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Analysis of Heavy Metals in Waste Water and Plants in Gombe Metropolis, Nigeria

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ABSTRACT

The present study was carryout to the determine of heavy metals (Cd), Chromium (Cr), Cupper(Cu), Iron (Fe), Magnesium(Mg), Manganese (Mn), Nickel(Ni), lead (Pb), and Zinc(Zn) concentration in water and plant. As essentially an ephemeral water body, each study area constitutes an important ecological system that supports considerable flora and fauna diversities, including aquatic macrophytes, riparian vegetation, amphibians, macroinvertebrates, and fish fauna. Plant samples along with water samples were collected, processed, and analyzed following by standard methods. Heavy metals in plant tissues/organs and water matrices were analyzed using Atomic absorption spectrophotometry (AAS model VGP 210). Heavy metal cannot be detected by sight, taste, or smell but by chemical analysis using suitable analytical techniques. Preventive measures can be taken and the pharmacists and doctors can offer a lasting solution after knowing the source of the problem. The aim was to determine the concentration of heavy metal such amount of heavy metal consume by living factors specially health risk to human beings. The present studies analysed results showed that the magnesium (Mn) ion has the highest concentration in *Ludwigia abyssinica* (19.5mg/l), *Setaria barbata* (20.0mg/l), *Cyperus esculentus* (18.6mg/l), *Eleusine indica* (19.73mg/l) in the location of Pantani, yelenguruza, nassarawo, bagadaza, and mallam inna, respectively. Chromium, Nickel, and Zinc were all below the World Health Organization's(WHO) maximum level in plant and water.

Keywords: Heavy metals, *Setaria barbata, Ludwigia abyssinica*, Gombe metropolis.

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INTRODUCTION

The entrance of contaminants into the natural environment that results in undesirable change is called pollution. Pollution can be in different forms including chemical materials or energy, like noise, heat, or light. Pollutants are the components that can be foreign substances/energies or naturally occurring contaminants. In 2015, nine million people in the world died as a result of [1]. Although some heavy metals are necessary to trace elements, most of them can be poisonous to all forms of life at high concentrations due to the formation of complex compounds within the cell. Contrary to organic pollutants, when heavy metals enter the environment they cannot be biodegraded. They remain indefinitely and cause pollution of air, water, and soil. Heavy metal repletion in the plant depends on some factors like plant species, genetics, types of soil and metal, soil conditions, weather, and environment. Heavy metals are environmental contaminants capable of causing human health problems if an excess amount is ingested through food from some plants, heavy metals are non-biodegradable and persistent, have long biological half-lives, and can be bio-accumulated through biological chains [2]. Heavy metal toxicity may occur due to contamination of irrigation water, the application of fertilizer, and metal-based pesticides, industrial emission, harvesting process, transportation, storage, and sale [3-6]. Plants grown in soils contaminated with heavy metals have greater accumulation than those grown in uncontaminated soils. The reason is that farmlands located in industrialized areas are apt to pollution by the release of chemicals into them resulting in contamination of plants. Elements such as Cadmium and Chromium, are considered carcinogenic while Iron, Copper, Manganese, Zinc, and Nickel are considered essential trace elements. Contamination of the water with heavy metals is a serious concern in today's world [7]. Recently, heavy metals' exceeding the carrying capacity of waters has resulted in some problems regarding the aquatic ecosystem balance [8]. Such unprecedented pollution of aquatic ecosystems needs eco-friendly cost-effective remediation. In the aquatic system, where the entrance of pollutants is not continuous and they are thus get diluted, the analysis of plant tissues provides information about the quality of the system [9]. Heavy metals are usually found in natural waters and some are vital for living organisms; however, if they present in high concentrations, they may become highly poisonous. Heavy metal cannot be detected by sight, taste, or smell but by chemical analysis using suitable analytical techniques. Preventive measures can be taken and the pharmacists and doctors can offer a lasting solution after knowing the source of the problem.

