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Assessment of Physical and Chemical Characteristics, Heavy Metals Composition in Awba Dam: Contamination Levels in Sediment, Soil, *Amaranthus hybridus* (L.) and Effluents from Drains in the University of Ibadan, Nigeria

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ABSTRACT

The indiscriminate use of heavy metal-compounded fertilisers and pesticides as well as the release of raw and ill-treated domestic wastewater into water courses poses threats to living organisms in the environment. This study therefore, evaluated the physical and chemical properties and heavy metals contamination levels in water and sediments of Awba dam, University of Ibadan with a view to assessing its quality and suitability for irrigation. Water samples from Upstream, Midstream and Downstream of Awba Dam and three drains containing outflows from areas with anthropogenic activities and solid sediment samples were collected from Awba Dam, while vegetable and soil samples were collected from a nearby farm (200 m away) from the dam. Samples were analysed for physical and chemical parameters (pH, Dissolved Oxygen (DO), Biochemical and Chemical Oxygen Demand (BOD, COD)], nitrate and phosphate), and heavy metals (Cd, Cr, Co, Ni and Pb) in the water, sediment, *Amaranthus hybridus* and soil were determined using standard methods. Data obtained were analysed using ANOVA at $p<0.05$. Results revealed DO having highest value (3.77 mg/L) at Tech and maximum values of BOD (14.67 mg/L) and COD (57.06 mg/L) were obtained at upstream and these were above the WHO limits. Highest nitrate level (36.45 mg/L) was at Tech and lowest (20.44 mg/L) at downstream. Similarly, phosphate value in all locations ranged from 0.09-0.61 mg/L. All heavy metal levels were in non- detectable quantities in water and *Amaranthus hybridus*. In sediment, Cr and Co had highest values of 13.67 and 5.33 mg/kg, respectively at upstream and Ni had 12350 mg/kg at midstream, all above the USEPA Sediment Criteria. Also, Ni had the highest value (18811.00 mg/kg) in soil. The chemical oxygen demand in water as well as nickel concentrations in both sediments from Awba Dam and soil were high. Therefore, there is need for regular monitoring of these parameters is recommended.

Keywords: Awba dam, Water quality, Heavy metals contamination, *Amaranthus hybridus* and Soil quality.

INTRODUCTION

Adequate water quality is essential not only for the well-being of humans but also for municipal, agricultural, industrial and recreational purposes (Sangeeta and Neha, 2015). Contamination of freshwater resources has attracted global attention in the recent years, this may be due to its impact on the ecological balance of the recipient environment and its diversity of aquatic organisms (Olayinka *et al*., 2017). Instances of alteration of surface water such as rivers, lakes, dams and reservoirs have led to extensive ecological degradation such as a decline in the quality and availability of water, changes in the distribution and structure of the aquatic biota, intense flooding and loss of species (Oberdorff *et al.,* 2002; Edokpayi *et al.,* 2017).

A decline or alteration in water quality may result from various channels but predominantly anthropogenic activities such as agricultural activities, urban and industrial development, mining, and recreation (Edokpayi *et al.,* 2017). Furthermore, the indiscriminate disposal of liquid wastes into water bodies causes changes in the physicochemical characteristics of water which may cause hazard to flora and fauna of the aquatic ecosystem and man (Ghorade *et al*., 2015; Jenyo-Oni and Oladele, 2016). In addition, the use of heavy metals containing fertilizers and pesticides in agriculture has resulted in deterioration of water quality and serious environmental problems posing threat to humans (Bellingham, 2012). Water quality analysis is important to protect the natural ecosystem (Patil *et al*., 2012).

Hence, physical and chemical properties (such as nitrates, phosphates, biochemical oxygen demand, chemical oxygen demand, hardness etc.) of water are very essential in obtaining the exact quality of water before it is used for drinking, domestic, agricultural or industrial purposes. Heavy metals are toxic even at low concentrations, non-biodegradable, persist in various environmental media and can accumulate in plants and animals (Ahmad and Goni, 2009; Edokpayi *et al.,* 2017; Ayomide *et al.* 2023). Thus, freshwater and sediment pollution by heavy metals is currently an environmentally important issue with consequences for aquatic organisms and human health (Eliku and Leta, 2018).

