POTENTIAL METAL TOXICITY OF SOME HERBAL PLANTS USED IN THE TREATMENT OF MALARIA IN ONDO STATE, NIGERIA

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ABSTRACT

Unorthodox medical practice involving the use of herbal plants and other biological specimens, though permissible, is growing unabated in many less developed Nations of the world due to poverty and lack of healthcare facilities without regard to the potential threat/ toxicity from the consumption of these alternative medicines. Thirteen (13) herbal plants commonly used for the treatment of malaria in Ondo state, Nigeria were selected for the study and evaluated for their heavy metal content viz: Cadmium, Zinc, Lead and Chromium using Atomic Absorption Spectrophotometer (AAS).The result showed increased cadmium concentration in the range of 0.014-0.077mg/kg with 76.9% of the selected plants having cadmium concentrations above the permissible limit. Zinc being an essential micro nutrient varied in the range of 0.304-1.539 mg/kg with 100% of the plants within the permissible limits for herbal plants. The lead concentration is within the permissible limit for all the selected plants and in the range of 0.141-0.464mg/kg. Chromium being a trace metal and of toxic potential was detected in 38.46% of the selected plants within the permissible limit and in the range of 0.002-0.356mg/kg. *Mangifera indica* leaves has chromium concentration of 0.180mg/kg but was not detected in the bark which might be due to anthropogenic influences and gaseous exchange in the leaves. The zinc, lead and chromium levels of these herbs were good for consumption, but cadmium level need to be adjusted to prevent kidney failure during consumption.

Keywords: Metals, herbal plants, concentration, Permissible limit.

INTRODUCTION

Medicinal plants are readily available and accessible to people than orthodox medicine (Arpadjan et al., 2008; Pytlakowska et al., 2012). Due to their high cost, side effects such as parasites being resistant to them. The medicinal plants used to treat malaria in South West includes: *Morinda lucida*, *Enantia chorantha*, *Alsotenia boonei*, *Azadirachta indica* and so on (Odugbemi et al., 2007). But due to the different sources of metal pollution such as industry, mining, exhaust fumes of vehicle and so on to the environment, metals such as lead, cadmium, mercury and so on can get into the river and streams and into the agricultural farms where most of these herbs were planted (Sun et al., 2010; Garba et al., 2012; Singanan et al., 2013). Medicinal plants can easily be contaminated by absorbing heavy metals from soil, water, air, rainfall, atmospheric dust and plant protection agents (Maobe et al., 2012).Thereby getting the herbs contaminated and when consumed by human beings, it affects their health by affecting their kidney, brain and other organs of the body (Mahmood et al., 2013; Mamania et al., 2005). Malaria is caused by the parasite called *Plasmodium falciparum* and it affects most of the people in South West (Odugbemi et al., 2007). And local herbs (such as *Ocimum basilicum, Mangifera indica*, *Psidium guajava*, *Waria afzelli* and so on) were been used to treat the disease. So it will be very important to investigate the metal content of these herbs used for malaria therapy, so they will not pose health hazard to people taking the herbs used for malaria therapy.

The aim/objective of this study is to investigate the heavy /toxic metals and essential metal (such as Cadmium, Zinc, Lead and Chromium) content in the leaves, bark and roots of herbs used to treat malaria therapy in Southwest Nigeria

Materials and Methods

Sampling and Sample Preparation

Thirtteen (13) different herbal plants (Table 1) were purchased from herbal vendors at King's market in Akure Ondo State, Nigeria. The plant samples obtained from the vendors consist of leaves, barks and roots. Samples were transported to the laboratory, after initial identification by the vendors. The samples were further identified by botanists from the Departments of Botany at Obafemi Awolowo University, Ile-Ife, Osun-State, Nigeria. All samples were washed with distilled water and oven dried at 60 °C for 24 hours. The samples were grinded using blender and transferred into a Ziploc® bag, and stored for analysis.

Heavy Metals Analysis

All reagents used in the study were of analytical grade from BDH Chemicals, UK. Calibration and certified reference materials were obtained from National Institute of Standard and Technology Reference Materials, Connecticut, USA. Ultrapure deionized water was used throughout the study (Prepared using Direct-Q® 3-UV Milipore Water Deionizer). Agilent Technologies 55AA Atomic Absorption Spectrometer was used for all metal analysis.

