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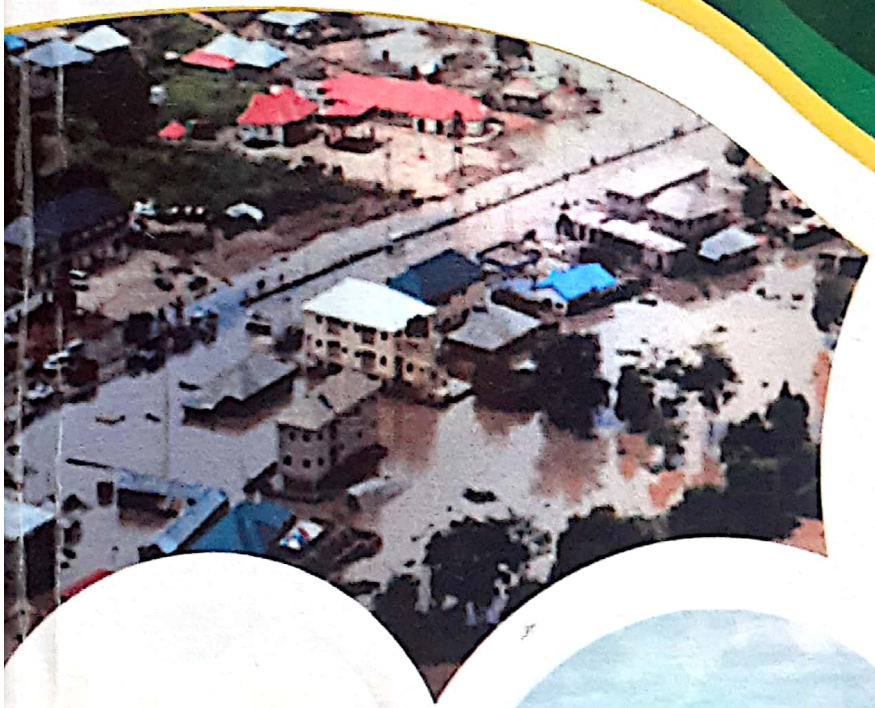

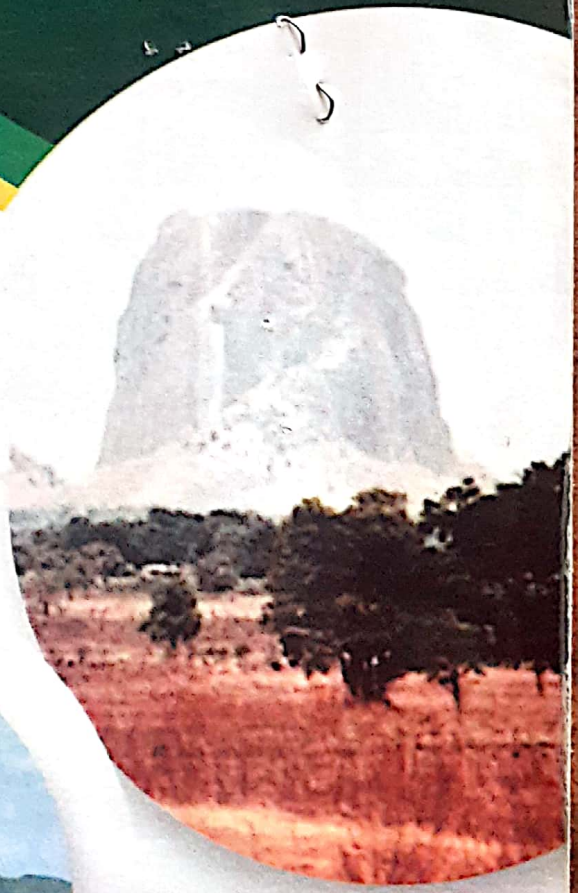

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AN ANALYSIS OF SPATIAL PATTERN OF STREAM WATER POLLUTION IN KADUNA URBAN AREA OF KADUNA STATE, NIGERIA

