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Abattoir Waste Management Impacts Surface Water: A Case Study of Ekpan Abattoir, Uvwie Delta.

Madukasi, E. I.[1], Obidiegwu, M.C.[2], Echika-Anujulu L. U[3]
[1, 2, 3]*Department of Environmental Management, Chukwuemeka Odumegwu Ojukwu University, Uli Campus*

Abstract*—Application of survey and laboratory methods, discrete abattoir composite water samples was assayed for physicochemical, microbiological and inorganics. The laboratory results showed that some of the assayed parameters were above WHO and NSDWQ Reference Standards. These include BOD (365 mg/l), COD (857 mg/l), alkalinity (72.23 mg/l), total suspended solids (755,25 mg/l) and total Coliform (23.25 CFU/ml). The mean were relatively higher at the point of discharge indicating pollution from the abattoir effluent. Plant nutrients, nitrate (58.70mg/l) in the river water samples surpassed both WHO and NESERA specified standards for river water designated for domestic and irrigation purposes. The impact of abattoir waste on surface water is predominantly high nutrients which could be nitrate, phosphate o ammonia that could lead to eutrophication. Nitrate in water is a serious health risk, animal paunch and gut washed in the river before being sold was the source of Nitrate in the investigated Ekpan River. To minimize the impact of abattoir waste on Ekpan River, appropriate waste management practices should be implemented which includes proper treatment prior to disposal of the generated wastes.

Key words: Surface Water; Plant Nutrients; Abattoir Wastes; Pollution; Ekpan River.

I. INTRODUCTION

One type of wastes that is of great concern in urban and rural areas in Nigeria Niger Delta region is abattoir wastes. In Nigeria, animals are slaughtered and the meat sold to the public daily for consumption. Abatoir wastes originate from killing, dehairing, paunch handling, and rendering, trimming and processing operations. Many abattoirs dispose its effluent waste directly onto nearby streams and rivers devoid of treatments; the slaughtered meat is also washed in the same water body. The abattoir wastes contain blood, fat, organic and inorganic solids, salts and chemicals (Olawuni et al., 2017: Fearon, et al., 2014). Ruminants' paunch contains undigested materials called paunch manure, which contains long hairs, whole grains and large plant fragment. In addition, the faeces of livestock that is the animal manure consist of undigested food, mostly cellulose-fibre, undigested protein, excess nitrogen from digested protein, residue from digested fluids, waste mineral matter, worn-out cells from intestinal linings, mucus, bacteria, and foreign matter such as dirt consumed, Calcium, Magnesium, Iron, Phosphorous and Sodium (Ezemonye, et al., 2016). Ezeohaa, 2011). Hence, high production of meat and meat products is synonym to high nitrogenous waste generation from abattoirs. Nigeria a developing nation has been characterized by inadequate waste disposal approaches, treatment and management technologies leading to pollution in most facet of human endeavors abattoir operation inclusive (Thomas et al.,2022). Studies have revealed that abattoir wastes contribute greatly to surface water pollution which represents a major source of wastewater discharge into surrounding water bodies (Tamenech et al.,2017). This informs the often location of abattoirs close to water bodies (rivers, streams or water channels). Wastes are generated at various stages of operations in an abattoir that includes heads and feet removal, stunning, removal of hides and skin, bleeding and evisceration. The waste could be either solid or liquid which if not properly managed could adversely affect the environment (Olanrewaju, 2019). Effective abattoir waste management involves several strategies, such as best management practices that reduces waste generation, separation and proper handling of different waste streams, and the use of treatment technologies to reduce the environmental impact of the wastes (Chunbo, et al., 2022.:Obidiegwu et al.,2019). Common treatment technologies used for abattoir waste management include composting, anaerobic digestion, rendering, and incineration. These technologies reduces waste volume and environmental impact while also producing useful byproducts such as fertilizer, biogas, and animal feed (Tamenech et al.,2017). Abattoir operation could be very beneficial to man (provides meat for human consumption and other by-products). At the same time it can be hazardous to public health if the

waste it generates is not properly disposed. The waste from abattoir operations is often separated into solid, liquid and fats and could be highly organic. The solid part of the wastes consist of condensed meat, undigested ingest, bones, hairs and aborted fetuses. The liquid waste on the other hand consists of dissolved solids, blood, Abattoir effluents whether it reaches the water body through a point source or non-point source reduces dissolved oxygen in water, endanger aquatic life leading to life threatening effect (Ojekunle and lateef, 2017) Hence, the need to plan and design a well-managed and hygienic abattoir is necessary for good public health.

