IAA Journal of Biological Sciences 7(1):14-20, 2021. ISSN: 2636-7254

Assesment of Heavy Metal Binding Ability of Selected Leaves Consumed In Adamawa and Gombe States, Nigeria

Gaila. Nami Marcel[1*], Ahmed Aisha and Lawal Halima
[1] Department of material science and Technology,Federal Polytechnic,Mubi
[2]Department of Science Laboratory Technology, Federal Polytechnic Mubi
Adamawa State, Nigeria.
[3] Depatment of Medical Chemistry and Quality control, NIPRD. IDU Abuja
*Corresponding author: nmgaila@gmail.com

ABSTRACT

Pollution interacts naturally with biological systems. The most problematic contaminants include heavy metals, pesticides and other organic compounds which can be toxic to wildlife and humans in small concentration. There are several existing methods for remediation, but the methods are expensive or ineffective. This research was aimed at determining the metal binding ability of *Spinous amarantthus*(Alayahon daji) (LF)*, Senna aceidental*(Tasba)(LG)*, Phyllanthus niruri* (mace maigoyo)(LH)*, Hisbiscusc sabdariff*(yakuwan daji)(LI) *and Lebtadenia hastate*(yadiya) (LJ), which are commonly consumed in Adamawa state, Nigeria. The sorption capacity of thesamples for the removal of metal ions ($Cd^{2+,}$ $Cu^{2+,}$ Pb^{2+}) in aqueous solutions was studied and the residual metal ion concentrations were investigated using Atomic Absorption Spectrophotometer (AAS). The AOAC enzymatic-gravimetric extraction method was employed to extract the soluble crude fiber and their respective insoluble fiber of the aforementioned fruits.All the extracts showed binding ability (affinity) for the divalent aqueous ions, but was more pronounced in the case of pb^{2+}(aq)ions. furthermore, the crude extract exhibit significantly higher binding ability than their respective insoluble fibers. The finding therefore reveals that the leaves extracted could be serve as fairly good biomaterials sequesetrators for Cd^{2+}(aq), Cu^{2+} (aq) and pb^{2+}(aq) ions. The heavy metal binding ability test should be extended to other divalent aqueous ion in order to have a more embracing spectrum
Keywords:Leaves, Extraction, Dietary Fiber type, Heavy Metals Binding Ability

INTRODUCTION

Biosorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physio-chemical pathways of uptake [1,2,3,4,5]. Pollution interacts naturally with biological systems [6]. The most problematic contaminants include heavy metals, pesticides and other organic compounds which can be toxic to wildlife and humans in small concentration [7,8,9,10]. There are several existing methods for remediation, but the methodsare expensive or ineffective [11,12,13].Biosorption may be used as an environmentally friendly filtering technique. Chitosan is among the biological adsorbents used for heavy metals removal without negative environmental impacts [14,15,16]. Toxic elements, mainly the heavy metals are normal elements found in the environment, and trace amounts of them are always found in foodstuffs [17,18,19,20] however, foods from contaminated areas may contain higher amounts. Toxic elements primarily enter foodstuffs through contact with the environment. Waterways and oceans are contaminated by the discharge of untreated municipal and industrial wastes. Polluted air falls as precipitation with rain, contaminating the environment, and eventually entering the food chain [21,22,23]. Depending upon the exposure route, each food type may become contaminated with different toxic elements. For instance, the high levels of arsenic found in the ground water of certain areas throughout the world contaminates plants, including vegetables, rice, and other cultivated grains [24,25]. There are several reports on high arsenic levels in rice, grains, and vegetables from different regions where the fields have been irrigated with arsenic contaminated water [26]. Contamination with toxic elements is a global environmental concern. Any contaminated food is able to transmit toxic elements through ingestion, with the risk increasing as the quantity consumed increases. Marine fish at the top of the aquatic food chain, for instance, contain elevated levels of certain toxic elements [27]. Primarily because of a higher concentration of some toxic metals, marine organisms have been subjected to extensive studies compared to terrestrial organisms. Some toxic elements, such as mercury and methylmercury, are neurological toxicants to humans. Mercury exposure is associated with slow mental development, blindness, cerebral palsy, and other birth defects in human [6-23]. Studies indicate that the adverse health effects of cadmium exposure, even at lower exposure levels, in the form of bone effects and fractures as well as kidney damage. Exposure to inorganic arsenic, which occurs predominantly through food and water intake, is primarily related to the risk of skin cancer as well as other skin lesions, such as hyperkeratosis and pigmentation changes [13]. Due to the health effects of toxic elements, several initiatives have been set up to reduce the contamination of food and to make it safer for human. This research was aimed at determining the metal binding ability of *Spinous amarantthus* (Alayahon daji) (LF), *Senna aceidental* (Tasba)(LG), *Phyllanthus niruri* (mace maigoyo)(LH), *Hisbiscusc sabdariff*(yakuwan daji)(LI) *and Lebtadenia hastate*(yadiya) (LJ), which are commonly consumed in Adamawa state, with the view to recommend the suitability of the extracts be use as biomaterial sequestrations of three divalent heavy metal ions ($Cd^{2+,}$ $Cu^{2+,}$ Pb^{2+}) in aqueous solutions.

