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# Consequences of River Obstruction: High Incidence of Pollutants in Kumadugu-Yobe Basin of Nigeria

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## ABSTRACT

The obstruction of the flow of Kumadugu-Yobe River in the north eastern region of Nigeria has affected the entire river system. This study was undertaken to determine the levels of metal pollutants and organic pollution indicators in the water body in order to assess the impact of the obstruction and possible environmental threats posed by pollutants. Water and sediment samples were collected from five selected locations which consisted of three sampling sites each and subjected to standard analytical tests to determine the levels of Fe, Cu, Zn, Co, Cr, Ni and Pb as well as the DO, BOD, COD and TOC of the water body. Results showed some level of pollution by organic pollutants and heavy metals when compared with WHO and NAFDAC specifications for drinking water and aquatic ecosystems. The correlation coefficient (r) values of the organic pollution indicators with the metals revealed positive correlations. The obstruction of the natural flow of water into the river also resulted in the invasion and spread of aquatic weeds into the surroundings. It is postulated that the pollution in the river came from upstream as well as washings from the surrounding lands due to flooding at the peak of the rains during the months of August to September. It is recommended that the management of the Kumadugu-Yobe basin should take proper steps to constantly monitor the flow of metal and organic pollutants in to the river.

**Keywords:** correlations, impact, metal pollutants, obstruction, pollution indicators
**Abbreviations: BOD**, biochemical oxygen demand; **COD**, chemical oxygen demand; **DO**, dissolved oxygen; **HM**, heavy metal; **NAFDAC**, National Agency for Food and Drug Administration and Control; **TOC**, total organic carbon; **WHO**, World Health Organization

## INTRODUCTION

Rivers are often of prime interest in environmental assessments, as major towns and cities have developed along rivers. The river is more than just a transporter of materials as they have often been called 'gutters' but also a processor of materials as the biota it contains, use, take up, convert and release materials that come into them. The river is therefore an active biological system that metabolizes the organic matter contained in it and also sustains the ecosystem in both socioeconomic development and climatic change (Gore 1985).

The quality of river water can be affected by the flow of wastes from domestic, agricultural and industrial activities whereby the material get dissolved, lie suspended or deposited in the river deteriorating the quality of the water (Radojevic and Bashkin 1999). Climatic conditions, litho logy of a river and atmospheric inputs can also affect the quality of a river at any point along its course of flow (Shrestha and Kazama 2007).

Metal and organic pollutants have been found to be the major cause of water quality problems in Nigeria and other parts of the world (Ademoroti 1988; Ogugbuaja and Kinjir 2001; Samecka-Cymerman and Kempers 2004). It is therefore important in water quality monitoring or control to know the amount of organic matter present in the system and the quantity of metals in water sediments and biota which gives direct information on the role of pollution in the aquatic environment (USEPA 1999). Recent studies on river Yobe provided relationships between similar pollution indicators providing basis for monitoring of such indicators (Waziri and Ogugbuaja 2010). The toxic effects of metal contaminants in river waters and sediments have also been implicated in a number of environmental hazards and endangering human and animal health (Rognerud and Fjed 2001; Binning and Baird 2001; Adeyemo 2003; Dimerel and Kulege 2004; Waziri *et al.* 2009).

The impact of organic pollutants on water quality in this study is expressed in terms of the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) which depends on the dissolved oxygen (DO). These parameters indicate the presence of organic pollutants but do not necessarily particularize them. However, they provide the extent of organic pollution in a water body. Sediment contamination by heavy metals in rivers has become an issue of environmental concern because it reflects the long term quality situation of the river regardless of current variations (Haslem 1991; Stronkhorst *et al.* 2004). Furthermore, one of the major effects of heavy metals (HMs) on aquatic organisms is their long biological half life (McCrady *et al.* 2003). Based on these facts, the assessment of the HM concentrations in this study was carried out through determination of HMs in the water sediment.

The Kumadugu–Yobe Basin used to be the major source of livelihood for the majority of people in Northern Yobe, Nigeria. The basin was the major source of fish, rice and vegetables to the state and neighboring states within Nigeria and Niger Republic. However, water shortages, poor fishing activities, poor agricultural harvests, weed infestation, heavy siltation, threats to human health, poverty and other environmental hazards have exposed the vulnerability of the basin to both the current climatic changes experienced worldwide and poor management of the basin (Haruna 2010). The hydrology, conservation and development of the basin were thoroughly investigated over a decade ago (Schultz 1976; Iwaco 1985; NEAZDP 1991; Diyam 1999).