Sediments serve as both sink and source of heavy metals. Continued deposition of heavy metals in sediments can also lead to contamination of groundwater (Ali *et al*., 2019). Soils may become contaminated by the accumulation of heavy metals through the application of fertilisers, pesticides, animal manures and sewage sludge on land as well as through irrigation by contaminated wastewater (Gebreyohannes and Gebrekidan, 2018). Usually, vegetables cultivated in soils irrigated with water containing high concentrations of toxic metals take up and accumulate these pollutants in edible and non-edible parts of the vegetables in quantities that are capable of causing potential health risks both to animals and humans (Naser *et al.,* 2014; Edokpayi *et al.,* 2017; Kacholi and Sahu, 2018). This high level of potential toxic elements accumulation in plants can lead to reduction in photosynthetic rate causing retardation and stunted growth as well as effect on reproduction via a decrease in pollen and seed viability (Inyinbor *et al.,* 2018) leading to yield reduction.

Awba Dam is an artificial lake located within the University of Ibadan, Ibadan, south-western Nigeria which has been used for domestic water supply, fisheries and research within the University. It receives untreated effluents from staff and students' residences, Zoological garden, wastewater generated from laboratory experiments in Faculties of Science and Technology laboratories and non-point sources resulting from erosion and leaching of chemicals from surrounding farmland (Natoli *et al*., 2019). Therefore, the potential pollution level of the dam is worth investigating. Monitoring the quality of water from Awba Dam and other relevant environmental media such as sediment, soil and plants around the dam ensures sound ecosystem protection in the environment.

The University of Ibadan Management has placed restrictions on people and agricultural activities around Awba Dam vicinities. This is due to sedimentation, and environmental pollution and perturbation on the dam. The aim of this study was, therefore, to evaluate the pollution status of Awba Dam, University of Ibadan, Nigeria, with a view to assessing its quality. The specific objectives were to: (i) determine the physical and chemical parameters of Awba Dam and some water drains into the dam, (ii) evaluate levels of Cd, Co, Cr, Ni and Pb contamination in water and sediments from Awba Dam as well as in soil and *Amaranthus hybridus* from a vegetable farm near Awba Dam.

MATERIALS AND METHODS

Sampling sites description

Awba Dam reservoir is located at the South-Western end of the University of Ibadan, Ibadan, South-Western Nigeria. It was constructed in 1964 by draining the Awba stream and impounding the water at a point where it flows through a natural valley (Chukwuma, and Adebisi-Fagbohungbe, 2015). It lies on latitude 7°26'3"N and longitude 3°53'30"E and at an altitude of 209 m above sea level; The Reservoir is 8.5 m high, 110 m long with a crest of 12.2 m high. It has a maximum depth of 5.5 m with a maximum length of 700 m. It can hold about 230 million litres of water. Samples were collected from Upstream, Midstream and Downstream of Awba dam and three water drains containing outflow from Zoological garden, residential quarters around Zik hall and the Faculty of Technology. *Amaranthus hybridus* and soil samples were also collected from a vegetable farm along Awba Dam. Sampling was carried out in mid-April 2021. The map of the sampling sites showing the locations of the samples collection is presented in Figure 1, while the coordinates of the specific sampling points are shown in Table 1.

