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ORIGINAL ARTICLE

# Assessment of metallic pollution status of surface water and aquatic macrophytes of earthen dams in Ilorin, north-central of Nigeria as indicators of environmental health

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**Abstract** The functional quality of an aquatic ecosystem is a reflection of the health of the environment. Therefore, the present study evaluates the trace metal contamination (Pb, Cd, Ni and Mn) of water and aquatic macrophytes in Asa, Agba, Unilorin and Sobi (Moro) earthen dams, north-central Nigeria to evaluate the level of anthropogenic impact on the immediate environment. The concentrations of trace metals in samples of water and available macrophytes from the earthen dams were determined by Atomic Absorption Spectrophotometry. Trace metal contamination of surface water in the earthen dams was assessed using metal index (MPI) and metal pollution index (HPI). The biological accumulation factor of trace metals in the aquatic macrophytes was extrapolated from trace metal concentrations in the water and macrophyte samples. The results of the MPI revealed gross metal contamination of the surface water by Pb and Cd ( > 6.0 for both metals) in the four earthen dams; while Agba and Sobi dams were slightly contaminated by Ni (MPIs = 1.43 and 1.14 respectively). All the earthen dams were considered safe from Mn contamination (MPI < 1.0). Considering the HPI, the four earthen dams fall within the critical pollution threshold for trace metals (HPI > 100), but Asa dam (HPI = 2682.4) was the most contaminated. The biological accumulation factor of Mn in the macrophytes indicated *Ceratophyllum demersum, Pycreus lanceolatus* and *Pistia stratiotes* as moderate accumulators of Mn, and can be used as bioindicators in monitoring Mn pollution of aquatic ecosystem. The obtained results in this study showed that the earthen dams are polluted by Pb, Cd and Ni which pose human health risks to the inhabitants through drinking water.


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## 1. Introduction

Water is an important natural resource which plays a vital role in human existence (Ahmed et al., 2011). It is a dynamic system, containing living as well as non-living components, organic, inorganic, soluble as well as insoluble substances that constitute life support systems. Changes in the water quality are known to

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affect the equilibrium of the aquatic environment, causing it to become unfit for designated uses. The availability of freshwater through surface and groundwater resources has become critical as only 1% of freshwater that is available for drinking, agriculture and domestic purposes is exposed to arrays of contamination (Karthika and Dheenadayalan, 2015).

Contamination of freshwater bodies by trace metals is one of the major environmental issues in developing countries in recent times (Goher et al., 2014a). Natural contamination such as chemical weathering and soil leaching is a gradual process whereas release of contaminants from anthropogenic sources is rapid and on the rise (El-Bouraie et al., 2010). Anthropogenic sources are associated mainly with industrial and domestic effluents, urban storm, water runoff, landfills, mining and rural agricultural activities (Hashim et al., 2011; Yang et al., 2012). Trace metal contamination of fresh water is a major threat to environmental health and a factor in geochemical cycling of metals (Kabata-Pendias and Pendias, 1992). It is of great concern due to their long biological half-lives, non-biodegradability and potential toxicity to the environment (Aktar et al., 2010; Jiang et al., 2012; Goher et al., 2014b; Singare et al., 2012). Contaminants like Hg, Cd, As, Pb, Sb, Cr and Sr are very toxic even at low concentrations; and being non-biodegradable, bioaccumulation in the human body can cause damages to nervous system and internal organs (Lohani et al., 2008). Other contaminants such as Cu, Fe, Mn, Ni and Zn that are essential micronutrients also pose detrimental effects to the functioning of living tissues at higher concentrations (Bruins et al., 2000).