MATERIALS AND METHODS

Sample Collection and Preparation

The samples of were coll Spinous amarantthus (Alayahon daji) (LF) NIPRD/H/7074, Senna aceidental (Tasba)(LG) NIPRD/H/7075, Phyllanthus niruri (mace maigoyo)(LH) NIPRD/H/7076, Hisbiscus sabdariff (yakuwan daji)(LI)) NIPRD/H/7077 and Lebtadenia hastate(yadiya) (LJ)NIPRD/H/7078, were collected from Madagali, Numan ,Yola agricultural farms in Adamawa State in Nigeria. They were packaged, coded and taxonomically authenticated by a Botanist in the Department of Biological Sciences, Modibbo Adama University of Technology, Yola. The samples were sorted-out to remove unwanted materials, then dried under room temperature for 72 h. They were ground to powdered form using mortar and pestle and sieved with laboratory test sieves (BS410/1986) to obtain the desired homogeneous particle size (30 mm). The experiment was carried out at National Institute for Pharmaceutical Research and Development (NIPRD), Abuja[15-16].

ENZYMATIC EXTRACTION

The insoluble dietary fiber (IDF) was extracted using AOAC enzymatic-gravimetric method as described by[5-19].A 20.0 g portion of the sample was suspended in sodium phosphate buffer (pH 6.0) and incubated with two drops each of alpha amylase (pH 1.5), pepsin (pH 6.8) and pancreatin (pH 4.5), for 1 h to remove starch and protein. The enzyme digestate was then filtered using ashless whatman filter paper. The residue is the IDF and the filtrate is the SDF.The IDF was further washed with ethanol and acetone, dried in the oven at about 37°c, then cooled and weighed for further analysis.[16]

HEAVY METAL BINDING ABILITY

Method described by[20]was employed in determining the heavy metal binding ability (HMBA) of the crude and insoluble fibers of the samples. A 1000 ppm stock solutions of Cd^{2+}, Cu^{2+} and Pb^{2+} were prepared by dissolving 2.68 g, 1.60 g and 2.29 g of their nitrate salts respectively, in de – ionized water and made up to 1 L mark in a volumetric flask. Serial dilutions of 200 ppm of each of the metal ions solutions were prepared with de – ionized water from the stock solution. Then, 50 mL of the metal ion solution was taken into a 100 mL conical flask. A 0.1 g portion of the sample was added into the conical flask and stirred for 1 h at 37 °C, on a thermostatic water bath. The residual metal ion concentrations were investigated using Atomic Absorption Spectrophotometer (AAS). The percentage removal was calculated using

$$\% \text{ Removal} = \frac{C_o - C_e}{C_o} \times 100$$

Where C_o is the initial metal ion concentration and C_e is the metal ion concentration after absorption.

RESULTS AND DISCUSSION

The absorption capacity or metal binding ability of the crude and the insoluble dietary fiber of the aforementioned leaves samples analyzed is shown in table 1 and The sorption capacity for the different metal ions using aforementioned sorbent is shown in figures1-3 as seen below.

