Removing chromium and lead metals using phytoremediation technique

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Abstract. Phytoremediation technique uses plants parts to remove, extract, and absorb heavy or toxic matter from soil and water. In the present study, *Catharanthus roseus* (Periwinkle) and *Nerium Oleander* (Oleander) were used for removing Chromium (Cr) and Lead (Pb) metals. These plant species were seeded in polyethylene pots containing 8kg of soil. Each pot was irrigated with wastewater for four months (May, June, July and August) and accumulation of the considered metals was analyzed after every month for leaf, stem and root by using Atomic Absorption Spectrophotometer (AAS). This experimental work was carried out in the laboratories of Water Desalination Researches Unit - Building and Construction Engineering Department and Environmental Research Centre at the University of Technology in Baghdad City, Iraq. The concentration of Cr was found to be increased with time. High Cr concentration, 20.34 mg/kg, was recorded at August in leaf of Periwinkle and 19.61 mg/kg in root of Oleander in case of using 100% wastewater (WW). While, for Pb, the maximum concentration, 22 mg/kg, was recorded in June in leaf of Periwinkle and 19.5 mg/kg in stem of Oleander. Accordingly, Oleander has the maximum removal efficiency.

1 Introduction

Water, air and soil pollution is the main environmental issue faced by the modern society. While, soils are considered as the major sink for toxic metals released to the environment by the mention anthropogenic activities [1]. Thus, contaminated soils and waters pose a major environmental and human health problem [2]. The heavy metals may come from natural sources, leached from rocks and soils according to their geochemical mobility or come from anthropogenic sources, as a result of human land occupation and industrial pollution [3]. Heavy metals are found soluble in water, so that, it can enter in ecosystems by water pathways [4].

So that, many researchers and environmentalists have developed cheap and good technology to remediate the pollutant through "Phytoremediation" [5]. Phytoremediation is an emerging technology that uses various plants to degrade, extract, contain, or immobilize contaminants from soil and water. This technology has received much attention lately as an innovative, cost-effective alternative to the more established treatment methods used at hazardous waste sites [6]. There are several factors which are considered to select the plant for phytoremediation, one of them is that the plant should have acceptable degree of tolerance to the site conditions to grow well and should be able to accumulate numerous metal contaminants and the most important factor is that the plant species should grow quickly and should be easy to harvest [7]. Several types

of phytoremediation are being used to-day Phytoextraction, Phytostabilization, Phytovolatilization, rhizofiltration and phytodegradation.

The objective of this research is to determine the ability of *Catharanthus roseus* (Periwinkle) and *Nerium oleander* (Oleander) plants to remove Chromium (Cr) and Lead (Pb) ions from soil by irrigating with wastewater (WW) and to determine the effectiveness of these plants in removing these metals.

2 Experimental works

In order to evaluate the effect of ornamental plants, such as Periwinkle and Oleander, in the removal of Cr and Pb from soil irrigated with WW, Experimental pots were conducted during the period from May 2015 to August 2015. This experimental work was carried out in the laboratories of Water Desalination Researches Unit (WDRU) - Building and Construction Engineering Department (BCED) and Environmental Research Centre (ERC) at the University of Technology (UOT), Baghdad, Iraq. The experiment was arranged for four months to evaluate the effect of ornamental plants; Periwinkle and Oleander as shown in Plate 1, in the removal of Pb and Cr from soil irrigated with (WW). Four levels of water were used for irrigation including tap water (control) (T1), 50% of WW + 50% of tap water (50% WW) (T2), 75% WW + 25% tap water (75% WW) (T3) and 100% WW (100% WW) (T4). The selected

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plants were planted in plastic pots (6 plant per pot; 25 cm length × 25 cm width × 25 cm height) filled with 8 kg of sandy loam soil. The pots were kept in the greenhouse of WDRU - BCED at UOT.

Plate 1. Tested plants.

The WW samples were collected from sewage nearby the experimental site in acid washed polyethylene containers. Potable water also collected from tap water nearby the experimental site. WW, tap water, soil and plant samples were monthly collected to determine the concentration of Cr and Pb.