Samples digestion

One (1) gram of the homogenized dried plant sample was weighed into 12 mL quartz vessels and 5 mL concentrated nitric acid (65%) was added for the acid digestion with the autoclave system. The quartz vessels were then closed with Teflon® caps and placed in the sample rack. The samples were digested with the autoclave according to the following program. The digestion program including the cooling time was 150 minutes with the temperature ramped from 25 °C to 80 °C in 5 minutes, 80 °C to 150°C in 15 minutes, 150 °C to 250 °C in 20 minutes and a holding time of 30 minutes at 250 °C. The digestion program was repeated for each sample. After the digestion, the digests were filtered through whatman filter paper, quantitatively transferred to polypropylene tubes and diluted to 50 mL with deionized water prior to metal determination by AAS (Agilent). Determination of Cd, Zn, Pb and Cr in the samples was then made directly on each of the final solutions using the Agilent Technologies 55AA Atomic Absorption Spectrometer.

Statistical Analysis

The data were analyzed using SPSS (version 22) with Tukey's test for analysis of variance at $p>0.05$

Table 1: Pharmacognostic features of 13 herbal plants investigated

Code	English Name	Botanical Name	Local Name	Parts	Uses
1	Mango	*Mangifera indica*	Mango	bark	To treat Malaria
2	Sweet Basil	*Ocimum basilicum*	Efinrin	Leaves	To treat Malaria
3	Common Bamboo	*Bambusa vulgaris*	Idaye	Leaves	To treat Malaria
4	Sausage Tree	*Kigelia africana*	Pangoro	Leaves	To treat Malaria
5	Cashew	*Anacardium occidentale*	kasu	Leaves	To treat Malaria
6		*Pandiaka imiolucrata*	Oruwo	Leaves	To treat Malaria
7	Raphia-palm	*Raphia hookeri*	Oguro	Leaves	To treat Malaria
8	Stool wood/cheese wood	*Alstonia boonei*	Ahun	Leaves	To treat Malaria
9	African greenheart	*Piptadeniastrum africana*	Agbonyin	Bark	To treat Malaria
10	Guava	*Psidium guajava*	Guava	Bark	To treat Malaria
11		*Waria afzelli*	Gbogbo nise	Root	To treat Malaria
12		*Aristolochia repens*	Akogun	Root	To treat Malaria
13	Arrow poison	*Strophantus hispidis*	Sagere	Root	To treat Malaria

RESULTS AND DISCUSSION

Based on World Health Organization (WHO) reports, almost 80% of the human population use herbal or plant-derived medicines (WHO, 1998). A number of essential and non- essential mineral elements accumulate in these plants. Thus, the potential toxicological impact and health effects of these herbal remedies is a source of major concern because herbal plants have been adduced as a potential source of heavy metal toxicity to both man and animals (Dwivedi and Dey ,2002).

The study showed that the selected herbal plants varied in their metal concentrations which could be attributed to their metal accumulation potential and location of harvesting. The results of analysis of the levels of heavy and trace metal concentrations in the selected herbal plants compares with WHO permissible limit was presented in (Table 2). Heavy and trace metal concentrations of the herbal plants were analyzed using AAS and the results were presented as mean ± std deviation for the metal concentrations. Differences in the metal concentrations were analysed by ANOVA (SPSS 22) followed by Tukey's test for analysis of variance at $p > 0.05$ to determine significantly different pairs of mean. The concentration of heavy metals in the plant samples were highest for Zinc followed by Lead, Chromium and Cadmium which have the least concentration in the selected plant samples. In the selected plants, *Strophatus hispidris* had the highest accumulation of metal with average Zinc concentration of 1.539±0.104mg/kg and *Raphia hookeri* had the lowest metal concentration of 0.002± 0.000mg/kg of Chromium. Chromium was not detected in 61.54% of the selected plants (Table 2).