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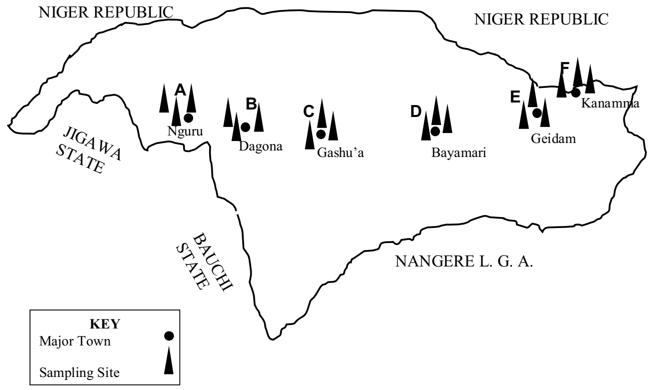


**Fig. 1 Map of the study area showing sampling locations (A-F), each with three sampling sites.**

The Yobe State Government, the federal legislators representing Northern Yobe and other stakeholders have been addressing the problems affecting the basin and have stood firm on the devastating effects of water obstruction and construction of the proposed Kafin Zaki dam. Studies have shown that the alteration of the hydrological cycle of surface and ground waters and change of sedimentation processes are some of the environmental impacts of a dam (Fredl and Wuest 2002).

From the foregoing, it is clear that the problems of the Kumadugu-Yobe basin is multidimensional, while others are looking at it from social, economic and political points of view, this work will look at the possible impacts of pollution resulting from the obstruction of water flow in to the river. The objective of this study is therefore to determine the levels of organic pollution indicators in the river water as well as the HM pollutants in the water sediment to appreciate the anticipated impacts of unregulated wastes brought about by blockages on the quality of the river and assess the suitability of the water for domestic use, fishing, livestock watering and irrigation activities which are common in the area.

## MATERIALS AND METHODS

### Study area

Yobe State is situated in North Eastern Nigeria, and the area of study is in the northern part of the state, an area which is greatly threatened by desertification. The Kumadugu-Yobe Basin is located between latitude 10° N and 130° N and longitude 9.45° E and 12.30° E. The major activities in the area are farming and fishing (Waziri *et al*. 2010).

### Sampling locations, sample collection and treatment

Water samples were collected from 18 sites spread across six sampling locations (**Fig. 1**).

Samples were collected at random along the river basin in 12 sampling excursions each for the wet (July to September) and the dry (March to May) seasons of 2010. Water samples for BOD and COD determinations were collected with a hydro bios water sample and transferred into pre-cleaned 3-L plastic container, kept at about 4°C and taken to the laboratory for analysis. Water samples for HM analysis were collected in pre-cleaned plastic containers and preserved by acidifying with 2M nitric acid while sediment samples were collected using plastic hand-trowel by scooping 1-3 cm of the top surface sediment layer, dried and digested using standard techniques (Waziri *et al.* 2009).

### Sample analysis

Dissolved oxygen was determined *in situ* using DO analyzer model JPB – 607 (Jenway, Essex, UK). COD and TOC were determined based on the standard procedures outlined for water analysis by Ademoroti (1996). A DO analyzer was used to measure the BOD after 5 days' incubation period. HMs were analyzed with an atomic absorption spectrophotometer Shimadzu AA-6800 (Shimadzu, Japan).

### Statistical analysis of the data

Results were expressed as mean ± SEM (standard error of mean) and statistically analysed for significant variations between locations and between seasons. Statistical analyses were conducted using Microsoft Excel and Analyse-it® v 2.22 (Analyse-it®, 2007). Variations of DO, BOD, COD and TOC between seasons/locations were assessed by analysis of variance (ANOVA) using Microsoft Excel, while test for significance in variations of HM concentrations between locations were determined by ANOVA with Tukey's error protection in a *post host* test at $P<0.05$. Student's *t*-tests were also conducted at $P < 0.05$.

