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Heavy Metal Levels in Water, Soil, Plant and Faecal Samples Collected from the Borgu Sector of Kainji Lake National Park, Nigeria

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Abstract

Heavy metals are persistent environmental contaminants and their toxicity is a problem of increasing significance for ecological, nutritional and environmental reasons. Their availability within the ecosystem via natural or anthropogenic sources has negatively affected the ability of wildlife to thrive adequately at all physiological levels. This study therefore evaluated heavy metal concentration in water, soil, faecal and plant samples of Borgu sector of Kainji Lake National park (KLNP). Water samples were collected by grab sampling while top soil (0-15cm) and plant samples were collected randomly. Faecal samples of wild animals were collected through opportunistic sighting. Samples of water (8), soil (8), plant (6) and faecal (6) were collected for two seasons (dry and wet) and analysed for heavy metals: Lead (Pb), Chromium (Cr), Nickel (Ni), Manganese (Mn), Iron (Fe) Cadmium (Cd), Copper (Cu), and Zinc (Zn) using Atomic Absorption Spectrophotometer after wet (acid) digestion. Data collected were subjected to descriptive (mean, standard deviation) and inferential (T-test) statistics using Statistical Package for Social Sciences with statistical significance set at α0.05. The mean values of heavy metals in the water samples revealed that all the heavy metals analysed (except Zn) during the wet season were above the WHO guidelines for drinking water. The level of Cd in the soil samples was higher than the comparable maximum allowable limit while the mean values of Pb, Cd, Cr, Ni and Fe were above the permissible limit. The relative low levels of metals in the sampled faeces indicate exposure of the animals in the wild to the heavy metals. The trend of heavy metal levels and influence of seasonal variation observed gave an insight into the contamination of studied ecosystem with possible health implication on wildlife. There is need to carry out the study over time to monitor heavy metal deposition, accumulation and contamination in the park.

Keywords: Heavy metals; Anthropogenic activities; Seasonal variation; Kainji Lake National Park

Introduction

Over the years, significant attention is being paid to environmental contamination of the wildlife by a wide variety of contaminants and the associated effect [1-3]. The environment plays a key role by forming a habitat for animals and humans. Current concerns about the loss of critical components of biodiversity have in fact indicated that environmental contaminants play a key role in the declines of many species across taxa [4,5]. Unfortunately, the world's environment is confronted with an array of threats including environmental contamination specifically that of heavy metal exposure due to anthropogenic influence [3]. Heavy metals are metallic elements with a relatively high density with some, toxic or poisonous even at low concentration [6,7]. They occur naturally and from anthropogenic sources in the ecosystems with large variations in concentrations. The major concern with heavy metals is related to their quantity, quality, toxicity, bioavailability and ability to bioaccumulate in biological systems, resulting in several deleterious health effects. These effects directly or indirectly, influence the overall fitness of the animal through observable parameters such as growth, locomotion, reproduction and survival and can manifest at all physiological levels [8].

Prolonged exposure to heavy metals even at low concentrations have been reported to induce morphological, histological and biochemical alterations in the tissues of animals [9,10] reported that heavy metals constitute the major pollutants within the environment likewise that the effects of heavy metal contamination, such as reported in lead poisoning, could pose a threat to the conservation status of all known species [11]. The interaction that exists between environmental contaminants and ecological receptors are important in assessing the risk and health of the ecosystem. Detecting environmental contamination through the accumulation of contaminants such as heavy metals and their effects on wild animals is crucial for the evaluation of environmental quality and to make headway in the understanding of tolerance capacity of natural populations to contamination [12]. With increasing human population, anthropogenic activities' contribution to metal levels in the environment continues to be overwhelming [13]. These unprecedented activities such as fossil fuel and coal combustion, manufacturing processes, industrial and effluent discharges, automobile exhaust, mining and metal processing, and so on have been identified to contribute more to metal levels with their persistence and bioaccumulation within the biota a great concern. Wild animal health is also dependent on plants (vegetation) and the abiotic components of the environment (water, soil and air). When any of these is contaminated, there is high possibility of a resultant effect on wild animal health. This study therefore assessed the levels of heavy metals in water, soil, plant and faecal samples collected from Borgu Sector of Kainji Lake National Park and seasonal influence on their levels.

Methodology

Study area

Figure 1: Map of Kainji Lake National Park showing Borgu and Zugurma Sectors [15].