Heavy metal contamination is very harmful. There are adverse effects related to it including health, environmental, or irrigational depending on the use of contaminated water. Many heavy metals do not have biological significance, hence, are toxic to living aquatic organisms even in minute concentration. In recent times, the contamination of the aquatic ecosystem with heavy metals largely from anthropogenic origin constitutes a serious environmental challenge at global, regional, and local side. The experiment aspect of this study was carried out in an analytical laboratory belonging to Abubakar Tafawa Balewa University (ATBU) and the laboratory is reliable and equipped. Not much study has been done on the status of heavy metal concentration and distribution despite its socio-economic and ecological significance.

MATERIALS AND METHODS

Description of study area

The study areas are located within Gombe state metropolis, they include pantami located around latitude 10°16' 21.30"N and longitude 11° 10' 3.90"E; Yelenguruza at 09°12' 11.20"N and 12°12' 11.42E; Nassarawo at 13°11' 5.90"N and 09°45' 09.30E; Bagadaza at 10°15' 20.40"N and 11°15' 12.80"E; Mallam Inna at 09°42' 10.50"N and 09°11' 5.70"E. As essentially an ephemeral water body, each study area constitutes an important ecological system that supports considerable flora and fauna diversities, including aquatic macrophytes, riparian vegetation, amphibians, macroinvertebrates, and fish fauna. On-site sources of pollution include chemical fertilizers and pesticides, household sewage, and garbage patches.

Sample collection

Total plant samples of twenty (20) were collected that is four (4) samples from each of the five (5) sampling locations, they include *Dactyloctenium aegyptium, Ludwigia abyssinica, Eragrostic tremula, Sida acuta, ipomoea violacea, Setaria barbata, hygrophilia rosefolia, eragrostis atrovirens, cyperus esculentus, ipomoea Aquatica, Sporobolus alroides, cyperus Flava, cyperus esculentus, Andropogon tectorum, ludwigia abyssinica, Digitaria horizontalis, eleusine indica, hydrolea palustris, stachytorpheta cayennesis, and aeachynomene indica.* Plant samples were collected longitudinally along the stretch of the stream at the littoral margin from five (5) sampling locations using a shovel, hand gloves, polythene bag, and masking tape and were taken to the laboratory for preparation. Water samples were also collected from corresponding sampling locations in a sampling bottle and taken to the laboratory.

Sample preparation

The plant samples were properly separated and washed with de-ionized water and shed dried until they were ready for grinding. The dried samples were grinded into the powdered form using clean porcelain mortar and pestle and sieved in a 0.5nm sieve to a fine powder. The powdered samples were then labeled into small crucibles for proper identification. Water samples were filtered using Whatmann No.1 filter paper and the filtrates were acidified with

5ml concentrated nitric acid and refrigerated prior to analysis.

Digestion procedure

The glasswares were properly washed and rinsed with distilled water. 2 grams of a powdered sample of each plant were weighed and transferred into a beaker. 10 ml of concentrated nitric acid and hydrochloric acids were mixed in a separate beaker of ratio 3:1 and added to the powdered samples. The mixtures were stirred thoroughly and allowed to stay overnight to enhance the complete digestion of the plant tissues. The resultant digests were heated in a water bath at 120°C until they turned transparently clear and allowed to cool. The digests were then filtered into a 100ml volumetric flask and were made to 20cm mark with distilled water and were then taken to the laboratory for heavy metal analysis [10].

