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LEVELS OF HEAVY METALS IN GUBI DAM WATER BAUCHI, NIGERIA

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ABSTRACT

The distribution of heavy metals in Gubi Dam, Bauchi, Nigeria was studied covering the highest turbulent and non-turbulent flow periods. The average concentrations of iron, manganese, nickel, zinc, cobalt, chromium and cadmium were generally highest in filtrate water, whereas the concentrations of copper and lead were always highest in the suspended materials which indicate the dominant role played by suspended materials in the transport of these metals. The total metal levels are within WHO safety limits as such do not reflect impaired suitability of the water. The relative levels of the metals at the entry points and spillway reflect the source, the path and stopover of the tributaries of the dam, thus the variation in the amount of metals at each point.

KEYWORDS: Distribution, Heavy metals, filtrate water, suspended matter, Gubi dam, Nigeria

INTRODUCTION

Dams are sinks for heavy metals that continuously wash off rocks and soils that are directly exposed to surface waters. The common sources of heavy metals are from dead and decomposing vegetation, animal matter, wet and dry fallouts of atmospheric particulate matters and from man's activities. The role of trace metals in biochemical life processes of aquatic plants and animals and their presence in trace amounts in the aquatic environment are essential. However, at high concentrations, these trace metals become toxic (Nurnberg, 1982).

Heavy metals in the aquatic environment exist in sediment, suspended particulate (>0.45μm), hydrous oxides and humic colloids, and in true solution (Guy and Kean, 1980). Of particular importance for the regulation of trace constituents or pollutants in natural waters are the particles. All substances that are strongly adsorbed on suspended matter or become incorporated into settling biomass have short relative residence times. Obviously, the relative residence time of a compound decreases with increasing adsorbability (Stum and Morgan, 1981). Particles are also of great importance in rivers and about 75% of the matter carried by the rivers to the ocean is in the form of particulate matter (Martin and Whitfield, 1983). This has resulted in high, although not alarming, levels of lead, cadmium and copper in some localized areas (Mohammed, 1987). Allen (1973) reported the results of trace metal analyses of relatively few regional lakes of Northwestern Canada. Such data have been used together with sediment data in geochemical exploration. Studies conducted in Central and Northwestern Sweden ascertained the distribution of trace metals in water, sediments and fish to be mostly within the range considered for natural background level (Bjorklund, 1982, 1984; Borg, 1984). The waters and sediments of several rivers and estuaries in Southwest England have been found to have high metal contents, largely due to mining

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activities in the region (Aston and Thornton, 1973, 1977). In a general lake survey performed in Norway, a clearly geographical pattern was found for zinc and possibly for lead, with the highest values in the Southern lakes (Henriksen and Wright, 1978).

In a recent work, the distribution of trace metals in suspended particulate matter (SPM) and water in the Conway estuary, North Wales were analyzed and the result showed dissolved Cu and Mn to vary monthly while most of the other dissolved trace metals displayed negative association with salinity (Zhou *et al*., 2003). Similarly, in a biogeochemical phase exchange study of trace metals in Dangava river and some parts of the Gulf of Riga, SPM was found to contain high organic matter, Mn and sorbed phosphates, with the Mn content of SPM following conservative mixing which was indicative of interface exchange (Yurkovski, 2004). Cenci and Martin (2004) also measured trace metals concentrations of Mekong river in dissolved phase suspended matter and superficial sediments and reported that metals in the dissolved phase, suspended matter were within the range for uncontaminated environment for both dry and wet seasons. Seasonal variations may however play a role in heavy metals contribution to water bodies. The impacts of domestic and industrial wastes on water and sediment chemistry was investigated by Gaur *et al*., (2005) for different seasons. The result showed high concentration of all the metals in both water and sediments in rainy season. This was attributed to be due to runoff from open contaminated sites, agricultural field and industries. Buck *et al*. (2005) also reported that the East rive-long Island system, provides the dominant source of most trace metals during low flow conditions. Van Aardt and Erdmann (2004) reported varying concentrations of Cd, Pb, Cu and Zn in three hard-water dams of Mooi river catchments in South Africa . Various methods have been employed to determine heavy metals in water. Inductively coupled plasma emission spectrometer had been used in the determination of suspended particulate matter from Yarra river, Australia (Sinclair *et al.,* 1989). A combination of neutron activation analysis and atomic absorption spectrometric techniques was used in the analysis of heavy metal content of sediments and algae from river Niger and the Nigerian coastal waters (Ndiokwere, 1984). The use of atomic absorption spectrometry had been reported by Sukiman (1989) in the determination of heavy metals in water, suspended materials and sediments from Langat river, Malaysia and Zhang *et al*. (1989) in the Xiangjiang river, China. This study is aimed at assessing the level of trace materials and their effects on the water quality of Gubi dam.

