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STUDY OF HEAVY METALS IN SOIL, WATER AND SOME CROPS OF SRI GANGANAGAR (RAJASTHAN), INDIA

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The aim of this study was to investigate the extent of heavy metal contamination in the agricultural area of Ganganagar district. The study was conducted for post monsoon season in year 2014.Concentration of Cd, Cr, Cu, Mn, Ni, Pb, and Zn were determined in the water, soil and some crops of the study area using Atomic Absorption Spectrophotometer (AAS). Significant variations in the concentration of different heavy metal were observed in the samples of soil, water and selected crops. Certain heavy metals exceeded the maximum permissible concentrations in some of the samples. The excessive concentration of such heavy metals may leads to severe health related issues in human as well as animals. It is thus suggested that regular monitoring of heavy metals must be carried out to mitigate the adverse impacts of the heavy metals.

Key words: Atomic Absorption Spectrophotometer; Heavy metals; Maximum permissible concentrations.

Introduction

The contamination of heavy metals in plants and water is one of the major issues to be faced throughout the world and requires attention. Heavy metals above their normal ranges are extremely threatened to both plant and animal life. The sources of heavy metal contamination in different ecosystems are including excessive use of fertilizer, pesticide, irrigation, atmospheric deposition, and industrial effluents pollution. A precise knowledge of heavy metals concentrations, the forms in which they are found, their dependence on soil physicochemical properties provides a basis for careful soil management. The poor management of soil and water resources may lead the motilities of heavy metals, which results in their incorporation into the food chain[1]. The major part of heavy metal accumulates on the surface of soil and in the upper layers of bottom sediments of water basins. They mix with the substances existing in such upper layers and change their characteristics. Soil reaction (pH) conditions a mobile form of heavy metal amounts and organic substances in sediments acting like a buffer and storing these materials for a long time[2-6]. Earlier, a study was carried out in Bikaner reason to assess some heavy metals contamination of

vegetable grown by using waste water as irrigation source[7]. The result of the study showed an elevated level of Fe, Mn, Zn and Cu. It was a little information about heavy metal exposure in the region. Therefore the present study was undertaken to find out the heavy metals related issues and their contamination in water, soil and selected crops of Sri Ganganagar district.

Study area: Ganganagar district is located in the northernmost part of Rajasthan State. Occupying an area of around 11154.66 sq km, the district is surrounded by Bikaner and Hanumangarh districts of Rajasthan. Arid type of climate prevails in major part of the district. It is characterized by hot summer and cold winter. Southwest monsoon season prevails during June to mid of September, of Ganganagar district which is followed by post monsoon period till the end of November. Main crops are also cultivated at large scale wheat, mustard and cotton and other crops are guar, bajra, sugar cane and grams etc. The northern part of the district is characterized by sierozems or arid soils which are light yellowish brown to pale in color. Presence of kankar layer (calcareous concretions) has been noticed in the depth range of 75 to 100 cm. Soils are deep and moderately drained. Permeability is moderate to slow and water holding capacity and natural fertility are generally poor. Loamy sand and sandy loam is the predominant types of soil met within this soil group. The four major crops (*Cyamopsis tetragonoloba, Vigna radiate, Pennisetum glaucum, Gossypium arboretum*) were selected for heavy metal contamination study. Study selection of these crops was based on area of their cultivation.

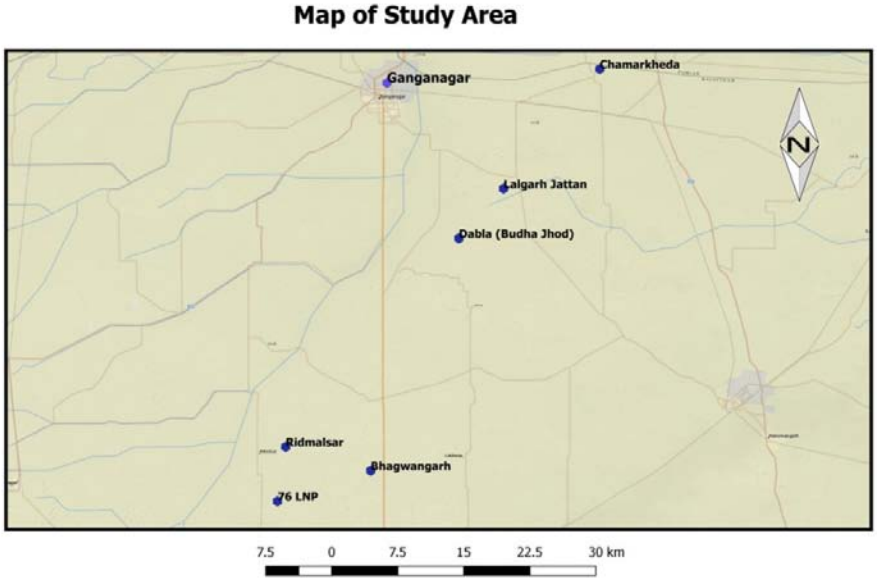

Fig 1. Sampling location in Sri Ganganagar District

Material and Methods

For analysis of heavy metals in water, soil and crops, samples were collected from the agricultural sites of Sri Ganganagar during post monsoon seasons. Water, samples were collected in plastic samples bottles, which were thoroughly cleaned with nitric acid and rinsed several time with distilled water.

