A STUDY ON HEAVY METAL ACCUMULATION IN *SIDA RHOMBIFOLIA* L., KERALA

***[1]Gautham Suresh, [2]Jayakumar K, [3]Rajesh M.G**

PG Department of Botany,
S.V.R.N.S.S College, Theerthapadapuram,
Vazhoor, Kottayam
*Corresponding author: gauthamsureshdec24@gmail.com

ABSTRACT

Roots of *Sida rhombifolia L.*, of Malavaceae is a common ingredient in medicine formulation especially in Ayurveda. Present study has analyzed the accumulation of heavy metals especially Cd, Zn, Cu, Cr, Pb and Ni in *Sida rhombifolia L.*, and soil samples collected from different polluted and unpolluted sites, Kerala. The data revealed the level of Cd, Zn, Cr, Pb, Ni and Cu in soil samples and plant parts (unpolluted) were below the WHO permissive levels. Soil samples from polluted sites showed Cd, Zn, Pb, Ni and Cu level significantly above the permitted value. Cr found to be within the permitted level. Of the root, stem and leaf samples analysed, root exhibited a higher accumulating tendency towards heavy metals followed by leaves and stem. Cd, Zn and Cr in root samples (polluted) were marginally below WHO permitted level whereas Pb and Ni showed higher values. Over accumulation of heavy metals in food chain may result in potential health hazards in human. Thus the regular consumption of roots of *S. rhombifolia* may lead to serious health problems. Sample from wild (unpolluted) are still found to be quite safer with heavy metals well below WHO permissive level. Further, studies are needed to confirm the mechanism of absorption and deposition of heavy metals in *S. rhombifolia* and the related health issues it may cause in human beings.

Key words: *Sida rhombifolia*, heavy metal, WHO, health hazards

INTRODUCTION

Plants have become an inevitable part of several herb based medical practices such as Ayurveda, Sidha and Unani. The quality and safety of herbal medicines is evoking a major concern worldwide, particularly due to adulterants and contamination by heavy metals and its associated health problems in humans. Natural processes are known to deposite heavy metals into the environment. However, anthropogenic activities contribute a major share of heavy metal dumping. Plants growing in polluted areas are more likely to accrue heavy metals, particularly in roots and leaves.

Senecio coronatus of Africa, known for its nickel (Ni) hyper accumulating potential, is a therapeutically used species (Meier et al., 2018). Similarly, medicinal *Datura metel* leaves is an accumulator of cobalt and Nickel (Bhattacharjee et al., 2004). Consumption of such herbs leading to adverse effects is well documented. In South Africa, cases of metal poisoning associated with the use of traditional medicines are common, with arsenic (As), chromium (Cr) and magnesium metals resulting in morbidity and mortality (Okem et al., 2014). Poisoning from heavy metal contamination of medicinal plant products has caused countless health implications including liver and kidney failure and even death (Steenkamp et al., 2000; Orr and Bridges, 2017).

Sida rhombifolia L., of Malavaceae is a common ingredient of many polyherbal formulations especially in Ayurveda such as ‘nayopayam kashayam’, ‘sudarshan churna’, ‘chandanbala laxadi tel’. Its roots find application in the treatment of several ailments such as bronchitis, heart diseases, scorpion sting, swelling, urinary bladder disorders, headache, sores, burn, chickenpox, malaria, rheumatism, depression, constipation and fever (Khan et al., 2014). At present, there is neither commercial nor homestead cultivation for the species. In Kerala, roots of *Sida rhombifolia* is commonly procured from polluted and unpolluted regions without any discrimination by the raw drug collectors who supply them to the dealers and the local physicians. Samples collected from heavy metal contaminated soil may cause biomagnification in man and interfere with our health management system. In this scenario, the present study focuses on the level of various heavy metals in the soil and various officinal parts of *Sida rhombifolia* L. collected from different polluted and unpolluted sites of Kerala.

MATERIALS AND METHOD

Plant Material

Sida rhombifolia of Malvaceae is a perennial herb. The plant is native to the new world tropics and subtropics. The leaves are elongated with toothed or serrated margins. The plant blooms throughout the year and produces yellow flowers. Fruit is a capsule (Fig. 1).

Fig. 1: *Sida rhombifolia* L.

Study sites

Five unpolluted and polluted sites of Kerala were selected for sample procurement and further heavy metal analysis (Fig. 2). Muthanga, Nilambur forest, thenmala, ponmudi and kuttikanam were the unpolluted sites whereas polluted sites included cochin harbor, vallarpadam, trippunithura, chavara and laloor.