Table 2: Elemental concentrations of the herbal plants in comparism with WHO standard

	Cd (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cr (mg/kg)
WHO MrLs	**0.020**	**2.00**	**2.00**	**1.30**
Waria afzelli	0.014±0.002[a]	0.732±0.101[efg]	0.233±0.020[ab]	ND
Kigelia africana	0.020±0.005[ab]	0.914±0.086[gh]	0.209±0.009[ab]	0.356±0.012[d]
Ocimum basilicum	0.017±0.003[ab]	0.692±0.041[defg]	0.436±0.006[de]	ND
Raphia hookeri	0.022±0.002[abc]	0.567±0.033[cdefg]	0.172±0.006[a]	0.002±0.000[a]
Bambusa vulgaris	0.034±0.002[bcd]	0.528±0.026[cdef]	0.346±0.020[cd]	ND
Strophatus hispidris	0.047±0.003[de]	1.539±0.104[i]	0.289±0.009[bc]	ND
Pandiaka imiolucrata	0.044±0.003[de]	1.246±0.154[hi]	0.192±0.031[a]	ND
Alstonia boonei	0.057±0.003[e]	0.304±0.005[abc]	0.146±0.001[a]	1.022±0.002[e]
Mangifera indica (bark)	0.044±0.001[de]	0.059±0.014[a]	0.141±0.002[a]	ND
Anacardium occidentale	0.039±0.001[cde]	0.824±0.022[fg]	0.457±0.007[e]	ND
Mangifera indica (leaves)	0.043±0.003[de]	0.361±0.001[abcd]	0.415±0.015[de]	0.180±0.020[c]
Psidium guajava	0.052±0.002[de]	0.122±0.022[ab]	0.464±0.014[e]	0.103±0.002[b]
Aristolochia repens	0.077±0.008[f]	0.424±0.002[bcde]	0.394±0.040[de]	ND
TOTAL	**0.0379±.00339**	**0.637±0.077**	**0.421±0.087**	**0.212±0.078**

Values with same superscript are not significantly different from each other using Tukey's test for analysis of variance at p>0.05

CADMIUM

Results showed that Cadmium was present in significant and varied concentrations in all the selected plant samples which might be due to geological and anthropogenic reasons as the plants were sourced from different locations and different environmental matrix. The biological concentration factor as well as the translocation factor of each plant might also be a factor in the varied concentrations of Cadmium in the selected plants as studies have shown that plants have different accumulation and translocation properties to metals (Malik et al.,2010, Zabin and Howladar, 2015).The cadmium concentration of the plants ranged between 0.014-0.077 mg /kg with twelve(12) of the plants having values above the permissible limits of 0.02mg/kg cadmium concentration (WHO, 1996). *Aristolochla repens* had the highest cadmium concentration of 0.077mg/kg followed by *Alstonia boonei* 0.057mg/kg and *Waria afzelli* had the lowest cadmium concentration of 0.014mg/kg(Fig. 1).The high cadmium levels of many of the plants were similar to the trend reported for medicinal plants (Olujimi et al.,2014).Thus, in view of the high cadmium content and toxicity of cadmium on the kidneys, skeletal system, lungs and as a human carcinogen(IPCS,1992; ATSDR,2008-2011) the plants can be regarded as unacceptable for consumption.

