Physicochemical Properties of Tagangu Seasonal River Receiving Abattoir Wastewater Discharge, Aliero, Kebbi State, Nigeria

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ABSTRACT

The physicochemical parameters of the thirty water samples collected at the point of discharge of abattoir wastewater as site A (upstream), site B (downstream) and site C (the irrigation space) of the seasonal River Tagangu were analyzed. The parameters tested include: pH, temperature, turbidity, conductivity, dissolved oxygen (DO), biological oxygen demand (BOD), nitrate, sulphate, phosphate and ammonium. All the parameters were tested following the standard procedures. The pH values obtained ranged from 6.5–7.9; suggestive of suitability of the water for bacterial growth. The temperature values ranged from 21.2–31.2°C; falling within the WHO standard. The turbidity of the water samples ranged from 520–627 NTU, which are exceedingly higher than WHO limit. The conductivity of the water samples ranged from 42.9–624.0 mS/cm; values were far higher than 400.0 mS/cm of WHO standard. The dissolved oxygen (DO) measured between 6.9–19.0 mg/l; which is also greater than WHO standard (6.0 mg/l). Biological oxygen demand (BOD) measured between 312–527.9 mg/l; greater than WHO threshold of 10.0 mg/l. The nitrate contents varied between 39.2–72.3 mg/l; greater than WHO standard (10 mg/l). The sulphate values varied between 45.6–93.9 mg/l; falling within the WHO threshold. However, values greater than 10 mg/l, suggests that the water has been polluted. The phosphate contents observed ranged from 0.435–0.849 mg/l across the three sites, values were higher than 0.3 mg/l of WHO standard. The ammonia contents of the water samples ranged from 27.7–948.5 mg/l; far greater than 0.5 mg/l of WHO standard. The physicochemical study across the three (3) sites shows the typical pollution of the river and rendered the quality of the water hazardous to humans, animals and aquatic lives that could be the users of the water.

Keywords: abattoir wastewater, physicochemical parameters, River Tagangu and WHO standard.

I. INTRODUCTION

Slaughter house activities have direct impact on the built up environment and health of people especially residents within the vicinity of the slaughter house where special or effective waste disposal system is not adequately practiced [1]. Slaughtering and downstream processing sectors of meat processing are heavy users of water and energy especially during the slaughtering process and refrigeration as well as other processing activities. Surface and ground water pollution is a major problem beclouding most developing nations, aside, very few percentage of the population in these nations have access to safe and good water quality while the surface water is either contaminated by industrial effluents, sewage or agricultural wastes [2].

Agricultural run-off is another major water pollutant as it contains nitrogen compound and phosphorus from fertilizers, pesticides, salts, poultry wastes and washes from abattoirs. Contaminants are usually of varied composition ranging from simple organic substances to complex organic compounds with varying degrees of toxicity [3]. In Nigeria, available reports cite gross contamination of most major river bodies across the nation by discharge of industrial effluents, sewage and agricultural wastes among others [4]. Abattoir activity is another source of pollution since human activities such as animal production and meat processing have been reported to impact negatively on soil and natural water composition [5]. Abattoirs are known all over the world to pollute the environment either directly or indirectly from their various processes [6]. Researches pointed out that abattoirs activities are responsible for the pollution of surface and underground waters as well as air quality which indirectly affect the health of residents living within the vicinity of abattoirs [7, 8, 9].

II. MATERIALS AND METHODS

A. Study Area

The study area comprises three sections (Downstream,
upstream and the irrigation space) on the seasonal Tagangu River at old kasuwa (market) area located in Sarkin Fada 1 Ward Aleiro, Kebbi State, Nigeria. The State was created on 27th August in 1991 from the old Sokoto State. It is located in the North-Western part of Nigeria between latitude 11.6781’N and longitude 4.0695°E. Kebbi State has a total of 3,802,500 populations according to the 2011 National Population Census (NPC) estimates.

A total of thirty (30) water samples: ten (10) each from the three sections designated as downstream, upstream and irrigation site and denoted as A, B and C respectively, were collected over a period of three months (May, June and July), along the Tagangu River receiving the abattoir effluent. The water samples were collected as described by [10], and transported to the laboratory in an ice chest box and subsequently processed within 4 hours of sampling.

C. Physicochemical Parameters

All the parameters were determined in accordance with American Public Health Association [10] and the National Research Council of Canada [11]. The parameters include:

- **pH**: Measured on the spot using digital pH meter, which was switched on and allowed to warm for 5 minutes before use. The electrode was rinsed with deionized water before taking the measurement, it was later immersed into each of the water samples, and the measurement was taken and recorded.

