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Environmental Impacts of Effluent Discharge from A Rice Processing Factory on River Benue's Water Quality in Makurdi, Nigeria

ThankGod Ochai[1], Obed Kohol Niambe[2*], Evalistus Nwankwo[2], Shaibu Ochoche[2], Peter Adio Ibukunoluwa[3]

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ABSTRACT

This study investigates the impact of industrial pollution on the environment surrounding a rice processing factory in Makurdi. Water samples were collected from five different sampling points within and around the factory premises in January 2018. The investigation focused on evaluating the effects of industrial discharge at these sampling points. Several key parameters indicative of pollution, including pH, temperature, total dissolved solids, total suspended solids, conductivity, dissolved oxygen, biochemical oxygen demand, copper, nitrate, and phosphate, were carefully analyzed. Sampling activities were conducted at weekly intervals over three weeks. Both field and laboratory investigations were carried out, revealing that the physico-chemical characteristics of the water samples indicated stressed water quality concerning pH (acidity), turbidity, total suspended solids (TSS), conductivity, dissolved oxygen (DO), and biochemical oxygen demand (BOD). However, certain parameters, namely temperature, copper, nitrate, and phosphate, remained within the acceptable environmental regulatory limits, suggesting no significant pollution from these factors. Notably, the sampling points 1, 2, 3, and 4 were located at distances of 10 meters, 20 meters, 30 meters, and 40 meters, respectively, from the point of discharge, but they were situated in different locations. This variation in distance may have contributed to the observed differences in water quality. Therefore, it is strongly recommended that all waste discharged from the factory be subjected to pollution control measures. Additionally, the practice of open discharge should be thoroughly reviewed to minimize potential health and pollution hazards to both human populations and the ecosystem.

INTRODUCTION

In today's rapidly changing world, the environment has become a matter of paramount concern. Defined as the forces of nature, the surrounding flora and fauna, the environment encompasses all that exists beyond us(Gobo *et al.*, 2009). Its significance cannot be overstated, as it provides the fundamental conditions necessary for life to thrive. The environment's scope extends beyond the physical realm and encompasses the very biological conditions that support the existence of organisms. FEPA (1991) aptly describes the environment as the sum of external factors that influence the life, development, and survival of all living beings, making it an all-encompassing term. However, the delicate balance of nature is being increasingly disrupted due to human activities(Siyanbola *et al.*, 2011). Human beings have profoundly impacted their environment, often on a grand scale compared to other species. This influence has led to various changes, including urbanization, which, in turn, has given rise to environmental pollution and altered the distribution of animals and plants across diverse ecosystems (Goudie, 2018). Among the numerous issues, water and air quality has emerged as a grave concern due to industrial and domestic waste. Urbanization has led to concentrated communities, with residential, educational, commercial, and industrial facilities in proximity, resulting in the degradation of the lower atmosphere in industrial regions. Industrial activities produce solid and liquid particles as well as chemical pollutants, contributing to air pollution(Akhtar *et al.*, 2021). Furthermore, the growth of industries in developing countries has exacerbated problems such as carbon monoxide emissions and combustion byproducts(Garidzirai, 2020). The need to find a harmonious balance between industrial development and environmental protection has given rise to the establishment of environmental laws. However, despite these efforts, environmental degradation persists, particularly in densely populated countries like Nigeria(Maton *et al.*, 2016). The improper disposal of waste, including industrial effluents, has significantly affected water bodies like freshwater reservoirs and estuaries, causing pollution and rendering these vital resources unfit for primary and secondary uses(Okereke *et al.*, 2016). Consequently, the health and well-being of millions of Nigerians are at risk due to waterborne diseases(Efe *et al.*, 2023). To address these challenges, the government must enforce necessary environmental laws and implement effective pollution control measures. Nigeria's urban areas face environmental and aesthetic problems due to inadequate management of municipal and industrial waste(Daramola & Ibem, 2009). Waste accumulation obstructs passage and poses a threat to the environment. This article focuses on a case study of rice factory's operations in Makurdi, Benue State, Nigeria, examining the industrial waste discharged and its environmental impact. The study aims to identify