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Abstract In this study, effects of land use practices on stream water quality of Kaduna River in urban Kadunawere assessed by stratifying the area into five zones of varying land use activities. Water samples were collected from every zone and analyzed for about twenty(20) water quality parameters (PH, EC, BOD, DO, TFS, FS, S, K, Ca, Cr, Mn, Fe, Ni, Zn, Cu, Br, Rb, and Sr). Student test was used to compare the main values of the parameters for pairs of the sampling points. The results obtained revealed that the main values of the parameters for the land use zones associated with industrial activities are, in most cases, above the limits specified by FEBA. With exception of four (4) parameters (Dissolved Oxygen, Nickel, Beryllium, and Rubidium), the parameters determined exhibit significant variation between the compared sampling points. The potential causes of these trends and their implication in the study area have been discussed.

Key words: *stream water quality, water quality parameters, stratifying, sample point.*

1 Introduction

Like most other developing countries, Nigeria has for a long time, embraced the concept of industrialization as the pivot for overall economic growth. Hence, since the 1960's the various national development plans have consistently emphasized industrial development as the means of achieving increase in the national productive capacity as well as improving living standard of the people. Unfortunately, these economic and developmental objectives have tremendous environmental implications that led to pollution and degradation of the environment and pathetically, a complete depletion of

environmental resources at times, in almost all the immediate environments of the industrial belts in the country.

Prior to 1960's and 70's when industrial activities and urbanization were at their lowest ebb in Nigeria, most of the environmental resources such as water, air, and land were in relatively standard quality and safety. River Kaduna was one of those resources, which passes safety and standard quality of water. According to Beecroft (1988); the Kaduna south water works/Board (KSWB) gauging data for 1947 to 1970 shows a medium flow rate of eight (8) cases, and the mean for dry season between 1947 to 1958 was 5.3 cusecs. A decade later it fell to 3.5 cusecs while in 1984 the flow rate further drop from 2 cases to less than 1.0 cusecs in 1986. This, according to Beecroft (1988) is due to abstraction of water by both industries, and domestic uses and discharge of influent by the industries into the river, which are containing high chemical, and biological oxygen demand pollutants together with some solid particle that continuously reduces the flow rate of the river. These pollutants have now turned the river into a complete black color during the dry season and a smelly odor (i.e. the discharges are dense, black liquid containing chocking and caustic volatile gases). Beecroft (1988) further argued that, in the dry season, the discharge falls appreciably reaching its lowest during the months of January, February and March when the flow in the river has to be supplemented by release from a purpose-build earth reservoir (The Kingimi dam See Figure 2.1) in other to support water abstraction at the municipal treatment works.

Therefore, rapid urban industrialization, social development, population growth and an increase in industrial activities in urban Kaduna are expected to cause water pollution and water resources depletion in River Kaduna..

2 Statement of Research Problem

Kaduna urban area is drained by a major river called river Kaduna. Previous studies such as Beecroft, (1988) and field observations have established that abstraction of water and discharge of toxic chemical effluent by industrial

and municipal services in urban Kaduna are giving rise to the deterioration of both water quality and flow regime of the river Kaduna. While this particularly calls for continuous monitoring of water quality level, giving the immense importance of the river to the Kaduna urban area, it specifically calls for proper examination of spatial variation in the pattern of determination since such a pattern has to be taken into account both in identifying the key areas that contribute the must to the deterioration, and in formulation and implementation of any meaningful guideline for water resources conservation and management in Kaduna urban area.

In essence an analysis of such spatial pattern can highlight the particular or group of urban activities or sectors that should be of primary concern in controlling the level of stream water pollution in urban Kaduna.

As no much research documentation on this is available, the need for empirical research becomes highly imperative and this constitutes the problem of interest to this research.

2.1 Aim and Objectives

The aim of this research is to critically analyze the spatial variation in stream water pollution in urban Kaduna, with a view to identifying key sources (and their spatial extent) of the pollutants to the river Kaduna. The aim shall be achieved through the following objectives.

1. To classify Kaduna urban area into different spatial units contributing water to the Kaduna river.
2. To collect and analyze water sample for quality parameters and use the water quality data and assess the level of pollution in each of the spatial units.
3. To compare the analyzed parameters for different units to evaluate spatial variation in the level of pollution.