## RESULTS AND DISCUSSION

### Seasonal variations of the pollution indicators

The results of the pollution indicators analyzed are presented in **Table 1**. Analysis of the results revealed that there were significant differences in DO, BOD and TOC between seasons ($P < 0.05$) (*t*-test) but no significant differences in COD between seasons. This agrees with the findings of Ogugbuaja and Kinjir (2001) who indicated that variations in the organo-indicator levels were due to accumulation of pollutants. The differences between seasons in the present study may be due to the variations in the seasonal nature of the pollutants which varies from one location to the other and amount of pollutants introduced into the river from domestic, agricultural activities and pollutants from upstream. These variations are similar to the one reported in the river Krishni (Dhakyanaika and Kumara 2010). Low DO levels were recorded during the dry season when the water is almost stagnant affecting the survival of aquatic lives as evidenced by the low population of fish and other aquatic organisms. However, despite the water obstruction upstream of the river, high DO levels were recorded during the wet season. More than 50% of the locations showed significant differences in DO during the wet season but insignificant in dry season except between locations B and

**Table 1** Mean seasonal variations of pollution indicators of the surface water at different locations of Kumadugu-Yobe Basin.

| Parameters | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **Dry season** | | | | | | |
| DO (mg/l) | 4.50 ± 0.34 | 4.32 ± 0.13 | 4.68 ± 0.43 | 4.72 ± 0.25 | 5.02 ± 0.33 | 5.22 ± 0.38 |
| BOD (mg/l) | 3.20 ± 0.29 | 3.09 ± 0.28 | 3.16 ± 0.18 | 3.19 ± 0.24 | 3.82 ± 0.20 | 3.22 ± 0.26 |
| COD (mg/l) | 170.50 ± 5.01 | 163.22 ± 6.57 | 163.83 ± 12.40 | 158.17 ± 10.61 | 157.90 ± 14.06 | 176.17 ± 16.23 |
| TOC (%) | 0.46 ± 0.08 | 0.38 ± 0.03 | 0.30 ± 0.13 | 0.25 ± 0.06 | 0.42 ± 0.08 | 0.25 ± 0.13 |
| **Wet season** | | | | | | |
| DO (mg/l) | 8.08 ± 0.41 | 9.47 ± 0.43 | 8.48 ± 0.52 | 7.35 ± 0.12 | 6.78 ± 0.23 | 8.92 ± 0.37 |
| BOD (mg/l) | 2.52 ± 0.20 | 2.11 ± 0.25 | 2.20 ± 0.13 | 2.27 ± 0.25 | 2.09 ± 0.16 | 2.23 ± 0.11 |
| COD (mg/l) | 178.83 ± 13.78 | 192.17 ± 15.75 | 191.83 ± 10.44 | 219.50 ± 6.75 | 214.13 ± 27.02 | 156.33 ± 15.45 |
| TOC (%) | 0.57 ± 0.11 | 0.70 ± 0.05 | 0.67 ± 0.09 | 0.82 ± 0.05 | 0.78 ± 0.02 | 0.83 ± 0.03 |

n = 6; Values represent mean ± SE

F. This may be due to the rapid flow of water as a result of heavy rainfall experienced within the year. Flow directly affects the amount of oxygen dissolved in the water providing suitable environment to the habitats and organisms. Similar observations have been made by Emoyan *et al.* (2006) who associated the low DO levels during the dry season to introduction of waste containing high organic matter into the river from refinery effluent in their area of research. Different species of fish are already visible in the water indicating good fishing activities in 2011. Though differences in DO were observed but all the values were within the WHO (1996) and NAFDAC (2001) permissible limits of greater than 4 for domestic water supplies and fishing (Pescord 1977).

High values of BOD observed during the dry season when compared to the wet season at most locations may be due to the increase in bacterial activities at warm temperature as indicated by the low levels of the DO during the period. Another possible reason for high levels of BOD is the high concentrations of $NO_3^-$ and $PO_4^{3-}$ in the water which aided in the fast growth and death of plant and algae as reported by Waziri *et al.* (2010). The high nutrient levels probably led to the accumulation and decomposition of organic waste in the water resulting in high BOD and low DO values. This is in agreement with the observations in variations of BOD which resulted from mixing of agricultural drainage water with river water as reported by Hafez *et al.* (2008). The BOD values obtained in the present study indicates that the water can be categorized to be moderately polluted (BOD 2.0-2.9) and polluted (BOD 3.0-3.9) at different locations during the wet and dry seasons respectively (Radojevic and Bashkin 1999). COD reflects the total concentration of organics in a water body. The COD levels observed conform to the WHO standard at most locations in all the seasons with the exception of locations E and F in the wet season. There were no significant differences in COD between locations with exception of locations: A and E; A and F. This may be due to obstruction of free flow of water resulting in high deposition of pollutants from domestic waste, poor sanitary environment, livestock activities and agricultural runoffs which entered the river thereby depleting the DO and raising the COD levels at the locations. High COD values have also been related to the presence of iron and manganese which exerted oxygen demand when they are oxidized (NRBP 2003). Several researchers (Ogugbuaja and Kinjir 2001; Marhe *et al.* 2007; Kolo *et al.* 2010) have reported variations in levels of organic pollution indicators as the major causes of water pollution. The sources of pollution reported include industrial, agricultural and anthropogenic activities.

