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Phytoremediation of Pb(II) by *Jasminum sambac*

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(Received on 2nd April 2010, accepted in revised form 25th October 2010)

Summary: Experiments were conducted to asses Pb(II) bioaccumulation in *Jasminum sambac* cultivated in a green house under controlled conditions. For this purpose *Jasminum sambac* plants were cultivated and irrigated with industrial wastewater contaminated with Pb(II). After an interval of 10 days for maximum 50 days *Jasminum sambac* plants were removed and analyzed for Pb(II) concentration in various parts. The Pb(II) accumulation was observed in soil and in different parts of plant e.g. leaves, stem, roots and flowers. The Pb(II) accumulation was found dependent on soil pH and Pb(II) in concentration in industrial wastewater. *Jasminum sambac* was found to be Pb(II) hyper-accumulator plant. The maximum amount of Pb(II) detected in soil, leaves, stem, root, and flowers was 1742±3, 825±7, 339±5 508±8, and 3.98±0.1 mg/kg, respectively after 50 days. Very low quantity of Pb(II) was accumulated in *Jasmine sambac* flowers suggesting that its flowers still can be used.

Introduction

The term "heavy metals" has been widely used for the last few years. It is often used as a group name for metals and semimetals that have been associated with contamination and potential toxicity or ecotoxicity. Lead is the most common of the heavy elements. Several stable isotopes exist in nature, Pb being the most abundant [1]. Lead is toxic to most living organisms at high exposure and there is no demonstrated biological need. Since most of the physiologically active tissues of plants are involved in growth, maintenance, and photosynthesis, it can be expected that lead might interfere with one or more of these processes [2]. Indeed, such interactions have been observed in laboratory experiments at lead concentrations greater than those normally found in the nature, except near smelters or mines [3].

There are a variety of industrial processes that involve the use of lead such as mining, smelting, manufacture of pesticides and fertilizers, dumping of municipal sewage and the burning of fossil fuels that contain a lead additive. Lead accumulates in the body organs (i.e., brain), which may lead to poisoning or even death. The gastrointestinal tract, kidneys, and central nervous system are also affected by the presence of lead. Phytoremediation is the use of a plant's natural ability to contain, degrade, or remove toxic chemicals and pollutants from soil or water. It can be used to clean up metals, pesticides, solvents, explosives, crude oil, and contaminants that may leak from landfill sites. The term phytoremediation is a combination of two words phyto, which means plant, and remediation, which means to remedy. Scientists are investigating phytoremediation's potential by using plants such as sunflower, ragweed, cabbage and geranium, as well as other less known species. The plants are often used in combination with other traditional technologies for cleaning up contaminated sites because of the phytoremediation's limitations [4]. Contaminated soils and waters pose a major environmental and human health problem, which may be partially solved by the emerging phytoremediation technology. This cost-effective plant-based approach to remediation takes advantage of the remarkable ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues. Toxic heavy metals and organic pollutants are the major targets for phytoremediation. In recent years, knowledge of the physiological and molecular mechanisms of phytoremediation began to emerge together with biological and engineering strategies designed to optimize and improve phytoremediation [5]. In addition, several field trials confirmed the feasibility of using plants for environmental cleanup [6]. Many of several vines or shrubs of the genus Jasminum, native chiefly to Asia and having usually compound leaves and white or yellow flowers. Lead phytoextraction, using plants to extract Pb from contaminated soils, is an emerging technology. Calculations of soil Pb mass balance suggest that this technology will be economically feasible only if systems can be developed to employ high biomass plants that can accumulate greater than 1% Pb in their shoots [7].

The present research work was undertaken with following objectives:

i) To asses the Pb(II) remediation potential of *Jasminum sambac*.

ii) To evaluate the influence of soil pH and Pb(II) concentration in soil on the Pb(II) remediation potential of *Jasminum sambac*.
iii) To determine the concentration of remediated Pb(II) in different parts of *Jasminum sambac* viz. root, stem, flowers and leaves.