Samples of soil from the superficial mineral layer (5-20 cm) and leaves of crops were collected after rainy season from area with the extensive agricultural cover. Prior to analysis, soil samples were air-dried at 20° C and ground in a mortar to pass a 2 mm sieve. Leaves of the selected crops were washed thoroughly in deionized water to remove particulates, dried at 70° and pulverized. 0.5 gm of samples of crops and soil were weighed and taken in the hard Borosil glass tube. Concentrated nitric acid and perchloric acid was added to each sample in 4:1 ratio. Samples were kept in water bath for 5 to 6 hours or until it gets digested completely and become clear. Then 3 to 4 drops of H_2O_2 (30%) was added to neutralize and to dissolve the fat. After cooling, each sample was diluted up to 10 ml with deionized water and transferred to sterilized Borosil glass vial and stored at room temperature prior to analysis[8].

Results and discussion

*Heavy Metal Assessment in Soil and water***:** Total 80 samples were analyzed for contamination of nine major heavy metals in soil and water of Sri Ganganagar district. The selections of different sites were based on extensive agricultural activities, intensity of application of agrochemicals and population distribution. The average concentration of different heavy metals in water samples were found as the Zn: 0.138 ppb; Pb: 0.125 ppb; Cu: 0.030 ppb; Cd: 0.006 ppb; Fe: 1.583 ppb; Ni: 0.068 ppb; Cr: 0.125 ppb; Mn: 0.076 ppb and Co: 0.033 ppb. The level of contamination of heavy metals in water samples were in order of Fe> Zn> Cr> Pb> Mn> Ni> Cu> Co> Cd. Similarly, the result of the study for soil samples analysis shows that the average concentrations of different heavy metals were Zn: 0.125 ppb; Pb: 0.125 ppb; Cu: 0.025 ppb; Cd: 0.003 ppb; Fe: 12.70 ppb; Ni: 0.050 ppb; Cr: 0.163 ppb; Mn: 0.376 ppb and Co: 0.020 ppb (Table 1). The level of contamination of heavy metals in soil samples were in order of Fe>Mn>Cr>Zn>Pb>Ni>Cu>Co>Cd. It is interesting to notice that the average concentration of heavy metals were comparatively higher in water than in soil. It may be due to their percolation in ground water. Heavy metals released from different agrochemicals applied on crops and naturally available in the form of water soluble salts may be the source of its contamination in ground water.

Table: 1 Concentration of different heavy metal in Soil and Water

S.No.	Heavy Metal	Soil (ppb)			Water (ppb)		
		Min.	Max.	Ave.	Min.	Max.	Ave.
1.	Zn	0.1	0.2	0.125	0.1	0.2	0.138
2.	Pb	0.1	0.2	0.125	0.1	0.2	0.125
3.	Cu	0.01	0.04	0.025	0.02	0.04	0.030
4.	Cd	0.001	0.003	0.003	0.004	0.008	0.006
5.	Fe	10.22	15.91	12.70	0.11	4.11	1.583
6.	Ni	0.02	0.08	0.050	0.04	0.09	0.068
7.	Cr	0.1	0.2	0.163	0.1	0.2	0.125
8.	Mn	0.33	0.43	0.376	0.03	0.2	0.076
9.	Co	0.01	0.03	0.020	0.01	0.05	0.033

The results of the present study may be correlated with findings of earlier study carried out in areas of Kettara abandoned Mine of Morocco, which explained the mobility of different metals in soil and water [9].