[1] Joseph Sarwuan Tarka University, Makurdi, Nigeria
[2] People's Friendship University of Russia Named After Patrice Lumumba, Moscow, Russia
[3] Ekiti State University, Ekiti, Nigeria
[*] Corresponding author's e-mail: 1032225329@pfur.ru

the sources of pollution, analyze its effects on the local environment, and propose potential solutions to address the challenges of industrial pollution in the region. By shedding light on this pressing issue, this study contributes valuable information to make informed environmental decisions, with the goal of preserving, restoring, and maintaining the integrity of the environment, particularly the water quality of River Benue and its surrounding areas. Only through dedicated research, awareness, and proactive measures can we hope to safeguard our environment and secure a sustainable future for generations to come.

LITERATURE REVIEW

Recently, the importance of the environment in a nation's development has become increasingly recognized. The environment provides natural habitats and forms the basis for agricultural, industrial, commercial, technological, and tourism development(Southgate & Sharpley, 2014). As a result, environmental issues have become a focal point in academic discussions and public discourse at both national and international levels. The environment encompasses a wide range of external circumstances and conditions that affect the existence and development of individuals, organisms, or societies(Giddings *et al*., 2002).

In Nigeria, environmental issues gained official attention following the 1988 cocoa toxic waste dumping saga, which highlighted the need to establish the Nigeria Federal Environmental Protection Agency (FEPA) and other relevant agencies to address environmental challenges(Ihonvbere, 1994). These challenges include pollution, sanitation, ozone layer depletion, desertification, flooding, erosion, poverty, bush burning, deforestation, and soil conservation(Usiobaifo, 2015). Research indicates that population growth and technological advancements contribute to environmental abuse and pollution, impacting the lives of people and other living organisms (Appannagari, 2017). Industrial, agricultural, and urbanization processes, as well as security and terrorist activities, contribute to environmental pollution. There is a growing awareness of the need to address these issues to ensure sustainable development and protect the environment for future generations (Evelyn & Tyav, 2012).

The Concept of Environment and Pollution

The concept of the environment encompasses all surrounding conditions and elements, including water, air, land, plants, and animals, and the interrelationships among them(Park, 2001). Pollution, on the other hand, is defined as the contamination or defilement of an object or thing, often resulting in a reduction in value. It is caused by the addition of harmful or unpleasant substances to the environment(Jarrige & Roux, 2020).

Pollution can be classified based on its site. It includes the air (atmospheric) pollution, aquatic or water pollution, and land or surface area pollution. Air pollution refers to the introduction of harmful gaseous substances into the atmosphere by human activities. This can lead to adverse effects on living organisms and the environment. Industrial activities and the combustion of fossil fuels are major contributors to air pollution(Vallero, 2014). On the other hand, water pollution occurs when chemical, physical, or biological materials are introduced into fresh or ocean waters, degrading their quality and affecting the organisms living in them. Urbanization and increasing population in Nigeria have led to the need to protect water bodies from contamination. Industrial effluents and uncontrolled exploitation of groundwaters are major causes of water pollution in urban centers like Lagos(Ado *et al*., 2015).

It is important to adhere to guidelines and standards set by regulatory bodies like the Federal Environmental Protection Agency (FEPA) to prevent excessive pollution and protect the environment and human health. The industrial sector in Nigeria comprises establishments of varying sizes and processes, spanning different industries such as metals and mining, food, beverages, tobacco, breweries, distilleries, furniture, pulp, paper, and chemicals. Effluent standards have been established based on the assimilative capacity of receiving waters, with uniform limits set for all industries. Specific limits are also provided for individual industries with unique characteristics(Kanu & Achi, 2011). Compliance monitoring is enforced through facility permits to ensure industrial sites meet these concentration limits for their effluents.

Table 1: Guidelines for interim uniform effluent limits in Nigeria for all categories of industries (mgl-1 unless otherwise stated).