Data analysis

Significant differences between concentrations of heavy metals, following different digestion methods, were analyzed by ANOVA (SAS institute, 1982) and were used to test the differences in concentrations of the heavy metals in water and plants. Digestion includes combusting volatile materials in the sample. These volatile materials namely carbohydrates, fats and oil, protein, and so on. This procedure can be done by two general methods are Dry ashing and Wet ashing [11]. This method includes the complete ignition of all organic substances in the raw and processed sample to remain only the non-volatile inorganic mineral element. The ignition begins by burning the substance on the non-luminous part of the Bunsen flame until it stops smoking and then transferred into a muffle furnace which is set between 450°C - 550°C [12]. Indiscriminate and extensive use of insecticides to protect crops possesses a serious threat to humans and the surrounding environment [13]. However, caution must be exercised against low results which may be due to any of the following reasons: Volatilization of elements, Combination or adsorption of elements with ash constituent or the vessel, and Incomplete extraction of the ash; such problems can usually be avoided. All acid procedure utilizes oxidizing agents to break down the organic substances. The method has some advantages compared to dry ashing as no volatilization loss happens. The nutrient components can be determined in one digest solution, but cannot be used for some hard materials as incomplete digestion may occur. Different chemicals like nitric acid, perchloric, and sulphuric acid can be used in the determination of lead, iron, copper, nickel, cadmium, and other heavy metals. Hydrochloric acid was used in this project since the digestion is very fast though it is dangerous and an explosion may happen in case of carelessness. The solution after digestion will then be made up to the mark in the volumetric flask to move the sample solution [11].

Theory of analysis

The analysis of trace elements present in the sample solution can be carried out by the use of the classical or instrumental method. However, the instrumental method of analysis is more reliable than the classical method. The instrumental method involves the use of instruments like the flame photometer, and atomic absorption spectrophotometer (AAS) [14]. In atomic absorption, there are two ways of adding thermal energy to a sample. A graphite furnace AAS makes use of a graphite tube with a strong electric current to heat the sample. Inflame AAS: we aspirate a sample into a flame by using a nebulizer. The flame is lined up in a beam of light of the proper wavelength. The flame (thermal energy) makes the atom undergo a transition from the ground state to the first excited state. When the atoms transit, they absorb some of the light from the beam. "The more concentrated the solution, the more light energy is absorbed" [15].

RESULTS AND DISCUSSION

The results obtained from the quantification of metal cations from soils and plant samples found in five locations of Pantami, Yelenguruza, Nassarawo, Bagadaza, and Mallam Inna within Gombe State metropolis are presented in **Tables 1-6** below. The results obtained from the quantification of metal cations from water samples found in Gombe are presented in **Table 1** below.

Table 1. The concentration of metalcations in water samples within various locations around Gombe metropolis

S/N	Location	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	Pantami	–	–	0.025	0.35	15.7	1.9	0.02	–	0.051
2	Yelenguruza	–	–	–	5.0	16.85	1.8	0.01	0.02	0.42
3	Nassarawo	–	–	0.05	2.35	11.50	2.0	0.04	0.01	0.55
4	Bagadaza	–	–	0.08	0.6	17.9	3.4	0.025	–	0.9
5	Mallam Inna	–	–	–	2.1	15.5	0.4	–	–	0.32

Comparison of the concentration of metal ions found in the various locations understudy was done based on Micronutrients and Heavy metal ion, respectively. The levels of Micronutrient concentrations found in the water were sampled for analysis from the above-listed locations is presented in **Table 1**. In it, it shows that the concentration of Magnesium ion appeared to be the highest, followed by Manganese, iron, Zinc, Copper, Nickel, Lead, in that order while cadmium and chromium are noted to be completely absent. The level of Magnesium ion concentrations was noted to be highest in Bagadaza and least in the environs around Nassarawo. The level of Iron ion concentrations was noted to be highest in Yelenguruza and lowest in the Pantami area. The level of Manganese ion concentrations was noted to be highest in Bagadaza and least in Mallam Inna. The level of Zinc ion concentrations was noted to be highest in Bagadaza and lowest in Pantami. The level of Copper ion concentrations was noted to be highest in Bagadaza and lowest in the environs around Nassarawo while areas around Yelenguruza and Mallam Inna area are completely absent. The level of Nickel ion concentrations was noted to be highest in Nassarawo and completely absent in Mallam Inna. The level of Lead ion concentrations was noted to be highest in Yelenguruza and lowest in Nassarawo while evirons around Pantami, Bagadaza, and Mallam inna were completely absent. The results obtained from the quantification of metal cations from plant samples found within pantami premise are presented in **Table 2** below.

