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INVESTIGATION ON THE BIODEGRADATION CAPACITY OF KADUNA RIVER, NIGERIA

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ABSTRACT: *River Kaduna is a major river in Nigeria, which transverses five states in the northern parts of Nigeria and various activities such as industrial, domestic and non-domestic activities channel their wastes into the river. This causes heavy pressure to the waterbody. The characteristic of the river water quality will affect pollution degradation process. This research was conducted to examine the biodegradation capacity of the River. Water quality data were collected from fifteen locations along the river channel for the period of three months. Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) concentrations were used to calculate the biodegradation capacity of the river. The calculation results show that during the period the ratio ranges between 0.41 and 0.74, which indicates that the rivers have average biodegradation capability, relatively high capability in biodegradation capacity and self-purification capability.*

KEYWORDS: Kaduna, biodegradation capacity, industrial, BOD_5/COD ratio, self-purification

INTRODUCTION

Biodegradation is the breakdown of a substance by biological activity, especially by microorganisms, into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary greatly, but the final product of aerobic degradation is usually carbon dioxide, water and minerals (salts). Other gases like nitrogen or H_2S may also result. Until the last 200 years, the deterioration of water courses due to organic pollution was not a serious problem because a relatively small human population lived in scattered communities and the wastes dumped into rivers could be coped with, by the natural self-purification properties (Dhall *et. at.* 2012)

River systems are often heavily degraded, a situation that is not confined to a particular geographic region of the world (Morley and Karr 2002). Development along river channels imposes enormous changes on the form and function of river systems (Gurnell *et. al*. 2007). Nowhere is the impact of human population growth and land alteration more apparent than in the water quality of urban rivers (Epstein *et. al*. 2016). The river water and sediment quality are affected by storm water and waste water drainage from different sources of pollutants. Naturally, the organic-polluted rivers can purify themselves. Biotic processes plays a very significant role in both lotic and lentic water system self purification (Ostroumov 2004). The removal of pollutants from a water body without any artificial controls is called self-purification, or natural purification. The mechanism of self-purification of water bodies can be divided into three groups: physical processes, chemical processes and biological processes (Thu et. al. 2015). The characteristic of the river water quality will affect the pollution

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degradation process. In a wastewater management, the target is to convert organic and inorganic matter into inert mineralized products under controlled conditions and at higher rates. Before any wastewater can be treated, it must first be characterized, because knowing the composition of the influent wastewater is essential for successful design and operation of wastewater treatment plants.

Monitoring of biochemical parameter is a routine water quality assessment for river quality where pollution is of concern due to rapid urbanization and industrialization that can post threat to the sustainability of river conservation. The impact of an effluent or wastewater discharge on the receiving water is predicted by its oxygen demand (Esener, *et al*., 1981). According to Khanna *et al*. (2011), the two most common parameters used to recognize the composition of wastewater are the biochemical oxygen demand (BOD_5) and the chemical oxygen demand (COD). The typical range of BOD_5 in domestic wastewater ranges from 100 to 300 mg/L. The BOD_5 and COD are two widely used parameters for organic pollution measurements (Contreras *et. al*. 2003).

The BOD_5/COD ratio is an indicator of biodegradation capacity (Metcalf and Eddy 2003) and is affected by the concentration of non-biodegradable material. The BOD_5/COD ratio is found to be reliable and useful indicator to relate organic matter content in the river under tropical climate condition. BOD_5/COD ratio can be used as crucial attribute for characterization of river and critical indicator for pollution measurement in the river water study (Contreras *et. al*. 2003). This ratio that has been commonly used as an indicator for biodegradation capacity is called "Biodegradability index" (B.I.). It is generally considered the cut-off point between biodegradable and non-biodegradable waste. There is no official value for BOD_5/COD biodegradability index for different types of wastewater, however, reported values for biodegradability index vary from 0.4 to 0.8, for municipal raw wastewater. A value of BOD/COD ratio >0.5 denotes rapid biodegradation, and a range of 0.2-0.4 indicates biodegradation only in favorable thermal condition (Contreras *et. al*. 2003). The ratio can exceed 10 for industrial wastewater. Monitoring the biodegradability of effluent wastewater may provide a key element for pre-evaluation of the efficacy of further treatment processes as well as for assessing the degree of the potential pollution when the effluent is released to nearby watersheds.