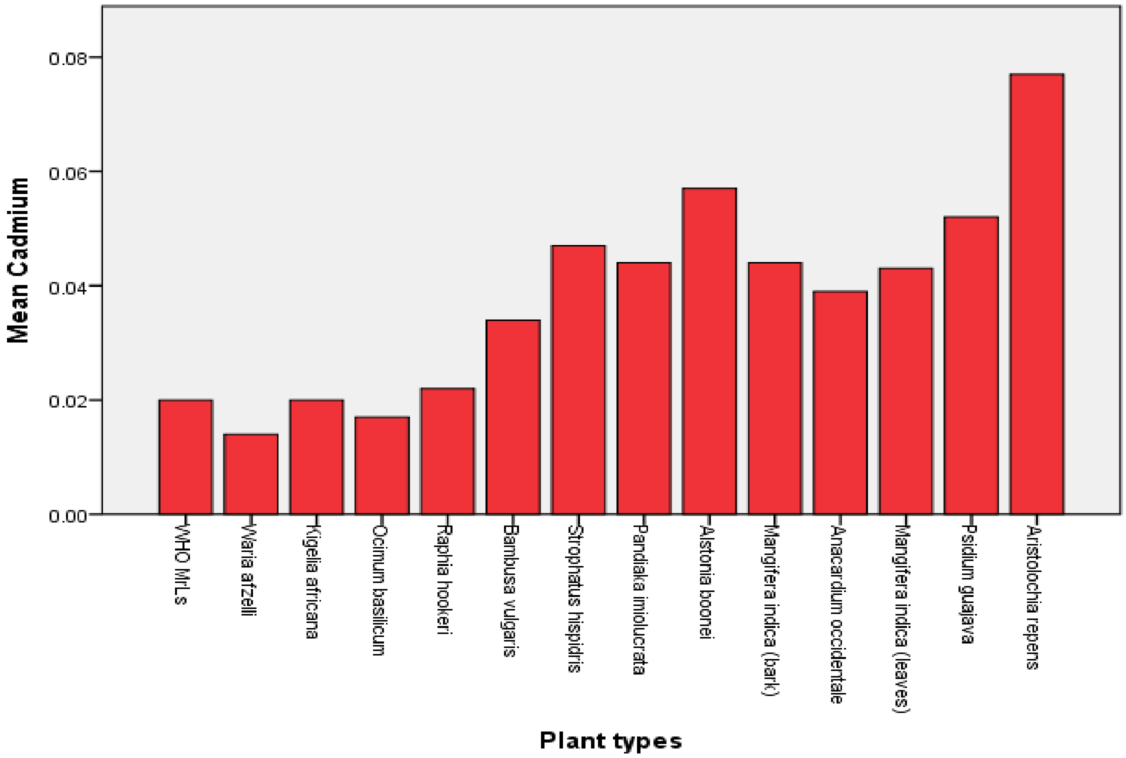

Fig. 1: Shows Cadmium concentrations of the herbal plants in comparism with WHO standard.

ZINC

Zinc is an essential micronutrient and constituent of many enzymes and proteins is needed by plants, humans and animals in small amount for enzymatic reactions, metabolic processes and oxidation-reduction reactions (Hafeez et al., 2013). The result showed that many of the plants exhibited high zinc concentration though all were withinin the permissible limit of 2.00mg/kg as stated by World Health Organization (WHO, 1996) .The zinc concentration in the herbal plant is relatively higher as compared to their cadmium concentrations. *Strophatus hispidris* had the highest zinc concentration of 1.539 ± 0.104mg/kg, followed closely by *Pandiaka imiolucrata* with zinc concentration of 1.246±0.154 mg/kg while *Mangifera indica* (bark) had the least Zinc concentration of 0.059±0.014 mg/kg (Table 2).The high zinc concentration in the selected herbal plants was similar to the trend reported for medicinal plants for cancer treatment in Ogun state, Nigeria (Olujimi et al., 2104) and in tune with high zinc concentration for raw medicinal plants in Zimbabwe and profile of heavy metals for the treatment of diabetes, malaria and pneumonia in Kisii Region, Southwest kenya as reported by (Dzomba et al., 2012 and Maobe et al., 2012) respectively. The high zinc content of the plant may be attributable among other factors to the abundance and ubiquitos nature of zinc in the environment constituting between 0.0005% and 0.02% of the earth crust and the concentration of zinc in the soil parent material (Irwin et al., 1997). Since the result of zinc in the studied herbal plants fell within the recommended limit, the plant zinc concentration can be regarded as acceptable but prolonged usage and exposure may result in toxicity and deleterious health effects (ATSDR, 1992).