Results and Discussion

Jasminum sambac plants were irrigated using industrial wastewater of varied pH (3-5) and initial Pb(II) concentrations (25-400 mg/L). The deposition of lead in soil increases during the irrigation period which is 50 days (Fig. 1). The minimum amount of Pb(II) after 10 days was 495±14 mg/kg at pH 3 and maximum amount of Pb(II) reside in soil was 545±30 mg/kg at pH 5. It was found that amount of Pb(II) deposited in soil increased with increase in Pb(II) concentration in wastewater. After 50 days of irrigation as much as 1742±13 mg of Pb(II)/kg of soil sample was deposited at pH 4.5 and initial Pb(II) concentration of 400 mg/L in wastewater. Soil pH was found to be very important factor for the phytoremediation of lead. Results showed that accumulation of Pb(II) was dependent on the pH and concentration of Pb(II) in industrial wastewater. Maximum deposition of Pb(II) in soil was approximately 64 % more after 50 days of irrigation. In another study Neugeschwandtner *et al.* [8] observed maximum Pb(II) deposition of 544±69 mg/kg in Czech Republic soil. Keeling and Werrn [9] analyzed metal contaminated soil and found 3.023 µg/g Pb(II) concentration in it. Haque *et al.* [10] found 207.4±1.3 mg of Pb(II)/kg of soil in Arizona, USA. In another study Tanhan *et al.* [11] found 979.3 mg of Pb(II)/kg of soil. The result of all these studies indicated higher Pb(II) concentration present in soil than the recommended one. Contaminated soils pose a major environmental and human health problem, which may be partially solved by the emerging phytoremediation technology.

Wastewater pH was also found to be important parameter in Pb(II) uptake. The lowest Pb(II) contents in *Jasminum sambac* were 589±45mg/kg at pH 3 and the maximum bioaccumulation of Pb(II) was 681±46 mg/kg at pH 4.5 after 10 days. The maximum amount of Pb(II) bioaccumulated in *Jasminum sambac* roots was 1169±35 mg/kg at pH 4.5 and minimum uptake of lead was 756±6 mg/kg after 50 days. While studying the effect of initial Pb(II) concentration it was found that 1308±25 of Pb(II) deposited per kilogram of root sample after 50 days (Fig. 2). Roots of *Jasminum sambac* approximately accumulated 49 % more Pb(II) than stem. *Jasminum sambac* was found to be hyper-accumulator as amount of Pb(II) accumulated in it exceed 1000 mg/kg. Keeling and Werrn [9] found 6,015-12,000 µg/g of Pb(II) in roots of Rhodes Grass. In Siam weed maximum amount of Pb found in roots was 4236.0±799.1 mg/kg [11].

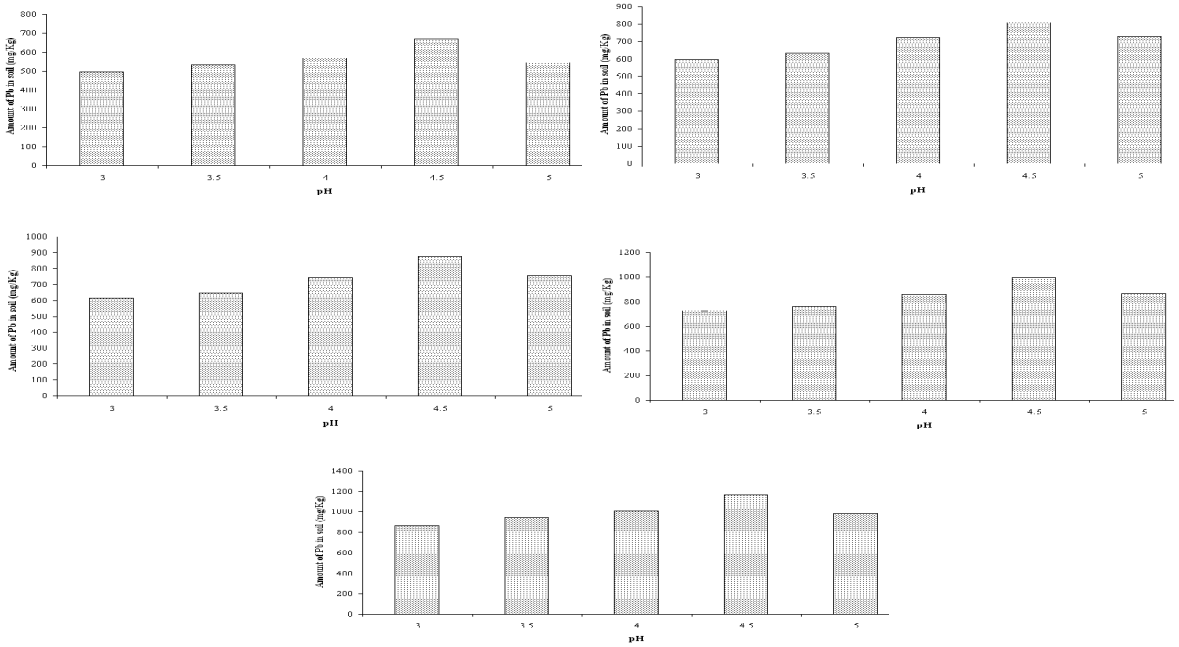

Fig. 1: Effect of pH on the deposition of Pb(II) by the soil after 10days (1a), 20 days (1b), 30 days (1c), 40 days (1d), and 50 days (1e).