TOC, which revealed the level of organic nutrients in the sediment samples, showed a steady significant increase

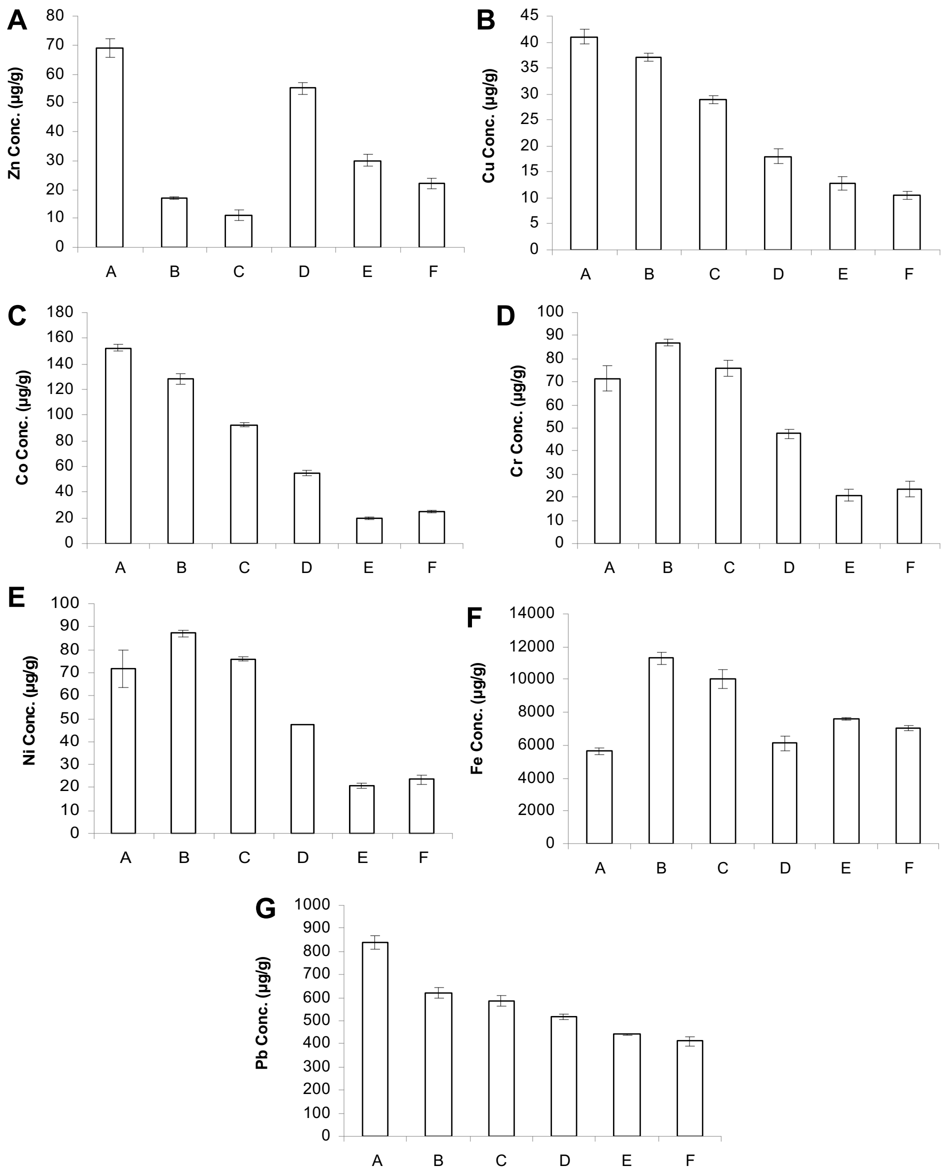


**Fig. 2A-G Annual concentrations of HM in the sediment samples (µg/g) at the various sampling locations of the Kumadugu-Yobe Basin.** The data are based on HM concentration measurements taken in 24 sampling excursions in 2010. Values represent mean ± SE. A-F on the X-axes represent sampling locations in **Fig. 1**.