Having the biodegradation capacity will suggest the further treatment and strategy to overcome the polluted urban rivers. In this study, different industrial processes and their processing facilities discharging into Kaduna River was investigated. The main objective of the analysis was to investigate the relation between BOD_5 and COD and thus describe the biodegradability capacity of Kaduna River for the purpose of suggesting an appropriate river management approach.

MATERIALS AND METHOD

Kaduna River is a major tributary of River Niger and has a total flow-length of 550 km from its source at the Kujama Hill in Plateau State to Shiroro Dam and finally discharge into River Niger. Most of its course passes through open savanna woodland. The river basin encompasses approximately 44,575 square miles and drains all or portions of the Jos Plateau, Kaduna and Niger States in Nigeria. This study focuses on the middle stretch of the river within Kaduna metropolis from Malali (Igabi LGA) to the Railway Bridge at Rigasa (Rigasa LGA) covering a total distance of 32.7 km and falls into Igabi, Chikun, Kaduna South and Kaduna North LGAs (Figure 1).

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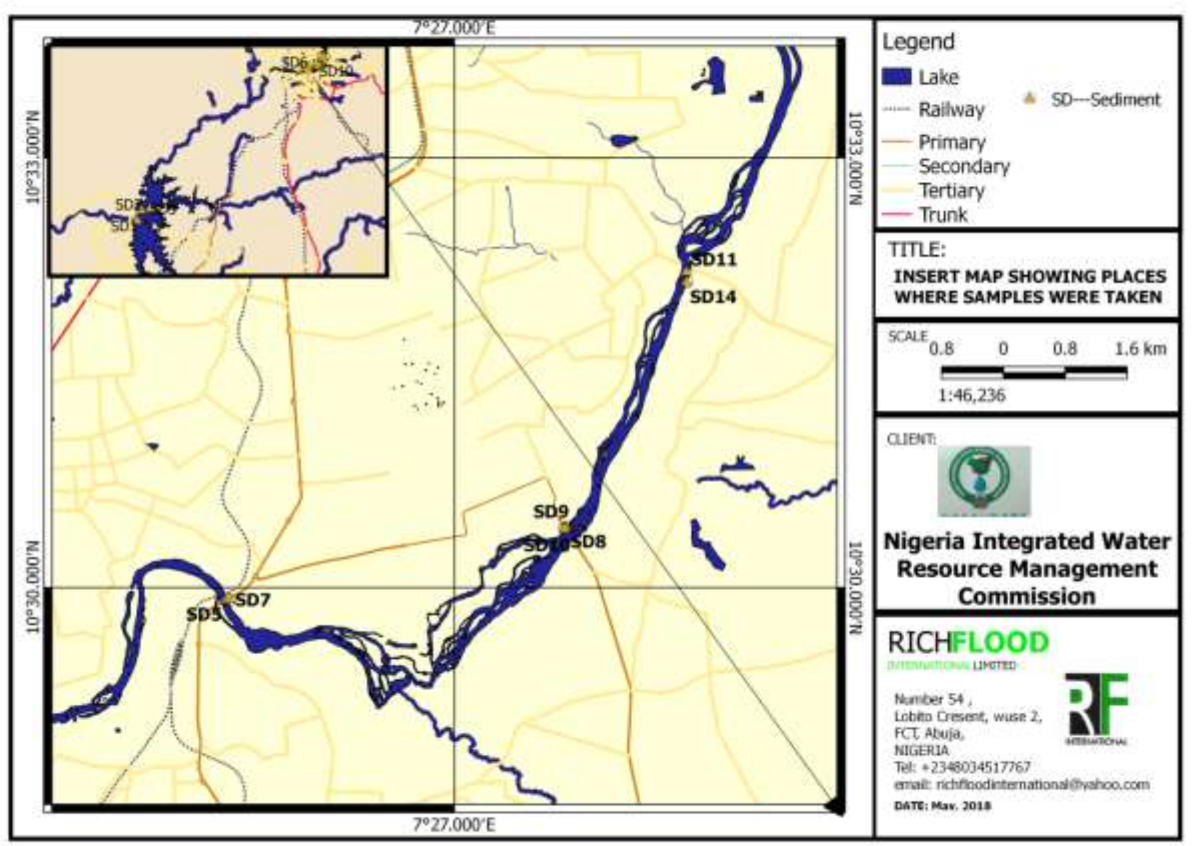

Figure 1: Map of Area showing sample distribution

The localities and communities that make up the study areas include; MalaliGabas, UngwaRimi, UngwaMaigero, Narayi, UngwaPama, Bayanduse, Kabala, Barnawa, UngwaBoro, Sabon Tasha, Kigo Road (new extension), TudunRomi and Maigiginya. The area is underlain by Basement complex comprising high grade metamorphic and igneous rocks (Akujieze *et al.,* 2003).