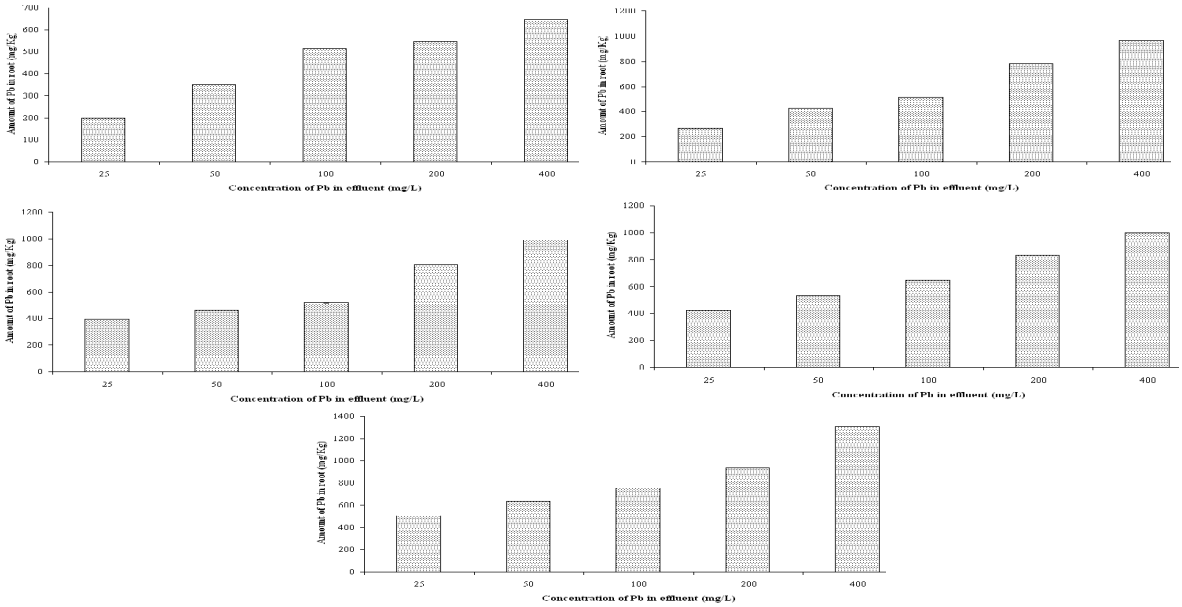

Fig. 2: Effect of concentration on bioaccumulation of Pb(II) by *Jasminum sambac* roots after 10 days(2f), 20 days (2g), 30 days (2h), 40 days (2i), and 50days (2j).

Pb(II) bioaccumulation in the *Jasminum sambac* leaves has minimum value of 316.50±1.10 mg/kg at pH 3 and maximum value at 663±5 mg/kg at pH 5 after 10 days. With the passage of time the uptake of Pb(II) increased in leaves. After 50 days the maximum concentration of Pb(II) in leaves was 789±4 mg/kg at pH 5 (Fig. 3). While studying the effect of initial Pb(II) concentration, the maximum Pb(II) accumulation in *Jasminum sambac* leaves was found to be 825±6 mg/kg at 400 mg/L after 50 days of treatment. Leaves of the *Jasminum sambac* accumulated a high amount of Pb(II) but it was not toxic to environment and food chain if contaminated leaves managed properly. *Jasminum sambac* is an ornamental plant which is grown for its beautiful fragrance rather than leaves. Higher Pb(II) accumulation in leaves suggesting the easy way to get rid from this toxic metal. In another study Varnay *et al.* [12] used leaves of *Lolium perenne* L. to accumulate Cr. They found 207±10.8µg of Cr/g of *Lolium perenne* L. leaves at 500 mg/L after 45 days of treatment [12].