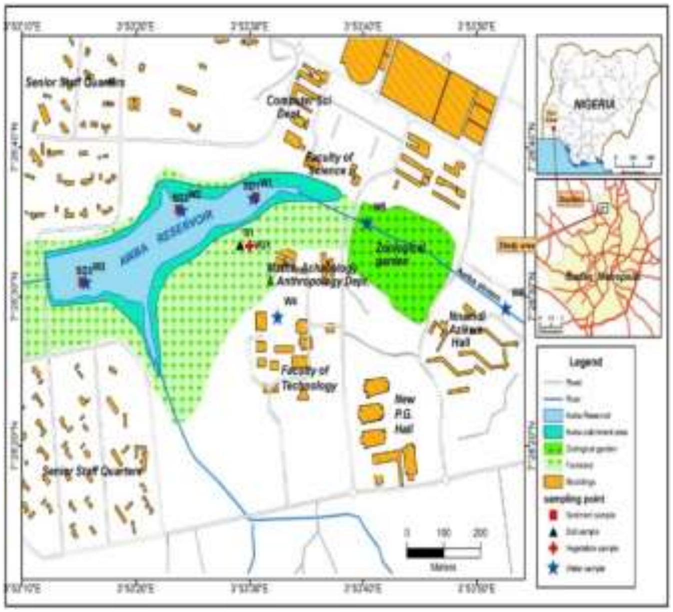

Figure 1: Map showing the sampling locations in University of Ibadan

Table 1: Description and coordinates of sampling locations

Study Sites	Coordinates	Description
Awba Dam-Upstream	Latitude 7°26'36.605"N, Longitude 3°53'30.324"E	The entry of Awba Dam
Awba Dam-Midstream	Latitude 7°26'35.791"N, Longitude 3°53'24.045"E	The middle stream of Awba Dam
Awba Dam- Downstream	Latitude 7°26'33.127"N, Longitude 3°53'18.193"E	The downstream of Awba Dam
Tech	Latitude 7°.26'28.648"N, Longitude 3°.53'32.478"E	The water drains around Faculty of Technology
Zik	Latitude 7°.26'29.234"N, Longitude 3°.53'52.570"E	The outflow containing wastewater from fishery farm around Nnamdi Azikwe Hall
Zoo	Latitude 7°.26'34.951"N, Longitude 3°.53'40.328"E	The outflow containing wastewater from Zoological garden
Vegetable Farm	Latitude 7°.26'33.377"N, Longitude 3°.53'29.994"E	The vegetable farm around Awba Dam

Samples collection and pre-treatment

All sampling containers used for the collection of water samples were thoroughly washed with detergent and initially rinsed with tap water and finally rinsed with distilled water prior to sample collection in order to prevent contamination. Plastic containers were used for physical and chemical and heavy metals determination in water. However, water samples for dissolved oxygen, biochemical oxygen demand and chemical oxygen demand were collected using 250 mL narrow mouthed dark amber glass bottles. Water samples were collected separately at three points of the dam (upstream, midstream and downstream) at 100 m away from each point and also at three different water drains into the Awba Dam. Water samples for heavy metals analysis were immediately acidified with one mL of concentrated nitric acid to prevent adsorption of the metals on the sampling containers.

Sediment samples were collected randomly from the upstream, midstream and downstream of Awba Dam with a Van veen grab (0.1 m^2). Composite sediment samples were obtained from each sampling location and transported in labeled polyethylene bags and treated with 5% nitric acid and rinsed with deionized water.

Vegetable samples of African spinach (*Amaranthus hybridus*) (whole plants) were collected from a farm located about 200 m away from the dam. The vegetable was washed under a running tap to remove soil and other dirt. The shoots of the vegetable samples were separated from the whole plants with the aid of a stainless steel knife. Vegetables were then taken to the Toxicology Research Laboratory, Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan for oven drying at 105°C for 48 hours in order to remove moisture. The oven dried samples were pulverized using agate pestle and mortar, and sieved through a 0.5 mm mesh size sieve to obtain a uniform particle size. The oven dried vegetable samples were stored in a polythene bag.

Soil samples were augered randomly at a depth of 0 – 15 cm from the same sampling points as the vegetables with the aid of a calibrated soil auger that had been pre-cleaned with nitric acid in order to prevent heavy metal contamination prior to analyses. The collected soil samples were bulked and thoroughly mixed to form a composite sample. The composite sample was taken to the Toxicology Research Laboratory, CPEB, University of Ibadan for air drying for five days at room temperature.

