoff from agricultural kinds, underground water and salt-water intrusion and inundation. The odour from the animal wastes, flies nuisance in the environment and hazardous effluents from the abattoir should be of great concern to urban environmental managers.

It is expected that the urban environment and cities must be sustainable to meet the needs and aspirations of future generations. For a sustainable urban environmental management, there must be paramount concern for the environmental impact of city-based production and consumption on the needs of all urban dwellers, and not just those within their jurisdiction. Accordingly, Goode (1990) maintained that the city environment in most developing countries is directly affected by pollution and development of the natural habitats. This is consistent with the work of Heyford (2017) which clearly confirms that city planners are now sensitive to environmental concerns especially the pollution of water bodies through anthropogenic sources. However, in the developing countries, the sensitivity to environmental concerns does not always mean that effective policies are formulated or that, even if formulated, they are adequately implemented.

Thus, minimizing waste generation from abattoirs and other sources in the cities, and optimizing the use of energy and other resources are important components of any strategy to make a city environment sustainable (Lukas, 2016). As part of sustainable urban environmental management, it is incumbent on the environmental managers to understand the finite nature of many natural resources and the capacities of the ecosystems in the wider national and international context to absorb or break down waste.

The result of this research has shown growing evidence that many current urban trends in the use of resources or sinks for wastes are not sustainable. Although there are several instances of anthropogenic activities destroying or seriously damaging natural resources and systems overtime, only relatively recently has the sum of all human resource consumption and waste generation reached the point where it can adversely affect the present and future state of the local, national and global environment, seriously diminish biodiversity and reduce the availability of certain natural resources.

Consequently, urban environmental managers in the city of Port Harcourt, Nigeria needs to factor in, the needs and survival of future city dwellers in the planning and management of the urban environment. This task becomes very essential since Nigeria is a signatory to the Agenda 21 document of the UNCED meeting in 1992. 'Promoting Sustainable Human Settlement' was the heading to Chapter 7 of Agenda 21. The chapter maintained that all countries must address their urban development needs with environmentalism in their reviews of policies, institutions and programmes. Thus, issues of promoting healthy cities, urban environmental strategies and actions, housing, urban planning, urban management, land policy and land management, infrastructure, energy and transport and disaster-prone areas with intent to bring sustainability more conspicuously were emphasised in the UNCED document.

4. CONCLUSION AND RECOMMENDATIONS

In conclusion, the findings of this research have shown that most of the parameters of the water quality of the river were above the recommended value of FEPA and WHO and the use of effluent treatment plant is lacking in the abattoir. It was further observed that upstream samples had increased values higher than the WHO (2011) and FEPA acceptable limits for Calcium content and Magnesium content thus increasing the total Alkalinity, which suggests that there may be contamination of Woji River from another source upstream.

In view of the above findings, this study recommends the stopping of further discharge of abattoir effluent in Woji River pending when government and other stakeholders put in place effluent treatment, the use of anti-odour chemicals to suppress odour from the animal waste and flies nuisance in the environment, the need for the use of wedge wire screen to remove the suspended solid materials from the effluents prior to its discharge into the river and the adoption of cleaner technologies by the urban environmental authorities to curb the environmental health risks posed by the hazardous effluents from the abattoirs.

The study further provides basis for research on the Quality of the River Upstream, to unravel the cause of the increase in Alkalinity, Calcium content and Magnesium content of the upstream water sample, observed in this study. It is also pertinent that the concerned environmental regulatory body in Nigeria (NESREA) needs to device mechanisms to enforce existing environmental laws concerning the discharge of effluents, such an effort will go a long way to ensuring an appreciable reduction in contamination of surface water and ensure their suitability for domestic and industrial use / usage.

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