TABLE I: Cadmium, Copper and lead Binding Potential of the crude and Insoluble dietary fiber of the leaves Samples

Sample Code	Cd^{2+} Absorbed (%)		Cu^{2+} Absorbed (%)		Pb^{2+} Absorbed (%)	
	Crude	IDF	Crude	IDF	Crude	IDF
LF	98.5±0.01	87.84.76±0.02	100±0.08	95.98±0.04	100±0.06	85.06±0.05
LG	97.9±0.05	93.07±0.04	100±0.02	89.52±0.07	100±0.02	91.26±0.06
LH	98.3±0.03	45.69±0.05	100±0.01	96.11±0.04	100±0.04	89.51±0.04
LI	98.1±0.06	62.35±0.03	95.3±0.03	93.63±0.05	100±0.05	98.76±0.02
LJ	98..3±0.07	54.44±0.02	95.8±0.02	96.11±0.03	100±0.03	86.39±0.03

The cadmium metal binding ability of the crude and their extracted insoluble dietary fibers (IDF) was studied and result presented in Fig.1

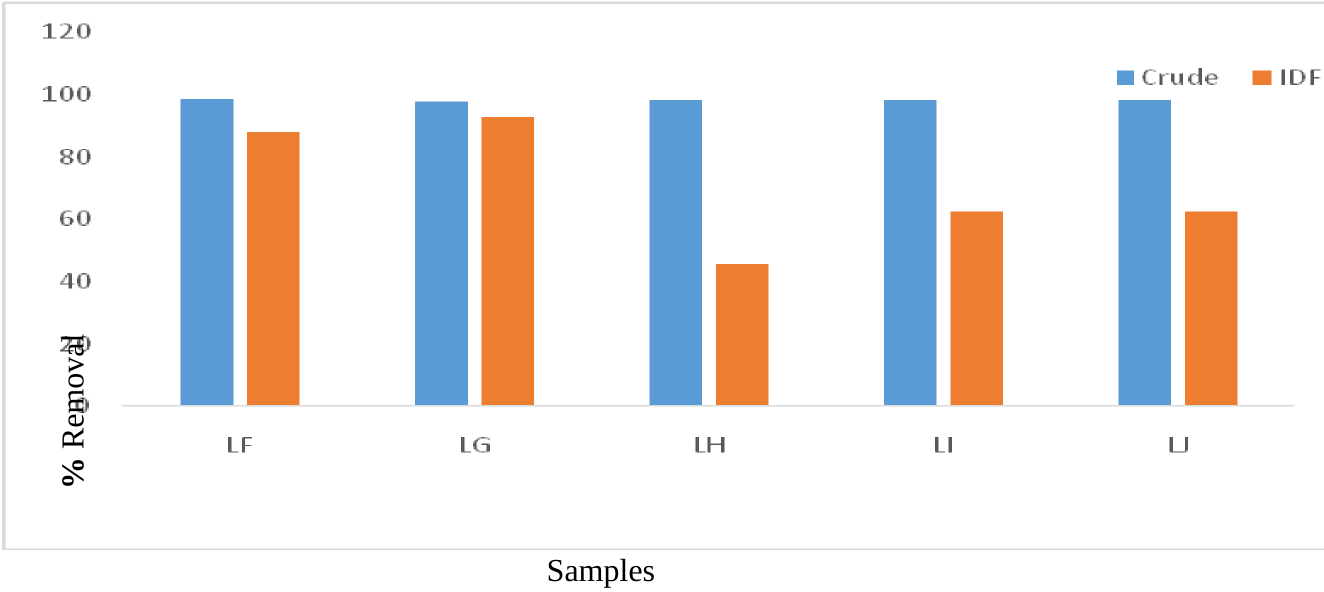

Fig. 1: Cd^{2+} binding potential of crude and insoluble dietary fiber of the leaves Samples

The copper metal binding ability of the crude and their extracted insoluble dietary fibers (IDF) was studied and result presented in Fig.2;