3 The Study Area

Kaduna metropolis occupies a total area of 260^2 km and is located on latitude Lat. 1052° N, Long 7.44°E. Kaduna is situated at the center of the Northern Nigeria. It was established and laid down as a

planned capital city to serve the protectorate of Northern Nigeria in 1917 by the British colonial government. With the creation of states by the Federal government in 1967, Kaduna ceased to be the capital of Northern Nigeria. It now serves as the capital of Kaduna state and has emerged as a strategic center for industries, Army, Defense, commerce and educational institutions. As at 2006, Kaduna had a population of 760,084. At a growth rate of 3.5% per annum, it is expected to have a population of 600,000 or more by the year 2030. Figure 2.1 shows the location of Kaduna on the greater Kaduna River catchment while Figure 2.2 shows the major sectors/wards of Kaduna urban area that are drain by the river and its tributaries.

4 Methodology

Selection of Sampling Points

Reconnaissance survey was conducted during the months of October 2011 to February 2012 to obtain comprehensive information the number of channels linking the Kaduna River to the various segments of Kaduna town. Following these field visits, it was established that there are five significant zones which are identified based on their sources from where water is draining into the river Kaduna. The points where channels conveying water from such sources and drain into the river were subsequently selected as points from where water samples for this study were collected. These points/zones are Kawo, Stadium, Makera, Bye-pass and Kudenda. The quality parameters considered have include PH, conductivity, dissolved Oxygen D.O. BOB, COD, TS, FS, S, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, Br, Rb, and Sr.

Water Sampling Procedure

Samples were collected from the midstream where reasonable mixing between water and discharged effluent are thought to be occurring, therefore immediately after the point where a drain is discharged.To collect samples, 1000, 500 and 250 plastic bottles were use; (as recommended in the standard methods for water and waste water analysis 15th edition 1980, published by American public health association Washington D.C USA) the bottles were submerged to about 5cm below the water surface and inclined against the direction of flow, crops were screwed on while the filling

Water Analysis Procedures

Table 1 Showing Parameters and the Methods use in determining them during analyses

Parameters	Methods
Dissolved Oxygen [D.O.].	YSI Do/T meter.
PH.	Coning EEI Digital PH meter
Conducting.	Beckman laboratory conductivity meter.
Chemical Oxygen Demand [COD].	Acidified Dichromate Method
Bio-chemical Oxygen Demand [BOD].	HACH Man metric Tech
Total Solids [TS]	Gravimetric.
Filterable Solids [FS]	"V".
Metals And Heavy Meters	I Special –TXFR i.e. Total reflection x-ray fluorescent.

Statistical Analysis

Descriptive statistics (Mean, Standard Deviation and Standard Error of the Mean) were calculated for each water parameter determined for each of the water sampling stations. This is to enable offer a good descriptive account of the spatial variation in water quality of the river. Student's t-test was subsequently used to further assess the significance of variation in the quality parameters determined between pairs of sampling stations. This is to enable identify the main spatial locations that vary significantly amongst the five sampling stations

5 RESULTS AND DISCUSSION

Table 2 presents a summary of description statistics (mean, standard deviation and standard error of the mean) of each of the 19-water quality parameters determined for each of the five land use zones.

Descriptive Statistics of the Water Quality Parameters Determined

From Table 2 on the other hand attempt a comparison, using students't-test, of pair of land use zones with the view of identifying those that most significantly contribute to the spatial variation discharge of effluent into the Kaduna River.

Levels of Individual Parameters

PH

The PH values in the various sampling stations vary in mean value of between 1.7 -8.4, indicating that the stream water quality varies from strongly acidic to weakly basic. At Kawo and Stadium, the water is weakly acidic and at By-Pass Bridge and Kaduna the water is weakly basic while at Makera, the water is strongly acidic. This goes to show that mixed Agriculture, Residential land uses and commercial promote weak acidic condition. While mixed light to medium industrial, Residential and agricultural land use promote slight alkaline condition and heavy industrial and light Agricultural promote acidic condition. Since the PH limits specified by FEPA range between 6-9 it can be said therefore that it is only at areas of mixed heavy Industrial and light Agricultural that the PH level is altered at extremely below the specified limit. This means attempts and controlling deterioration in PH level of River Kaduna should be concentrated around the activities going on at Makera land use zone.

