Use of wild plant species as indicator of some heavy metals in the soil of General Company for tire industry in Najaf Governorate

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Abstract. Concentration of seven metals (Pb, Cu, Zn, Mu, Ni, Cr, and Cd) in the samples of soil and some plant species collected from General Company for tire industry in Najaf were determined. The mineral ions were assayed using the acid digestion method and atomic absorption spectrophotometry (AAS). Physicochemical parameters (pH, EC, Bulk density, water holding capacity and Total Nitrogen) of the soil samples were also determined of the 7 metals determined in the soils samples, the concentration of Pb (15.25 ± 5.79 mg/kg⁻¹) was the highest compared to the concentrations of other metals. Physicochemical parameters were within the range that allows effective use of wild plant species as indicator of some heavy metals in the soil. Cu showed the lowest concentration (0.65 ± 1.78 mg/kg⁻¹). Ni was below the detectable limit in most of the samples. Similarly, concentrations of Pb (12.35 mg/kg⁻¹) in the shoot of Sonchus asper (L.)Vill. among other metals were higher than those of the other metals in the plant tissues. Concentration of Cd (0.01 mg/kg⁻¹) in the root of Rumex cyprius Murb. was the lowest. Generally, metal ion concentration in the soil and plant samples of the General Company for tire industry in Najaf(polluted site) significantly differed from those of the non-polluted site (P<0.05). Plantago boissieri Hausska.et Bornm. among the plant species had the highest translocation factor (TF = 2.91). Although the TF was higher in the plant of the polluted site (TF >1), reasonable amount of them were retained within the underground tissues (roots).

Keywords: Heavy metals, Translocation, General Company for tire industry, Najaf Governorate, Physicochemical parameters and wild plant

1. Introduction

Heavy metals are released to the environment usually through anthropogenic activities such as firing of ammunitions, mining, electroplating, smelting etc. (1). They constitute a major pollutant and make a significant impact to the environment. According to (2), all heavy metals have strong toxic effect, hence they can contaminate the environment. In contemporary times the possibility of using certain species of plants to decontaminate environments polluted by the accumulation of heavy metals, a process referred to as phytoremediation, has been seen to be very promising and reliable (3). In the process of phytoremediation, plant roots play a very vital role in the cleanup of the metals as they are usually located in the soil. Phytoremediation by plants can be achieved through filtration, adsorption, cation exchange and plants induced chemical changes in the rhizosphere (4). It has also been reported that
plants, notably *Thalaspi caerulescens, Arabidopsis thaliana, Phragmites australis* can be used in the cleaning up of environments polluted by heavy metals (5). Generally, factors such as stage of plant growth, variations in plant species and characteristics of the metals affect their absorption rates and accumulation. (6). (7) also reported that physiological adaptations control metals accumulations by a process of sequestering metals into the roots. Consequently removal of metals by plants can be greatly enhanced by the selection of plant species. The aims of this study are potentials of different plants to absorb, accumulate and translocate metals under varying condition is necessary with regard to the choice of plants for effective and efficient indicator to polluted environment. Therefore, the concentrations of metals such as Pb, Cu, Zn, Mn, Cr, Ni, and Cd were determined in the samples of soil and 6 wild plant species, that is shrubs, herbs and grasses, found growing within the study area and a neutral area not subjected to the impact of General Company for tire industry in Najaf site (8).

2. Methodology

The research was conducted at the site of the State Company for Rubber Goods Industries and Tires, one of the companies of the Ministry of Industry and minerals in Iraq which is located in ( Al Najaf governorate -Al- Haydariah district – Karbala - Najaf road) Babylon tire factory located in the site of the company in Al- Najaf governorate-Al- Haydariah district. 160 km. south west Baghdad. Established in 1994, centered by longitudes 32°1730’N and 44°1545’E (Fig. 1). The general picture of the region showed desert region and a typical plant of desert adaptations. The soil in the area is sandy. The factory's production includes solid and liquid waste and is disposed of and buried in the vicinity of the factory. Soil samples were taken from study area for three replication in two season (winter and summer). In the solid waste disposal area of the plant using soil auger which was deepened into the soil to the depth of 15 cm. After air drying for 2-3 weeks 10g of each soil samples were taken into a clean dried beaker and oven dried at 100 °C for 1hr. The dried soils were pounded and sieved through 250 μg mesh size. Samples were then analyzed for total metals (Pb, Cu, Zn, Mn, Ni, Cr, and Cd) pH, electrical conductivity (EC), bulk density and water holding capacity after pretreatments due for each test. Total metal concentrations were extracted by triacid digestion method (9). The pH and EC were measured using pH meter and EC meter respectively (10). Bulk density and water holding capacity and total nitrogen were determined as reported by Anderson and Ingram (11).