Physical and chemical analysis of water samples

The physical and chemical parameters determined in water samples were Potential hydrogen (pH), total dissolved solids (TDS), electrical conductivity (EC), hardness, nitrates, turbidity, total suspended solids (TSS), total alkalinity, chloride, phosphate, dissolved oxygen (DO), five-day biological oxygen demand (BOD) and chemical oxygen demand (COD). pH was determined using pH meter (Jenway 3510), TDS and EC were determined using TDS and Electrical Conductivity (EC) Meter (Hold Health Metric), Hardness was determined with Hardness Test Kit (Hanna instrument HI3812), nitrates was determined with Pocket Nitrate Meter (Horiba – B-742) using ion selective electrode meter techniques, turbidity was determined with turbidity tube, TSS was determined by gravimetry after filtration (APHA, 2012). Total alkalinity was measured using titrimetric analysis (APHA, 2012), chloride was determined using Argentometric method (APHA, 2012) while phosphate determination was achieved by spectrophotometry using the Ascorbic acid method (APHA, 2012). DO and BOD were determined by Winkler Titrimetric method (APHA, 2012) while COD determination was carried out by titrimetric method using potassium dichromate solution (APHA, 2012).

Heavy metals analysis

Analysis of water samples for heavy metal contents

The digestion flask and measuring cylinder was rinsed with the deionized water samples to avoid contamination. A 100 mL each of the water samples (upstream, middle stream and downstream) was measured using a standard measuring cylinder and then transferred to the digestion flasks and 5 mL of the concentrated HNO_3 was added to the content in the digestion flasks. The mixture was heated on a hot plate in the fume cupboard until the volume reduced to almost dryness. After cooling, the digested samples were filtered using a Whatman filter paper to remove all suspended solid and other particles. The resulting filtrates were transferred to a 50 mL standard flask and made up to 50 mL mark with distilled water. Laboratory blank sample was prepared using all the reagents and following the same procedure, but without the sample. The digested samples were analysed for heavy metals including Cd, Co, Cr, Ni and Pb at FATLAB Nigeria Company, Ibadan using Atomic Absorption Spectrophotometer (Bulk Scientific Model 210) according to the procedure of AOAC (2005).

Analysis of Vegetable Samples (*Amaranthus hybridus* L.) for Heavy Metal Contents

The dried vegetable sample (*Amaranthus hybridus*) was pulverised using agate pestle and mortar followed by sieving through a 0.5 mm mesh size sieve to obtain a uniform particle size. Half gram of the processed vegetable sample was weighed into 30 mL porcelain crucible and placed in a muffled furnace at a temperature between 450 - 500°C for a period of 6 – 8 hours. The ash sample was removed after cooling and its solution was prepared by adding 5 mL of 1N HNO3. The solution was evaporated to dryness on a hot plate at low heat under ventilation (in fume chamber). The sample was returned into the furnace and heated at 400°C for 10 – 15 minutes until a perfectly white or grayish white ash was obtained. The sample was cooled and 10 mL of 1N HCl was added to form a solution which was filtered into a 25 mL volumetric flask. The crucible and filter paper were washed with additional portion of 1N HCl three times to make up to 25 mL mark. The digested sample was analysed for Cd, Co, Cr, Ni and Pb using Atomic Absorption Spectrophotometer (Bulk Scientific Model 210) according to the procedure of AOAC (2005).

