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Surface Water Pollution by Open Refuse Dumpsite in North Central of Nigeria

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Abstract**—**Water is a vital resource that is important in ensuring the growth and development of any country. To sustain the basic human needs and the demands for agriculture, industry, conservational and ecosystem, enough quality and quantity water is needed. Contamination of water resources is now a global and public health concern. Hence, this study assessed the water quality of Ndawuse River by measuring the physicochemical parameters and heavy metals concentrations of the river using standard methods. In total, 16 surface water samples were obtained from five locations along the river, from upstream to downstream as well as samples from the dumpsite. The results obtained were compared with the standard limits set by both the World Health Organization and the Federal Environmental Protection Agency for domestic purposes. The results of the measured parameters indicated that biological oxygen demand (85.88 mg/L), turbidity (44.51 NTU), Iron (0.014 - 3.511 mg /L) and chromium (0.078 - 0.14 mg /L) were all above the standard limits. The results further showed that the quality of surface water is being significantly affected by human activities around the Ndawuse River which could pose an adverse health risk to several communities that rely on this river as their primary source of water. Therefore, there is a need for strict enforcement of environmental laws to protect the aquatic ecosystem and to avoid long term cumulative exposure risk that heavy metals may pose on human health.

Keywords**—**Abuja, contaminants, heavy metals, Ndawuse River, Nigeria, surface water.

I. Introduction

At present, approximately one-third of the world's people live in different countries with moderate to high water stress. And many parts of the world are facing water scarcity problem due to the limitation of water resources coinciding with growing population and contamination of water sources [1]. In the developed and some developing countries in the world, sewage, agricultural, industrial and domestic wastes are treated at the central wastewater works in order to reduce contaminants before their discharge into freshwater bodies; however, in Nigeria, this is not the case [2]. Industrial and open dump of solid wastes disposal in the cities is some of the most occurring sources of pollution [1]. Agriculture as one of the backbones of any economy has greatly been affected by the upsurge in the indiscriminate dumping and disposal of wastes into land and water bodies which has reduced the quality and quantity of both surface and underground water sources [2].

The World Health Organization (WHO) and UNICEF report for 2012 ranked Nigeria as the third country after China and India, with the largest population without adequate water and sanitation conditions [3], [4]. The challenge is critical as women and children trek long distances to fetch water from rivers, streams, and ponds that are most of the times contaminated. Municipal solid waste dumpsite when in contact with water (rainwater) generates leachate which may affect both groundwater and surface water near them. One of the principal concerns regarding leachate is related to the pollution by uncontrolled leachate migration into nearby surface water sources and infiltration into groundwater aquifers [5].

Leachate consists of many different dissolved or suspended organic and inorganic compounds that could cause more potential groundwater and surface water pollution, as well as public health hazards. Moreover, leachate as one of the environmental pollutants was generally not a matter of concern until recently, when a few cases of water pollution linked to their impact on the physical, chemical, and biological properties of receiving water bodies were reported [2], [5], [6].

It is therefore very important to determine the water quality around the major cities in Abuja, at the Federal Capital Territory of Nigeria, most especially in areas that lack municipal water supplies. This study is highly significant due to the rapid and continuous increase in population and the demand for good quality water in this city [7]. It has also increased the drilling of boreholes and the use of surface water in several residential and industrial areas as a complementary source of water supply. Several reports have also shown that human health and environmental quality are undergoing degradation due to population growth and rapid expansion of cities, which have resulted in the generation of huge waste and indiscriminate waste disposal into the water bodies [6]-[9]. This could constitute serious health and environmental problems [5], [10]. Therefore, the aim of this study was to determine the effect of Mpape dumpsite on the quality of water collected from Ndawuse River at Phase 1, Abuja, Nigeria. It is vital to investigate the effect of pollutants loads from the Mpape dumpsite on the quality of surface water in FCT, with River Ndawuse as a case study.

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II. MATERIALS AND METHODS

A. Description of Study Area and Water Collection

The study area under investigation is the drainage pathways from Mpape dumpsite to River Ndawuse at Phase 1, Abuja, FCT, Nigeria. Water and leachate samples were collected in duplicates at different sampling points along the upstream and downstream of Ndawuse River (Pt1, Pt3, Pt4, Pt5, and Pt6) and Mpape dumpsite (Pt2). The samples were then transported to the laboratory at 4°C for both physicochemical and heavy metal analysis. Sample taken from the upstream served as the control point for all the analyses.

B. Analytical Tests

Temperature, pH and electrical conductivity (µS/cm) were measured onsite during sampling using portable pH/ conductivity meter. Turbidity meter (NTU) and total dissolved solids (TDS) meter were used to measure turbidity and TDS, respectively. The BOD_5 was measured after 5 days using the DO meter according to standard methods. Samples were pre-treated using concentrated nitric acid in a fume cupboard according to Sharma and Tyagi [11], and the concentrations of heavy metals in water samples were analysed using flame atomic absorption spectrophotometer (AAS) (Unicam Solaar 969). Working standard solutions of copper (Cu), iron (Fe), arsenic (As) and chromium (Cr) were prepared from stock standard solution (1000 ppm) in 2M HNO_3, and absorbances of standard solution for each element were noted. Each sample was analysed in triplicates, the mean and standard deviations were determined.