Heavy Metal in Selected Crops: To assess the impact of heavy metals on crops growing in heavy metal contaminated area, four major crops viz. *Cyamopsis tetragonoloba* (Gawar), *Vigna radiata* (Moong), *Pennisetum glaucum* (Bajara) *Gossypium arboretum* (Narma) were selected for present investigation. The concentration of Zn, Pb, Cu, Cd, Fe, Ni, Cr, Mn and Co in selected crops was analyzed. The samples of ropes were collected from seven different sites. All the samples were analyzed to determine the heavy metal content of different parts (roots, leaves, and leaf) of the crops. The results of investigation (Table- 2) revealed that the average concentration of Zn was found in different crops in order as Gawar (0.300 ppb)> Moong (0.250 ppb)>Bajra (0.201 ppb)> Narma (0.150 ppb). The maximum average concentration of Pb was found in Gawar (0.113) while its minimum average concentration was reported in Moong (0.105). At higher concentrations, Pb decreases root expansion by restricting cell division and elongation in plants. Excessive amount of Pb in animals fodder can cause acute or chronic poisoning in animals leading to decreased hemoglobin synthesis, neurobehavioral impairment, peripheral neuropathy reproductive effects and neurotoxic malfunctioning in infants[10]. Average concentration of Cr was found highest in Gawar (0.125 ppb) and its lowest average concentration were observed in Bajara (0.115 ppb). The Cr content in crops was alarmingly higher than the maximum permissible limits for fodder[11] (CERSPC 2009). Cr content above the permissible limits can cause deleterious effects on plant physiological process such as photosynthesis and respiration[12]. Heavy metal toxicity (Pb, Cd, Cr, Cu, Mn etc.) in animals due to contaminated fodder has been observed by many researchers in other parts of India[13-15]. The Maximum average concentration of Cd was found in Gawar (0.005ppb) while its minimum average concentration was reported in Bajara (0.001 ppb). Similar study was conducted in Kumasi, Ghana on vegetables grown on waste dumping sites showed high cadmium contamination of 0.68-1.78 mg/kg[16]. Cadmium toxicity is becoming an increasing health concern in wastewater irrigated crops, especially due to its association to damage kidneys and bones and its potential carcinogenic nature[17]. In general, Cu and Zn are the most abundant metals found in Cropsand they are the essential micronutrients for plants[18,19]. The highest concentration of Zn was reported in Gawar (0.300 ppb), while its lowest average concentration was found in Narma (0.150 ppb).Similarly, the average concentration of Cu in Gawar (0.050 ppb) and Moong (0.042 ppb) reflected its higher level. The average concentration of Ni in Bajara (0.059 ppb) and Gawar (0.058 ppb) was observed. The plant metrics used for analyzing the effects of heavy metals on their growth were plant height, shoot and root biomass, leaf soluble sugars and starch and the Ni contents of the shoots and roots. Nickel generally reduced leaf soluble sugars, which indicated an effect on plant carbohydrate metabolism and the growth, morphology, photosynthesis, mineral nutrition and enzyme activity of plants[20].Themaximum average concentration of Fe was found in Bajara (6.945 ppb). The Fe is one of the essential elements for all plants as it plays many biological important functions including photosynthesis,

biosynthesis[21]. The highest average concentration of Mn was found in Gawar (0.261 ppb) and minimum was reported in Bajara (0.196 ppb). The results of the present investigation are in linearity with the findings of study showed that accumulation of excessive manganese (Mn) in leaves causes a reduction of photosynthetic rate[22] (Kitao *et al.,* 1997).

The average concentration of Cobalt was found maximum in Narma (0.20 ppb) and minimum in Bajara (0.010 ppb). It is reported that plants can accumulate small amount of Cobalt from the soil. The uptake and distribution of Cobalt in plants is species-dependent and controlled by different mechanisms[23-25].

Table 2: Concentration of different heavy metal in selected crops.

S. No.	Crops	Average Concentration of Heavy Metals (ppb)								
		Zn	**Pb**	**Cu**	**Cd**	**Fe**	**Ni**	**Cr**	**Mn**	**Co**
1.	*Cyamopsis tetragonoloba (Gawar)*	0.300	0.113	0.050	0.005	6.585	0.058	0.125	0.261	0.019
2.	*Vigna radiata (Moong)*	0.250	0.105	0.042	0.002	4.212	0.049	0.120	0.201	0.011
3.	*Pennisetum glaucum (Bajara)*	0.201	0.108	0.035	0.003	3.145	0.059	0.115	0.196	0.010
4.	*Gossypium arboretum* (Narma)	0.150	0.111	0.021	0.001	4.200	0.057	0.117	0.250	0.17

Conclusion

The main aim of the present investigation was to assess the concentration of various heavy metals in soil, water and some commonly grown crops in Sri Ganganagar district. It was observed that heavy metal concentration in water samples were found in the order of Fe> Mn> Cr> Zn> Pb> Ni> Cu> Co> Cd, while in case of soil sample, it was found in the order as Fe> Mn> Cr> Zn> Pb> Ni> Cu> Co> Cd. It was noticed that concentration of Co and Cd in water as well as soil samples were found lowest in the study area. The source of contamination of such heavy metals in the ecosystem could be due to release of untreated waste water from industrial as well as domestic sector, unjustified use of pesticide and synthetic fertilizer, atmospheric deposition of suspended particulate matter released from automobiles etc. Such heavy metals may exert severe health related problems in human being. Therefore, regular monitoring of such heavy metals is necessary for combating the problems related with them.

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