Variables	Discharge to surface water	Land application
Temperature	<40°C within 15m of out fall	<40°C
Colour (Lovibond units)	7	-
pH units	6-9	6-9
BOD_5 at 20°C	50	500
Total Suspended Solids	30	-
Total dissolved Solids	2,000	2,000
Chloride (as CL)	600	600

Sulphate (as SO_4^{2-})	500	1,000
Sulphide (as S^{2-})	0.2	-
Cyanide (as CN)	0.1	-
Detergents	15	15
Oil and grease	10	30
Nitrate (as NO_3) NO_3	20	-
Phosphate (as PO_4^{3-})	5	10
Arsenic (as AS)	0.1	-
Barium (as Ba)	5	5
Tin (as Sn)	100	10
Iron (as Fe)	20	-
Manganese (as Mn)	5	-
Phenolic compounds (as phenol)	0.2	-
Chlorine (Free)	1.0	-
Cadium, Cd	<1	-
Chromium (Trivalent hexavalent)	<1	-
Copper	<1	-
Lead	<1	-
Mercury	0.05	-
Nickel	<1	-
Selenium	<1	-
Silver	0.1	-
Zinc	<1	-
Total metals	3	-
Calcium (as Ca^{2+})	200	
Magnesium (Mg^{2+})	200	
Boron (as B)	5	
Alkyl mercury compounds	Not detectable	Not detectable
Polychlorinated biphenyls (PCBs)	0.003	0.003
Pesticides (Total)	<0.01	<0.01
Alpha emitters (uc ml^{-1})	10-7	-
Beta emitters (uc ml^{-1})	10-6	-
Coliforms (daily average MPN/100ml)	400	500
Suspended Fibre	-	-

Source: (FAO, 1991)

MATERIALS AND METHODS

The Study Area

Benue State was created in 1976, with the capital located at Makurdi. The location of the state is within the middle belt region of Nigeria. Principally, the state lies between longitude 60 451 and 80 151 E and Latitude 70 301 and 90 451 N. The location of the state within the lower Benue trough endows it with well drain surface waters such as rivers and streams(Ujoh & Kwaghsende, 2014). The Rice Factory in Makurdi was established in June 2001. The company is situated at Kilometer 5, Gboko Road, Makurdi, Benue State. The company generates aqueous effluents discharged into arable lands and find their way into surface/ underground water. The effluents may be high in total dissolved solids, oxygen-demanding material, heavy metals, and other toxic chemicals.

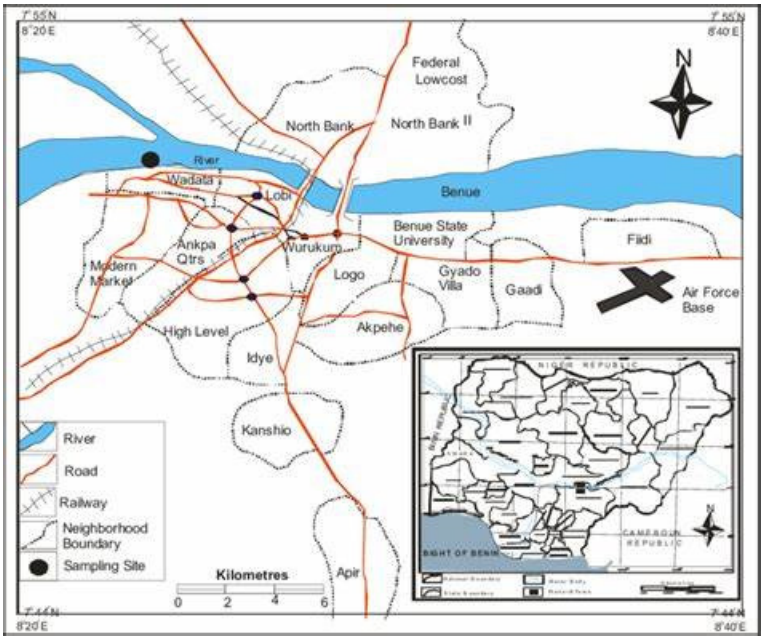

Figure 1: Map showing the location of the study area
Source: (Uruku & Adiknu, 2017).