C. Data and Statistical Analyses

GraphPad Prism version 7.0 for Windows (San Diego California, USA) was used for statistical analysis. Mean values of the parameters obtained for the various locations were compared with the various permissible limits of the parameters set by WHO and FEPA in order to identify problems that are associated with water quality of the area [12], [13].

III. RESULTS AND DISCUSSION

A. Physico-Chemical Parameters

Electrical conductivity at the upstream of Ndawuse River in this study was lower than the values recorded at the other sampling points (downstream), the dumpsite had more leaching effect on the surface water downstream along Ndawuse River when compared with the upstream value. The highest TDS value of 3.55 mg/L was recorded at the dumpsite but decreases downstream. This may be attributed to the fact that the ions in the leachate are absorbed on the surface of suspended sediments along the river. The TDS could be used as an indication of aesthetic characteristics of drinking water and the presence of a broad array of chemical pollutants. It naturally gets into the surface water from weathering and dissolution of rocks, soils or through the primary sources such as agricultural runoff, residential runoff, and leaching of soil contamination [14]. The turbidity of water samples ranged between 36.42 NTU and 56.19 NTU, with the mean value of 44.51 NTU. Generally, the lowest turbidity value (36.42 NTU) was recorded at the source of Ndawuse River catchment, Pt1 but, as it flows along the course of the river through the dumpsite where the highest concentration was recorded (56.19 NTU). Based on this, it is evident that the turbidity of these sampling points along the investigated river is negatively influenced by the dumpsite. The turbidity of the surface water samples obtained is above standard limits (5 NTU and 1 NTU) set by WHO [13] and the Federal Environmental Protection Agency [12] guidelines, respectively, for domestic water uses. These values made this receiving water body to be unfit for domestic purposes.

The pH of the surface water samples varied from 6.7 to 7.5 with a mean pH of 6.98 mg/L ± 0.286. The highest pH (7.5) was recorded at the Mpape dumpsite (Pt2) when compared with other samples obtained from the upstream and downstream of River Ndawuse. Leaching from Mpape dumpsite could have contributed to an increase in pH of the river water at the downstream when compared with the pH value of the water sample obtained from the upstream of the river. High or low pH values have been reported to have an effect on aquatic life [15]. The mean value of 85.88 mg/L ± 30.27 for BOD_5 was recorded with the highest concentration at Pt2 (dumpsite) and decreased downstream. These concentrations were above the safety limits set by WHO and FEPA for domestic water usage. This is comparable to the work of Maiti et al. [16] who recorded high COD and BOD_5 concentrations in the leachate samples analysed in their study. This condition is an indication of the very poor aeration system and could cause a damaging effect on the health of both human and animals if the surrounding surface water is to be used for domestic purposes. Subsequently, it will have negative effects on aquatic life especially the reduction of fish diversity at the downstream [17].

B. The Concentration of Heavy Metals in the Leachate and Surface Water Samples

The known chromium concentrations at the different sampling sites were between 0.078 mg/L and 0.14 mg/L with an average concentration of 0.098 mg/L ± 0.021 (Fig. 1), above the safety limit of 0.05 mg/L set by the WHO. The range of iron (Fe) concentration was 0.014 mg/L to 3.511 mg/L with an average of 1.203 mg/L ± 1.314, which means that Fe concentration for the sampled water is above the threshold limit of 0.1 mg/L set by both WHO and FEPA. There was a significant difference in the mean concentration of Fe in all the sampled sites at $p < 0.05$. The Fe concentration at the dumpsite greatly increased (3.511 mg/L) when compared with the measured concentration (0.014 mg/L) upstream of the river. Cr was found to be abundant, above the acceptable limit for drinking water in this study. While, Fe results showed that there was a decrease of Fe concentration from the dumpsite to the downstream of the river. This indicates that this dumpsite could be one of the major contributors of Fe into the investigated river. The surface water from the river could be considered unsafe with respect to Cr and Fe content [9]. Furthermore, Cu was below the standard limit set for drinking water as compared to other measured heavy metals concentrations, as shown in Fig. 2. Arsenic concentrations at the different sampling points ranged between 0.01-0.08 mg/L with an average concentration of 0.004 mg/L. There was negligible detection of As at the upstream (Pt1), this shows that the dumpsite (Pt2) with the highest concentration had a negative influence on the Ndawuse River as shown in heavy metals results obtained for Pt3 up to Pt6. The results indicated that there is a migration of leachate and heavy metals into the river, through the dumpsite. This dumpsite contributes significantly to the concentrations of heavy metals at the downstream. Hence, high concentrations of Cr, Cu, As and Fe in this study is a serious concern as it renders the water unsuitable and unsafe for human consumption in terms of heavy metals toxicity according to standard limits for water quality set by FAO/WHO and it should not be used for domestic and recreational purposes [18]. Similar to this study, Uyom et al. [19] reported high concentrations of some heavy metals in Nigerian rivers. High levels of metals have been a serious problem in the environment due to toxicity in most aquatic biota in the last few decades. Chromium toxicity is frequently as a result of long term and low-level exposure to pollutants in the environment: air, water, food, and numerous consumer products. Exposure to chromium is associated with many chronic diseases such as dermatitis, kidney damage, chronic ulceration and perforation of the nasal septum, respiratory illness, nasal cancer, asthma, and other skin surfaces [20]. Most especially, Cr^{6+} has been reported for its carcinogenic effect when overly exposed to humans [21], [22]. Therefore, high concentrations of these metals in the surface water due to leaching of leachate poses a public health risk, if not addressed.