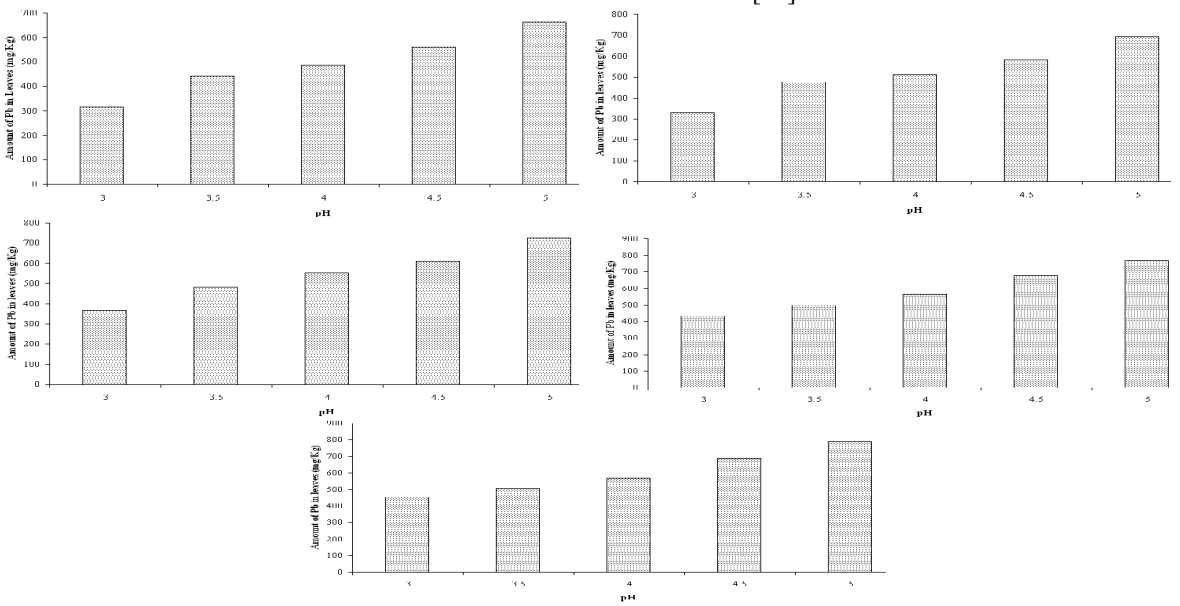

Fig. 3: Effect of pH on bioaccumulation of Pb(II) by *Jasminum sambac* leaves after 10 days (3a), 20 days (3b), 30 days (3c), 40 days (3d), and 50 days (3e).

The *Jasminum sambac* stem was also analyzed to determine the Pb(II) contents in it (Fig. 4). While studying the effect of pH maximum Pb(II) concentration of 306±5 mg/kg was detected at pH 5 after 50 days. The minimum Pb(II) contents were 224±7 mg/kg at pH 3 after 50 days. During evaluation of effect of initial Pb(II) concentration after 50 days maximum of 339±6 mg/kg of Pb(II) was detected in *Jasminum sambac* stem. Accumulation of Pb(II) in *Jasminum sambac* stem was very low in comparison to *Jasminum sambac* roots and leaves. This suggested that *Jasminum sambac* stem act as only Pb(II) transporter not as Pb(II) accumulator. In other studies similar type of results were found. Haque *et al.* [10] detected 107.3 mg of Pb(II) per kilogram of *Baccharis sarothroides* shoots. In another study maximum amount of Pb (II) in shoots of Siam weed was 1377±13 mg/kg [11].

After 50 days of experiment the minimum and maximum Pb(II) amounts detected in *Jasmine sambac* flowers were 2.11±0.7 mg of Pb(II)/kg at 25 mg/L and 3.98±0.9 mg/kg at 400 mg/L, respectively. The flowers of *Jasminum sambac* are an important part of the plant. *Jasminum sambac* flowers are cultivated for production of its essential oil having unique fragrance for perfumery. The bioaccumulation of Pb(II) in flowers was very low as compared with other plant parts (Fig. 5). These results suggested that *Jasminum sambac* can be cultivated at Pb(II) contaminated area without transferring too much toxic Pb(II) into its flowers and it will remediate Pb(II) as well as still useful for commercial essential oil production.