Collection

Sida rhombifolia and soil samples from 5 polluted and 5 unpolluted sites were collected. Five samples from each sites were taken for analysis. Samples were washed under tap water, oven dried at 50 °C and ground into powder. Powdered samples were used for analysis.

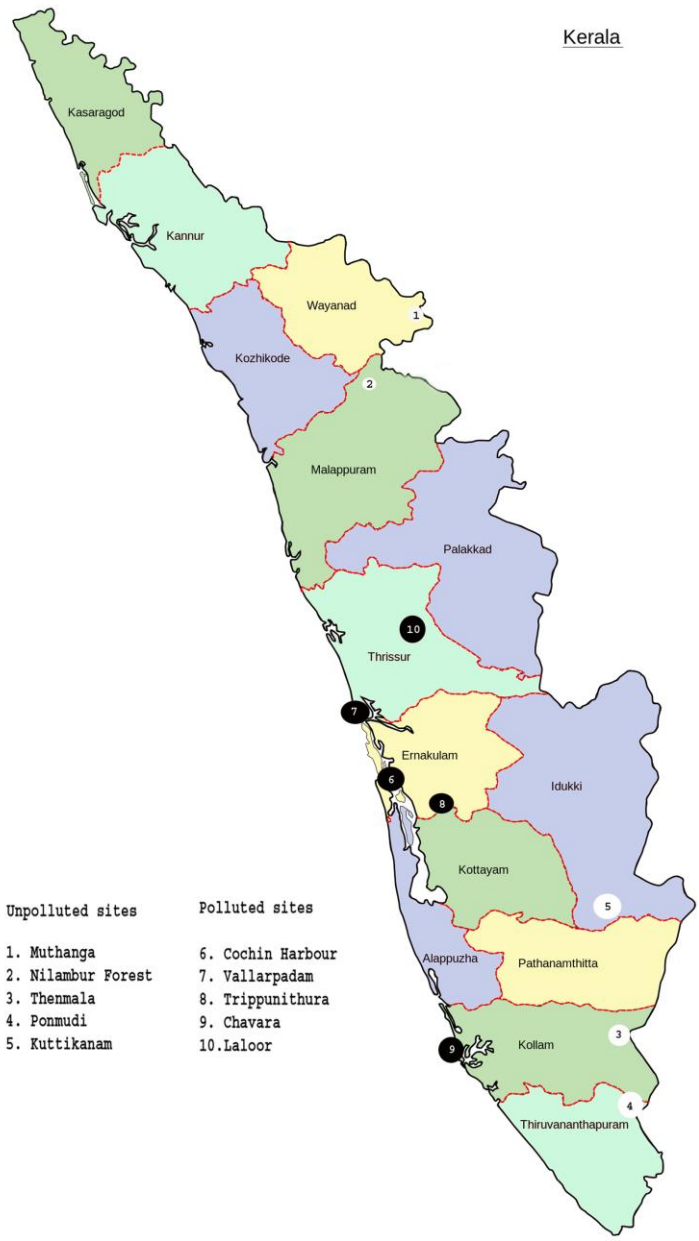


Fig. 2: Map showing study sites

Microwave acid-assisted digestion and analysis of heavy metal

A known quantity of the sample was digested with a mixture of concentrated nitric acid and perchloric acid (4:1) for eight hours and the digested sample was cooled filtered and made upto a known volume. The analysis of trace elements (Cadmium, Chromium, Lead, Zinc, Nickel

and Copper) was carried out by aspirating the digested sample into Atomic absorption spectrophotometer (Perkin Elmer model 2380) and the values were expressed in mg/Kg. The chemicals used in the experiments were of analytical grade and reagents were prepared using double distilled water. All experiments were performed in triplicate (Annan et al., 2013)

Further bioconcentration factor (BCF) and translocation factor (TF) were calculated using the standard formula (Balabanova et al., 2015)

$$\text{Bioconcentration factor (BCF)} = \frac{\text{Metal concentration in the plant(root/stem/leaf)}}{\text{Metal concentration in the soil}}$$

$$\text{Translocation factor (TF)} = \frac{\text{Metal concentration in stem+leaf}}{\text{Metal concentration in root}}$$

Statistical analysis

Experiments were repeated 3 times and analysed statistically by standard deviation.