2.1 Plant Sampling and Analysis

Wild plants in study regions were studied and chose the most abundant species. Six plant species were chose , two of each of the 3 plant groups ( shrubs, herbs and grasses) were collected from the four locations within the study site from February to July, 2018. They were transferred to the Ecological Science laboratories , Kufa university . They were identified in the herbarium . The species found consisted of 6 genera and 5 families (Table 1) , forming the most abundant species in the metal polluted site. Samples were washed, Shoots and roots of the plants were separated and oven dried at 70 °C to constant weight (12). Then ground into powdery form for chemical analysis. Concentrations of metals (Pb, Cu, Zn, Ni, Cr and Cd) of the plant samples were determined after digestion using atomic absorption spectrophotometer (AAS) (GBC Avauta, Australia (13).

| N. | Plant Species                     | Family         |
|----|-----------------------------------|----------------|
| 1  | *Sonchus asper* (L.)Vill.         | Compositae     |
| 2  | *Salsola cyclophylla* Baker.      | Amaranthaceae  |
| 3  | *Rumex dentatus* L.               | Polygonaceae   |
| 4  | *Rumex cyprius* Murb.             | Polygonaceae   |
| 5  | *Plantago boissieri* Hausska.et Bornm. | Plantaginaceae |
| 6  | *Malva parviflora* L.             | Malvaceae      |
2.2. Determination Of Translocation Factor

Translocation factors (TF) is the ability of plant to accumulate, tolerate and translocate metals from underground tissues to shoot. It was determined for each plant by calculating the ratio of metal concentration in shoot to the concentration in the root using the formula below for each plant (14).

$$TF = \frac{\text{metal (shoot)}}{\text{metal (root)}}$$

3. Results and Discussions

Table 2 showed the Chemical and physicochemical characteristics of study area soils. Content of the soil heavy metals were high and varied for seven detected metals (Table 2). The highest average concentration of Pb was $(15.25 \pm 5.79 \text{ mg/kg})$ and the lowest average concentration was observed in Cu $(0.65 \pm 1.76 \text{ mg/kg})$. Table 2 showed alkaline soils in the study sites with an average pH of 7.6 which were suitable for plant growth and phytoremediation. The average EC of the soil was $8.21 \mu \text{cm}$. Total nitrogen and average moisture content were approximately 0.6% and 24% respectively.
| Characteristics | Concentrations (mg/kg\(^{-1}\)) |
|-----------------|---------------------------------|
| P               | UP                              |
| Pb              | 15.25 ± 5.79                    | 4.99 ± 3.15                  |
| Cu              | 0.65 ± 1.78                     | 0.50 ± 0.41                  |
| Zn              | 1.04 ± 0.32                     | 1.83 ± 0.29                  |
| Mn              | 8.64 ± 1.28                     | 2.30 ± 0.37                  |
| Ni              | BL                             | BL                           |
| Cr              | 14.55 ± 1.45                    | 3.87 ± 1.03                  |
| Cd              | 1.84 ± 0.27                     | 0.24 ± 0.03                  |

**Physicochemical Parameters**

- pH: 7.6, 7.01
- EC (μ/cm): 8.21, 8.04
- Total N\(_2\) (%): 0.5, 0.72
- Moisture content (%): 24.01, 26.25
- Bulk Density (gm/ml): 0.97, 0.79

**Key:**
- P = Polluted site
- UP = Unpolluted site
- BL = Below Detectible Limit

Table 2. Chemical and physicochemical characteristics of study area soils (means± SE)

Accumulation of Metals and Uptake by the Plants in the Study sites.

Plant concentrations of heavy metals (Pb, Cu, Zn, Mn, Ni, Cr, and Cd) were measured in two areas in polluted and Unpolluted site of the General Company for tire industry in Najaf. As per the figures (from 2 to 8) the studied plants showed significant differences in metal concentrations among the species and this indicating their different capacities for metal uptake. of highest concentration was in *Sonchus asper* (*S. asper*) accumulated a significantly higher Pb (11.40 mg/kg\(^{-1}\)shoot and 8.71 mg/kg\(^{-1}\)root) compared to others species and metals. Also *Salsola cyclophylla* (*S. cyclophylla*) accumulated higher Pb (11.21 mg/kg\(^{-1}\)shoot and 8.12 mg/kg\(^{-1}\)root) than other metals. Accumulation of Pb in the tissues of other species was comparatively higher than the other metals. The lowest accumulated metal was Ni in *Rumex cyprius* (*R. cyprius*) (0.01 mg/kg\(^{-1}\)root). Out of the 6 plant species *Malva parviflora* (*M. parviflora*) only had the highest concentration of Ni (0.12 mg/kg\(^{-1}\)root) which was below detectable limit (BDL) in most of the species such as *S. asper*, *S. cyclophylla*, *P. boissieri* etc. Translocation factor, ratio of the metal content in shoot to root, showed the occurrence of internal metal transportation. The data as presented in Table 3 clearly indicate that metals accumulated by the sampled plant species were significantly retained in the roots. (TF = <1). This is evident in most of the species, except in some such as *S. asper*, *S. cyclophylla*, *R. dentatus*, *R. cyprius*, *P. boissieri*, *M. parviflora* for Pb (TF = 1.51, 1.25, 1.21 and 1.01 respectively); *R. dentatus*, *R. cyprius* for Cu (TF = 1.22 and 1.91 respectively); *S. asper*, *S. cyclophylla*, and *M. parviflora* for Zn (TF = 1.03,1.35 and,1.46 respectively); *S. asper*, *S. cyclophylla*, *R. dentatus* and *P. boissieri* for Mn (TF = 1.25, 1.02, 1.01 and 1.30 respectively); *S. asper*, *S. cyclophylla*, *R. dentatus*, *R. cyprius*, *P. boissieri* and *M. parviflora* for Cr (TF = 1.10, 1.02, 1.32, 1.05, 1.00, 1.09, and 1.56 respectively); and *R. dentatus* for Cd (1.93).

