Heavy Metals Biomonitoring by Plants Grown in an Industrial Area of Isfahan' Mobarakeh Steel Company

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Extended Abstract

Biomonitoring is the one of the cost-effective and simple ways for investing the environmental quality and refers to process that uses living organisms to obtain quantitative information on environmental quality. Industrial activities causes to entrance considerable amount of heavy metals to the atmosphere and use of boimonitoring potential of plants growing in the nearby zone of industrial areas can be useful. The aim of this study was to investigate the possibility of monitoring atmospheric pollution with Iron, Nickel and Lead in the vicinity of Mobarakeh Steel Company as an industrial zone with using biomonitoring potential in plants. For this reason, three trees (*Cupressus arizonica*, *Pinus eldarica* and *Quercus branatii*) and three shrubs (*Nerium oleander*, *Berberis vulgaris* and *Thuja orientalis*) were selected and concentration of these metals were measured in soils and aboveground plant parts (leaves and bark) by ICP-AES. In studied soils, a little concentration of these metals were available for plants due to high pH value(8.02), presence of more than 60 % $CaCO_3$ and 0.5% organic matter, while Fe and Ni concentration in aboveground plant parts states atmospheric pollution with these metals. In most cases, trees better than the shrubs and evergreen plants better than the deciduous ones indicated heavy metal contamination and bark of these plants had more ability. The highest concentration of Fe and Ni were observed in leaves of Cupressus and bark of Pinus which indicated significant differences with all plants for Fe and in most plants for Ni. Pb content in plants was lower than pollution limit of this element. Results also indicated that Nerium was not a good indicator for Fe monitoring in this area.

Introduction

Heavy metals contamination is a major environmental problem. Contamination usually results from industrial activities, such as mining and smelting of metalliferous ores, electroplating, gas exhaust, energy and fuel production, fertilizer and pesticide application, and generation of municipal waste, which causes to entrance considerable amount of heavy metals to the atmosphere and soil.

Air quality can be monitored by measuring the pollutants directly in the air or in deposition, by constructing models depicting the spread of pollutants or by using biomonitors. Direct measurements provide important information about the level of pollutants, but they are expensive and there is a risk of contamination when determining low concentrations. The models provide information about extensive area and they can be used to produce predictions of future air quality. However their accuracy is dependent on the quality of pollutants and their effect on the occurrence and condition of biomonitors. Thus bioindication and biomonitoring have proven to be excellent and cheap ways to observe these impacts of external factors

Biomonitoring refers to process which in that using living organisms or part of them can obtain quantitative information on environmental quality.

The use of higher plants, especially different parts of trees, for air monitoring purposes is becoming more and more widespread. The main advantages are greater availability of the biological material, simplicity of species identification, sampling and treatment, and ubiquity of some genera, which makes it possible to cover large area.

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Trees also exhibit greater tolerance to environmental changes which is especially important for monitoring areas with elevated anthropogenic influence.

This study was proposed to investigate Fe, Ni and Pb contamination monitoring in the atmosphere of an industrial area by using biomonitoring potential in some tree and shrub species and to assess which plant parts (leaf or bark) are better.

Material and methods

This study was performed in botanic garden of Mobarakeh Steel Company located in southwest of Esfahan in center of Iran in August 2007. This region has an arid climate with mean annual rainfall of 140 mm. The area of garden was approximately 3 ha with 9 plots and 3 replications. Soil (around each plant), leaf and bark sampling was done from three trees (*Cupressus arizonica*, *Pinus eldarica* and *Quercus brantii*) and three shrubs (*Nerium oleander*, *Berberis vulgaris* and *Thuja orientalis)*. Plant sampling carried out at wind direction (SW-NE). All of the bark samples of both species were taken from the external surface of bark by using a stainless-steel knife and after transferring to laboratory, the wood part was separated as the thickness of the bark samples was about 2 mm. Soil samples were also collected randomly to a depth 0-30 cm around each plant. The main soil chemical properties were determined according to the following methods. Organic carbon was determined by a modified wet oxidation. Soil pH was measured by potenciometry in extract of paste. Cation exchange capacity (CEC) was measured by Ammonium Acetate. Calcium carbonate was determined by back titration. Soil texture was measured by Hydrometer method. The total metal concentrations (Fe, Ni and Pb) were determined after digestion with 10 ml HNO_3 70% for soil samples and with 10ml 2N HCl for plant materials. Finally, heavy metal concentrations in plant and soil samples were determined by ICP- AES (GBC Integra XL).

Results and discussions

Soil

Plant-available heavy metals of soils were few in comparison with total values of them. Plant ability for heavy metal uptake is not only a function of total concentration of the soil metal, but depend on different factors such as soil pH, organic matter content, cation exchange capacity(CEC) and plant species. The mean pH value about 8, more than 60 percent $CaCO_3$, 0.5% organic matter and CEC about 12 meq.100g^{-1} were factors those were influenced mobility and availability these metals in studied soils and decreased plant available concentrations of them.