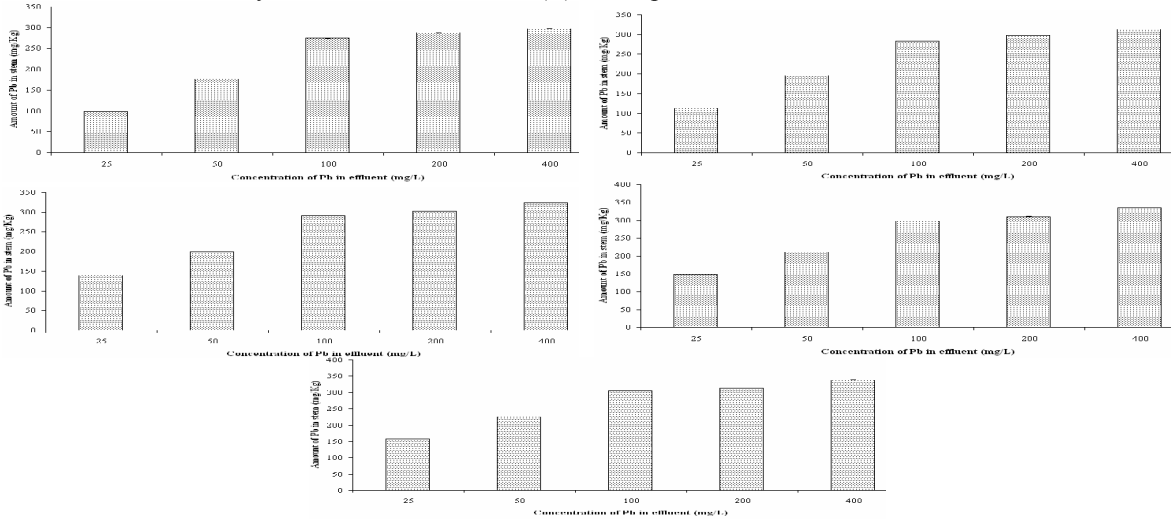

Fig. 4: Effect of concentration on bioaccumulation of Pb(II) by *Jasminum sambac* stem after 10 days (4f), 20 days (4g), 30 days (4h), 40 days (4i) and 50 days (4j).

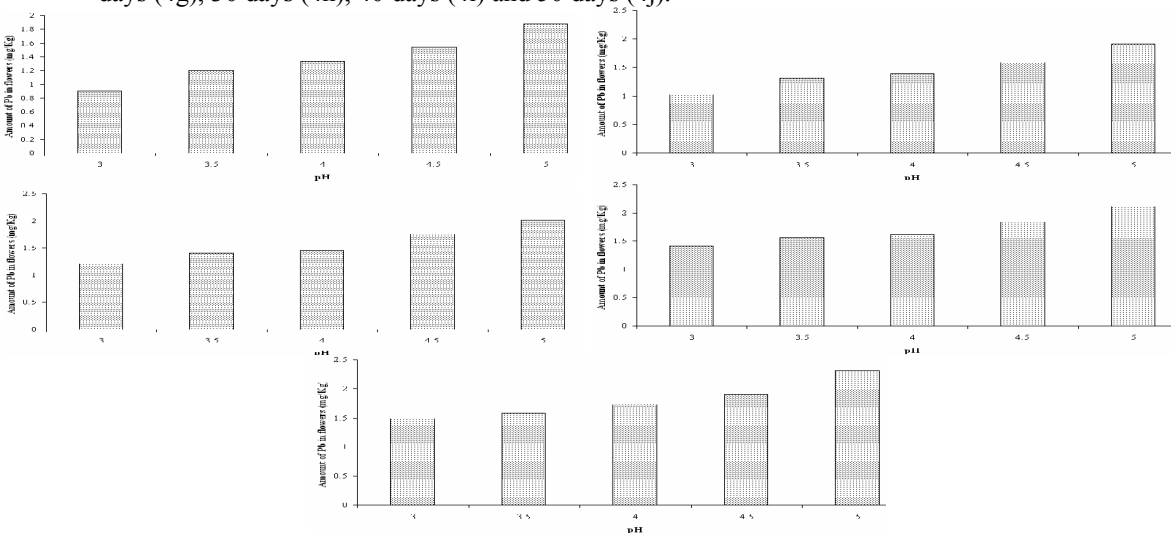

Fig. 5: Effect of pH on bioaccumulation of Pb(II) by *Jasminum sambac* flowers after 10 days (5a), 20 days (5b), 30 days (5c), 40 days (5d) and 50 days (5e).