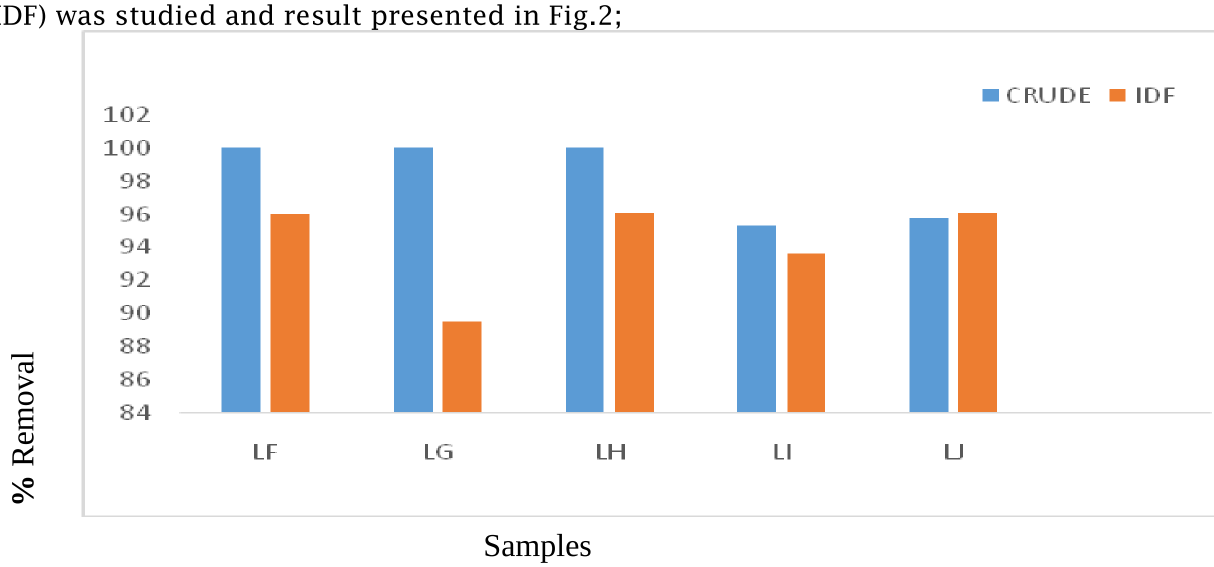

Fig. 2: Cu^{2+} binding potential of crude and insoluble dietary fiber of the leaves samples. The lead metal binding ability of the crude and their extracted insoluble dietary fiber IDF) was studied and result presented in Fig.3;

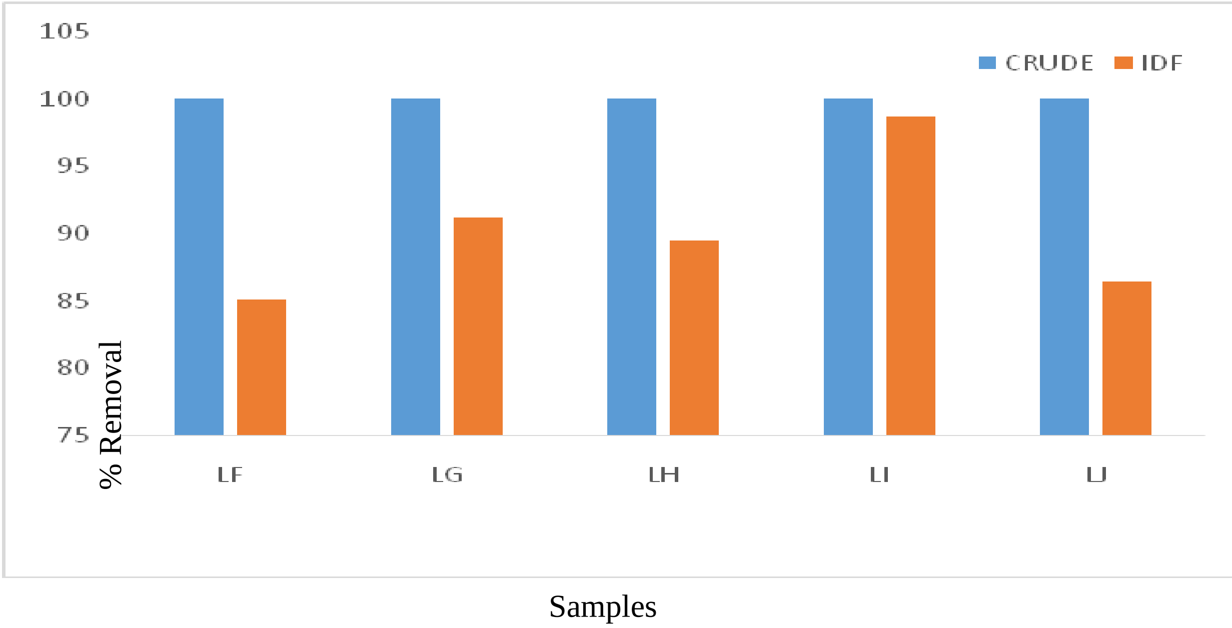

Fig. 3: Pb^{2+} binding potential of crude and insoluble dietary fiber of the fruit sample.