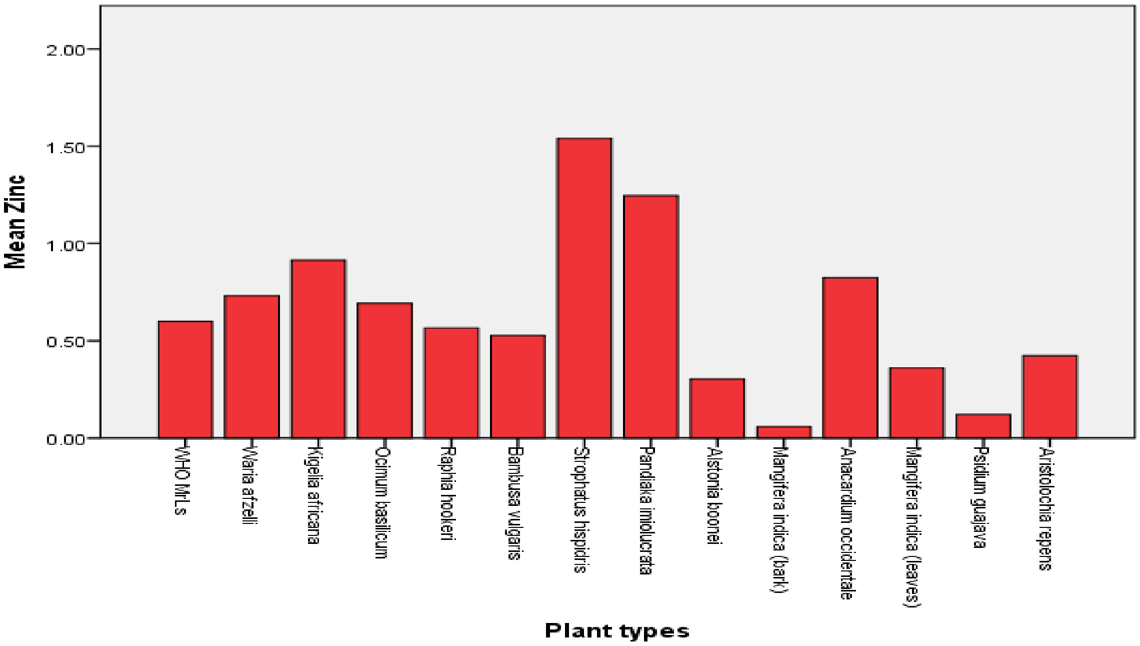

Fig. 2: Shows zinc concentrations of the herbal plants in comparism with WHO standard.

LEAD

Lead is a highly toxic trace element with no recognized biological requirement in organisms. Lead is the most researched environmental pollutant. It builds up in the skeleton, especially in bone marrow. It is neurotoxic and causes behavioral anomalies, mental retardation and semi-permanent brain damage (Olujimi et al., 2014). Moreover, there may be no concentration threshold for lead in humans or other mammals. The concentration of the metal has been substantially elevated by anthropogenic activities. The lead level in the studied herbal plants ranged from 0.141-0.464mg/kg with nine (9) of the thirteen (13) selected plants having lead concentration above the permissible 2.00mg/kg (Table 2). The roots of *Psidium guajava* had the highest lead level of 0.464±0.014mg/kg, which was closely followed by *Anacardium occidentale* with 0.457±0.007mg/kg, which could be attributed to varied bioaccumulation potential of the plants (Malik et al.,2010). The leaves of *Mangifera indica* (leaves) exhibited high lead level of 0.415±0.015mg/kg which might be due to translocation potential of plants and anthropogenic gaseous influences.