RESULTS AND DISCUSSION

The WHO published permissive level of heavy metals (Lone et al., 2003) and obtained data are shown in Fig. 3a,b,c

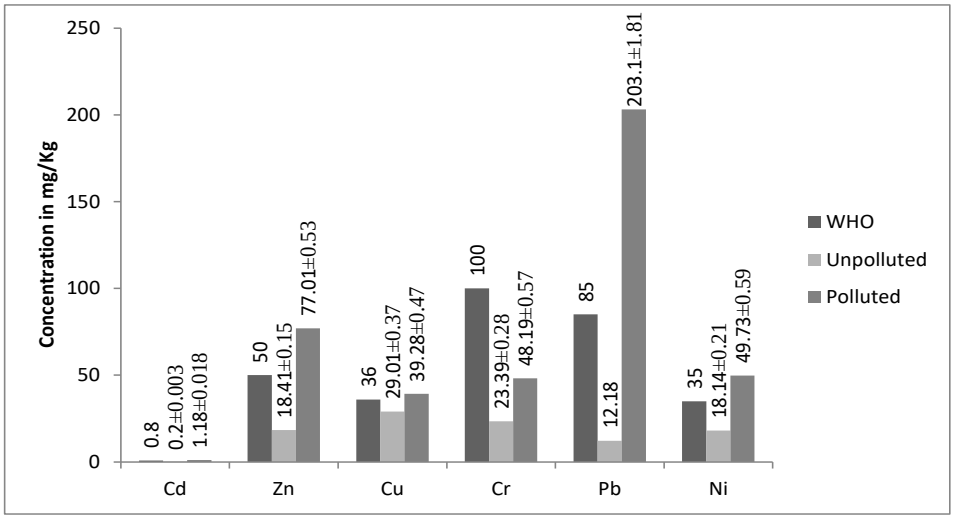
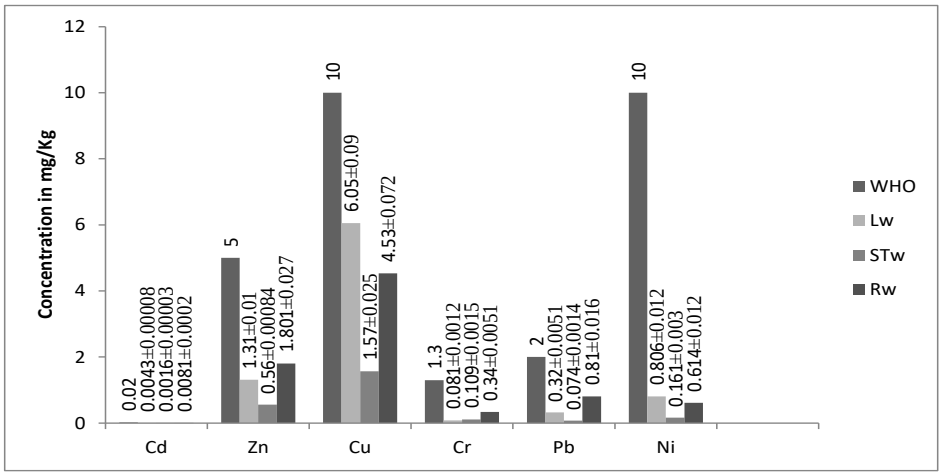
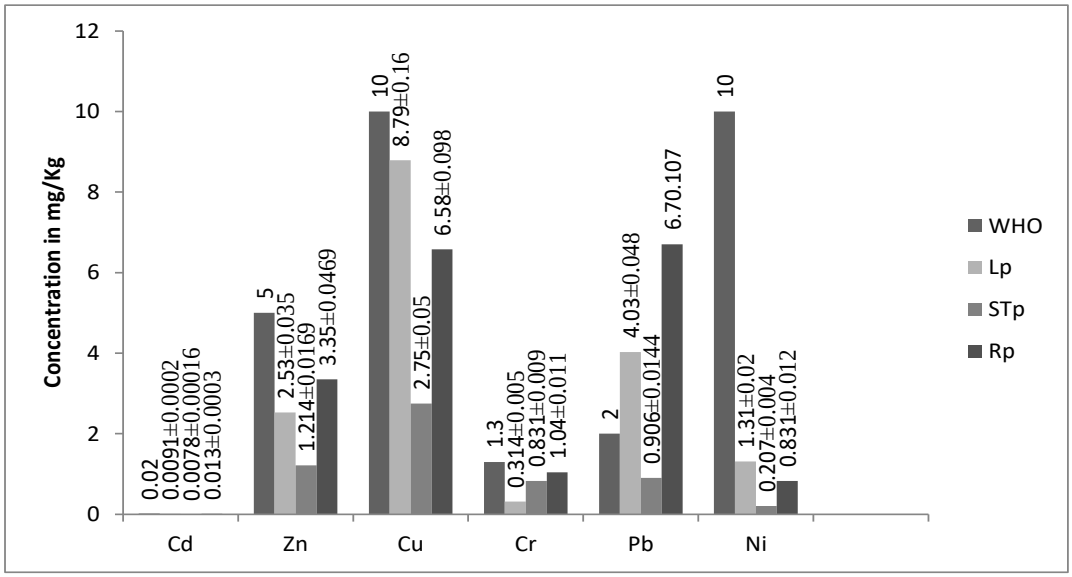