- **Temperature (°C)**: Measured on site using mercury bulb thermometer. The thermometer was immersed in each water sample until constant value appeared; the values were taken and recorded.

- **Turbidity (NTU)**: Determined using spectrophotometer, aliquot of water was placed in cuvettes and then inserted into the machine; the values on the spectrophotometer were taken and recorded.

- **Electrical Conductivity (µS cm⁻¹)**: Measured using digital conductivity meter. The electrode was immersed into each of the water sample until the constant conductivity values appeared and the readings then taken and recorded.

- **Dissolved Oxygen (DO)**: Two hundred and fifty (250 ml) of the water sample each was measured; 5 ml of 10% manganese chloride solution was added, followed by 5ml of alkaline iodide solution, this was mixed properly, turned dirty brown on inversion. Then 10 ml of 25% dilute HCl was added; mixed thoroughly, turned to reddish yellow solution. This was then emptied into 250 ml conical flask with addition of 3 drops of starch indicator. The precipitate was finally titrated with 0.05 ml of Na₂S₂O₃ which became colorless at the end point.

- **Biological Oxygen Demand (BOD)**: After determination of the dissolved oxygen at 20°C for 5 days, the dissolved oxygen analyzer was used to determine dissolved oxygen, and then later, the BOD was determined by subtraction of day 5 results from day 1 results.

- **Chemical Oxygen Demand (COD)**: Potassium dichromate (K₂Cr₂O₇) was used to oxidize all organic matter under acidic condition in order to create CO₂ as the final product. After the oxidation, silver phosphate (Ag₂SO₄) was added to the solution as catalyst, heated for 2 hours, and allowed to cool before titration. Titrant ferrous II ammonium sulphate was added; chromium (Cr⁺³) ion present in K₂Cr₂O₇ was reduced to chromium (Cr⁺³) ion while Fe²⁺ was oxidized to Fe³⁺; the end point was noted potentiometrically.

- **Nitrate (NO₃)**: Demonstrated by redistilling each of the water sample and set at zero absorbance, a wavelength of 220 nm was used in order to obtain nitrate reading through interference due to dissolved organic matter.

- **Phosphate (PO₄)**: Demonstrated using phosphate vials based on reaction of auto phosphate anions in a sulphuric solution with ammonium vanadate and ammonium heptamolybdate to form orange-yellow molybdovanado phosphoric acid that was determined spectrophotometrically. The absorbance levels of each of the sample was measured with spectrophotometer at λ = 410 nm.

- **Sulphate (SO₄)**: A 20 ml buffer solution was added to 100 ml of water sample in a 250 ml Erlenmeyer flask. The flask was constantly stirred while a spatula of barium chloride (BaCl₂) crystal was added and stirred for 1 min. The suspension was poured into absorption cell of photometer and the turbidity of the sample was measured at 5±0.1 min.

- **Ammonia (NH₃)**: Hundred millilitre (100 ml) of water sample each was prepared where 1 ml of zinc sulphate (ZnSO₄) solution and 0.5 ml of NaOH was added to obtain a pH of 10.5. The content was allowed to settle, filtered the supernatant through filter paper, an aliquots of samples were taken and 3 drops of Rochella salt solution were added and mixed. Nessier reagent (3 ml) was added to the mixture, transmitted after 10 min of 410 nm and the reading was taken.

D. Statistical Analysis

Analyses of variance (ANOVA) and Duncan Multiple Range Tests (DMRT) tests were applied using SPSS version 20 computer applications. The data were analyzed, with significance set at p <0.05.

III. RESULTS AND DISCUSSION

The mean pH value of the water samples from all sites was highest (7.9) in sample C1 of the irrigation site, while the lowest (6.5) was obtained in sample B2 of the downstream, which is the feeding port for animals (Tables 2 and 3). The values fall within the WHO standard (6.5–8.5), optimum pH 7 has been attributed to affect many chemical and biological processes in water permitting flourishing of different organisms in water. The pH regimes vary significantly (p<0.05) in the water samples throughout the study period.

The mean temperature value of the water samples was highest (31.2°C) in sample B4, while the lowest (21.2°C) was observed in sample C4 (Tables 2 and 3). These fall within the WHO guidelines (40°C) for water temperature (Tables 1–3). [12 and 13] uphold that temperature greatly influences biological activity and growth; it determines the kind of organisms that live in the aquatic regions of which
aquatic species have preferred temperature range.