The Kainji Lake National Park (KLNP) is located approximately 560km north of Lagos, and 385km Southwest of Abuja, the Federal Capital Territory of Nigeria. It is made up of two non-contiguous sectors; the Borgu and the Zugurma sectors covering a total area of 5,340.82km^2. These two sectors lie approximately between latitudes 9° 40'N and 10° 30'N and longitudes 3° 30'E and 5° 50'E. The Borgu sector (covering an area of 3,970.02km^2) is situated on the land area shared between the Borgu Local Government Area in Niger State and Kaiama as well as Baruten Local Government Areas of Kwara State. The soils of the park have been described as ferruginous tropical soils according to the soil map of Africa [14,15] and the variation in soil properties influence the distribution of the vegetation complex. The topography of KLNP is such that the terrain of the park is gently undulating with the highest elevation (excluding the hills) about 300-350m above sea level. The park is rich in both flora and fauna species (Figure 1).

Sample site selection

This study was carried out at Borgu sector of Kainji Lake National Park (KLNP), purposively selected based on the availability of perennial rivers and biodiversity richness sequel to a thorough reconnaissance survey and suspected increased anthropogenic contact or influence.

Samples collection and technique

Water sampling at four sampling stations [Oli River, Kilometer 3, Kilometer 5 (Crocodile pool) and Kilometer 8 (Hippo pool)] was performed using the grab sampling technique. Water samples were collected randomly at each sampling station into sample bottles that were properly rinsed and labelled adequately. For soil sampling, soil samples of the top soil (0-15cm depth) were collected randomly at four points within Borgu sector of KLNP using a hand-held auger into clean cellophane bags that were well-labelled. For plant sampling, four plants species that are most preferred by a large percentage of herbivores (sequel to a reconnaissance) were collected randomly at different points within the park and transported to the laboratory for analysis. These plants are *Diospyros mespiliformise, Strychnous spinosa, Cynodon plectostachyus* and *Andropogon gayanus*). For faecal sampling, faecal samples from wild animals (herbivores and omnivores) were collected from different points within the study areas (through opportunistic sighting) into sample bottles, properly labeled and evaluated as a biomarker of exposure to heavy metal contamination. All samples (water, soil, plant and faecal) were after collection, taken to the laboratory within forty-eight (48) hours of collection and assessed for heavy metal exposure. Collection of samples was done with the help of park rangers for two seasons (dry and wet) to evaluate the impact(s) of seasonal variation on heavy metal levels.

Heavy metals analyzed and laboratory analysis

Cadmium (Cd), Copper (Cu), Lead (Pb), Chromium (Cr), Zinc (Zn), Nickel (Ni), Iron (Fe) and Manganese (Mn) were analyzed in all the samples. These heavy metals were purposively selected

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because they constitute part of the eleven heavy metal elements of highest wildlife protection concern [16]. For water sample analysis, about 50ml of the water samples were taken at each sampling station and acidified with 10% HNO_3 immediately in order to prevent analyte loss and thereafter placed in an ice bath and taken to the laboratory where they were transferred into 250ml beakers and properly digested using wet acid digestion method. For soil sample analysis, about 1gm of each soil sample was air-dried, pulverized with an agate mortar and then sieved through a nylon sieve (a pore diameter of less than 0.149mm). About 0.3gm sieved soil sample was put in a tetrafluoroethylene (PTFE) beaker, thoroughly mixed with 6ml HNO_3, 3ml HCl and 0.25 ml H_2O_2, and then heated for proper digestion in a microwave extraction system [17].

For plant sample analysis, plant samples were dried using drying oven and pulverized with a pulverizer. Then, about 1.0g of each plant sample was appropriately digested with 1ml H_2SO_4, 8ml HNO_3 and 1ml $HClO_4$. The digestion process was repeated until the digested solution became clear. For faecal sample analysis, about 0.5gm of dry fecal was weighed in a glass tube. Concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) were added to each sample in 4:1 ratio [18]. Digestion of samples was repeated until the solution became clear. Once the solution became clear, about 3 to 4 drops of H_2O_2 (30%) was added to neutralize and dissolve any remaining fat content.

Sequel to complete digestion, all the samples were subjected to heavy metals determination using the Atomic Absorption Spectrophotometer (AAS) at specific wavelengths for each of the heavy metals.