Analysis of soil samples for heavy metal contents

The representative composite soil and sediment samples were air-dried for five days, ground and sieved to obtain a uniform particle size at the Toxicology Research Laboratory of CPEB, University of Ibadan, Nigeria. Each sample was labeled and stored in a clean polythene bag prior to analyses. One gram was taken from each composite soil and sediment samples, respectively and digested using 20 mL of 1:1 nitric acid (analar). This was boiled gently on a hot plate (in a fume chamber) until volume of nitric acid reduced to about 5 mL. A 20 mL of de-ionised water was added and boiled gently again until the volume was approximately 10 mL. The suspension was cooled and filtered through a Whatman filter paper. The beaker and filter paper were washed with small portions of de-ionised water until volume was made up to 25 mL standard flask. Analyses of heavy metals Cd, Co, Cr, Ni and Pb were done using Atomic Absorption Spectrophotometer (Bulk

Scientific Model 210) according to the procedure of AOAC (2005).

Quality assurance and statistical analysis

Analytical grade reagents were used for all analyses. All prepared solutions were standardised against primary standards to confirm their actual concentrations. All glassware and plastic containers used for heavy metals analysis were soaked in 10% HNO_3 solution overnight and rinsed thoroughly with distilled water before use.

Data collected were analysed using Analysis of Variance (ANOVA) by DSAASTAT (version 1.101) and significant means were separated using Least Significant Difference (LSD) at probability of 5% ($p<0.05$).

RESULTS AND DISCUSSION

Physical and chemical properties of water samples of Awba dam

The results of some physical and chemical properties (pH, EC, TDS, TSS, turbidity, total alkalinity and hardness) of Awba dam water samples are shown in Table 2, while the results of others (DO, BOD, COD, chloride, nitrate and phosphates) are shown in Table 3. The pH of the water samples ranged from 6.73 to 7.16 and showed no significant difference ($p>0.05$) across the different locations. The mean pH values were indicative of slightly alkaline water samples and were within the World Health Organization (WHO) limits of 6.5-8.5. The Total Dissolved Solids (TDS) had the highest value of 243.33 mg/L from Faculty of Technology (Tech), while the lowest value of 137.33 mg/L was recorded for Midstream of Awba dam. No significant differences ($p>0.05$) were observed in TSS and Turbidity (Table 2). The turbidity value was below the World Health Organization (WHO) limits of 5 nephelometric turbidity units (NTU). However, the high turbidity value observed at midstream could be due to surface runoff from farmland (Taiwo *et al*., 2012). High total dissolved solids (TDS) may be due to an increased influx of dissolved salt as a result of rainfall. The TDS also increased significantly with an increase in electrical conductivity. This is in agreement with the report of Olayinka *et al*. (2017).

Electrical Conductivity (EC) revealed significant difference ($p<0.05$) across the different locations with the highest value of 486.67 µs/cm recorded at Tech drain water, while the lowest value 137.33 µs/cm was from Downstream of Awba dam (Table 2). The electrical conductivity values in all the water samples were below the WHO limits of 1000 µs/cm. High electrical conductivity may lower the aesthetic value of water by giving mineral taste to the water (Rahmanian *et al*., 2015). Also, food-plant and habitat-forming plant species are also eliminated by excessive electrical conductivity (Rahmanian *et al*., 2015). However, its highest value (486.67 µs/cm) measured at Tech site may be due to high dissolved solids (Olayinka *et al*., 2017).

Highest value of 811.67 mg/L in alkalinity was from Zik site, while 92.00 mg/L lowest value was from Upstream of Awba dam (Table 2). The mean total alkalinity values of 92.00 to 811.67mg/L in this study was higher than 6.43 to 9.23 mg/L reported by Ugbaja and Ephraim (2019) in Surface Water of Oban Massif, Nigeria. Very high level of alkalinity indicates the presence of industrial or chemical pollution. Water with moderate amounts of alkalinity can be consumed without adverse health effect but excessive contents would cause objectionable or unwanted taste (Ugbaja and Ephraim, 2019). Hardness (mg/L) had the highest value of 167.00 from Tech, while the lowest value of 84.67 was from the midstream of Awba dam (Table 2). The water from Awba dam can be classified as moderately hard based on the values measured in this study. Moderately hard water has no known adverse effects in the environment but high hardness creates problems for daily human uses (Fadaei andiss Sadeghi, 2014).