EXPERIMENTAL DETAILS

The Study Area

Gubi dam is a storage dam constructed in 1979 to impound water from the upstream side of river Gubi during the periods of excess supply. It has a top water level of about 577M and 3KM long. It is located in the northern part of Bauchi town, Nigeria. It lies within the boundary of longitude $10^0 25^/$N to $10^0 26^/$N and latitude $9^0 51^/$E to $9^0 52^/$E (Fig. 1). The region is classified as tropical and the rainfall in the dam basin ranges from 970mm to 1400mm with about 50 to 60% of this rainfall occurring between July and August. The dam receives its water from Tatimari (Shadawanka, Dinya) Larkarina, Suntum and Kumi tributaries. The dam is used for drinking, irrigation and fishing by settlers around the dam (BASWB, 1990, Agya, 2002).

Five sampling stations were chosen along the Gubi dam water. Each of the sampling locations was further divided into three points, which summed up to fifteen sampling points. The main sampling locations were the entry points of Larkarina, Tatimari, Kumi, Suntum and Spillway (Fig. 1).

Sample Collection and Preparation

Water samples were collected in September, 2001 and January, 2002. These represent the highest turbulent and non-turbulent flow periods respectively. Water samples were collected from both sides and in the middle of each sampling points of the entry points by immersion of polythene bottles to approximately 40cm below the surface. All containers used for sampling and storage were thoroughly washed with solution of detergent and distilled water. They were then soaked in10% “Analar” nitric acid overnight followed by rising with distilled water to remove trace element contamination.

Analytical Method

The pH of water was determined using digital analyzer model 61A pH-meter. Raw water was digested by measuring 100ml unfiltered water into a beaker and 20ml “Analar” nitric acid solution plus 10ml of 50% hydrochloric acid solution were added. The acidified sample was then evaporated to almost dryness on a hot plate, 5ml of 50% hydrochloric acid was added and heated for 15 minutes. The beaker was removed and allowed to cool before transferring quantitatively into a 100ml volumetric flask and made up to the mark with distilled water. It was filtered and the metals were determined using a Buck Scientific Model GP210 Atomic Absorption Spectrophotometer (AAS). Also, 100ml of the raw water was filtered using a Whatman filter paper No. 1. The filtrate was acidified, digested and analyzed as described above for unfiltered water sample. 1g of suspended particles obtained from filtration was digested for 1 hour in 3ml concentrated nitric acid and was filtered into 100ml volumetric flask. The residue was washed with 0.1M nitric acid. It was made to the mark and the metals determined using AAS.

RESULT AN DISCUSSION

The mean concentration of trace elements in the filtrate and suspended materials are shown in Figure 2. This chart gives some indications of average values in the stretch of the dam surveyed, rather than for each sampling station. The concentrations of iron, manganese, nickel, zinc, cobalt, chromium and cadmium were generally high in the filtrate, whereas copper and lead concentrations were always found to be high in the suspended materials. This shows that suspended materials could be good indicators for copper and lead pollution, suggesting the dominant role played in the transport of copper and lead in the reservoir by the suspended materials. Poikane *et al*. (2005) had analyzed to fate of trace metals in suspended particulate matter and surface sediments of Dangava river and the Gulf of Riga and reported that the fluvial particulate matter and particulate Al, Fe, Cr and Ni were brought into the Gulf during spring flood. This suggests the influence of season on the fate of trace metals in water bodies. The works of Gaur *et al*. (2005) supports this assertion that the impact of domestic and industrial wastes contributes to high concentration of metals in water and sediments in rainy season due to runoff. However, the partition coefficient of trace metals between suspended particulate matter and water decline with increasing suspended particular matter concentration (Zhou *et al*., 2003).