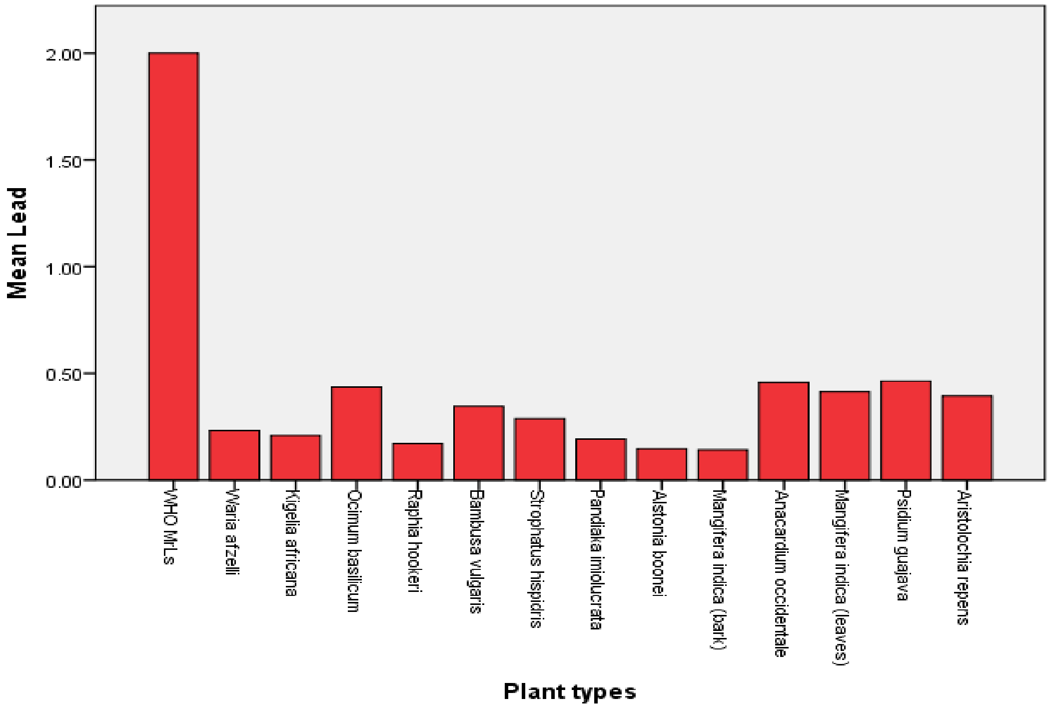

Fig. 3: Shows lead concentrations of the herbal plants in comparism with WHO standard.

CHROMIUM

Chromium is the sixth most abundant element in the earth crust, where it combined with iron and oxygen in the form of chromate ore. It is regarded as an essential trace and toxic element depending on the concentration, route of exposure, bioavailability and oxidation state of the metal. Chromium is an essential dietary mineral and is require to potentiate insulin and for normal glucose metabolism. It is deficiency had been associated with many chronic diseases such as diabetes, infertility, cardiovascular disease etc. (Olujimi et al., 2014). Five of the thirteen selected herbal plants representing 38.46% had varied Chromium concentrations in the range 0.002±0.000 – 0.356±0.012 mg/kg. Chromium was detected in *Mangifera indica* leaves which might be due to anthropogenic influences and gaseous exchange within the leaves as it was not detected in the *Mangifera indica* bark. Comparison of the chromium concentrations of the investigated plants showed that the plants have chromium concentrations within the permissible limit for medicinal plants (WHO, 1996). However, it should be noted that the health effects of chromium are primarily related to the valence state of the metal and Chromium could exist in the stable +3 and +6 oxidation states, which was not within the scope of this study.

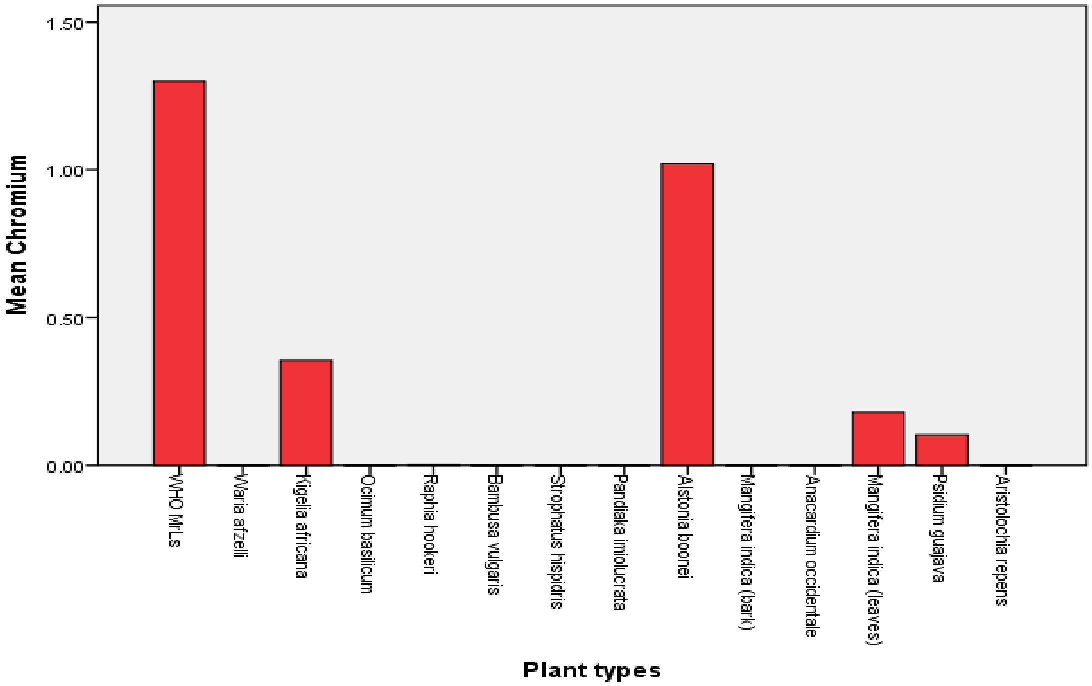

Fig. 4: Shows chromium concentrations of the herbal plants in comparison with WHO standard.

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