The 6 studied plant species were also collected from the unpolluted site (control) located 20 km away from the studied or (polluted) site. Generally, the concentrations of metals in the plants from the polluted site were higher than the unpolluted site. Although species for the polluted and unpolluted site were the same, the physicochemical parameters in their substrata were remarkably differed.
| No. | Species                        | TF  | Pb  | Cu  | Zn  | Mn  | Ni  | Cr  | Cd  |
|-----|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | *Sonchus asper* (L.) Vill.     |     | 1.51| BL  | 1.03| 1.25| BL  | 1.10| 0.06|
| 2   | *Salsola cyclophylla* Baker.   |     | 1.25| BL  | 1.35| 1.02| BL  | 1.02| 0.51|
| 3   | *Rumex dentatus* L.            |     | 1.21| 1.22| 0.96| 1.01| 0.03| 1.32| 1.93|
| 4   | *Rumex cyprius* Mur.           |     | 1.01| 1.91| 0.67| 0.83| 0.02| 1.05| 0.74|
| 5   | *Plantago boissieri* Hausska et Bornn. | | 1.76| 0.05| 0.78| 1.30| BL  | 1.00| 0.05|
| 6   | *Malva parviflora* L.         |     | 0.84| BL  | 1.46| 0.94| BL  | 1.09| 0.08|

Key: B L = Below Limit

Figure 2 Concentrations of Pb in the Sampled Plants of studied Sites

Figure 3 Concentrations of Cu in the Sampled Plants of studied Site

Figure 4 Concentrations of Zn in the Sampled Plants of studied Sites

Figure 5 Concentrations of Mn in the Sampled Plants of studied Sites
4. Conclusion

4.1 Tolerance of heavy elements concentration in studied plant species

This study shows the high concentration of minerals in contaminated soil in the soil of a neutral control site in the General Company for tire industry in Najaf governorate, which indicates pollution. Pb, Mn, Cr, Cd, and Zn concentrations were significantly higher in soil samples at the contaminated site than in the non-contaminated site. Pb concentrations were higher than other metals. This corresponds to the report (15), which contains lead and new pellets containing a higher proportion (90%) of lead than most other metals. The results of physical and chemical parameters, pH, EC, N and water retention ability were suggestive of the fact that they were suitable for taking minerals from plants. Therefore, the plant bearing results showed a high concentration of minerals. The results also showed clear differences between plant species in their ability to assemble elements.

Concentrations in the root tissue were higher than in the shoot. This refers to the plant's ability to assemble the substrate minerals in the root as well as the limited internal movement of ions in plants, a factor that depends on the relationship between water and vegetation and the solubility and pressure, and agree on previous reports of (16 and 17). The mineral concentrations in the plant root of contaminated sites were higher in most of the species studied more than others.

The concentration of minerals in plant tissues usually depends on their concentrations or level of availability in the soil. The result of the metal concentration in this study indicates that the strategy of carrying heavy metals has been widely developed among different plant species and is usually observed in species that grow in mineral contaminated areas. The results of the displacement factors are based on the absorption capacities of the species, in particular the relationship between the concentrations of the
metals in the shoots and the roots. Although TF in plant species at the contaminated site is much higher (TF> 1) than those in the control site, the minerals have accumulated in the roots more than the shoots (18). This helps to use wild plants as natural indicators.

4.2 Indicators Use of plant Species

Plants vary in their ability to accumulation of heavy metals depending on the differences in mineral absorption capacities, any type of wild plant with a transformation factor greater than 1 (TF> 1) can be used as a potential plant indicators. As evidenced by the results of the present study, A.zgyia, R. dentatus , C hispidium, P. boissieri , E trenuda etc. could be selected as very good candidates for indicators. Therefore, the purpose of this study was to examine the plants that grow in the contaminated site to determine their ability to absorb and accumulate minerals and use them as indicators. Therefore, the result of this study indicates the fact that most of the six plant species can grow in heavily polluted sites, absorb a wide range of heavy metals in the soil and are not affected by high concentrations of metals and also possess the ability to tolerate metals and resistance from the most sensitive species.

It was suggested that the concentration of metals higher than toxic in some species that the process of internal mineral detoxification may also exist, and therefore can be used effectively for plant indicators to pollutants. The result also suggests that soil and plant interactions should be considered when selecting plant species and also in the development of any indicators technique.

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Appendix : Plants picture appeared in the soil of General Company for tire industry in Najaf Governorate

Sonchus asper
Salsola cyclophylla
Malva parviflora

Plantago boissieri

Rumex dentatus

Rumex cyprius