Waste reduction, reuse, recycle, recovery, treatment and disposal are the hierarchy of waste management. Application of waste management hierarchy to abattoir waste management will lead to reduction of waste generated in abattoirs consequently minimizing the impact of such waste in the environment. Adopting waste management hierarchy, abattoirs can effectively manage its waste and minimize its impacts on surface water to ensure a robust sustainable environment.

The problem under investigation is assessing the management of Ekpan abattoir waste and its impact on the multipurpose Ekpan River, which is surface water in Uvwie Local Government Area of Delta State. Ekpan abattoir is one of the important markets in Uvwie that serves as a mini market and slaughterhouse for people within that environment.

Conceptual framework on Water quality

The study is based on the concept of integrated waste management and sustainable water quality. Sustainable environment is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long term environmental quality. Water is the most common and vital liquid for all living things, man in particular, cannot live without suitable water. Nature and source of water contamination, varies from one nation to another, even so, only a minor percentage of the population in these nations have access to safe and portable water while most surface water is either contaminated by industrial effluents or by municipal sewage (Quinta et al.,2018) Usually, pollution is either of a point source or non-point source. Globall, abattoirs are well-known to pollute the environment either directly or indirectly from its various processes. Water is a prime natural resource and precious national asset that forms the chief constituent of ecosystem. Water sources may be mainly in the form of rivers, lakes, glaciers, rain water, and ground water. Besides the need of water for drinking, water resources play a vital role in various sectors of economy such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries and other creative activities. The availability and quality of water either surface or ground, have been decreased and deteriorated due to some important factors like increasing population, industrialization, urbanization, indiscriminate disposal of waste. Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they occurred more than acceptable limits. The World Health Organization (WHO 2017) defines water quality as the characteristics of water that determines its suitability for a particular use. These characteristics include parameters such as color, odor, taste, turbidity, pH, hardness, conductivity, total dissolved solids, microbiological contaminants, and chemical pollutants. Overall, the definition of water quality refers to the condition of water in relation to its intended use and the presence or absence of contaminants that could pose a risk to human health or the environment. The concept of water quality is closely linked to human health, as poor water quality can lead to various health problems, including waterborne diseases, infections, and exposure to toxic substances. Water quality is also important for the health of ecosystems, as it affects the survival and growth of aquatic organisms, and the functioning of aquatic ecosystems. To ensure the safety and sustainability of water resources, it is essential to monitor and manage water quality effectively. This involves regular testing and analysis of water samples, the development of water quality standards and guidelines, and the implementation of management strategies to reduce or prevent contamination and protect water quality (Victor et al., 2018).

A typical waste management system comprises collection, transportation, pre-treatment, processing, and final abatement of residues. The purpose of waste management is to provide sanitary living conditions to reduce the amount of matter that enters or leaves the environment and encourage the reuse