It experiences the tropical continental climate with two distinct yearly seasons, mean annual temperature of 25^0C and rainfall at about 1200 mm (Mallo, 2000; Okanlawon. 1992).The area have been identified of having more municipal and industrial activities compared to the other sections of the river as it passes through the Kaduna city metropolis which is more of urban area with its likelihood of it been more polluted at the middle stretch compared to other parts of the River.

The river is used for various purposes – domestic, agricultural, fishing and industrial. It also serves as a sink for domestic and industrial effluents. Kaduna is one of the few highly industrialized cities in Nigeria with over ninety-two industries (Yusuf, 2004). Continuous urbanization and the promotion of greater industrial activities have increased the danger of extensive pollution of the river that runs through the city (Carmichael and Strzepek, 1987). Most of the industries in Kaduna are located in the two industrial estate - Kaduna South (Kakuri) and Kudenda Industrial Estates. The major industries that generate liquid effluent in Kaduna are the textiles, food/beverages, and petrochemical industries. Others include chemical, fertilizer, automobile, paper, glass and ceramic factories (Yusuf, 2004).

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These industries discharge 165,000m3/day of untreated effluent into the Kaduna River (Okanlawon, 1992: CIWAT, 2002). The wastewater pollution load is put at l5, 740 rnetric tons/year. The effluents from the textile industries have increased values of BOD, COD, nitrogen, phosphate, temperature, pH. alkalinity-acidity, oils and grease, sulphides and toxic chemicals such as phenols, chromium and heavy metals (USEPA, 1974; Akintunde, 1986). A wide variety of chemicals such as dyes, surfactants, oxidizing and bleaching agents, reducing agents, silicones and organic salts are found in textile effluents (Ibidapo, 1986). Effluents from the food and beverage industries contain substances in suspension, nitrogenous substances, residues of beer and yeast, particles of chaff (Nemerow-1978). They have increased value of BOD, suspended solids, oil and grease (Ogedengbe *et al*, 1984). Effluent from refinery and petrochemical plants contain high levels of polluting substances such as oil and grease, surfactants, heavy metals, ammonia, phenols and sulphides (IINEP, 1987; Pierce *et al*, 1997).

Sample collection and Analysis

Fifteen water samples were collected monthly for three months from the water body. Details of sample location and coordinates are indicated in Table 1. At each of the sampling station, samples were collected using a one litre plastic container that have been pre-treated by washing in dilute hydrochloric acid and rinsed with distilled water. At the sample collection point the plastic container was rinsed with the relevant sample to be collected. Water samples were taken by submerging the container below the surface and allowing it to overflow. Duplicate Winkler bottles were also used to sample in the same manner for the determination of COD.

Table 1: Geographical coordinates of the sampled stations

S/No	Sampling Codes	Sampling Coordinates	
		Northing	Easting
1	SW1	9°57' 0.33"	6°50' 18.8"
2	SW2	9°57' 41.4 "	6°50' 35.5 "
3	SW3	9°59' 9.6 "	6°50' 46.5 "
4	SW4	9°59' 59 "	6°51' 5 "
5	SW5	10°0' 19 "	6°51' 15"
6	SW6	10°1' 4.8 "	6°51' 29 "
7	SW7	10°1' 18.8 "	6°51' 36.85 "
8	SW8	10°1' 35 "	6°51' 44 "
9	SW9	10°1' 58.6 "	6°51' 56 "
10	SW10	10°2' 18 "	6°52' 2 "
11	SW11	10°1' 58 "	6°52' 26 "
12	SW12	10°1' 57 "	6°52' 51 "
13	SW13	10°0' 41 "	6°52' 60 "
14	SW14	10°1' 32 "	6°52' 59 "
15	SW15	10°0' 17 "	6°52' 39 "

BOD and COD analysis were carried out using dilution method and dichromate method, respectively, according to the (APHA, 1998).