Results for Dissolved Oxygen (DO) recorded no significant difference ($p>0.05$) across the different locations (Table 3), although the DO of the water samples ranged from 1.91 to 3.77mg/L. The DO level was below the WHO limits of 5 mg/L. Popoola and Otalekor, (2011) reported a similar DO value of 1.21 to 3.10 mg/L in the Awba dam.

The observed low DO values possibly reflect early indication of undesirable conditions in the physical and chemical factors (Ugbaja and Ephraim, 2019). Dissolved oxygen is essential for the survival of aquatic life and it is used to assess the degree of freshness of a river. According to Olayinka *et al*. (2017), a DO value as low as 1–5 mgL^{-1} may reduce the growth rate of fishes when continuously exposed, while a value below 1 mgL^{-1} is reported to be toxic to fish when exposed for more than a few hours. The Biochemical Oxygen Demand (BOD) revealed significant difference ($p<0.05$) across the different locations with the highest value of 14.67 mg/L recorded at upstream of Awba dam, while the lowest value, 3.26 mg/L was from Tech. According to Ugbaja and Ephraim (2019), BOD gives an indication of the organic load of water bodies, especially those receiving wastewater effluents. The BOD recorded in this study was higher than the value (3.60 - 7.66 mg/L) reported by Ugbaja and Ephraim, (2019). The high BOD measured at upstream signifies high load of organic matter (Ogunfowokan *et al*., 2005).

The Chemical Oxygen Demand (COD) had the highest value of 57.06 mg/L from upstream of Awba dam, while the lowest value of 46.47 mg/L was from Tech. The obtained COD in this study in all water samples exceeded the acceptable value of 20 mg/L for unpolluted surface water quality as reported by Olayinka *et al*. (2017). The high COD may be due to the presence of organic loads from animals (Zoological garden), agricultural and domestic wastes (Alum *et al*., 2021). However, the BOD and COD levels were above WHO limits. These may be due to large amount of oxygen demanding wastes from domestic and agricultural sources entering the dam (Onyegeme and Ogunka, 2017).

No significant difference was observed in chloride and phosphate (Table 3). In this study, the mean concentration of chloride was below the WHO limits of 250 mg/L and ranged from 6.50 to 8.23 mg/L, although it was higher than the values (0.89 – 3.50 mg/L) reported by Ugbaja and Ephraim (2019). This may be due to the fact that surface water bodies often have low concentration of chloride (Merinde and Ayenew, 2016). High chloride concentration damages metallic pipes and as well harm growing plants (Meride and Ayenew, 2016).

Table 2: Mean Concentrations of Physicochemical Properties of Water Samples of the Awba Dam and effluents from drains, University of Ibadan, Nigeria [a]

Parameter	Upstream	Midstream	Downstream	Tech	Zik	Zoo	WHO 2011	LSD
pH	7.16a±0.04	6.93a±0.01	6.85a±0.01	6.73a±0.01	6.84a±0.01	6.86a±0.01	6.5 – 8.5	NS
EC (μs/cm)	283.00d±1.22	280.33d±4.49	272.00e±2.45	486.67a±10.98	323.33b±4.55	294.00c±2.83	1000	6.39
TDS (mg/L)	142.00cd±1.41	137.33d±1.47	140.33d±2.48	243.33a±1.08	160.00b±1.41	147.67c±2.16	1000	6.39
TSS (mg/L)	0.24a±0.01	0.34a±0.01	0.16a±0.01	0.27a±0.01	0.04a±0.01	0.16a±0.00	< 500	NS
Turbidity (NTU)	0.75a±0.02	1.05a±0.02	0.46a±0.03	0.82a±0.02	0.13a±0.001	0.48a±0.01	5	NS
Alkalinity (mg/L)	92.00 f ±7.48	175.33 e ±3.56	261.33d ±7.26	611.67c ±7.36	811.67a ±7.36	795.33b ±9.63	-	6.39
Hardness (mg/L)	127.33b±4.55	84.67d±3.56	87.33d±4.55	167.00a±1.87	88.00d±5.10	101.67c±2.04	-	6.39