The partitioning of metals between particles and water is influenced by the residence time, hence the residual concentration of these elements in the water. The geochemical fate of metals is controlled by the chemical processes occurring between the solid surfaces and the water. Knowledge of the origin and transport of the suspended solids is essential for an interpretation of regional variation in the trace metal contents. The suspended materials can act as scavengers for trace metals in the water and may be introduced into the natural bodies of water by natural forces such as weathering, hydrothermal activities and biosynthesis or by human activities through sewage discharge, dredging and agricultural excavation (Allen, 1973; Aston and Thornton, 1973, 1977). The concentration of iron was found to be highest in all filtrates and suspended materials (Fig. 2). This relationship may be due to the ability of iron to remain fixed to the suspended material during transport in aerated water (Salomons and Forster, 1984).

The mean total concentration of trace metals in raw water is shown in Figure 3. The concentration of copper appears to be equal in all tributaries. This may be as a result of reduced flow rates, large volume and increased human activities along all the tributaries, such as farming, finishing and disposal of wastes by the settlers, which increased the concentration of copper at their entry points to the dam. Water flow rates was reduced at the spillway, thus all the transported materials were concentrated around this point, which explains the relatively equal concentration of copper. Wastewater from the city which may contain high concentration of this metal drains into the dam via Dinya and Shadawanka tributaries (Fig. 1). The level of copper in the dam reservoir is considered to be low enough as to have no effect on water quality (WHO, 1984). Iron concentration at Larkarina was 0.360 mgL^{-1} while Suntum (0.170mgL^{-1}) and Tatimari (0.160mgL^{-1}) have about the same concentration (Fig. 3). Wastewater discharging through Larkarina tributary perhaps passed through some mineral deposit that is rich in iron. Manganese concentration in all locations varies slightly from each other. Nickel has the lowest concentration with little increase at Kumi (0.010mgL^{-1}), which may be due to the deposition of nickel-cadmium batteries that have been assimilated and mobilized into the dam (Jones, 1982) as it passes through some city parts. This reflects the cadmium concentration at all the tributaries. The spillway records the least concentration of Cd (0.007mgL^{-1}), which perhaps must have been removed by phytoplankton before reaching the down stream. Zinc average concentrations at Tatimari, Kumi and Larkarina tributaries were about the same with slight variation (0.267, 0.273 and 0.297mgL^{-1} respectively). This may be due to the disposal of local dye spent effluents and garbage containing zinc waste or galvanized waste. The relatively high value at Suntum and Spillway (0.360 and 0.310mgL^{-1} respectively) with slightly small variation in concentration may be due to low flow rates. Similarly, all the tributaries have less than 0.05mgL. The tributaries were steadily supplied by wastewater from the city. The lead content may be due to disposal of tyres, batteries, garbage containing lead and soldered tins and fittings. This result is higher than the maximum allowable limit of 0.01mgL^{-1} Pb (WHO, 1984). Cobalt concentration is similar at all the tributaries suggesting the same level of mobilization of cobalt minerals into the dam. Chromium was not detected at Kumi. This shows that this point has no source of chromium with Larkarina having little chromium (0.003mgL^{-1}) and slightly increasing at Tatimari (0.10mgL^{-1}). The observed metal levels do not reflect impaired suitability for wide usage of the water as the slightly high lead content occurs in the undissolved form in the dam.