Data Collection

Five (5) water samples were collected from the rice factory's recipient environment and the receiving stream, using Grab standard method (Blomqvist, 1991). This involved using a clean container to collect water samples from the surface (0-15m). Sampling was carried out weekly for a period of 3 weeks to minimize error. The Sampling points included:

1. Effluent at the discharge point.
2. Flowing effluent at the discharge point into the recipient environment (Land).
3. Stagnant effluent at the discharge point into the recipient environment (Land).
4. Receiving stream at 100 metres
5. Underground water from a well within the area.

Sampling Identification/ Coding

The sampling involved the collection of samples from varying sampling points. All samples were properly given code numbers and labeled with a water-resistant permanent marker on a label held to the container with a firm tag. Samples were properly sealed, carrying labels with the following information:

- Sample number
- Date and time of sampling
- Point of sampling

In-Situ field Analysis

All the water samples collected were assembled and the following parameters were determined.

- pH/Temperature: Determined with a potable HACH pH meter with a temperature compensating device.
- Total dissolved solids/ total suspended solids / conductivity: was determined by use of CO150 HACH Conductivity meters.
- Dissolved Oxygen was determined using a Jenway dissolved oxygen meter. This was carried out using calibrated equipment of high precision. All field instruments were regularly cleaned and calibrated before use. Proper records of the readings for each sample were immediately recorded into the field notebook.

Laboratory Analysis

Water samples were analyzed using the appropriate standard methods for each Parameter as specified by the Federal Ministry of Environment (FME) and the Federal Environmental Protection Agency (FEPA) as documented in the guidelines and standard manual of 1991. The laboratory analysis was carried out at the Greater Makurdi waterworks laboratory-Makurdi Benue State. The parameters determined were:

- pH, Temperature, Turbidity, total suspended solids, total dissolved solids conductivity and heavy metals (Cu, NO_3, & PO_3); determined by use of HACH spectrophotometer.
- Biochemical Oxygen demand; determined by use of HACH SHELAB BOD track.

RESULTS AND DISCUSSION

Field Observation

Water samples were collected from the effulent channels and recipient environment. Effluent from the discharged point was without oil sheen. The effluent at the outlet into the receiving environment was without oil sheen, and the surrounding area was overgrown with weeds, though there was a large portion of land clear of any plant growth and appeared brownish with oil-like stains.

Data Presentation

Data from the analysis of the various parameters was presented on the tables 1-4. This method is adopted to make it easier for comparism with the conventional tables given by FEPA.

Table 2: Results of laboratory analysis of water bodies around the rice factory environs for week 1

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
pH	4.11	3.99	5.17	6.81	5.57
Temperature °C	37.8	37.4	37.8	36.2	36.1
Turbidity, FAU	209	222	35.4	97.4	6.24
TSS, Mg/L	660	689	122	83	81
TDS, Mg/L	51	82	620.33	45	42
Conductivity, ms	97.67	78.8	1192.00	103.00	187.67
DO, Mg/L	6.72	8.10	5.80	4.50	5.70
BOD, Mg/L	4.60	4.16	2.30	1.70	3.8
Copper (Cu)	0.27	0.49	0.18	0.23	0.21
Nitrate Mg/L	1.06	0.91	0.31	0.60	1.71
Phosphate, Mg/L	2.29	1.73	0.92	0.31	0.23

TDS = Total dissolved solids, TSS = total suspended solids, DO = demand of oxygen, BOD = Biochemical oxygen demand
Field work, 2018.