Statistical analysis

Data collected were presented and expressed as Mean ± Standard Deviation and subjected to T-test. Statistical significance was set at $\alpha_{0.05}$. All statistical analyses were done using IBM Statistical Package for Social Science (SPSS, version 20.0).

Results

Heavy metal levels in the water samples

Table 1: Heavy metal levels in the sampled waterholes of Borgu Sector of KLNP (Dry Season, 2018).

Water Holes	Coordinates	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Cr (mg/l)	Ni (mg/l)	Fe (mg/l)	Mn (mg/l)	Zn (mg/l)
Oli River	N 09° 54' 43.0 E 003° 57' 11.3	0	0	0	0	0	0.12	0.09	0.16
KLM 3	N 09° 54' 11.8 E 003° 58' 24.2	0	0	0	0	0	0.16	0.1	0.16
KLM 5	N 09° 53' 54.0 E 003° 59' 07.4	0	0	0	0	0	0.18	0.11	0.18
KLM 8	N 09° 54' 02.6 E 003° 59' 43.1	0	0	0	0	0	0.2	0.11	0.19

Table 2: Heavy metal levels in the sampled waterholes of Borgu Sector of KLNP (Wet Season, 2018).

Water Holes	Coordinates	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Cr (mg/l)	Ni (mg/l)	Fe (mg/l)	Mn (mg/l)	Zn (mg/l)
Oli River	N 09° 54' 43.0 E 003° 57' 11.3	0.71	0.62	3.23	0.23	0	51.02	0.12	0.12
KLM 3	N 09° 54' 11.8 E 003° 58' 24.2	2.77	0.52	4.52	3.67	1.17	163.03	14.53	0.91
KLM 5	N 09° 53' 54.0 E 003° 59' 07.4	1.47	0.86	3.37	0.27	1.86	191.51	13	0.17
KLM 8	N 09° 54' 02.6 E 003° 59' 43.1	3.47	0.97	5.01	0.13	0.27	172	15	2.77

Table 3: Mean values of heavy metals in the sampled waterholes of Borgu Sector of KLNP.

Mean Values ± Std. Deviation			WHO (2011) Guidelines for Drinking Water
Heavy Metals	Dry Season (January 2018)	Wet Season (June 2018)	
Pb (mg/l)	0.00 ± 0.00	2.11 ± 1.25	0.01
Cd (mg/l)	0.00 ± 0.00	0.74 ± 0.21	0.003
Cu (mg/l)	0.00 ± 0.00	4.03 ± 0.87	2
Cr (mg/l)	0.00 ± 0.00	1.08 ± 1.73	0.05
Ni (mg/l)	0.00 ± 0.00	0.83 ± 0.85	0.07

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Fe (mg/l)	0.16 ± 0.04	144.39 ± 63.67	0.3
Mn (mg/l)	0.10 ± 0.01	10.66 ± 7.08	0.4
Zn (mg/l)	0.17 ± 0.14	0.99 ± 1.24	5

The result showed that the levels of Pb, Cd, Cu, Cr and Ni in the water samples during the dry season were not detected while other metals detected were below the WHO guidelines for drinking water as shown in Table 1. Furthermore, in the wet season, the levels of Pb, Cd, Cu, Cr, Ni (except at Oli River), Fe and Mn (except at Oli River) were above the WHO guidelines for drinking water as exemplified in Table 2. The mean values of the analyzed heavy metals in the sampled waterholes revealed that all the heavy metals analyzed (except Zn) during the wet season were above the WHO guidelines for drinking water as shown in Table 3.

Heavy metal levels in the sediment samples

The result showed that the levels of all the heavy metals were below the comparable (Sweden) maximum allowable limit. Only Cadmium level in all the sampled sediments was above comparable maximum allowable limit as shown in Table 4.

Table 4: Heavy metal levels in the sampled waterholes' sediments of Borgu Sector of KLNP.

Heavy metals	Oli River SED	KLM 3 SED	KLM 5 SED	KLM 8 SED
Pb (mg/kg)	5.7	12.62	9.27	5.06
Cd (mg/kg)	0.97	1.37	1.77	2.03
Cu (mg/kg)	12.62	16.03	10.03	8.46
Cr (mg/kg)	20.36	5.7	9.11	5.07
Ni (mg/kg)	27.33	33.33	20.47	13.3
Fe (mg/kg)	48850	25323.02	12975.01	8375.01
Mn (mg/kg)	247.53	695.03	339.5	193.53
Zn (mg/kg)	21.71	45.07	23.96	7.66

Note: SED = Sediment.