CONCLUSION

Trace metals in Gubi dam water are not evenly distributed; concentrations of iron, manganese, nickel, zinc, cobalt, chromium and cadmium were found to be higher in dissolve species whereas copper and lead were in higher concentrations in the undissolved species. The entry points and spillway reflect the source, the path and stopovers of the metal levels in tributaries of the dam, thus the variation in the amount of metals at each point. For all the metals studied the average level found in the reservoir were below the value set by the World Health Organisation (WHO, 1984) as a result, the dam is harmless to both aquatic and human life.

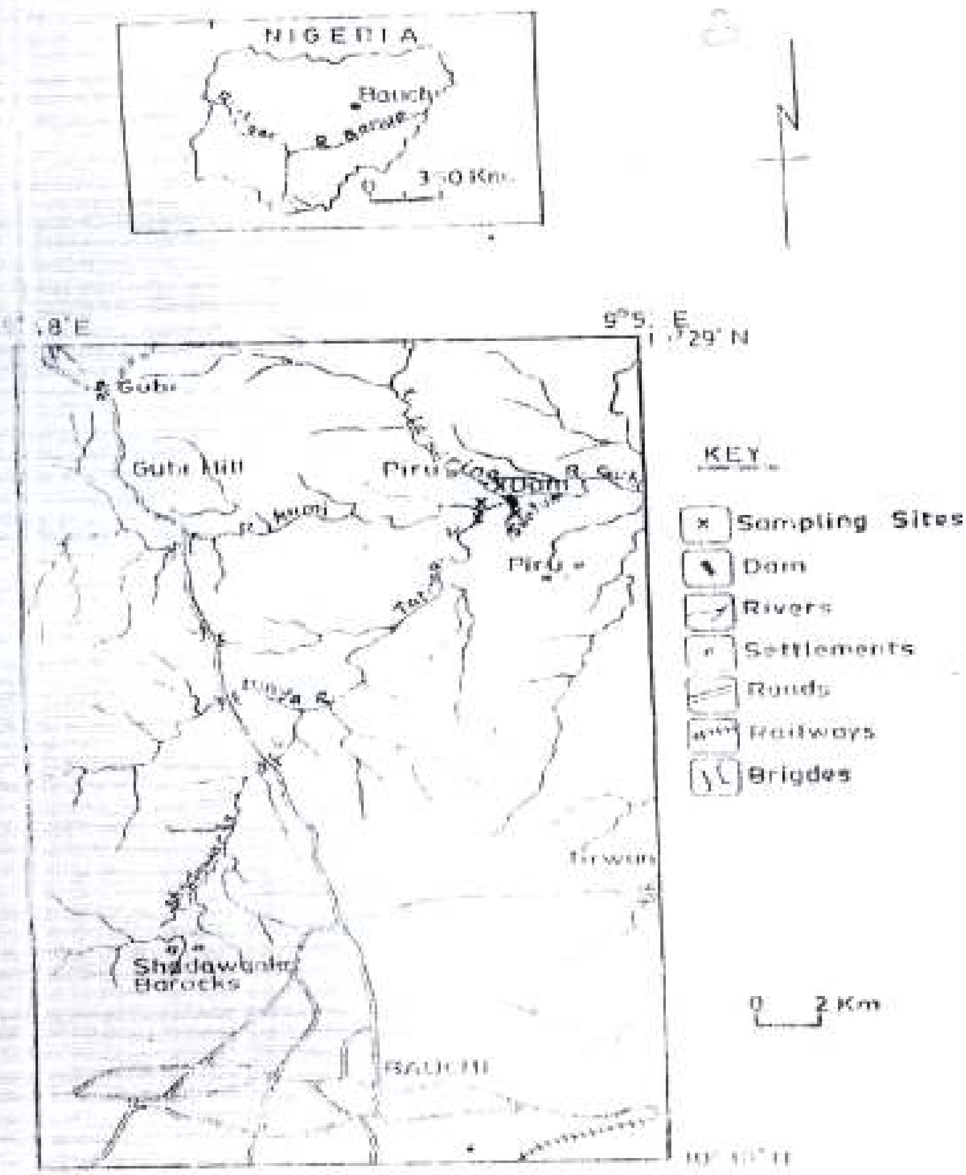