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RESULT AND DISCUSSION

Levels of COD and BOD in the collected water samples are as presented in Table 2 and Figures 2 and 3. Lowest mean value of BOD was recorded in Station (21.3±2.85 mg/l) while the highest mean value was recorded Station 12 (123.0±15.22 mg/l). Highest values of COD (221.0±28.55 mg/l) and lowest (41.7±4.28 mg/l) were recorded in Stations 15 and 4 respectively. The values recorded during this study were higher than the values recorded by Ojutiku *et. al*. (2016) on the same river but similar to the values obtained by Yusuf *et. al*. (2008), Al-Amin (2013). Garba (2014) though with slight variations in some of the locations by these authors. The high variations in the levels of BOD_5 and COD in the different locations are caused principally by industrial, domestic and agricultural effluents outfall. The high values of BOD and COD in some sections of the river are indications of increased pollution levels. It is also an indication of low oxygen levels for living organisms in the water when they are utilizing the organic matter present in the river. BOD and COD are not pollutant, but is a measure of organic pollution. Similarly, the high COD concentrations at the same locations indicate the presence of toxic conditions and the presence of biologically resistant organic substances. The use of water with high COD values for irrigation may restrict plant-growth, especially on poorly drained soils. High concentration of COD reduces dissolved oxygen levels in water, thus affecting the survival of aquatic organism through fish kills and objectionable water qualities.

Table 2: The mean BOD, COD and Biodegradability Index of Kaduna Water Samples

Sampling Codes	**COD**	**BOD_5**	**Biodegradability Index**
SW 1	96.0 ±6.22	67.9±4.21	0.51
SW 2	130.0±15.21	92.3±5.66	0.52
SW 3	154.7±12.14	27.3±2.08	0.59
SW 4	41.7±4.28	74.4±4.95	0.65
SW 5	180.0±22.04	21.3±2.85	0.41
SW 6	44.4±2.28	76.2±8.62	0.48
SW 7	155.0±21.04	99.3±10.08	0.49
SW 8	159.7±15.62	44.4±5.62	0.62
SW 9	83.0±12.02	79.3±9.98	0.53
SW 10	197.0±25.04	75.9±7.84	0.40
SW 11	183.0±18.52	75.9±5.62	0.41
SW 12	166.7±12.85	123.0±15.22	0.74
SW 13	172.7±21.42	97.4±9.89	0.56
SW 14	49.5±9.04	25.3±2.09	0.51
SW 15	221.0±28.55	89.7±8.62	0.41

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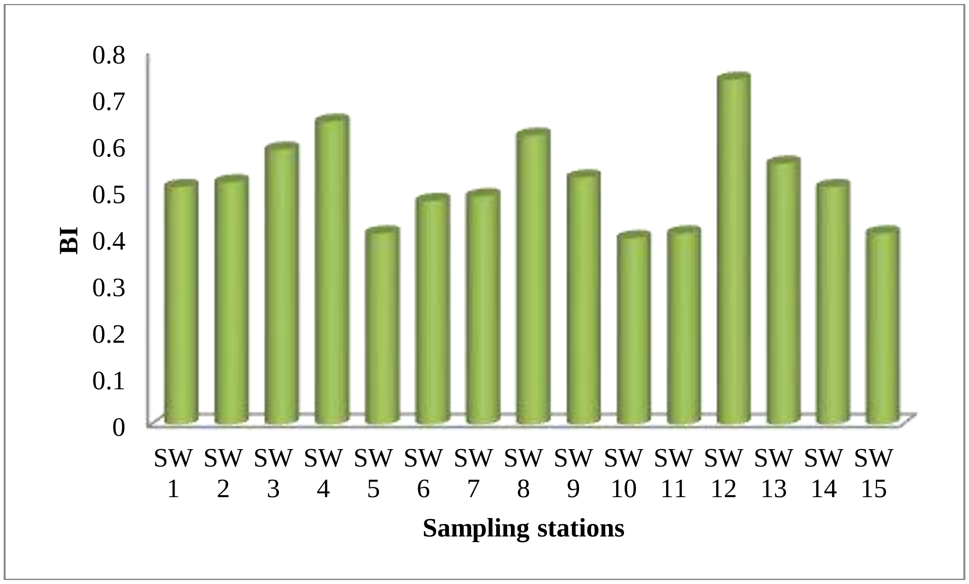

Figure 2: Average biodegradability index

The biodegradability index is indicated in Figure 2. The index varied from 0.41 to 0.74 indicating that most of the effluent sources are from municipal waste (Ogedengbe *et. al*. 1984; Contreras *et. al*. 2003) and fast biodegradation taking place in the river system.

