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Heavy Metals Content of Some Medicinal Plants from Kwazulu-Natal, South Africa

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Abstract: Trace metals in eight different plants commonly available in South Africa, Kwazulu-Natal Province namely *Gunnera perpensa*, *Pentanisia prunelloides*, *Carissa bispinosa*, *Ledebouria revoluta*, *Pomaria sandersonii*, *Eucomis autumnalis*, *Alepidea amatymbica*, *Artemisia afra* and *Berkheya setifera* have been quantitatively analyzed using Atomic Absorption spectrophotometer. Medicinal plants were disinfected with 0.1% $HgCl_2$ and digested with 95% H_2SO_4 and 35% H_2O_2. Six heavy metals (Fe, Cu, Mn, Pb, Ni, Zn) were chosen on the basis of their effects on human health. From the results of the study, all six heavy metals were present in all the plants, except that Pb was not detected in six of the plants. The highest level of Fe was observed in *Gunnera perpensa* at 1.12±0.003 ppm whilst the lowest level was found in *Alepidea amatymbica* at 0.0001±0.00 ppm±0.0005. The concentrations of Mn, Pb, Ni and Zn were all less than 1.5 ppm and the lead concentration in the water extract of *Berkheya setifera* was found to be high at 5.74±0.110 ppm but still falls below permissible limit of 10 ppm. The concentration of Cu was found to be 1.36±0.0021 ppm in *Pomaria sandersonii* and lowest in *Gunnera perpensa* at 1.24±0.002 ppm. The findings generally suggest that the use of these plant species for controlling diseases will not cause heavy metal toxicity and can be of good use to the users in cases of micronutrient deficiency.

Key words: Medicinal plants, heavy metals, spectrophotometer

INTRODUCTION

Generally, medicinal plants are important sources of traditional medicine for millions of people and additional inputs to modern medicine in terms of exploring and producing new drugs to meet the need for the overgrowing population of the planet (Abad *et al*., 2007). Medicinal plants such as *Gunnera perpensa* (G.p), *Pentanisia prunelloides* (P.p), *Carissa bispinosa* (C.b.), *Ledebouria revoluta* (L.r.), *Pomaria sandersonii* (P.s.), *Eucomis autumnalis* (E.a.), *Alepidea amatymbica* (A.a.), *Artemisia afra* (At.a) and *Berkheya setifera* (B.s.) are continually being used as therapeutic agents in formulations for treating diseases in the traditional ethnomedicinal systems in South Africa. However, environment, atmosphere, pollution, soil, harvesting and handling are some of the factors which may play important roles in contamination of medicinal plants by metals (Ajasa *et al*., 2004). It has been established fact that overdoses or prolonged ingestion of medicinal plants leads to the chronic accumulation of different elements which causes various health problems (WHO, 1992; Sharma *et al*., 2009).

Mining activities in South Africa leads to contamination of the soil and water with heavy metals. Many plants that grow in these areas derive their nutrients and water from the same environment and may assimilate high quantities of the hazardous heavy metals (Hussain *et al*., 2011). Despite the accumulation of toxic elements like mercury, arsenic, lead, nickel and cadmium which might cause harm to children and adults, useful elements such as calcium, magnesium, zinc manganese and iron might be present in plants, which helps in the good health (Hussain *et al*., 2010). WHO recommends that medicinal plants which form the raw materials for various medicines should be checked for the presence of different contaminants such as heavy/toxic metals, pesticides, fungi and microorganisms (WHO, 1998, 2003, 2007). The main purpose of the present study was to quantify the heavy metals in the selected medicinal plants and to provide a scientific data base line for traditional practitioners as well as for pharmaceutical industries. In this context, the concentrations of heavy metals contents of the medicinal plants are very important and need to be screened for toxic trace elements.

MATERIALS AND METHODS

Reagents and chemicals: Analytical grade reagents, chemicals and deionized double distilled water were used throughout this work.

Plant materials: The fully matured leaves of *Artemisia afra* Jacq. ex Wild *Berkheya setifera* and the roots of *Pentanisia prunelloides*, *Gunnera perpensa L*, *Eucomis*

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autumnalis Mill Chitt, *Pomaria sandersonii*, *Alepidea amatymbica* and *Berkheya setifera* were collected from Mabandla Village, KwaZulu-Natal Province South Africa. The Plants were positively identified by Prof. J.N Eloff from the University of Pretoria South Africa. The voucher specimens of the plants are authenticated at the herbarium of the Department of Botany at the same University.