Figures 1-3 show the respective Cd^{2+}, Cu^{2+} and Pb^{2+} binding potential of the crude an extracted IDF of*Spinous Amarantus* (Alayahon daji)*(*LF) NIPRD/H/7074, *Senna accedentalis(Tasba)(LG)* NIPRD/H/7075, *Phyllantus niruri (*Mace mai goyo/ stone broker*)(LH)*NIPRD/H/7076, *Hibiscu sabdrariffa (*Yakuwan daji*)(LI)* NNIPRD/H/7077 *and Leptadenia hastate (*Yadiya*)(*LJ*)* NNIPRD/H/7077. Results in Figs 1-3 shows that all the crude samples investigated show higher binding potential for heavy metal (Cd^{2+}, Cu^{2+} and Pb^{2+}) than their respective IDF. This can be explained as a result of chemical composition and structural properties of the crude samples and their IDF. The extraction process could have increased the surface area of crude samples and thereby increasing their metal adsorption capability.[10] reported chemical components of amine and alkene to be responsible for Cd^{2+} and Pb^{2+} uptake. This confirms that chemical composition plays important role in metal uptake. These chemical components interact and absorb the metal ion. Thus, during fiber extraction, most soluble chemical components in the crude sample are removed and thus, the IDF contains less of these chemical components which causes reduction in its metal uptakability. [6] suggested that the higher metal binding potential of the crude samples could be attributed to different treatment procedures during fiber extraction which may result in distinct surfactant assemblies, interfering with either electrostatic surfactant-precursor assembly interactions or hydrogen bonding. The findings in this study is in agreement with a report by [7], where higher metal chelating potential by total dietary fiber (TDF) than IDF was observed for defatted rice bran. It is observed that the sorbent has different degree of affinity in the metal ions with Pb^{2+}coming highest (86.39-100) percentage affinity for IDF and crude leaves samplesrespectivelywhile cadmium has the least (45.69 – 98.50) percentage affinity for IDF and crude respectively. The differences observed in the sorption capacities for different metal ions can be explained in terms of differences in hydration free energy, the ability of metalto form covalent bond with ligand, the metal polymeric cations within the matrix structure and the nature of the surface sites available [3] Hence, the binding ability of the dietary fiber types may attribute to the chemical composition and the structural properties of the samples under examination [10].

CONCLUSION

The experiments have reveals that the leaves extracts and their extracted fibers could be serve as biomaterial sequestrations for the selected divalent aqueous ion (Cd^{2+}, Cu^{2+} and Pb^{2+}). The extraction process could increase the surface area of crude samples and thereby increasing their metal adsorption.The crude extracts and the IDF of all the studied samples has higher Pb^{2+}binding potential than Cd^{2+} and Cu^{2+}. This might be due to the stronger affinity for Pb^{2+} by the chemical components present in the crude samples than the other metal ions. The ability to remove heavy metals from solution indicates the tremendous potential that the aforementioned Herbs samples could have for cleaning the environment and industrial waste effluents from toxic metal ions.

RECOMMENDATION

The metal binding ability test for of *Spinous Amarantus* (Alayahon daji)*(*LF) ,*Senna accedentalis(Tasba)(LG), Phyllantus niruri (*Mace mai goyo/ stone broker*) (LH), Hibiscu sabdrariffa (*Yakuwan daji*)(LI)Leptadenia hastate (*Yadiya*)(*LJ*)*herbs extracts to be extended to the other divalent aqueous ions in order to have a good spectrum for comparison.

ACKNOWLEDGEMENT

The authors wish to thank the Director General, Staff and Management of National Institute for Pharmaceutical Research and Development, Abuja, Nigeria; for providing the technical support and laboratory space for the research.

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