Plant

Iron: Threshold value of Fe in plant tissues was assumed 750 mg in kg dry weight. Fe concentrations in both parts of all tree plants were higher than the threshold value except for Quercus' bark. The highest concentration of Fe was observed Cupressus leaves and Pinus bark, significantly ($p<0.05$). Cupressus leaves has little waxy surfaces in comparison with Pine needles but less cuticle thickness, scaly and rough leaves were factors which lead to effective accumulation. Pinne has also thick, porous and rough bark. In shrub species also the highest concentration belonged to Thuja leaves and Berberis bark which had significant difference with other species. (Fig. 1)

Nickel: Contamination range of Ni in plant tissues was assumed 3 to 50 mg in kg dry weight. Ni concentrations in all studied plants indicated levels of contamination. The greatest value of Ni was found in Cupressus leaves and had significant difference with the other trees. Unlike Fe, concentrations of Ni in Quercus leaves were higher than the Pinus needles. This result suggests that contaminants characteristic is another important factor in metal accumulation in plant tissues.

Lead: Lead easily uptake by plant root, but very low amount of it transfers to above ground plant parts. Natural concentration of lead in plant tissues is lower than 10 mg in kg dry weight, so threshold value of this metal in plant was assumed 10 ppm. Pb concentrations in both parts of all plant were below threshold value, except in Pinus bark. This result is reasonable with regarding to low traffic density in studied area.

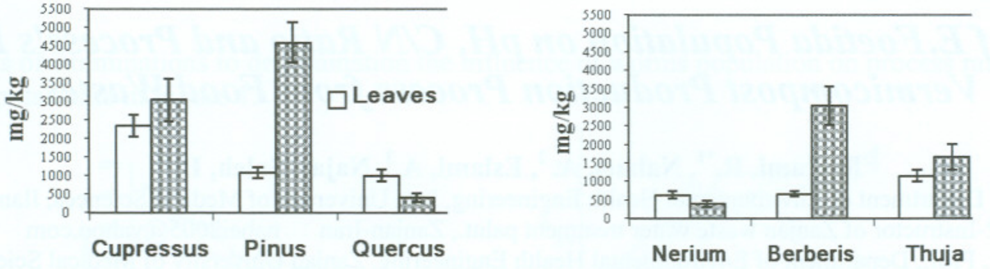

Fig.1: Mean concentration of Fe in tissues of tree and shrub species

The highest accumulation of Ni in shrub species was observed in scaly leaves of evergreen Thuja species, significantly, whilst maximum accumulation of Ni in bark related to Berberis that only had significant difference with Nerium (Fig.2)

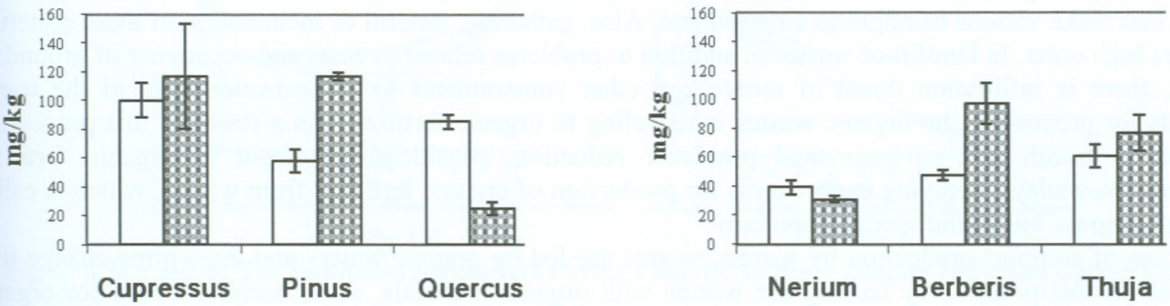

Fig. 2: Mean concentration of Ni in tissues of tree and shrub species

Conclusion

Comparison of metal concentrations in soils and plant tissues were disproved the probability of plant contamination through the soil and were confirmed the theory of atmospheric source of these elements in this industrial area. Biomonitoring potential evaluation of studied plants species indicated tree species were better than shrubs and evergreen plants better than deciduous ones for airborne Fe and Ni contamination monitoring. Especially, Cupressus leaves and Pine bark can be considered suitable biomonitors for atmospheric contamination in examined area. Results also indicated that accumulative capability of metal by plant tissues affected with plant species, physico-chemical contaminant characters and structural properties of these tissues, as increased with increasing waxy surface and roughness and decreasing cuticle thickness in leaves and increasing porosity and roughness in bark. In the most cases, bark potential for metal accumulation were higher. Nerium was not a good indicator for Fe contamination.

Key words

Biomonitoring, Heavy metals, Contamination, Leaf, Bark, Soil