of matter within the environment (Bandaw. and Herago. 2019:Ayhan 2010), Waste management in abattoirs is an important environmental and public health issue, as poorly manage waste can pose risks to human and animal, also the built environment. Several studies have been conducted on waste management in abattoirs, and various guidelines and best practices have been developed to promote sustainable waste management in the sector (Chukwu et al., 2011).Types and quantities of waste generated in abattoirs can vary depending on several factors, such as type and number of animals processed, processing methods, and waste management practices put in place (Mamhobu et al.,2019). Abattoirs generate solid, liquid, and gaseous waste. Solid waste generated in abattoirs include animal carcasses, blood, bones, and other organic materials, packaging materials and other non-organic waste. The wastes can be disposed of through landfilling, incineration, or composting. Liquid waste generated in abattoirs include blood, manure, wastewater from cleaning and processing activities, and other organic and inorganic materials. These wastes can be treated through various methods such as anaerobic digestion, aerobic treatment, and chemical treatment, before being discharged into the environment or reused for agricultural purposes. Gaseous waste generated in abattoirs include methane, carbon dioxide, and other greenhouse gases emitted during animal digestion and waste decomposition, and ammonia, hydrogen sulfide, and other gases released during animal handling and processing activities. These gases can contribute to air pollution and climate change. Improper disposal of waste generated from abattoirs can result in water resources pollution If the wastes are not managed properly, it can contaminate nearby surface water and groundwater sources through direct discharge or leaching into the soil. Pollution of water resources from abattoir waste has significant impacts on the environment, human and animal health. Contaminated water can cause the spread of waterborne diseases, harm aquatic ecosystems, and impact water quality. Best practices for abattoir waste management include reducing waste generation, improving waste segregation, treating liquid waste before discharge, and utilizing waste as a resource through composting or biogas production (Mamhobu et al.,2019).Therefore, effective abattoir waste management practices is essential to protect and prevent deterioration of water quality. The study will fill empirical gap and identify common wastes generated from the abattoir, provide basic information on abattoir waste management and its impact on surface water (Ekpan River).

II. MATERIALS AND METHODS

2.1 Study Area:

Delta state covers a landmass of about 18,050 km^2 (6,970 sq mi), of which more than 60% is land. The state lies approximately between 5°00' and 6°45' E and 5°00' and 6°30' N. It is geographically located in Nigeria's Midwest, bounded in the north and west by Edo State, the east by Anambra, Imo, and Rivers States, southeast by Bayelsa State and on the southern extreme is the Bight of Benin which covers about 160 kilometres of the state's coastline. Delta State is generally low-lying without any remarkable hills and has a wide coastal belt inter-laced with rivulets and streams. Uvwie local government is bounded by Okpe to the North, Udu to the South, Warri South to the West, Ughelli North to the East and Ughelli South to the South Eastern axis. [Figure 1] .Until the 60s and 70s Uvwie and Warri was separated by arcs of bushes and virgin lands there was an obvious boundary between both areas, during the exploration of Oil in the creeks, the former administrative capital and closest hinterland, Warri, attained a city status, due to the sitting of various oil companies and firms the 30 km^2 town became congested. The western axis of Warri (Warri South West, Warri North and other parts of Warri South) had a swampy terrain so the expansion of the then booming city drifted towards its closest neighboring uplands. Ekpan community is located in Uvwie Local Government Area of Delta State, part of the Niger Delta Basin, which is known for its abundant oil and gas reserves [Figure 2].The geology of Ekpan can be divided into two main units: the sedimentary rocks and the unconsolidated sediments. The sedimentary rocks in Ekpan consist of sandstone, shale, and limestone. These rocks were deposited during the Cretaceous period, about 65 to 145 million years ago. The area is located in the Niger Delta Basin, which is known for its abundant oil and gas reserves. Oil exploration and production activities have been ongoing in the area for several decades, and the oil and gas industry is a major contributor to the local economy. However, the oil and gas industry has also had significant environmental impacts on the area, including oil spills and pollution of groundwater and surface

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water sources. In addition to oil and gas, the geology of Ekpan also supports agriculture and other economic activities. The fertile soil and abundant groundwater resources make it possible to grow crops such as cassava, maize, and yam. The area is also home to several small-scale industries, including palm oil processing and fishing.