[a]Mean values with the same letter along the same row are not significantly ($p<0.05$) different from each other. pH: Potential Hydrogen, EC: Electrical Conductivity, TDS: Total Dissolved Solids, TSS: Total Suspended Solids. WHO: World Health Organisation Stipulated limit for Drinking Water, LSD: Least Significant Difference

Table 3: Mean Concentrations of other physicochemical properties of Water Samples of the Awba Dam, University of Ibadan, Nigeria[a]

Parameters (mg/L)	Upstream	Midstream	Downstream	Tech	Zik	Zoo	WHO 2011	LSD
DO	1.91a±0.01	1.97a±0.02	2.12a±0.02	3.77a±0.05	2.65a±0.03	2.50a±0.02	5.0-6.59	NS
BOD	14.67a±0.15	12.47ab±0.04	12.67a±0.11	3.26c±0.05	6.12b±0.07	8.41abc±0.02	2	6.39
COD	57.06a±1.03	56.86a±1.66	55.90ab±0.49	46.47c±0.61	48.83c±0.60	50.23bc±0.64	-	6.39
Chloride	8.23a±0.18	7.90a±0.25	8.23a±0.18	6.67a±0.11	6.50a±0.14	7.10a±0.07	250	NS
Nitrate	20.86b±0.44	21.30b±0.62	20.44b±0.28	36.45a±0.80	23.85b±0.32	21.83b±0.10	45	6.39
Phosphate	0.09a ±0.02	0.19a±0.02	0.13a±0.02	ND	0.43a±0.04	0.61a±0.02	<5	6.39

[a]Mean values with the same letter along the same row are not significantly ($p<0.05$) different from each other. DO: Dissolved Oxygen; BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; WHO: World Health Organisation Stipulated Limit for Drinking Water, LSD: Least Significant Difference

Maximum value of 36.45 mg/L in nitrate was from Tech, while 20.44 mg/L minimum value was from Downstream of Awba dam (Table 3). The nitrate and phosphate levels were below the WHO limits of 45 mg/L and 5 mg/L, respectively. The high nitrate value observed at Tech may be due to runoff from fertiliser application in nearby farms. Nitrate is a major ingredient of farm fertilisers necessary for plant uptake and is essential for plant growth (Ma *et al.*, 2020). Moreover, continuous rise in the concentration of nitrate might lead to eutrophication and methemoglobinemia (lack of oxygen) in infants, if not properly controlled. The high phosphate level (0.61 mg/ L) observed at Zoo may be attributed to the use of phosphate containing cleaning agent at the Zoological garden. Phosphates enhance the growth of planktons and water plants that serve as food for fish and aquatic life. However, Ma *et al*. (2020) reported that the combination of nitrate and phosphate levels may induce eutrophication.

Heavy metals in water, sediment, *Amaranthus hybridus* and soil

All the heavy metals were not detected in the water samples. It is evident that the concentrations of heavy metals in the water samples were very low. Cadmium (Cd), Chromium (Cr), Cobalt (Co), Nickel (Ni) and Lead (Pb) were present in non-detectable quantities in the water samples compared to their concentrations in the sediment samples. This was also reported by Jenyo-Oni and Oladele (2016). This could be attributed to sedimentation of the metals and low pollutants input from few anthropogenic activities in the University community in the period between year 2020 and April 2021, when the University campus was closed due to a strike action and COVID 19.

Results presented in Table 4 showed the heavy metals contents in the solid sediments of Awba dam with Cd and Pb in non-detectable quantities in the s samples. However, Cr was detected in sediments but not significantly different ($p>0.05$) across the different locations. Also, Co was detected in sediments at the upstream and midstream with no significant difference ($p>0.05$) but not detected in sediments collected from the downstream of Awba dam. Higher concentration of Ni (12350 mg/kg) in sediments was recorded at midstream, although not detected in sediments at the Upstream and downstream of Awba dam (Table 4). Heavy metals (Cd, Cr, Co and Pb) in sediment samples were relatively low except for Ni which was considerably high. The high concentration of Ni may be due to run offs from constant application of fertilisers on nearby farmlands. According to Tam and Wong (2000), most fertilisers have Ni as a base and Co and Cd as trace elements.