Preparation of extracts: The plant materials (roots and leaves) were washed several times with distilled water disinfected with 0.1% $HgCl_2$ solution for 5 min and dried at room temperature. The dried plant materials were milled to a fine powder in a Macsalab mill (Model 200 LAB), Eriez®, Bramley and stored at room temperature in closed containers in the dark until used. The powered samples were extracted with hexane to remove lipids. They were then filtered and the filtrate was discarded. To prepare for mineral analysis, the washed and dried plant materials were taken into precleaned and constantly weighed silica crucible and heated in muffle furnace at 400°C till there was no evolution of smoke. The crucible was cooled in a desiccator at room temperature. The carbon free ash was moistened with Conc. H_2SO_4 and heated on hot plate till fumes of sulphuric acid were no longer coming out. The silica crucible with sulphated ash was again heated at 550°C in muffle furnace until weight of the sample was constant. The resultant ash was dissolved in 5 ml of HNO_3/H_2O_2 (1:1) and heated gently on hot plate until brown fumes disappeared. To the remaining material in each crucible, 5 ml of deionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask by filtration through whatman filtter paper and volume was made to the mark with deionized water. The resulting solutions were used for elemental analysis by atomic absorption spectrophotometer (Shimatsu, AA 6800) (Aliyu *et al.*, 2008). The standard operating conditions for AAS for analysis of heavy metals are given in Table 1.

Statistical analysis: All determinations were replicated three times and results were reported as mean values ± standard deviation

Table 1: Standard operating conditions of AAS for the analysis of heavy metals in plant materials (roots and leaves)

Element	8_{max} (nm)	Slit size (nm)	Flame type
Fe	248.3	0.2	Air/Acetylene
Zn	213.9	1.3	Air/Acetylene
Mn	279.6	0.4	Air/Acetylene
Ni	232.0	0.2	Air/Acetylene
Cu	324.8	1.3	Air/Acetylene
Pb	283.3	1.3	Air/Acetylene

RESULTS AND DISCUSSION

The profiles of medicinal plants used in the analysis are shown in Table 3 and Fig. 1. As evident from this table, maximum concentration of Fe was found in *G. perpensa* 1.12±0.003 ppm and the lowest concentration of Fe was observed in *A. amatymbica* 0.0001±0.00 ppm (Table 3 and Fig. 1a). The maximum tolerable level for cattle was suggested as 1000 ppm by National Research Council (1994). On the other hand, the permissible limit set by FAO/WHO (1984) in edible plants was 20 ppm. Iron is an important element for human beings and animals because is an essential component of hemoglobin (Ashraf *et al.*, 2010). It facilitates the oxidation of carbohydrates, protein and fat to control body weight which is a very important factor in diabetes (Khan *et al.*, 2008). When compared with the metal limit proposed by FAO/WHO (1984), the Fe concentration of the medicinal plants under study was found to fall far below the proposed permissible limit. Low Fe content causes gastrointestinal infection, nose bleeding and myocardial infarction (Hussain *et al.*, 2011).

The range of Mn concentration as shown in Table 3 and Fig. 1c varied from 0.536±0.002 ppm in *P. prunelloides* and 5.74±0.110 ppm *B. setifera*. Manganese is one of the major minerals, which is related to the carbohydrate and fat metabolism (Kirmani *et al.*, 2011). The permissible limit of Mn according to FAO/WHO (1984) in edible plants was 2 ppm. From our study, it was found that *B. setifera* accumulated Mn above the permissible limit. In human being, deficiency of Mn causes the interruption of blood supply to a part of the heart, causing heart cells to die. It also causes disorder of bony cartilaginous growth in infants and children and may lead to immunodeficiency disorder and rheumatic arthritis in adult (Hussain *et al.*, 2011).

Table 2: Importance of medicinal plants

Zulu name	Scientific name	VSN	Ethno-botanical use (Watt *et al.*, 1962)	PPU
Isicimamlilo	*Pentanisia prunelloides*	352-5	Aches and pains (Watt *et al.*, 1962)	Roots
Ugobho	*Gunnera perpensa* L.	2537-1	Painful body after birth (Watt *et al.*, 1962)	Roots
Umathunga	*Eucomis autumnalis* Mill Chitt	3790-4001	Waits pains (Watt *et al.*, 1962)	Roots
Isitholwane	*Pomaria sandersonii*	14806-0	Build strength after child birth (Watt *et al.*, 1962)	Roots
Ikhatazo	*Alepidea amatymbica*	2116-0	Cough (Watt *et al.*, 1962)	Roots
Mhlonyane	*Artemisia afra* Jacq.ex Wild	3166-4001	Coughs colds headaches, fever (Watt *et al.*, 1962)	Leaves
Umvhusankunzi	*Carissa bispinosa* (L.) Desf. Ex Brenan	984-2	Male impotency (Watt *et al.*, 1962)	Roots
Ulwimi lwenkomo	*Berkheya setifera*	2001-1	Treats children, ailments like coughs and diarrhea (Watt *et al.*, 1962)	Leaves