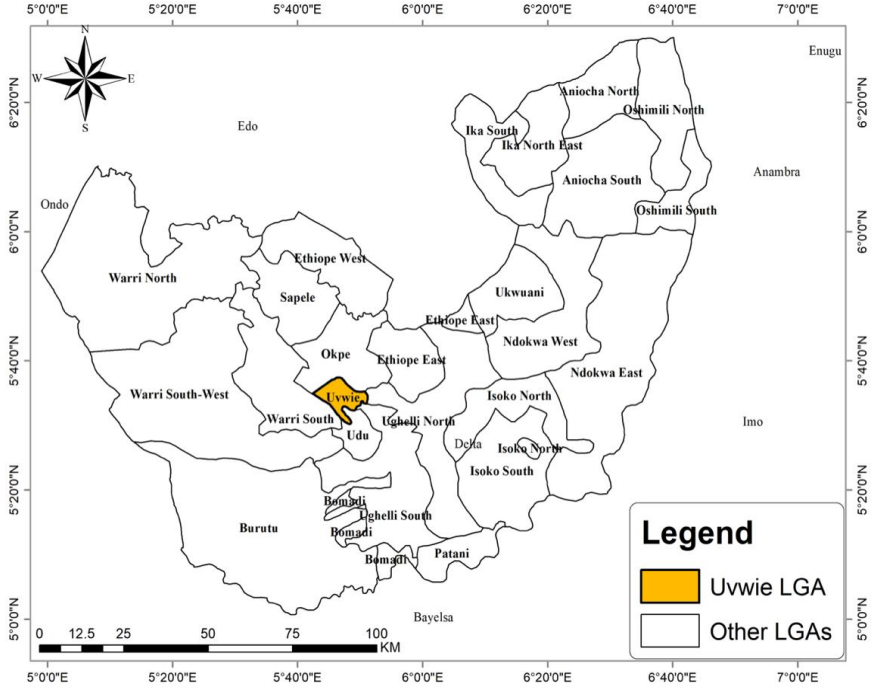

Fig 1: Location of Uvwie local government on the map of Delta state
Source: Degree Group Ltd 2023

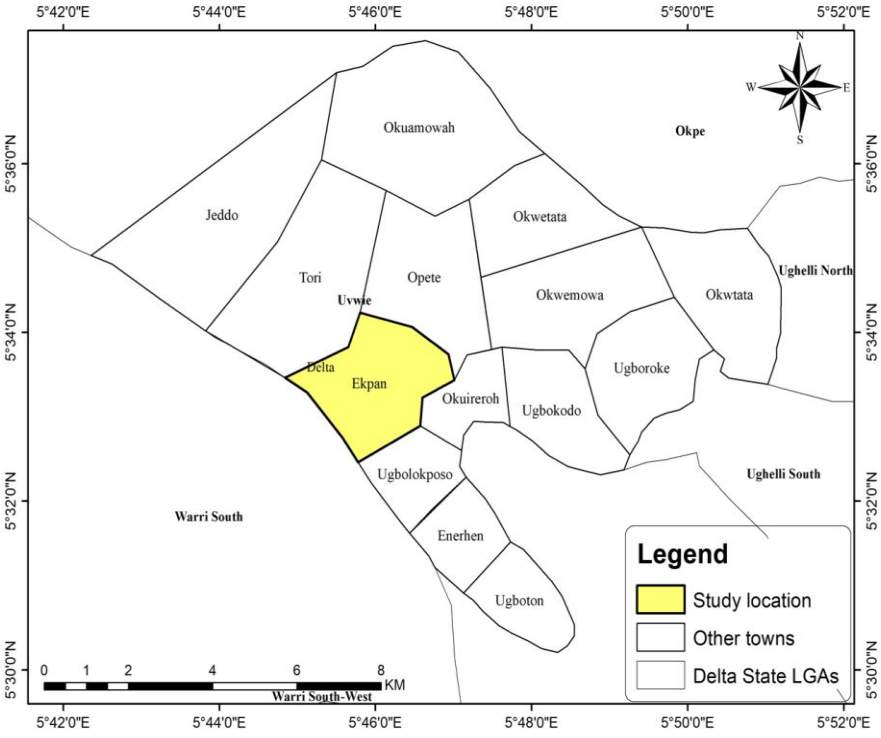

Fig. 2: Location of Ekpan on the map of Uvwie local government
Source: Degree Group Ltd 2023

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2,2 Research Design:

The study adopted field survey and experimentation design in order to achieve the research aim and objectives. Experimental design focused on Ekpan river sampling and sample analysis. For the field survey design, a personal observation was deployed in collecting information on all activities around the abatoir and the Ekpan river

2,2,1 Field Observation and Survey: Field observation was conducted as part of the data collection exercise. A hand-held GPS was used to determine coordinates where river samples were collected in the study area as shown in Figure 3. For the field survey, structured questionnaire was administered to some abattoir operators, individuals living within the abattoir vicinity, farmers and fishermen to ascertain awareness level of abatoir activities and its impacts on the river and environment.