The highest mean turbidity value of 627.0 NTU was recorded in sample A7 while the lowest value of 526.0 NTU was observed in sample C9 (Tables 1 and 3). The 520–627 NTU values exceeded the WHO guidelines. [14] suggested that the chemical composition of organic and inorganic components in wastewater are assumed to have high turbidity values due to high quantity and quality of materials injected into the water body and consequently have effect on the persistence of microorganisms.

The mean conductivity of the water samples was highest (624.0 mS/cm) in sample A10, while the lowest (42.9 mS/cm) was observed in sample B1 (Tables 1 and 2). The conductivity values of some of the samples were high and majority of the values are above the WHO limits (400.0 mS/cm). [14] had proposed that any river with high conductivity might have been polluted with either agricultural runoff or sewage from abattoir effluent that have mixed up with the water body.

The mean dissolve oxygen (DO) value of the water sample was highest (19.0 mg/l) in sample B2, while the lowest (6.9 mg/l) was observed in sample A10 (Tables 1 and 2). These values are greater than WHO guidelines (6.0 mg/l). DO is required for respiration and release of energy from food, thus it affects the growth, survival, distribution, behavior and physiology of some aquatic organisms. The dissolved oxygen content of water is a single most important parameter that influences aquatic biota life [15, 16].

The Biological oxygen demand (BOD) of the water samples have highest mean value of 527.9 mg/l in sample B7, while the lowest value of 312.0mg/l was recorded in sample C1 (Tables 2 and 3). This far exceeded the WHO limit (10.0 mg/l). The BOD measures the quantity of oxygen required for oxidation of biodegradable organic matters present in water by aerobic and anaerobic biochemical action [17]. The highest BODs of 312.0–527.9 mg/l as obtained in this study indicates that the water body is heavily polluted.

The Chemical oxygen demand (COD) values obtained ranged from the highest (617.7 mg/l) in sample B1 to the lowest (42.4 mg/l) in sample B4 (Table 3). This was higher than limits of 10–20 mg/l set by WHO. The high COD values were obtained at the abattoir point of discharge at the upstream of the river channel. [18 and 19] reported that undesirable COD values have negative effect on the quality of aquatic life in water system.

The highest nitrate content of the water samples obtained (72.3 mg/l) was in sample A2, while the lowest (39.2 mg/l) was in sample C1 (Tables 1 and 3). These values are greater than WHO limit of 10 mg/l. The concentration of nitrates in the water body is suggested to be from leached fertilizer applied to farms in the area, refuse runoff or contamination with human or animal wastes. This assertion was collaborated in the work of [20]. However, high nitrate content in the water body can cause excessive growth of algae and water plants which can adversely affect water quality [21].

The sulphate content of the water samples obtained was highest (93.9 mg/l) in sample B7, while the lowest (45.6 mg/l) was in sample A7 (Tables 1 and 2). These values are lower than the WHO limit (250.0 mg/l). However, if the amount of sulphate in a water body is less than 10 mg/l, it indicates that the water is fresh and unpolluted. In this situation where the sulphate content is greater than 10 mg/l suggests that the water might have been contaminated from abattoir effluent, human animal and agricultural wastes.

The phosphate content of the water samples obtained was highest (0.849 mg/l) in sample B2, while the lowest value of 0.435 mg/l was recorded in sample C1 (Tables 2 and 3). The values were above WHO guideline of 0.3 mg/l. The concentration of phosphate in the river body could speed up eutrophication in water [22]. Therefore, high levels of phosphate obtained could originate from detergent used in washingroasted animals killed in the abattoir as well as the detergent used in washing clothes at the river banks.

The ammonia content of the water samples obtained was highest (48.9 mg/l) in sample B8 and the lowest (27.7 mg/l) in sample C1 (Tables 2 and 3). These values are far above the WHO limit (0.5 mg/l). The high ammonia concentration is attributable to leaching of fertilizers from the farms and other decomposing organic materials from animal wastes into the river channel. [21] posited that ammonia has toxic effect on humans. Its intake is higher than detoxifying capacity at a dose of 100 mg/kg of body weight per day.
IV. CONCLUSION

Due to the very high recordings of many of the physicochemical parameters (except in pH, temperature and sulphate), it is evident that the physicochemical parameters of the Tagangu River did not meet the WHO guidelines for untreated water body that can be used for recreational or domestic purposes. Thus, the River poses serious hazard to humans, animals and aquatic lives that are associated with the river.