Furthermore, heavy metals (Cd, Cr, Co, Ni and Pb) were present in non-detectable quantities in *Amaranthus hybridus* (vegetable). Out of the five metals analysed, Cd was not detected in all samples (water, sediment, *Amaranthus hybridus* and soil). This could be that its concentration was below the detectable limit (0.01 mg/kg) of the Atomic Absorption Spectrometer (Bulk Scientific model 210).

Heavy metal concentrations in soil samples are presented in Table 5. The soil samples contained notable levels of heavy metals (Co, Cr and Pb) except for Ni which was extremely higher than the WHO (2011) permissible level of 100 mg/kg. No significant differences (p>0.05) were observed in Cr, Co and Pb in the soil samples from the vegetable farm along Awba dam (Table 5). Higher Ni level of 18811 mg/kg was obtained in the soil samples from the vegetable farm around Awba dam. However, Cadmium was not detected in the soil samples. No significant differences (p>0.05) were observed in Cr, Co and Pb in the soil samples from the vegetable farm around Awba dam (Table 5). High levels of Ni in soil could be due to accession of soil eroded from elsewhere in addition to agricultural chemicals such as fertiliser and lime (Chauhan and Sharma, 2008). Elevated levels of Ni in the soil may cause toxicity and lead to several deleterious alterations in plants (Shahzad *et al.*, 2018). Its toxicity symptoms include chlorosis, necrosis, growth inhibition, reduced photosynthesis and mineral nutrition disorders (Shahzad *et al.,* 2018).

Table 4: Mean Concentrations (mg/kg) of Heavy Metals in Solid Sediment Samples from the Awba Dam, University of Ibadan, Nigeria

Heavy Metals (mg/kg)	**Sediment**	**WHO 2011**
Cadmium	ND	1
Chromium	35.33b±0.82	-
Cobalt	28.67b±0.41	-
Nickel	18811a±105.54	100
Lead	37b±0.71	60

ND- non detectable

Table 5: **Mean Concentrations (mg/kg) of Heavy Metals in Soil Samples from vegetable farm along the Awba Dam, University of Ibadan, Nigeria**

Heavy Metals (mg/kg)	**Soil**	**WHO 2011**
Cadmium	ND	1
Chromium	35.33b±0.82	-
Cobalt	28.67b±0.41	-
Nickel	18811a±105.54	100
Lead	37b±0.71	60

CONCLUSION

Physical and chemical parameters as well as selected heavy metals (Cd, Cr, Co, Ni and Pb) were determined in Awba dam water and in some selected drains in the University of Ibadan community. The heavy metals were also determined in Awba dam sediment, *Amaranthus hybidus* and soil from a vegetable farm near Awba dam. Low dissolved oxygen and high chemical oxygen demand in Awba dam water were observed which may be due to indiscriminate discharge of raw or partially treated wastewater from residential quarters, Zoological Garden in University of Ibadan and surface runoff from fertiliser application on agricultural lands. Heavy metals were in non-detectable quantities in the Awba dam water which may be due to sedimentation and low pollutants input from few anthropogenic activities in the University of Ibadan community in 2020 to April 2021. High Ni contents were observed in Awba dam sediments and soils from vegetable farm. Heavy metals (Cd, Cr, Co, Ni and Pb) were not detected in the sampled vegetable *Amaranthus hybidus.*

Recommendations

There is need for regular monitoring of the quality and status of Awba dam frequently considering its importance as a source of water supply for domestic use and irrigation in the University of Ibadan Community.

Continuous research activities to assess the impact of environmental influences such as farming activities, fishing and others around the dam

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