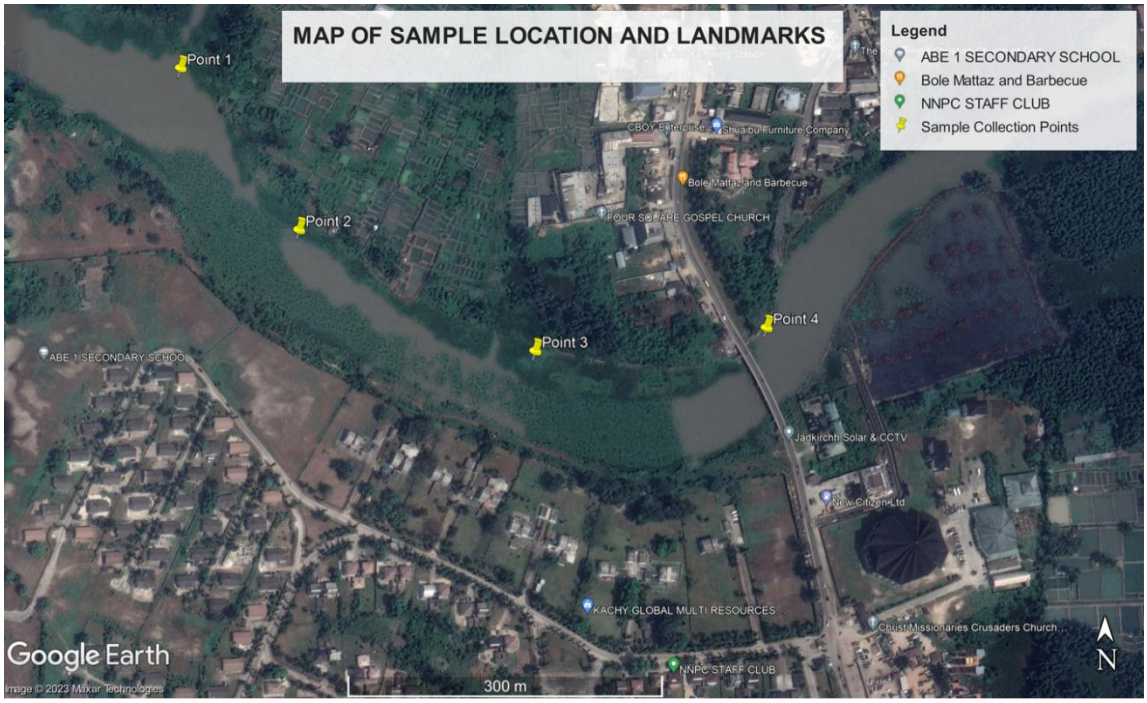

Fig. 3: Google earth image showing Ekpan River, its environs and water sample points.

2,3 Sample Collection and Preparation:

This study is an empirical research work that adopted a composite sample technique for water sample collection from the Ekpan river. Physicochemical, microbiological and inorganic materials were analysed on the water samples. Four water samples were collected as follows: At the point of abatoir effluent discharge (O.m), 20 m upstream, 40 m and 80 m respectively. Water samples were collected using sterilized 1-litre plastic cans between the hours of 6 am and 7 am when the river seems docile. At each collection dept, water samples were collected three times and a composite was made before storing it in a 1-litre plastic container, securely corked and stored in an ice-parked container before transport to a laboratory (Madukasi and Odieli, 2024). The parameters analysed include DO, BOD, COD, phosphate, alkalinity, conductivity, turbidity, TSS, ammonia, nitrates and nitrite faecal coliform, total Coliform according to American Public Health Association (APHA), 2005 methods of analyses and USEPA, 2008).