Table 3: Results of laboratory analysis of water bodies around the rice factory environs for week 2

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
pH	3.88	3.72	5.89	6.45	6.17
Temperature °C	38.1	38.0	38.1	38.0	38.0
Turbidity, FAU	236	40.4	35.2	30.4	2.24
TSS, Mg/L	321	177	80	48	40
TDS, Mg/L	41.69	77.26	601	39.2	95.1
Conductivity, ms	83.40	72.49	1202.00	78.70	190.20
DO, Mg/L	7.2	8.80	6.2	4.60	5.62
BOD, Mg/L	3.8	4.21	2.60	1.61	4.0
Copper (Cu)	0.31	0.52	0.16	0.31	0.41
Nitrate Mg/L	1.66	1.22	0.81	0.46	2.1
Phosphate, Mg/L	3.2	2.1	1.8	0.61	0.72

TDS = Total dissolved solids, TSS = total suspended solids, DO = demand of oxygen, BOD = Biochemical oxygen demand
Field work, 2018.

Table 4: : Results of laboratory analysis of water bodies around the rice factory environs for week 3

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
pH	5.21	4.0	5.20	7.1	6.02
Temperature °C	37.8	38.6	37.1	36.8	36.2
Turbidity, FAU	210	210	35.8	102.4	6.40
TSS, mg/1 Mg/L	642	690	132	84	86
TDS, Mg/L	55	81	610.31	46	44
Conductivity, ms	102.45	80.6	1082.00	104.20	190.00
DO, Mg/L	5.60	8.02	6.04	5.01	6.20
BOD, Mg/L	3.80	4.12	3.10	2.22	3.2
Copper (Cu)	0.31	0.46	0.20	0.26	0.24
Nitrate Mg/L	1.26	1.12	0.42	0.70	1.82
Phosphate, Mg/L	2.30	1.70	1.02	0.36	0.35

TDS = Total dissolved solids, TSS = total suspended solids, DO = demand of oxygen, BOD = Biochemical oxygen demand
Field work, 2018.

Table 5: : Mean results of laboratory analysis of water bodies around the rice factory environs for (week 1-3)

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	FEPA LIMITS
pH	4.90	3.90	5.42	6.79	5.92	6-9
Temperature ^{0}C	37.91	37.80	37.67	37.00	36.77	<400c
Turbidity, FAU	218.30	157.47	37.47	76.73	14.93	<25
TSS, Mg/L	541.00	516.67	111.33	71.67	69.00	<30
TDS, Mg/L	49.23	80.09	610.55	46.33	60.37	<2000
Conductivity, ms	94.51	77.30	1118.67	75.97	170.73	<800
DO, Mg/1 Mg/L	6.50	8.31	6.01	4.70	5.84	>10
BOD, Mg/L	4.07	4.16	2.67	1.84	3.67	>50
Copper (Cu)	0.30	0.49	0.39	0.27	0.29	<1
Nitrate, Mg/L	1.33	1.08	0.51	0.59	1.88	20
Phosphate, Mg/L	2.83	1.84	1.25	0.42	0.40	5.1

TDS = Total dissolved solids, TSS = total suspended solids, DO = demand of oxygen, BOD = Biochemical oxygen demand
Field work, 2018.

The physico-chemical quality of effluent water bodies indicated the following characteristics;

The mean hydrogen ion concentration as pH of the effluent and recipient water body (River Benue) ranged from 3.90 to 6.78 which shows that only sample point 4 was within National Standard Regulation Enforcement Agency (NESREA) Limit of 6-9 while sample point 1, 2, 3 and 5 fall outside the Federal Environmental Protection Agency (FEPA) limit indicating pollution due to acidity, probably due to discharge of untreated waste. This acidity can lead to the bonding of ions in the water which can make it not to be readily available for plants to take in thereby affecting the plants growth leading yellowish leaves (George *et al.*, 2012).

The mean temperature of the water samples appears normal within a range of 36.77 to 37.91 as within the FEPA limits of <400C, not indicating pollution. Mean turbidity of the water samples ranges from 14.93 to 218.30. Mean turbidity of sample point 5 is 14.93 as within FEPA limit while that of sample point 1, 2, 3 and 4 are against the FEPA limits indicating pollution. Mean total suspended solids (TSS) of water samples ranges from 69.00 to 541.00 as against the FEPA limits of <30mg/1 indicating pollution. Total suspended solids are particles that are larger than 2 microns found in water column. This can pollute the water by reducing the water clarity.