VSN = Voucher Specimen Number, PPU = Part of Plant Used

Table 3: Average concentration (ppm) (n = 3) along with standard deviation of elements in selected plants

Extract	Fe	Cu	Mn	Pb	Ni	Zn
G.p.	1.12±0.003	0.124±0.002	1.46±0.001	0.153±0.003	0.239±0.006	0.201±0.0002
P.p.	0.00780±0.0003	0.595±0.025	0.536±0.002	0.147±0.001	0.117±0.002	ND
E.a.	0.117±0.00130	0.662±0.022	1.39±0.001	ND	0.190±0.002	0.325±0.003
P.s.	0.0817±0.00078	1.36±0.0021	0.857±0.003	ND	0.454±0.008	0.115±0.0001
A.a.	0.000100±0.00005	0.156±0.004	0.553±0.007	ND	0.171±0.0001	0.0816±0.002
At.a.	0.0806±0.0044	0.298±0.007	3.65±0.015	ND	0.313±0.0062	0.112±0.001
B.s.	0.0307±0.0008	0.599±0.006	5.74±0.110	ND	0.243±0.003	0.157±0.0001

ND = Not Detected, G.p. = *Gunnera perpensa*; P.p = *Pentanisia prunelloides*; E.a = *Eucomis autumnalis*; P.s = *Pomaria sandersonii*; A.a = *Alepidea amatymbica*; At.a = *Artemisia afra*; B.s = *Berkheya setifera*