III. RESULTS AND DISCUSSION

Among the objectives of the research was identification of common wastes generated at Ekpan abattoir in Uvwie local government of Delta State. The results were shown on Figure 3. From Figure 3, the type of wastes generated at the abattoir as indicated by the respondents include; 18% bone, 38% blood, 20% feaces, 6% paunch content and 18% decomposable manure piles. This showed major wastes generated at the abattoir to be blood followed by feaces.

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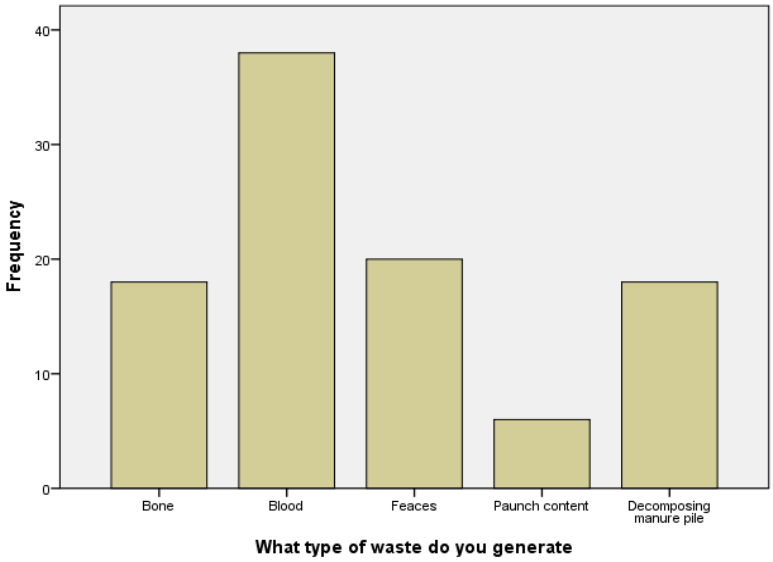

Figure 3 Type of wastes generated at the abattoir.
Source: Researcher's field work, (2024)

A second objective of the research was assessment of how the generated abattoir waste at Ekpan abattoir was managed and its impact on the river. Cursory look oo the analyzed data of the survey (Table 1), revealed that more than half of the respondents (74%) do throw away the waste generated from all the activities at the abattoir market while a small proportion (26%) do sell off the waste generated. In addition, figure 4 revealed that 6% throw away the waste generated at the refuse dump, 48% throws away the waste at nearby water body (Ekpan river), Nearby drainage 26% while 20% nearby bush. It showed that higher proportion of the wastes generated was being emptied in the water body (Ekpan river).

Table 1 Action Taken on the Generated Waste

Action	Frequency	Percent	Valid Percent	Cumulative Percent
Thrown away	74	74.0	74.0	74.0
Sold off	26	26.0	26.0	100.0
Total	100	100.0	100.0	

Source: Researcher's field work, (2024)

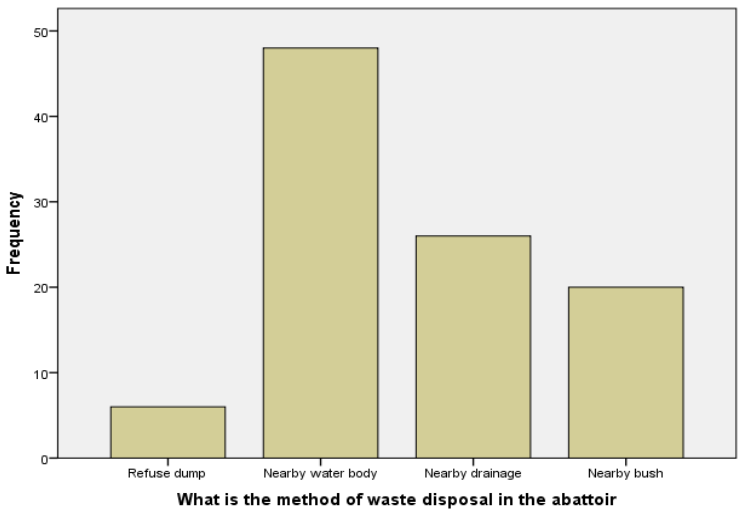

Fig. 4: Methods of waste disposal at Ekpan abattoir.
Source: Researcher's field work, (2024)

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The water samples drawn from Ekpan river were analyzed for some water quality parameters. The results were grouped into three categories namely: physical, chemical and biological parameters respectively.