Fig. 3a: WHO published permissive level of heavy metals in soil compared with soil samples from unpolluted and polluted sites



L-Leaf; ST-stem; R-root, w-wild

Fig. 3b: WHO published permissive level of heavy metals in plant compared with plant samples from unpolluted sites



L-Leaf; ST-stem; R-root, p-polluted

Fig. 3c: WHO published permissive level of heavy metals in plant compared with plant samples from polluted sites

Present study has analyzed the accumulation of six heavy metals Cd, Zn, Cu, Cr, Pb and Ni in *Sida rhombifolia* L., and soil samples collected from different polluted and unpolluted sites, Kerala. Data indicate that the level of Cd, Zn, Cr, Pb, Ni and Cu in soil samples and plant

parts (unpolluted) were below the WHO permissive levels of 0.8, 50, 100, 85, 35, 36 mg/Kg (soil) and 0.02, 5, 1.30, 2, 10 and 10 mg/Kg (plants) respectively. Soil samples from polluted sites showed Cd, Zn, Pb, Ni and Cu levels significantly above the permitted value i.e., 1.18, 77.01, 203.1, 49.73, 39.28 mg/Kg respectively. Interestingly, Cr was found to be within the safety level. Of the root, stem and leaf samples analysed, root exhibited a higher accumulating tendency towards heavy metals in most cases. Cd, Cr and Zn in root samples (polluted) were only marginally below WHO permitted level i.e., 0.013, 1.04 and 3.35 mg/Kg whereas Pb showed higher values i.e., 6.7 mg/Kg against the permitted levels of 2 mg/Kg. Pb exhibited nearly 3.5 fold increase in root samples (polluted) compared to WHO value 2 mg/Kg. Ni in soil sample (polluted) exceeded the WHO permissive level by nearly 1.5 fold and a proportional increase in Ni level in plant samples was also noticed. The data is further analyzed by translocation factor and bioaccumulation factor (Fig. 4 & Table 1). Data show that plant accumulate heavy metals above permissible limit. Cu, Ni and Zn are plant micronutrients and found to be translocated effectively.