The linear regression results are shown in Figure 3. The fitted equations on the entire data (COD and BOD_5) set on Kaduna River surface water was generated with the corresponding correlation coefficients (*r*). The correlation coefficient of the fitted equation ranged was 0.0313. This implies a weak positive correlation between BOD_5 and COD. When the correlation coefficient was squared (r^2) values of 0.0313 obtained for the Kaduna River the (R) value of 0.177 was obtained. This means that 17.7% of occurences did not happen by chance rather it indicates that COD and the $BOD_5$are highly correlated. However, the BOD_5/COD ratio for the various sampling stations along the studied section of Kaduna River ranged from 0.41 – 0.65 (Figure 2). This implies that the compounds in the effluents discharge into the Kaduna River are relatively biodegradable as obtained values are within 0.4 to 0.8 ratios (Rim-Rukeh, *et al*., 2006). Thus, a possible depletion of the dissolved oxygen in the receiving river and a potential effect on aquatic life is palable.

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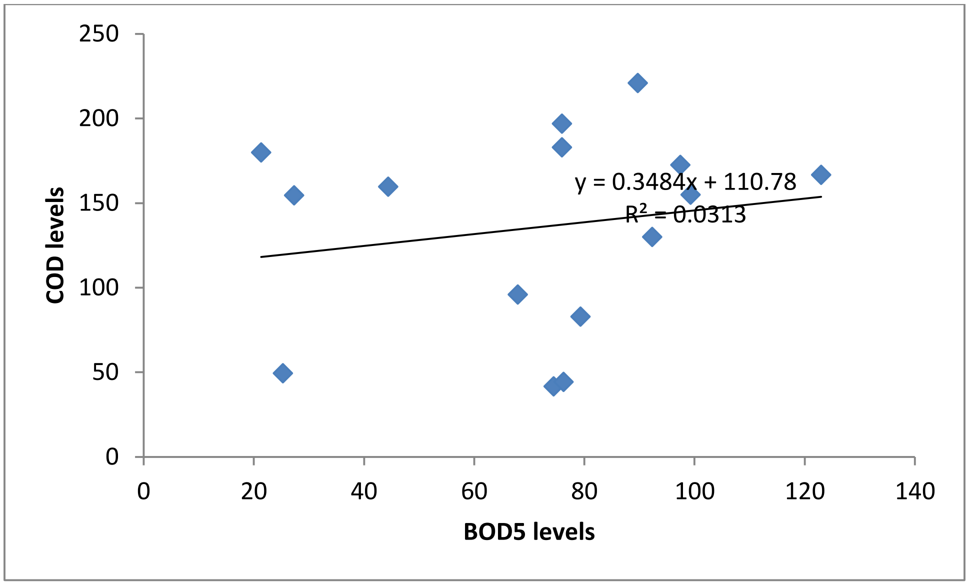

Figure 3: BOD_5/COD Correlation for the Kaduna River at various sampling stations

The BOD/COD ratios are highly affected by the wastewater discharged into the river. Variation of the ratios in each of the sampling station showed that every river segments is influenced by the activities of wastewater located near it. Other factors might affect the BOD/COD ratio are river's physical condition, decomposer microorganism existence, etc (Yustiani, Y. M. and Komariah, I. (2017). Fluctuation of water quality can be caused by many factors. Therefore the unpredictability in the water quality management is physical characteristics and phenomena change of nature [19]. The activities to manage the domestic and non-domestic wastewater are needed to be continuously conducted.

CONCLUSION

Kaduna is one of the main industrial city in northern Nigeria. Based on the BOD/COD ratio values, it can be concluded that Kaduna River generally has high biodegradation capacity. This may be due to its high low organic, inorganic loads and high capacity for self-purification. There is probability of more industries springing up in the City in the near future due to its increasing population and proximity to the Nigeria federal capital city. This influx might decrease the biodegradability index of the River if there is no well-planned river management process in place.

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