The physical parameters here represents the conservative constitutes (i.e. those constitutes or pollutants that are not chemically or biochemically reactive) of the river at the point and period of sampling. The data are presented in table 2. From table 2, most parameters were relatively high at the point of effluent discharge and low 20m upstream of the effluent discharge point. It depicted evidence of pollution from the abattoir waste while due to flowing water, it get diluted as the dept increases.

Table 2: Physical Parameters of Water Samples from Ekpan River

Physical Parameters					
Sampling Distance (m)	pH	Conductivity (us/cm)	Dissolved Solids (mg/l)	Total suspended solid (mg/l)	Turbidity (520mm)
0m (point of discharge sample A)	6.8	196	45.5	1026	0.38
20m (Sample B)	6.5	153	77.9	524	0.18
40m (Sample C)	6.9	150	73.7	400	0.26
80m (Sample D)	6.4	196	79.9	1071	0.20
NESREA Permissible limit	6 - 9	500 Max	500 Max	500 Max	5 NTU
WHO Permissible limit	6.5 – 7.8	500 Max	500 Max	500 Max	250 Max

Source: Researchers analytical laboratory work

The chemical parameters represent level of pollution on the river by non-conservative constituents (constituents that are chemically and biochemically reactive) at the peak period of effluent discharge from the Abattoir into the river (Table 3). It showed alkalinity, phosphate, BOD and COD the principal source of pollution indicator from abattoir effluents to be relatively high at the point of discharge, again depicted that abattoir activities affects the water quality of Ekpan River.

Table 3 Chemical Parameters of Water Samples from Ekpan River

Chemical Parameters							
Sampling Distance (m)	Ammonia (mg/l)	Nitrate (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Phosphate (mg/l)	Alkalinity (mg/l)
0m (point of discharge sample A)	4.40	0.27	0.01	670	1675	6.58	106.70
20m (Sample B)	0.18	0.14	1.70	270	680	1.16	54.00
40m (Sample C)	0.21	0.10	2.70	140	350	1.15	68.20
80m(D)	0.52	0.17	1.39	380	725	3.05	60.00
NESREA Permissible limit	10 Max	10 Max	50 Max	50 Max	50 Max	5 Max	50 Max
WHO Permissible limit	10 Max	10 Max	_	50 Max	50 Max	5 Max	50 Max

Source: Researchers analytical Laboratory work.

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The biological parameters of Ekpan River are shown on table 4. From table 4, nitrate concentration was the highest followed by Total Coliform. As exhibited in the previously tested parameters, the mean concentrations were relatively high at the point of discharge an indication of pollution from the abattoir effluent which in turns had affected the water quality.

Table 4 Biological Parameters of water samples from Ekpan River

Parameters	0m (point of discharge)	20m (Sample B)	40m (Sample C)	80m (SampleD)	NESREA Permissible limit	WHO Permissible limit
Faecal Coliform (E. Coli) CFU/ml	10	8	10	6	0 CFU/ml	0 CFU/ml
Total Coliform CFU/ml	30	23	20	20	0 CFU/ml	0 CFU/ml
Nitrate	66.8	62.5	53.9	51.57	0mg/l	0mg/l
Nitrite	0.25	0.20	0.29	0.16	0.2mg/l	0.2mg/l

Source: Researchers analytical Laboratory work.

A percentage compliance test with standards

A percentage compliance test on the water sample parameters with regulatory standards was conducted. NESREA guideline values were adopted for the compliance test. Considering the compliance level of the river water parameters as detailed on Table 5. It can be deduced (if all parameter is weighted equally) that there will be obnoxious environmental concern over time; since 60% of parameters considered were within acceptable limits.