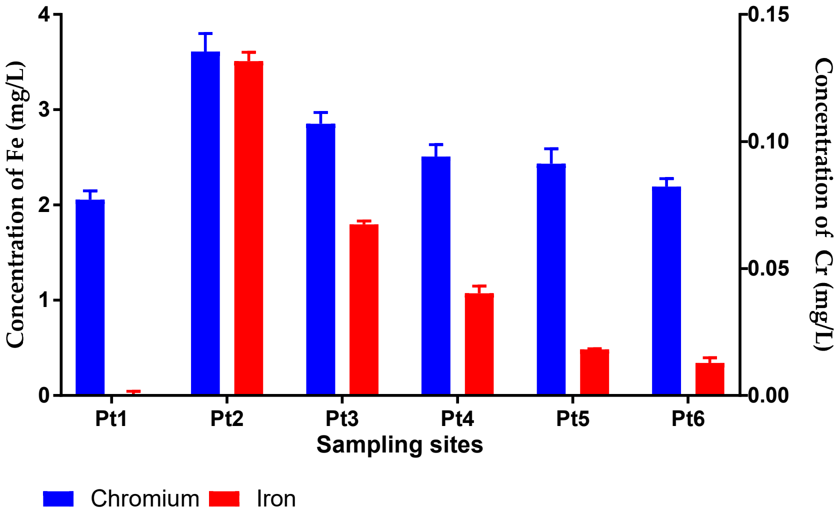

Fig. 1 Average concentrations of chromium and iron in the leachate and surface water samples taken at the different sampling sites along Ndawuse River during the study period

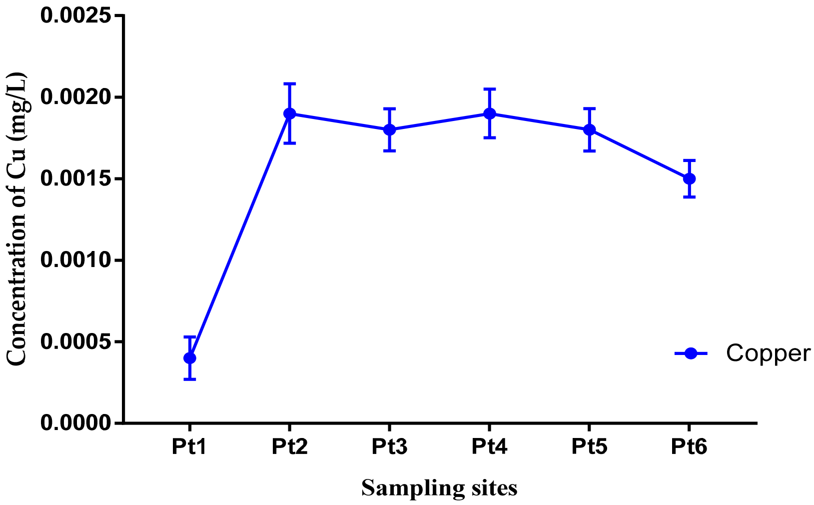

Fig. 2 Average concentrations of copper in the leachate and surface water samples at different sampling sites along Ndawuse River

IV. Conclusions

The dumpsite investigated in this study poses a great threat to the surrounding environment and serves as a major source of pollution to surface water. Based on the results obtained in this study, it can be concluded that physical parameters such as the turbidity and BOD_5 are above the standard limits across the river. Most of the metals analysed in this study have concentrations above the safety limits set by WHO/FEPA for drinking water, especially at the dumpsite. Hence, precautions need to be taken due to human activities near or within freshwater bodies. These metals do not occur naturally in fresh or surface water or are they geogenic in nature, but originate from external sources. Good management measures should be employed to make sure that the river regains its fitness for the support of aquatic life and also for other domestic purposes. Wastes sites should be placed at a safe distance with respect to the river to prevent or minimise indiscriminate leaching of leachate into the water bodies.

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