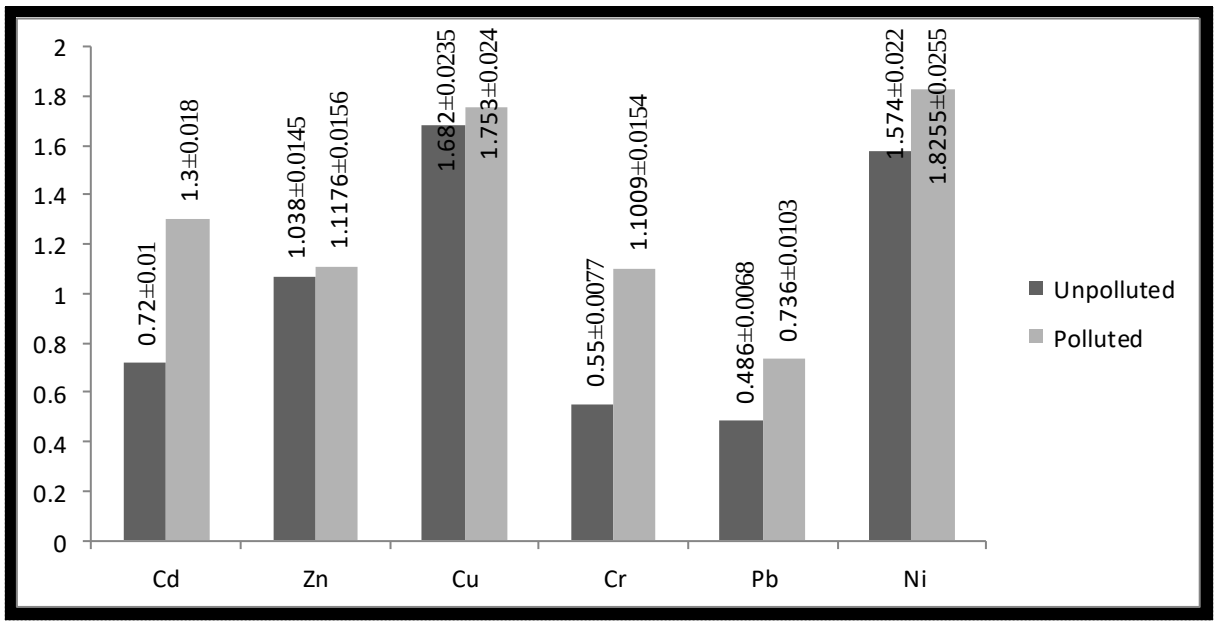


Fig. 4: Graph showing translocation factor of *Sida rhombifolia* collected from unpolluted and polluted sites

Table 1: Bioaccumulation factor of various parts of *Sida rhombifolia*

	Unpolluted (Wild) (mg/kg)			Polluted (mg/kg)		
	Leaf (L_w)	**Stem(ST_w)**	**Root(R_w)**	**Leaf(L_p)**	**Stem(ST_p)**	**Root(R_p)**
Cd	0.0215±0.0002	0.008±0.00016	0.0405±0.00064	0.0077±0.00015	0.0066±0.00016	0.011±0.0002
Zn	0.0711±0.001	0.0304±0.0006	0.0978±0.0014	0.0328±0.0005	0.0157±0.00028	0.0435±0.0006
Cu	0.208±0.0033	0.054±0.0011	0.156±0.0026	0.223±0.0033	0.07±0.00133	0.167±0.0033
Cr	0.0034±0.00006	0.0046±0.0001	0.014±0.00025	0.006±0.00009	0.017±0.00027	0.021±0.00037
Pb	0.0262±0.0004	0.006±0.00018	0.066±0.0011	0.0198±0.0003	0.004±0.00008	0.0329±0.00056
Ni	0.0444±0.00075	0.0088±0.00013	0.033±0.00059	0.026±0.00055	0.0041±0.000061	0.0167±0.0003

Hyper accumulation of heavy metals in food chain is detrimental to human health. International Agency for Research on Cancer (IARC) has placed Ni, Pb, Cd and Cr (VI) in Group I which are potent carcinogens in nature (Ahmed et al., 2016; IARC, 1987). Cr (VI) are also strong mucosal irritant (Zahid et al., 2011). Cd is a non-essential element which exhibit bioaccumulation tendency affecting vital organs on long exposure and other health complications such as elevated blood pressure, damge to red blood cells and interfere with body's metallo-enzyme (Duruibe et al., 2007). Lead (Pb) is one of the major pollutant seen in industrial and urban areas. The major sources of Pb include natural weathering and anthropogenic activities such as emissions from automobiles and factories, metal plating, mining, pesticides, battery and gasoline. Prolonged exposure to lead (Pb) leads to neuro and renal toxicity (Emmanuel et al., 2009). Zn in higher concentrations has adverse effect on gastrointestinal tract and modulate or alter serum cholesterol balance (Plum et al., 2010; Nriagu, 2010). A plethora of medical reports revealing heavy metal toxicity due to consumption of contaminated herbal formulations is available. One of the studies reported elevated concentrations of heavy metals residues in the blood samples

procured from patients in Nigeria (Ibeto and Okoye, 2010). Stewart et al., (1999) has reffered to Johannesburg foresic record where traditional remedy was considered as the cause for death or poisoning in 206 cases studied. Further, 34% of patients who were under plant based treatment showed higher level of Zn in urine samples. Another report refers to multiple metal poisoning in a seven month old infant after the intake of a herbal medicine. Similarly, Cr(VI)-containing traditional remedies have been indicated as the ground for poisonings and morbidity cases in young children (Steenkamp et al., 2002).

CONCLUSION

Present study has confirmed the heavy metal accumulation in *S. rhombifolia* collected from polluted sites, the root of which is extensively used in ayurvedic preparations. This will turn out to be a serious apprehension when it reaches food chain and get accumulated in humans instigating complications in the health care sector. Samples from wild are safer with only permissive level of heavy metals studied. Further, studies are needed to confirm the mechanism of absorption and deposition of heavy metals in *S. rhombifolia* and the consequent health issues in human beings.

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