Table 5 Percentage Compliance of Water Samples with NESREA and WHO Standards

Parameter	Min Value	Max Value	Mean	NESREA Permissible limit	WHO Permissible limit
pH	6.20	6.90	6.66	6 – 9	6.5 – 7.8
Temperature (°C)	27.00	29.00	27.90	Ambient	_None
Turbidity (520m)	0.25	0.38	0.092	5 NTU	250 Max
Conductivity(us/cm)	105.00	196.00	160.00	500 Max	500 Max
Dissolved oxygen (mg/l)	0.01	4.40	2.48	50 Max	_Non
BOD (mg/l)	40.00	70.00	50.50	50 Max	50 Max
COD (mg/l)	150.00	375.00	263.50	50 Max	50 Max
Ammonia (mg/l)	0.04	4.40	1.07	10 Max	10 Max
Nitrates (mg/l)	4.10	12.20	8.45	10 Max	10 Max
Phosphate (mg/l)	0.05	3.05	2.35	5 Max	5 Max
TDS (mg/l)	360.70	1071.50	887.00	500 Max	500 Max
Faecal Coliform (mg/l)	5	10	8.25	0 CFU/ml	0 CFU/ml
Total Coliform	20	30	23.25	0 CFU/ml	0 CFU/ml
Nitrate (mg/l)	53.9	83.1	64.9	0mg/l	0mg/l
Nitrite (mg/l)	0.09	0.29	0.21	0.2mg/l	0.2mg/l

Source: Researchers analytical Laboratory work.

The research work finally investigated the Role of Federal and/or State Government towards adequate management of abattoir waste regarding its river pollution tendency. (Table 6), It showed clearly that neither the Delta state government nor the local environmental bodies do carry out monthly inspection at the Ekpan abattoir as 62% of the respondents indicated that the government do not carry out inspection, 22% opined yes and 16% were ignorant.

Table 6 Do government and environmental bodies come to inspect this site?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	22	22.0	22.0	22.0
	No	62	62.0	62.0	84.0
	Dont know	16	16.0	16.0	100.0
	Total	100	100.0	100.0	

Source: Researcher's field work)

Two hypothesis were tested, the first Null Hypothesis was tested using the test statistics of simple Pearsons moment correlation coefficient (r) at 0.05 significant levels, the aim was to identify if there is a relationship in water quality of Ekpan river and effluent generated from Ekpan abattoir, the result showed that majority of the parameters correlated strongly positive with each other at 0.05. Based on the decision rule, It indicates that there was a positive correlation between abattoir waste management and surface water pollution of Ekpan river which had caused changes on some parameters of the river. Hence, Ha statement was accepted, which signifies a strong relationship between abattoir waste management and surface water pollution of Ekpan river.

The second hypothesis tested was to infer if abattoir waste was efficiently managed at Ekpan abattoir or not, the variables of the analysis were ‘’what type of waste do you generate’’? and ‘’what do you do with the generated waste’’? The significance level (0.000) was less than 10%, thus, the null hypothesis was rejected that “Abattoir wastes were effectively managed in Ekpan abattoir and then the alternative hypothesis was accepted. Thus, the study concludes that abattoir wastes were not effectively managed at Ekpan abattoir and sanitary regulations governing abattoir operation was poor..

IV. CONCLUSION

Abattoir wastes adverse effects are enormous. The laboratory results showed some parameters of Ekpan river samples to be above WHO and NESERA standards. These include BOD, COD, phosphate, alkalinity and total suspended solids. Peak period of the abattoir effluent discharge showed nitrate concentration to be highest followed by total coliform which had affected the river quality. Abattoir waste management is crucial to protect the environment and public health. Improper disposal of abattoir waste leads to contamination of surface water, with serious impacts on aquatic life, human health, and water quality for most uses. Impact of abattoir waste on surface water is significant in that the waste could contain high levels of nutrients that lead to eutrophication harming aquatic ecosystems even humans. To minimize abattoir waste impact on surface water, appropriate waste management practices should be implemented. These include proper treatment prior to disposal and such treatment could be done through the use of anaerobic digestion, composting, or land application. The methods help to reduce quantity of nutrients and pathogens present in the waste, making it safer for environment and public health.

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