Heavy metal levels in the soil samples

Table 5: Heavy metal levels in soil samples of Borgu Sector of KLNP (Dry Season, 2018).

Soil Samples	Coordinates	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
SS1	N 09° 54' 43.0 E 003° 57' 11.3	0	0	0.01	0	0	7.5	0.15	0.02
SS2	N 09° 54' 12.2 E 003° 58' 24.2	0.01	0.01	0.01	0	0.01	7.81	0.17	0.03
SS3	N 09° 53' 53.9 E 003° 59' 08.3	0.01	0.01	0.02	0.01	0.01	8	0.19	0.03
SS4	N 09° 54' 05.0 E 003° 59' 41.0	0.01	0.01	0.03	0.01	0.01	80.8	0.2	0.04

Table 6: Heavy metal levels in soil samples of Borgu Sector of KLNP (Wet Season, 2018).

Soil Samples	Coordinates	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
SS1	N 09° 54' 43.0 E 003° 57' 11.3	12.37	0.72	7.27	2.42	8.77	9150.03	109.5	11.53
SS2	N 09° 54' 12.2 E 003° 58' 24.2	13.57	0.42	15.96	9.93	33.43	25900.01	1145	52.82
SS3	N 09° 53' 53.9 E 003° 59' 08.3	13.42	0.73	11.31	7.92	45.36	16325.03	390.03	25.57
SS4	N 09° 54' 05.0 E 003° 59' 41.0	20.96	1.03	12.57	3.67	21.72	15700.01	400.04	26.02

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The result showed that all the heavy metals analysed in the soil samples during the dry season were below the maximum allowable limit as specified by Sweden (Table 5) while during the wet season, Cd (in all the soil samples) and Ni (in SS3) were above the maximum allowable as specified by Sweden. Similarly, very high levels of Fe, Mn and Zn were also observed in the sampled soils during the wet season (Table 6). The mean values of the analyzed heavy metals in the soil samples showed that Cd level during the wet season was higher than the maximum allowable limit as specified by Sweden (Table 7).

Table 7: Mean values of heavy metals in the soil samples of Borgu Sector of KLNP.

Mean Values ± Std. Deviation			Maximum Allowable Limit (Sweden)
Heavy Metals	Dry Season (January 2018)	Wet Season (June 2018)	
Pb (mg/kg)	0.01 ± 0.01	15.08 ± 3.95	80
Cd (mg/kg)	0.00 ± 0.00	0.73 ± 0.25	0.4
Cu (mg/kg)	0.02 ± 0.01	11.78 ± 3.59	100
Cr (mg/kg)	0.00 ± 0.00	5.99 ± 3.53	120
Ni (mg/kg)	0.01 ± 0.01	27.32 ± 15.69	35
Fe (mg/kg)	22.87 ± 32.40	52093.77 ± 70272.27	NA
Mn (mg/kg)	0.19 ± 0.40	511.14 ± 443.51	NA
Zn (mg/kg)	0.02 ± 0.01	28.99 ± 17.26	350

Heavy metal levels in the plant samples

Table 8: Heavy metal levels in plant samples from Borgu Sector of KLNP (Dry Season, 2018).

Plant Samples	Coordinates	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Cynodon plectostachyus	N 09° 54' 43.0 E 003° 57' 11.3	0	0	0	0	0	0.28	0.16	0.03
Andropogon gayanus	N 09° 54' 12.2 E 003° 58' 24.2	0	0	0	0	0	0.35	0.13	0.02
Strychnos spinosa	N 09° 53' 53.9 E 003° 59' 08.3	0	0	0.01	0	0	0.39	0.18	0.04
Dyrosporus mesiliformes	N 09° 54' 05.0 E 003° 59' 41.0	0	0	0.02	0	0	0.27	0.16	0.03

Table 9: Heavy metal levels in plant samples from Borgu Sector of KLNP (Wet Season, 2018).