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COMPETING INTEREST

No competing interests exist.

REFERENCES

[1] Y.O. Bello and D.T.A. Oyedemi. “The impact of abattoir activities and management in residential neighborhood: A case study of Oghomosodo,” Nigeria. Journal of Social Sciences, vol. 19, no. 2. pp. 121-127, 2009.

[2] Food and Agricultural Organization. Livestock products: Food and Agricultural Organization statistical database. Food and Agricultural Organization of the United Nations, 2009. Available: http://faostat.fao.org/site/569/default.aspx

[3] J.A. Adelegan. Environmental policy and slaughter house waste in Nigeria, in 228th WEDC conference report, 2002. Calcutta, India.

[4] World Health Organization. Guidelines for drinking water quality recommendation, World Health Organization, Geneva, 2008, vol. 1, pp. 130-135.

[5] A.O. Adesemoye, B.O. Opere and S.C.O. Makinde. “Makinde. Microbial content of abattoir waste water and its contaminated soil in Lagos, Nigeria,” African Journal of biotechnology, vol. 5, no. 20, pp. 1963-1968, 2006.

[6] C. Ogbonnaya. “Analysis of ground water pollution from abattoir waste in Minna Nigeria,” Research Journal of Dairy Sciences, vol. 2, no. 4, pp. 74-77, 2008.

[7] C.L. Raymond. “Pollution control for agriculture. A substantial revision of the agricultural waste,” vol. 1, no. 2, pp. 123-213, 1977.

[8] R.C. Patra, D. Swarup, R. Naresh, P. Kumar, D. Nandi, P. Shekhar and S.L. Ali. “Tail hair as an indicator of environmental exposure of cows to lead and cadmium in different industrial areas,” Ecotoxicology and Environmental Safety, vol. 66 no. 1, pp. 127-131, 2007.

[9] S.A. Odomoelam and O. Ajunwa. “Heavy metal status and physicochemical properties of agricultural soil amended by short term application of animal manure,” Current World Environment, vol. 3, no. 1, pp. 21, 2008.

[10] American Public Health Association. Standard Methods for the Examination of Water and Wastewater, APHA, US, 1998, pp. 21, 1378.

[11] National Research Council of Canada. Effect of Sodium and Potassium in the Canadian Environment, Associate Committee on Scientific Criteria for Environmental Quality, Ottawa, 2011 No.150154.

[12] M.O. Jaji, O. Bangbose, O.O. Odukoya and T.A. Arowolo. “Water quality assessment of Ogun River, Southwest Nigeria,” Environmental Monitoring and Assessment, vol. 133, no. 13, pp. 473-482, 2007.

[13] M.F. Al-Mutair. “The incidence of enterobacteriaceae causing food poisoning in some meat products,” Advance Journal of Food Science and Technology, vol. 10 no. 3, pp. 16-21, 2011.

[14] R.B. Hennings. Stream Temperature Management in the Tualatin Watershed: Is It Improving Salmonid Habitat?, 2014.

[15] M. Henze and Y. Comeau. Wastewater Characterization Biological Wastewater Treatment. Principles, Modeling and Design, London IWA Publishing, 2008, pp. 33-53.

[16] K.E. Lagler, J.E. Bardach, R.R. Miller and K.W. Passion. “Variable on sediment addition on stream benthos,” Hydrobiologia, vol. 79, pp. 187-194, 1981.
nutrients,” *Water Standard Analysis*, vol. 27, no. 4, pp. 475-480, 2001.

[19] O.S. Fatoki, P. Gogwana and A.O. Ogunfowokan. “Pollution assessment in the Keiskamma River and in the impoundment downstream: water standard analysis, vol. 29, no. 2, pp. 183-188, 2003.

[20] C.P. Young and M. Morgan-Jones. “A hydro-geochemical survey of the chalk groundwater of the Barnstead area, Surrey, with particular reference to nitrate,” *Journal of the Institute of Water Engineers and Scientist*, vol. 34, pp. 213-236, 1980.

[21] World Health Organization. *Health hazard from nitrate in drinking water, 1985. Report on a meeting*, Copenhagen World Health Organization Regional Office for Europe, Copenhagen.

[22] United State Geological Survey (2015). Turbidity. Online 2015. Available: [http://water.usgs.gov/edu/turbidity.html](http://water.usgs.gov/edu/turbidity.html)

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