The soil was air-dried, powdered, sieved through a 2 mm sieve and Cr and Pb concentration was measured. The total concentration of soil Pb and Cr was measured using wet digestion method. The WW samples were collected in acid washed polyethylene containers. 100 ml of WW sample has been filtered using Whatman filter paper (0.45 µm pore size) for estimation of dissolved heavy metals (Cr and Pb). Another 100 ml of the sample have been digested with (3: 1) of Hydrochloric acid (HCl) and Nitric acid (HNO₃) to determine total heavy metals. Procedures followed for analysis have been in accordance with the standard methods for examination of water and WW [8]. Analysis of the total and dissolved of heavy metal was performed with a flame atomic absorption spectrophotometer (AA6300, Shimadzu, Japan).

3 Results and discussion

The concentration of Cr and Pb heavy metals that were found in the parts of plants which were irrigated with WW during the experimental period (four months) is shown in Tables I and II. The measured concentrations of Cr in Periwinkle and Oleander plant parts are listed in Table I. The minimum concentration, 1.35 mg/kg, was found in the stem of Oleander plant in May in the control treatment and the maximum concentration, 19.855 mg/kg, was observed in the leaf of the Oleander plant at 100%WW in May. While the minimum concentration of Cr, 1.37 mg/kg, was found in the roots of Periwinkle plants at a control treatment in May and maximum concentration was measured in Periwinkle, 20.34 mg/kg, in August T 100%WW. However, the experimental results indicated that the Periwinkle plant can be considered as an effective plant to remove the Cr from

soil irrigated with WW.

Table II demonstrates the results of concentration of Pb in leaf, stem and root of Periwinkle and Oleander. The results show that the minimum concentration, 4.7 mg/kg, was measured in May at the control treatment in the leaf of Periwinkle plant and maximum concentration, 22.00 mg/kg, was observed in the leaf of Periwinkle plant in June at 100% WW. For Oleander plant, the maximum and minimum concentration of Pb was observed in leaf at 25%WW in May and stem of plant at 100%W) in June. The highest and lowest value was 4.02 and 19.5 mg/kg, respectively. The percent of removal efficiency of each heavy metal was calculated as follows:

$$\text{Removal Efficiency (\%)} = \left(\frac{C_i - C_f}{C_i} \right) \times 100 \quad (1)$$

Where C_i is the initial concentration of heavy metal (mg/kg) and C_f is the final concentration of heavy metal (mg/kg).

Figures 1 to 4 show the removal efficiency in the level of heavy metals in plants for all treatment. The percentage of removal efficiency of Cr and Pb in the Periwinkle and Oleander for all the treatment was calculated for every month.

Figures 1 and 2 show that the maximum removal efficiency of Periwinkle to remove Pb from soil that was irrigated with WW was 91.08% which occurs in August. While for Oleander it was 95.96%. The minimum removal efficiency of Periwinkle and Oleander for removing Pb was 6.89 % and 6.08 %, respectively which occurs in May.

Figures 3 and 4 illustrated that the maximum removal efficiency to remove Cr from soil that was irrigated by WW of Periwinkle and Oleander was 94.36% and 94.92% which occurs in August. While the minimum was 1.82 % and 2.64 %, respectively, this occurs in May. Generally, the removal efficiency increases with time and both Periwinkle and Oleander are good plant to remove Pb and Cr from soil irrigated with WW.

4 Conclusions

In this research and from the obtained results, it can be concluded that both Periwinkle and Oleander observed in this study were very effective in removing Cr and Pb because of their acceptable percentage of removal efficiency. The efficiency of removing Pb for both plants, (94.36 % for Periwinkle and 94.92 % for Oleander), is better than that of Cr which is 91.08% and 95.96% for Periwinkle and Oleander, respectively.

Accordingly, it can be concluded that Periwinkle and Oleander have hyper accumulation properties and are good to remove heavy metals.

Table 1. Concentration of Cr in plant parts during the experimental period.

[illegible]

Table 2. Concentration of Pb in plant parts during the experimental period.

[illegible]

Fig. 1. Removal efficiency (%) of Pb for Periwinkle.

Fig. 2. Removal efficiency (%) of Pb for Oleander.

Fig. 3. Removal efficiency (%) of Cr for Periwinkle.

Fig. 4. Removal efficiency (%) of Cr for Oleander.

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