Mean TDS of water samples ranges from 46.33 to 610.55appear normal within a range the FEPA limits of <2000mg/1 indicating no-pollution.

The mean conductivity of the water samples ranges from 75.97 to 1158.67 having sample point 4 is 1158.67 as against FEPA limit of <800 indicating pollution at this point. The mean DO ranges from 4.70 to 8.31 indicating stress to aquatic organism and pollution. The mean BOD, which ranges from 1.83 to 4.16 is an indicating pollution with organic contaminant and against regulatory standards of >50mg/1. The mean heavy metal concentrations in the water sample of copper ranges from 0.27 to 0.49 indicating no pollution because it falls below the FEPA limit of <1. The mean concentration of Nitrate ranges from 0.51 to 1.88 as within the FEPA limit of 20 indicating no-pollution. The mean phosphate of the water samples ranges from 0.42 to 2.83 appears normal within the range of FEPA limit of 5.1mg/1.

Implication for the Environment

Natural, undisturbed ecosystems provide habitat for a broad range of biota, exhibiting taxonomic richness and complex trophic structure. The physio-chemical parameters of the water samples that are indicators of pollution include pH depicting acidity, Turbidity of all the water samples with exception of point 5, TSS and TDS of all the water samples, conductivity of sample point 3, low pH which is less than 5 indicates acidity concentration. Many biological processes such as reproduction cannot function properly in acidity waters (Pörtner *et al.*, 2004).

Dissolved Oxygen (DO) is a basic requirement for a healthy aquatic ecosystem(Davis, 1975). Most fish and beneficial aquatic insects and plants breathe in oxygen dissolved in the water column(Kramer, 1987); (Hershey *et al.*, 2010). Though some aquatic organisms may adapted to low oxygen conditions. Those that are not will suffer due to the low dissolved oxygen concentration. Prolonged episodes of depressed dissolved oxygen concentration can eventually result in "death" of the water organism(David, 2021). BOD is a measure of the organic content of water. It also represents to some extent, the amount of oxygen which would be required to stabilize the water body(Pradeep *et al.*, 2012). The BOD of the water samples was very low thus organisms in the environment may suffer from low oxygen level.

CONCLUSION

From the study carried out to access the effect of effluent discharge from rice factory on the water quality of the physico-chemical quality of the effluent water bodies indicated pollution and non-compliance with environmental regulatory limits in parameter such as

pH (acidity), Turbidity, TSS, Conductivity, DO, BOD. Parameters that did not indicate pollution include temperature, copper (Cu), Nitrate, and Phosphate. The company does not have any waste treatment/ management procedure. The effluents are released into the environment without treatment; this does not comply with the environmental regulatory requirements. Overall, the environment is under some form of stress because some parameters were not within Federal Environmental Protection Agency (FEPA) limits, thus indicating pollution that may affect the ecosystem. The natural quality of water is influenced by the continuous introduction of substances which leads to changes in the parameters.

RECOMMENDATIONS

With the incidence of the KOKO toxic waste episode in Nigeria in 1988, which was the climax of pollution, the Federal Government of Nigeria set up the Federal Environmental Protection Agency (FEPA) with decree 58 of 1988 to protect Nigeria's environment. The decree also empowered the agency to promulgate regulations; to date the Agency has promulgated or issued several regulations(Ihonvbere, 1994). It is therefore recommended, in accordance with the result of this research, that the rice processing factories in Makurdi should:

- Ensure routine maintenance of facilities equipment to ensure compliance of effluent discharges with environmental standards.
- Ensure self-monitoring of the environmental indicator parameters to check pollution and avoid environmental damage.
- Ensure environmental awareness training to familiarize the plant personnel with the need to be environmentally conscious and friendly in their daily activities.

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