Plant Samples	Coordinates	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Cynodon plectostachyus	N 09° 54' 43.0 E 003° 57' 11.3	0	0	0.02	0	0	0.27	0.14	0.03
Andropogon gayanus	N 09° 54' 12.2 E 003° 58' 24.2	1.96	1.47	9.82	5.83	15.17	300.25	103.53	20.51
Strychnos spinosa	N 09° 53' 53.9 E 003° 59' 08.3	16.11	1.93	8.63	1.73	13.53	276.32	344.3	11.17
Dyrosporus mesiliformes	N 09° 54' 05.0 E 003° 59' 41.0	2.77	1.57	10.91	1.93	17.87	266.32	345.25	23.53

The result showed that the levels of Pb, Cd, Cr and Ni were not detected in the plant samples during the dry season while detected metals were also below the WHO recommended limit (Table 8). In the wet season, Pb (*Strychnos spinosa*), Cu (*Dyrosporus me-*

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siliformes), Mn (*Strychnos spinosa*, *Dyrosporus mesiliformes*) and Cd, Cr, Ni and Fe (all plant samples except *Cynodon plectostachyus*) were above the WHO recommended limit for medicinal plants as shown in Table 9. The mean values of Pb, Cd, Cr, Ni and Fe were above the comparable WHO permissible limit as shown in Table 10.

Table 10: Mean values of heavy metals in the plant samples of Borgu Sector of KLNP.

Heavy metals	Mean Values ± Std. Deviation		WHO Permissible Limit
	Dry Season (January 2018)	Wet Season (June 2018)	
Pb (mg/kg)	0.00 ± 0.00	5.21 ± 7.36	2
Cd (mg/kg)	0.00 ± 0.00	1.24 ± 0.85	0.3
Cu (mg/kg)	0.10 ± 0.01	7.35 ± 4.97	10
Cr (mg/kg)	0.00 ± 0.00	2.37 ± 2.46	1.5
Ni (mg/kg)	0.00 ± 0.00	11.64 ± 7.97	1.5
Fe (mg/kg)	0.32 ± 0.06	210.80 ± 141.07	20
Mn (mg/kg)	0.16 ± 0.02	198.30 ± 174.32	200
Zn (mg/kg)	0.30 ± 0.01	13.95 ± 10.54	50

Heavy metal levels in the faecal samples

Table 11: Heavy metal levels in faecal samples from Borgu Sector of KLNP (Dry Season, 2018).

Faecal Samples of Animals	Coordinates	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Cr (mg/l)	Ni (mg/l)	Fe (mg/l)	Mn (mg/l)	Zn (mg/l)
Olive baboon	N 09° 54' 44.2 E 003° 57' 15.2	0	0	0.03	0	0	7.5	0.15	0.17
Hippopotamus	N 09° 54' 12.9 E 003° 58' 23.7	0	0	0.02	0	0	1.88	0.72	0.04
Kob	N 09° 54' 47.3 E 003° 57' 18.7	0	0	0.01	0	0	0.43	0.43	0.05

Table 12: Heavy metal levels in faecal samples from Borgu Sector of KLNP (Wet Season, 2018).

Faecal Samples of Animals	Coordinates	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Cr (mg/l)	Ni (mg/l)	Fe (mg/l)	Mn (mg/l)	Zn (mg/l)
Olive baboon	N 09° 54' 44.2 E 003° 57' 15.2	0.14	0.21	0.04	0.04	0.04	13.4	29.32	7.81
Hippopotamus	N 09° 54' 12.9 E 003° 58' 23.7	0.3	0.39	5.6	0.9	0.19	49.7	84.7	6.8
Kob	N 09° 54' 47.3 E 003° 57' 18.7	0.33	0.49	6.23	0.91	0.09	88.35	124	8.28

Table 13: Mean values of heavy metals in the faecal sampleas from Borgu Sector of KLNP.