Table 2. The concentration of metal cations in some selected plant samples found within Pantami premises

S/N	Plant	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	*Dactyloctenium aegyptium*	–	–	0.045	11.85	17.35	2.9	–	–	–
2	*Ludwigia Abyssinica*	–	–	0.155	1.1	19.5	10.85	0.01	–	0.025
3	*Eragrostic Tremula*	–	–	0.405	0.8	17.8	4.9	0.01	–	–
4	*Sida Acuta*	–	–	0.38	6.7	18.2	1.2	–	–	0.01

The levels of Micronutrient concentrations found in the plant that were sampled for analysis from Pantami are presented in **Table 2**. It shows that the concentration of Magnesium ion to be the highest, followed by Iron, Manganese, Copper, Zinc, Nickel in that order while Cadmium, Chromium, and Lead are noted to be completely absent in all the plant samples. The level of Magnesium ion concentrations was noted to be highest in *Ludwigia Abyssinica* and lowest in *Dactyloctenium aegyptium.* The level of Iron ion concentrations was noted to be highest in *Dactyloctenium aegyptium* and lowest in *Eragrostic Tremula.* The level of Manganese ion concentrations was noted to be highest in *Ludwigia Abyssinica* and lowest in *Sida Acuta*. The level of Zinc ion concentrations was noted to be highest in *Ludwigia Abyssinica* and lowest in *Sida Acuta*. The level of copper ion concentrations was noted to be highest in *Eragrostic Tremula* and lowest in *Dactyloctenium aegyptium*. The level of Nickel ion concentrations was noted to have the same minimal concentration. The results obtained from the quantification of metal cations from plant samples found in the environs around Yelenguruza are presented in **Table 3** below.

Table 3. The concentration of metal cations in some selected plants samples found in environs around Yelenguruza

S/N	Plant	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	*Ipomoea violacea*	–	–	0.595	1.75	21.3	–	0.02	0.01	0.26
2	*Setaria Barbata*	–	–	0.63	0.5	20.0	4.5	–	–	0.15
3	*Hygrophilia Rosefolia*	–	–	0.79	0.3	19.2	–	–	–	0.01
4	*Eragrostic atrovirens*	–	–	0.65	11.0	19.2	4.0	–	–	0.01

The levels of Micronutrient concentrations found in the plant that were sampled for analysis from the above-listed locations are presented in **Table 3**. It shows that the concentration of Magnesium ion appeared to be the highest, followed by Iron, Copper, and Zinc. The level of Magnesium ion concentrations was noted to be highest in *Ipomoea Violacea* and lowest in both *Hygrophilia Rosefolia* and *Eragrostic atrovirens*. The level of Iron ion concentrations was noted to be highest in *Eragrostic atrovirens* and lowest in *Hygrophilia Rosefolia*. The level of Copper ion concentrations was noted to be highest in *Hygrophilia Rosefolia* and lowest in *Ipomoea violacea*. The level of Zinc ion concentrations was noted to be highest in *Ipomoea violacea* and lowest in both *Hygrophilia rosefolia* and *eragrostic atrovirens.* While Cadmium and chromium are noted to be completely absent whereas nickel and lead are found in trace amounts. The results obtained from the quantification of metal cations from plant samples found in the environs around Nassarawo are presented in **Table 4** below.