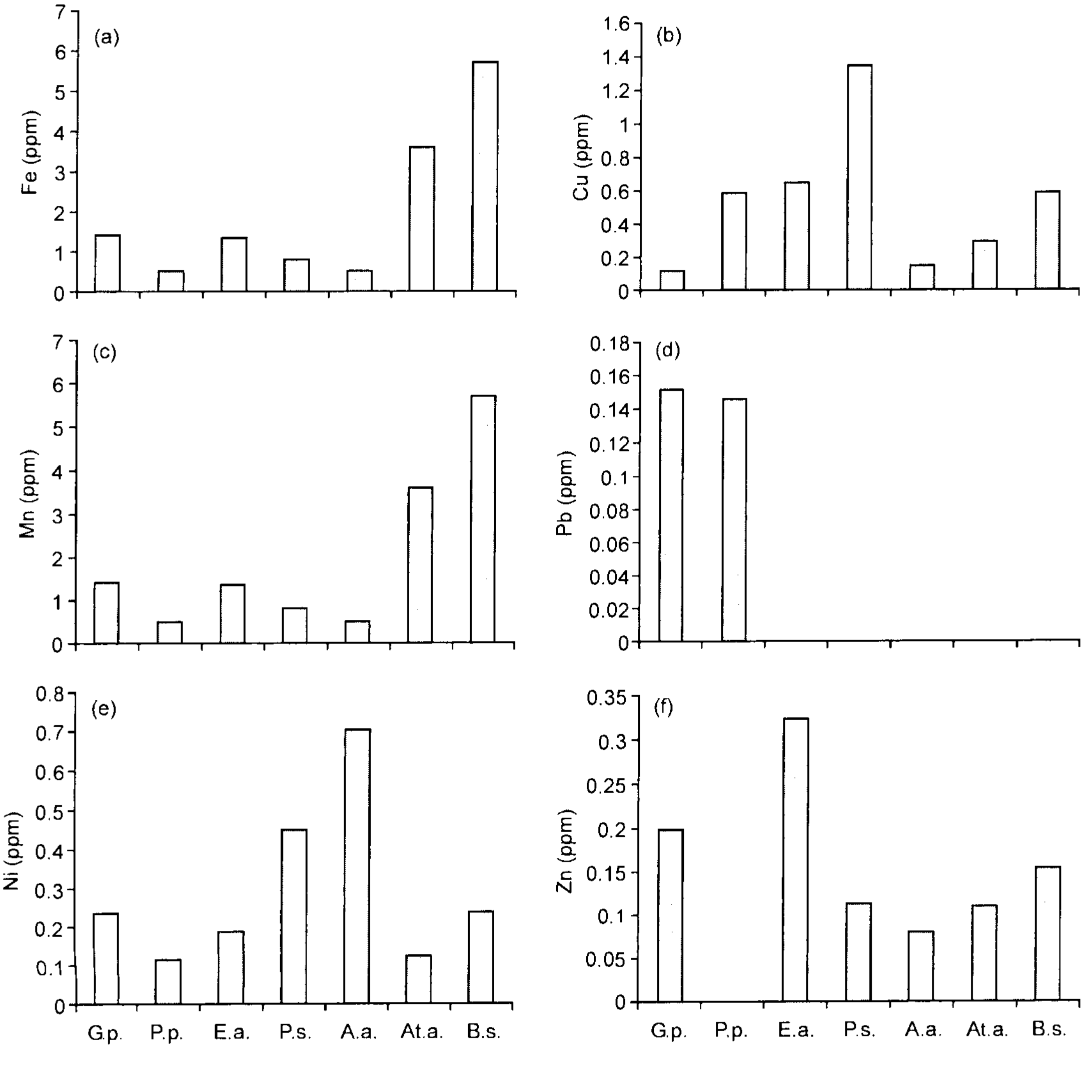

Fig. 1: Concentration levels of element in selected plants

Copper is one of the essential elements for plants and animals, however, it can be toxic at excessive levels (Khan *et al.*, 2007). In our study, the highest level of copper was found to be 1.36±0.0021 ppm in *Pomaria sandersonii*, followed by 0.662±0.022 ppm *Eucomis autumnalis* as seen in Table 3 and Fig. 1b. The permissible limit set by FAO/WHO (1984) in edible plants was 3.00 ppm. After comparison of the metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984), it was found that all plants accumulated Cu below this limit. High level Cu may cause "Monday morning fever", which is an illness caused primarily by exposure to certain fumes. Its deficiency on the other hand results in anemia and congenital inability to excrete copper resulting in Wilson's disease (Pendias and Pendias, 1992).

Zn composition was found to be maximum at 0.325±0.003 ppm in *Eucomis autumnalis* and undetectable in *Pentanisia prunelloides* as shown in Table 3 and Fig. 1f. Zn is in a state of rivalry for absorption with calcium non-herme iron and copper since they are all divalent and present in living-Willian's series (Sanjay *et al*., 2010). It plays a role in the synthesis, storage and secretion of insulin (Cunningham, 1998; Roussel *et al*., 2003). The maximum tolerable zinc level has been set at 500 ppm for cattle and 300 ppm for sheep (National Research Council, 1994). The permissible limit set by FAO/WHO (1984) in edible plants was 27.4 ppm. When compared to the metal permissible limits set by FAO/WHO (1984), it is found that all plants studied were below the stipulated limit for Zn.

In studied plants, Ni concentration varied between 0.313±0.0062 ppm in *Artemisia afra* and 0.117±0.002 ppm in *Pentanisia prunelloides* as seen in Table 3 and Fig. 1e. The permissible limit set by FAO/WHO (1984) in edible plants was 1.63 ppm. From the study, it is found that the concentration of Ni accumulated by the plants is lower than that set by FAO/WHO (1984). Recently, there is growing evidence however, that low concentrations of Ni are beneficial to plant growth and development, respiration intensity and photosynthesis as well as for antioxidant enzyme activity (Kastori and Petrivic, 1993).

Among investigated medicinal plants, only *Gunnera perpensa* and *Pentanisia prunelloides* exhibited the presence of Pb with the concentrations of 0.153±0.003 ppm and 0.147±0.001 ppm respectively (Table 1 and Fig. 1d). The permissible limit set by FAO/WHO (1984) in edible plants was 0.43 ppm. The permissible limit set by China, Malaysia, Thailand and WHO is set at 10 ppm which is agreement with the limit set by Canada. After evaluation, it was discovered that Pb content of *Gunnera perpensa* was above the permissible limit set by FAO/WHO (1984). Pb causes both acute and chronic poisoning and also poses adverse effects on kidney, liver, vascular and immune systems (Heyes, 1997).

Conclusion: The present study revealed that the heavy metals content of the selected medicinal plants from Mabandla Village, KwaZulu-Natal Province, South Africa were within the safe limit. It is therefore concluded that these plants may not contribute to metal toxicity and the human health may not be directly affected by these medicinal plants when taken orally or consumed as part of diet.

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