The Nigerian inland water bodies have been subjected to various forms of degradation due to pollution (Sabo et al., 2013). Riverine systems in Ilorin, the capital and commercial hub of Kwara state, north-central Nigeria, are not an exception in this menace. The level of contamination of surface water of lake dams within Ilorin metropolis has been worsened by the indiscriminate deposition of wastes from multifarious sources into river and water channels which eventually end up in lake dams. Lake dams (Asa, Agba, Unilorin and Sobi lake dams) within Ilorin metropolis provide water for the populace of Ilorin city and the immediate communities for the purposes of drinking, domestic and industrial uses. Although, various studies have assessed the trace metal status in sections of River Asa (Ahaneku and Animashaun, 2013; Ibrahim et al., 2013; Oyedeji et al., 2013); no attempts have been made to assess the quality of the surface water in Asa lake dam using water quality index (WQI) and biological analysis approaches. In addition, there is paucity of information on the pollution index of trace metals in Agba, Unilorin and Sobi lake dams. Therefore, this study was conducted to assess the metal pollution status of surface water and aquatic macrophytes of the four lake dams in Ilorin metropolis using water quality index and biological analysis approach to evaluate the health of the environment.

## 2. Materials and methods

### 2.1. Study area

The study area is Ilorin metropolis, north-central Nigeria. The four lakes with earthen dams that provide drinking water for the inhabitants of Ilorin metropolis were chosen for this study (Fig. 1). These water reservoirs are Asa dam, Agba dam, Unilorin dam and Sobi dam. Asa dam is located on River Asa (8° 44″ N; 4° 56″ E) at approximately 5 km from the city centre. The dam has an overall length of 597 m and storage capacity of 43 million $m^3$ with lake extension of 18 km. The length and breadth of the spillway are about 65 m and 14 m respectively with discharge capacity of 79,000 $cm^3$ (Araoye, 2009; Ayanshola, 2013). Agba dam is located on River Agba (8° 47″ N; 4° 60″ E) which is one of the tributaries of River Asa. The dam is 17.8 m high, with the length of 570 m and has a reservoir capacity of 1344 million litres (Busari et al., 2014). The University of Ilorin dam (Unilorin dam) is located on River Oyun (8° 46″ N; 4° 67″ E), with the primarily purpose of water supply to the University community. The dam has a reservoir capacity of 1,800,000 $m^3$, live storage capacity of 1,540,000 $m^3$ and the length of the river is 48 km. The spillway has a length of 50 m, height of 7.7 m and maximum flood discharge of 434.8 $m^3/s$ (Sule et al., 2011). Sobi dam (9° 58″ N; 8° 25″ E) is located on River Moro (a tributary of River Asa); and it is the second largest dam in Ilorin with yield capacity of 14,000 $m^3$/day (Ayanshola, 2013). It was constructed primarily to supply portable water to the Nigerian Army cantonment situated at Sobi, Ilorin.

### 2.2. Sampling and chemical analysis

Sampling activities were carried out at the four lake dams in the year 2014. Ten samples of dam water were collected at each earthen dam in a pre-acid washed glass bottles and acidified immediately on-site to pH < 2.0 with nitric acid (Sigma Aldrich) after filtration. Water samples were collected at the inflowing (3 samples), intermediate (4 samples) and outflowing (3 samples) points of the four dams. Macrophyte species were collected at the dam sites based on availability, as the macrophytes were mostly floating and submerged types which only survive close to the bank. Physico-chemical parameters of the water samples such as the pH, electrical conductivity (EC) and turbidity were determined on-site using digital multiparameter portable meters (HI-98129 & 93414 models, Hanna Instruments). Other parameters were determined later in the laboratory according to the standard method of APHA (1985).

Available macrophytes in each of the dams were collected and identified either immediately at the site or later at the Department of Plant Biology herbarium, University of Ilorin, Nigeria. The acidified water sample (50 ml) was digested in 5 ml concentrated $HNO_3$ (Sigma Aldrich) and allowed to evaporate slowly on a hot plate; thereby reducing the volume to 20 ml. The digested water sample was allowed to cool, then filtered using Whatman filter paper No 42 and diluted to 50 ml volume with distilled water. The air-dried samples of the macrophytes were pulverized into powder and digested using $HNO_3$ + $HClO_4$ acid mixture according to Hseu (2004). Concentrations of trace metals (Pb, Cd, Ni and Mn) in the digest were measured using atomic absorption spectrophotometer (Buck Scientific model 210 VGP, USA). Quality control and quality assurance procedures were carried out to ensure reliability and integrity of the results.

### 2.3. Water quality index

The metal index (MPI) of water samples in the lake dams was calculated to determine the level of trace metal contamination