Table 4. The concentration of metal cations in some plants samples found in environs around Nassarawo

S/N	Plant	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	*Cyperus esculentus*	–	–	0.645	11.7	18.6	2.6	–	–	–
2	*Ipomoea Aquatica*	–	–	0.49	0.2	18.25	2.1	–	–	0.03
3	*Sporobolus Alroides*	–	–	0.03	8.65	17.4	1.1	–	–	0.32
4	*Cyperus Flava*	–	–	0.02	10.2	18.0	1.7	0.01	–	0.36

The levels of Micronutrient concentrations found in the plant that were sampled for analysis from the above-listed locations are presented in **Table 4**. It shows that the concentration of Magnesium ion appeared to be the highest, followed by Iron, Manganese, and Zinc in that order. The level of Magnesium ion concentrations was noted to be highest in *Cyperus esculentus* and lowest in *Sporobolus alroides*. The level of Iron ion concentrations was noted to be highest in *Cyperus esculentus* and lowest in *Ipomoea Aquatica*. The level of Manganese ion concentrations was noted to be highest in *Cyperus esculentus* and lowest in *Sporobolus alroides*. The level of Zinc ion concentrations was noted to be highest in *Cyperus Flava* and lowest in *Ipomoea Aquatica*. The level of copper ion was noted to be the highest in *cyperus esculentus* and lowest in *cyperus Flava* while Cadmium, Chromium, Lead, and Nickel are noted to be completely absent. The results obtained from the quantification of metal cations from plant samples found in the environs around Bagadaza are presented in **Table 5** below.

Table 5. The concentration of Metal Cations in some Selected Plants Samples Found in Environs around Bagadaza

S/N	Plant	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	*Cyperus Esculentus*	–	0.01	–	0.5	18.9	6.2	0.02	–	0.51
2	*Andropogon Tectorum*	–	0.01	–	0.5	17.9	4.9	0.01	–	0.55
3	*Ludwigia Abyssinica*	–	–	–	0.3	18.3	11.05	–	–	0.64
4	*Digitaria Horizontalis*	–	0.01	–	4.0	16.5	0.6	–	–	0.34

The levels of Micronutrient concentrations found in the plants that were sampled for analysis from the above-listed locations are presented in **Table 5**. It shows that the concentration of Magnesium ion appeared to be the highest, followed by Manganese, Zinc, Iron, Nickel, and Chromium. The level of Magnesium ion concentrations was noted to be highest in *Cyperus esculentus* and lowest in *Digitaria horizontalis.* The level of Iron ion concentrations was noted to be highest in *Digitaria horizontalis* and lowest in *Ludwigia Abyssinica.* The level of Manganese ion concentrations was noted to be highest in *Ludwigia Abyssinica* and lowest in *Digitaria horizontalis.* The level of Zinc ion concentrations was noted to be highest in *ludwigia abyssinica* and lowest in *Digitaria horizontalis*. Nickel, copper, lead, and Cadmium cations were noted to be completely absent in the plant samples while chromium is found in trace concentrations. The results obtained from the quantification of metal cations from plant samples found in the environs around Mallam Inna are presented in **Table 6** below.

Table 6. The concentration of Metal Cations in some Selected Plants Samples Found in Environs around Mallam Inna

S/N	Plant	Cd	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
1	*Eleusine Indica*	–	0.01	–	0.2	19.73	11.1	–	–	0.645
2	*Hydrolea Palustris*	–	0.01	–	12.5	19.6	9.05	–	–	0.665
3	*Stachytorpheta cayennesis*	–	0.01	–	8.25	17.9	2.5	0.015	–	0.67
4	*Aeachynomene indica*	–	0.01	–	5.6	18.2	2.9	0.015	–	0.77

The levels of Micronutrient concentrations found in the soil that were sampled for analysis from the above-listed locations are presented in **Table 6**. It shows that the concentration of Magnesium ion appeared to be the highest, followed by Manganese, iron, and Zinc. The level of Magnesium ion concentrations was noted to be highest in *Eleusine indica* and lowest in *Stachytorpheta cayennesis*. The level of Iron ion concentrations was noted to be highest in *Hydrolea palustris* and lowest in eleusine indica. The level of Manganese ion concentrations was noted to be highest in *Eleusine indica* and lowest in *Stachytorpheta cayennesis.* The level of Zinc ion concentrations was noted to be highest in *Aachynomene indica* and lowest in *Aleusine indica*. Cadmium, copper, and lead were found to be absent while chromium and nickel are found in trace.