Electrical Conductivity (EC)

The mean value of EC varies substantially between the five land use zones. But as similar to PH, Makera zone has values that are extremely above those of other stations by over 1000%, followed by area of mixed medium to light industrial, Agricultural land uses promote very low levels of EC in the area.

Dissolved Oxygen (DO)

Unlike PH and EC, areas of mixed Residential/Commercial/Agricultural promote comparatively higher DO mean values and those of mixed Industrial/Agricultural/Residential promote medium DO levels, while those of Industrial only promote the lowest levels. This means, the major source of this effluent into the river is human activities concentrated within the Commercial/Residential/Agricultural land uses zones.

Chemical Oxygen (COD) and Bio-Chemical Oxygen Demand (BOD)

The pattern of COD and BOD are almost exactly the same as that of EC, with the areas associated with industrial activities contributing comparatively higher levels into the river than the other areas. The similarity in pattern between EC, BOD and COD as observed here is expected since EC is known to greatly influence the levels of chemical oxygen that is demanded by aquatic lives.

Total Dissolved Solid (TDS)

and Filterable Solids (FS)

The land uses associated with industrial activities maintain comparatively higher levels of TDS than the other areas. However, only at Makera is the level above that specified by FEPA while FEPA specified 2459 as the upper limit, the Makera has 4876 of TDS and 3800 FS as mean values. This certainly reflects the effects of discharges through industrial waste water of several dissolvable solids in the river. Thus, even the perceived contribution of agricultural activities to soil erosion and sediment yield is not causing significant increases in TDS in Kaduna River.

Metallic Ions

The concentration of all the metals (Potassium, Calcium, Manganese, Iron, Nickel, Copper, Zinc, Beryllium, Sulphur, Rubidium and Strontium) is all comparatively higher at the two areas associated with industrial activities in urban Kaduna (i.e. Makera and By-Pass Bridge). In most cases, the differences in the concentration between the each of these two areas and the other look apparently large. While it is not difficult to advance industrial discharges as the major cause of the observed highly elevated levels of various metals whose concentrations were determined. Particularly at Makera where the industrial activities are comparatively higher, the levels of almost all the elements determined are above the maximum permissible limit set by FEPA.

Stations Comparison of the Parameters between the Sampling

A close look at table 3 reveals that Beryllium, Rubidium, Dissolved Oxygen and Nickel are the only parameters that are not significantly differentiated among the pairs of sampling stations. This suggests that differential in land use type in Kaduna urban areas are not causing significant changes in the levels of the four water quality parameters. All the other parameters considered indicate significant difference between most of the compered sampling stations. In particular, the differences tend to be significant either between the two industrial areas, or between the industrial and other areas. This suggests that the major causes of significant changes in the levels of most of the considered water parameters in Kaduna urban area is industrial activities. This seems to be in good agreement with the observation of several other research workers to the effect that

in most industrial urban areas of developing countries, industrial activities serve as major source of stream water pollution (see for instance: Balarabe et al; 199

6 Conclusion

It is clear from the results obtained here that contrary to what might be expected, non-industrial urban activities in Kaduna Urban Area do not cause significant rises in levels of key water quality parameters of River Kaduna. On the other hand, however, almost all the parameters determined are at elevated levels that are above the limits specified by FEPA. It can therefore be concluded that despite the efforts by governmental and other agencies towards fighting the phenomenon of stream water pollution in, especially, urban areas associated with industrial activities, industrial activities are still causing significant negative changes in water quality of the Kaduna River.

7 *RECOMMENDATIONS*

Consequently, it is recommended here that there is the urgent needed for a change in the present approach toward combating stream water pollution by industrial activities. More particularly, there is the need for strict enforcement on the guidelines for control industrial pollution of stream water. However, it is recommended that more frequent monitoring be carried out of the non-industrial zones with a view to ascertaining the stage in time when pollution from the zones will become significant enough as to warrant some remedial measures.

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