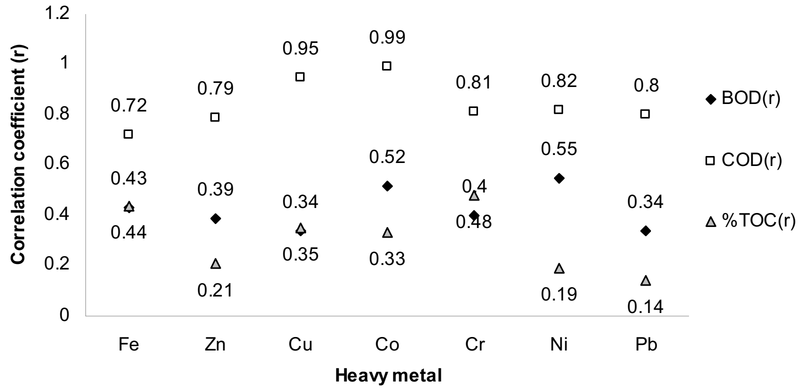


**Fig. 3 Correlation coefficients (r) between values of pollution indicators in water and HM concentrations (µg/g) in sediment samples collected at the six locations (A-F) in Kumadugu-Yobe Basin.** Values above or below plots indicates correlation coefficient (r).

between the wet and the dry seasons but insignificant locational differences. This is expected because blockages have encouraged the spread of weeds which may be deposited on sediments.

## HM concentrations in the sediment samples

The HM levels in the examined sediment samples are shown in **Fig. 2A-G**. Location A showed the highest concentrations of the HM with the exception of Fe. Location B was next to A in terms of high concentrations of the HM with the exception of Zn and was enriched with Co and Cr. Significant differences ($P < 0.05$) in HM concentrations (Ni, Cr, Cu, Cr, Zn, Pb, Fe) at the various locations were recorded based on ANOVA. However, no significant variations in the HM levels were recorded between locations: A and C; A and D; B and C; E and F. The results indicate high levels of HM probably from the upstream river or the source of the river where industrial and agricultural pollutants enter the river. It may be observed from results that the concentrations of Fe and Pb (**Figs. 2F, 2G**) in the sediment samples are appreciably high and exceeded the WHO (2006) and NAFDAC (2001) standards for drinking. The significant differences in levels of Fe and Pb at all the locations indicates sediment pollution attributed to drainage of the area, poor farming techniques and human activities, similar to the levels reported by Waziri *et al.* (2009). Factors indicated to be responsible for the variations of Fe and Pb includes prolonged effects of human activities. The correlation coefficient of the organic pollution indicators (BOD, COD and TOC with the HM were used to determine their scavenging abilities. Positive correlations were established between the organic pollution indicators and all the HM with BOD-Pb having lowest value (r = 0.14) while COD-HM gave high values (r = 0.72-0.99) (**Fig. 3**). This relationship indicates the ability of the organic pollutants to scavenge the metal ions. The higher the r value, the greater the scavenging ability. The relationship obtained in this study is comparable with results of similar research conducted in the Kaduna River, Nigeria (Mahre *et al.* 2007).

## CONCLUSION

This work reveals the variation of organic pollution indicators in Kumadugu-Yobe River Basin. DO values and COD at some locations were within the WHO permissible limits for domestic use throughout the seasons but the TOC and BOD values were on the high side. Though bumper fish harvest is expected in the year 2011 but fish should be consumed with caution because the resultant high HM concentrations especially Pb and Cr could accumulate in the fish species endangering the health of the human and animal that consumed them. The high HM content can also cause habitat destruction, alteration of species diversity and render the water unsuitable for other uses. Possible causes of pollution could be the water blockages experienced from upstream of the basin which contributed to reduction in volume of water especially in the dry season and accumulation of wastes thereby contaminating the water. Other possible sources may be from run offs due to flooding, natural sources and anthropogenic activities. Whatever the sources of pollution are, the high level of HMs is a cause for concern, therefore the management of the basin should intensify efforts to monitor the water quality and prevent further obstructions of the river to safeguard human and aquatic ecosystems.

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