The results of this study showed the concentrations of heavy metals in wastewater and plant samples. The enrichment factor showed that Zn, Cd, Cr, Cu, Ni, and Pb are essentially from the anthropogenic source while Fe, Mg, and Mn originate from natural and anthropogenic sources. There is a growing concern on the gradual build-up of toxic metals in streams as a greater percentage is in the mobile fractions. These will become available to plants or groundwater over a geological time scale where they are biomagnified. The information on the potentially available trace metals, as opposed to estimated total metals, may be useful in designing a remediation program for contaminated sites. It provides the relationship between contaminants and the environment. The results obtained from the assessment of heavy in wastewater and plants in this project research have tally with the result obtained by various researchers in the same assessment of heavy metals in wastewater and plant from a different environment.

The result obtained by Ibrahim-Z (2010) in Jigawa metropolis which was 1.533mg/l, 0.11mg/l, 0.222mg/l, 1.233mg/l for Mn, Fe, Zn, and Pb, respectively, while the result obtained from these assessments are 2.0mg/l, 2.35mg/l, 0.42mg/l, 0.01mg/l for Mn, Fe, Zn, and Pb, respectively, while traces of cadmium and chromium are absent in all locations and these show no significant difference between the result. Generally, high concentrations of heavy metals were measured in the water and plant samples in different locations. The concentration of metal ions found in the various locations understudy was done based on Micronutrients and Heavy metal ions, respectively. The levels of Micronutrient concentrations found in the water were sampled for analysis showed that the concentration of magnesium ion appeared to be the highest. The level of Magnesium ion concentrations was noted to be highest in bagadaza (19.9mg/l) and lowest in the environs around nassarawo (11.50mg/l). Whereas, the concentration of cadmium, chromium, and lead were noted to be absent from the water samples.

With regards to the levels of heavy metal concentrations found in the plant samples that were collected for analysis from around pantami environs shows that the concentration of magnesium ion in *lugwigia abyssinica* (10.85mg/l) appeared to be the highest and lowest in *Dactyloctenium aegyptium* (17.35mg/l). The concentrations of cadmium, chromium, and lead were noted to be absent with nickel showing only a little amount of concentrations in the plant samples. Copper also showed variation in the environs around yelenguruza with the highest concentration seen in *Hygrophilia Rosefolia* followed by *Eragrostic atrovirens, Setaria Barbata,* and lowest seen in *Ipomoea violacea* in the order 0.79>0.65>0.63>0.595, respectively. Cadmium, chromium, and lead were found to be absent in *Dactyloctenium aegyptium, lugwigia abyssinica, Eragrostic Tremula, Sida Acuta,* and few traces of nickel were noted around pantami environs. Environs around mallam Inna showed no concentration of cadmium, copper, and lead with few traces of nickel ions. Based on the study or analysis carried out, magnesium, iron, and manganese are considered to be in high concentration compared to other studied heavy metals. Hence, magnesium, manganese, and iron are considered an important metal when accumulated in plants and causes less harm.

CONCLUSION

The present study revealed that high concentration was found in both plant and water was noted in magnesium ion and iron ion while cadmium, lead, and copper were mostly absent. *Ludwigia Abyssinica, Ipomoea violacea, Cyperus esculentus,* and *Hydrolea Palustris* have the highest concentration of magnesium ion. The concentration of all the heavy metals was found to be less in water compared to the selected plant species except for zinc and nickel. It is recommended that farmers should engage in the cultivation of plants containing that are rich in magnesium, manganese, and iron considering their importance while lead, cadmium, and chromium ion should be avoided due to their toxicity in plants when ingested by humans. Market basket surveys should also be done in other to gain reliable scientific data about our contaminants and the use of good agricultural practices.

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