Fig 1 The map of Bauchi L.G.E. showing Gubi Dam and Sampling Sites

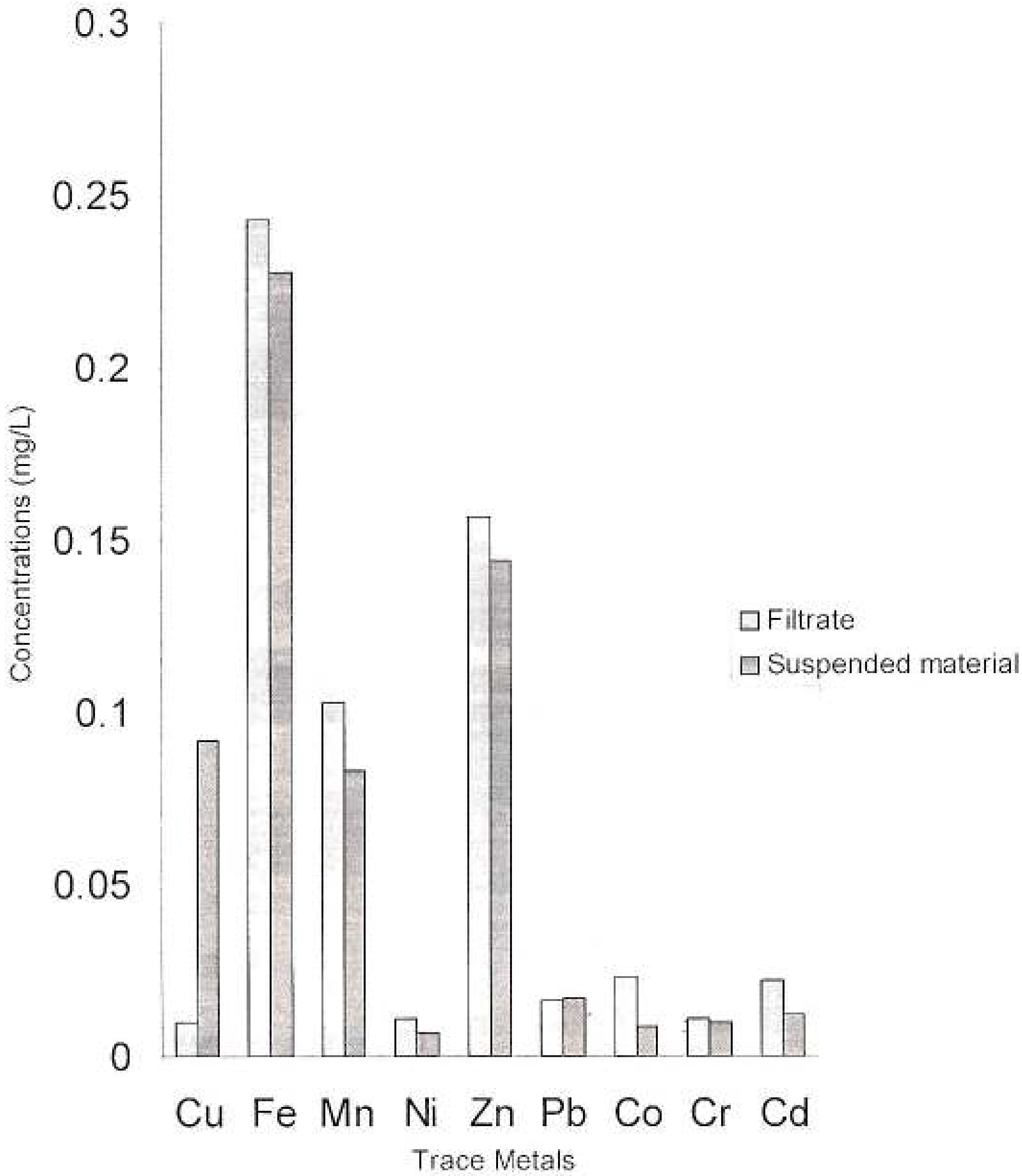

Fig.2 Trace Metal Concentrations (mg/L) in Filtrate and Suspended Materials

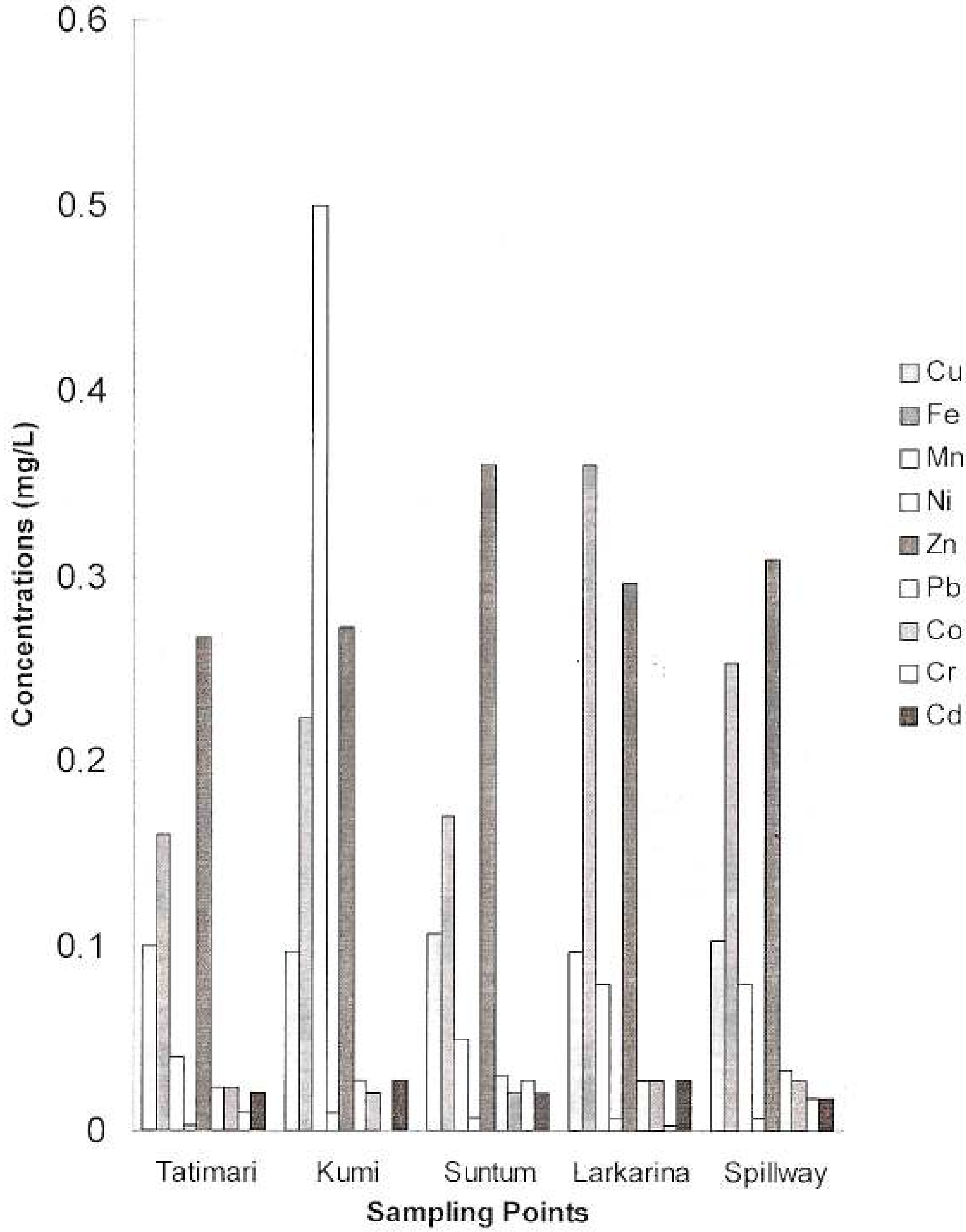

Fig.3 Mean Total Concentrations (mg/L) of Trace Metals in Raw Water

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