Heavy metals	Mean Values ± Std. Deviation	
	Dry Season (January 2018)	Wet Season (June 2018)
Pb (mg/kg)	0.00 ± 0.00	0.26 ± 0.10
Cd (mg/kg)	0.00 ± 0.00	0.36 ± 0.14
Cu (mg/kg)	0.02 ± 0.01	3.96 ± 3.40
Cr (mg/kg)	0.00 ± 0.00	0.62 ± 0.50
Ni (mg/kg)	0.00 ± 0.00	0.11 ± 0.08
Fe (mg/kg)	3.27 ± 3.73	50.48 ± 37.48
Mn (mg/kg)	0.43 ± 0.29	79.34 ± 47.56
Zn (mg/kg)	0.09 ± 0.07	7.63 ± 0.76

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The result showed that Pb, Cd, Cr and Ni levels were not detected in the samples during the dry season while Fe (0.43-7.50), Mn (0.15-0.72) and Zn (0.04-0.17) levels varied (Table 11). Similarly, in the wet season, the metals ranged from: Pb (0.14-0.33), Cd (0.21-0.49), Cu (0.04-6.23), Cr (0.04-0.91), Ni (0.04-0.19), Fe (13.40-88.35), Mn (29.32-124.00), and Zn (6.80-8.28) as shown in Table 12 with their mean values across the seasons of sampling exemplified in Table 13.

Discussion

The Borgu sector of Kainji Lake National Park is a woodland savannah with large litter deposit during the dry season and has a gentle undulating terrain which allows surface runoffs into the waterholes allowing for nutrient and contaminant deposition. The heavy metal levels in the water samples showed that Fe had the highest mean concentration which may have elicited from surface run-off. This finding is like those of [19,3] who reported high level of Fe in River Omo of Omo Forest Reserve and in sampled perennial waterholes of Old Oyo National Park respectively. Also, the Mn and Fe levels observed in this study are significantly higher than those reported by [20]. Furthermore, all the heavy metals analysed (except Zn) were above the comparable WHO guidelines for drinking water which may make these waterholes not to be potable [20] had earlier also reported the non-potability of waters in KLNP. The sampled waterholes had more contamination in the wet season than the dry season. This may be attributed to agricultural run-off, fertilizer leaching and anthropogenic discharges into the sampled waterholes as averred by [19,3]. The high deposition of the heavy metals in the sediments from the sampled waterholes clearly and extensively shows the accumulation and deposition of the metals in the waterholes over time with all the metal levels above the comparable WHO guidelines.

Most often, the concentration of heavy metals in soils vary according to their rate of deposition, soil particle size and the availability of organic matter in the soil samples [21]. From this study, the level of heavy metals in the sampled soils revealed that Cd level was higher (during wet season) than the comparable maximum allowable limit for Sweden. This could have been due to run-off from fertilizer-applied farms and the mining site situated some distance from the park. [22] also reported high level of cadmium in the soil samples of Old Oyo National Park while [19] observed low cadmium level in the soil samples of Omo Forest Reserve. The Pb, Cu, Ni, Fe and Zn levels observed in this study are significantly higher than those observed by [22] in the analyzed soil samples of Old Oyo National Park. Very high concentration of Fe in the sampled soils agrees with [23] who posited that Fe occurs at high concentrations in most Nigeria soils. The heavy metals levels in the plant samples shows that Fe had the highest concentration which may have come majorly from uptake from the soil and not excluding the possibility of atmospheric deposition. There is a great possibility of bioaccumulation in the plant tissues and biomagnification along the food chain with health implication on the animals. From the study, it was observed that Pb, Cd, Cr, Ni and Fe (during the wet season) were above the comparable WHO permissible limit for medicinal plants. These levels are of great concern especially for Pb, Cd and Cr whose toxicity is a great concern [24,25]. The analysis of the faecal samples showed detectable levels of heavy metals which one, list them in the faecal samples. Metal concentration faeces often equals that in food with additional concentration possible through other routes of exposure like inhalation and dermal contact [26]. Though these levels are relatively low, there is possibility of increase above permissible limits if drastic measures are not taken to monitor heavy metal deposition, accumulation and contamination in the park. The continuous exposure and subsequent bioaccumulation/biomagnification of heavy metals in wild animals may resultantly cause reproductive disruption which may eventually take a toll on wild species population and perpetuation.

Conclusion

The analyzed heavy metals (except Zn) levels in the water samples of Kainji Lake National Park were found to be higher than the WHO guidelines for drinking water and this implies that the sampled water may not be potable or safe for drinking. Also, heavy metal toxicity was also observed in soil, plant and faecal samples analyzed. As such, the trend of heavy metal levels and influence of seasonal variation observed in this study gave an insight into the contamination of studied ecosystem with possible health implication on wildlife. There is need to carry out the study over time to monitor heavy metal deposition, accumulation contamination and route of exposure in the park.

Conflict of Interest

The authors have not declared any conflict of interests.

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