Experimental

Chemicals and Reagents

All the chemicals and reagents used in this study were of analytical grade including $Pb(NO_3)_2$, HNO_3, H_2O_2, HCl, NaOH and Pb(II) stand solution (1000 mg/L) for atomic absorption spectrometry.

Biomass Cultivation and Pb (II) Phytoremediation

Jasminum sambac plants were irrigated using industrial wastewater contaminated with Pb(II). The concentration of Pb(II) in wastewater was varied from 25-400 mg/L. The control treatments were maintained in all experiments. Plants were grown under controlled conditions in Green House from May to August 2009 at Rose Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan. The plants were planted in mud pots. Five replicates were selected for a single treatment. After the cultivation, plants were exposed to different conditions of soil pH (3-5) and concentrations of lead (25-400 mg/L) by watering plants using lead contaminated stagnant water. Subsequently, soil and plant parts viz. leaves, flowers, stem and roots samples were collected after a predetermined time interval of 10 days. The collected plant parts were extensively washed with deionized distilled water (DDW) to remove dust particles and debris. Soil and parts of plant samples were at first sun dried following by drying in an oven at 60 $^{\circ}$C for 24 h.

Digestion of Biomass Samples

Fully dried plant samples were grounded into a powdered form to increase homogeneity of collected samples. One gram of dried and powdered leaves, flowers, stem, root and soil samples were wet digested. Each sample (1g) was mixed thoroughly in cold with 20 mL of concentrated nitric acid in a 100 mL glass beaker. The sample was slowly heated at ≈70°C on an electric plate in a fume hood. When the volume of sample was reduced up to half, 5 mL of hydrogen peroxide were added. After heating for 10 min more at same temperature, the sample was removed from electric plate. The sample was allowed to cool down to room temperature. Afterward the volume of sample was made up to 50 mL by addition of DDW. Finally sample was filtered using Whatmann filter paper no. 40 and stored at 4 °C until analysis [13].

Determination of Pb(II) Concentration

The concentration of Pb (II) in the leaves, flowers, stem, root and soil was determined by Flame AAS using a Perkin-Elmer Aanalyst 300 Atomic Absorption Spectrophotometer equipped with an air acetylene flame. The hollow cathode lamp was operated at analytical wavelength of 232 nm for Pb(II) and slit as 0.2 nm for both metal ions.

Statistical Analysis

All experiments were done in triplicate and results are reported as mean value± SD values. Microsoft Excel 2003, version Office XP was used for statistical analysis. The error bars shown in figures represents mean ± SD values.

Conclusions

Pb(II) accumulation was higher at pH 5 for an initial Pb(II) concentration of 400 mg/L in industrial wastewater. Pb(II) accumulation in different *Jasmine sambac* parts were in following order: roots > leaves > stem >>> flowers. *Jasmine sambac* flowers accumulated too low Pb(II) concentration which suggests that the plant is still useful for essential oil production.

References

1. K. Michael, T. Pavel, S. Jirina, C. Vladislav and E. Vojtech, *Chemosphere*, **67**, 640 (2007).
2. E. W. Wilde, R. L. Brigmon, D. L. Dunn, M. A. Heitkamp and D. C. Dagnan, *Chemosphere*, **61** 1451 (2005).
3. F. J. Ager, M. D. Ynsa, J. R. Domínguez, M. C. L. Martín, C. Gotor and L. C. Romero, *Nuclear Instruments and Methods in Physics Research*, **210**, 401 (2003).
4. S. Clemens, *Planta*, **212**, 475 (2001).
5. N. Terry, *Plant Physiology*, **106**, 133 (2006).
6. D. E. Salt, R. D. Smith and I. Raskin, *Biotechnology*, **49**, 643 (1998).
7. J. W. Huang, J. Chen, W. R. Berti and S. D. Cunningham, *Environmental Science and Technology*, **31**, 800 (1997).
8. R. W. Neugeschwandtner, P. Tlustos, M. Komarek and J. Szakova, *Geoderma*, **144**, 446 (2008).
9. S. M. Keeling and G. Werrn, *Journal of Environment Cleanup Costs*, *Techniques and Technologies*, **15**, 53 (2005).
10. N. Haque, J. R. Peralta-Videa, G. L. Jones, T. E. Gill and J. L. Gardea-Torresday, *Environmental Pollution*, **153** 362 (2008).

11. P. Tanhan, M. Kruatrachue, P. Pokethitiyook and R. Chaiyarat, *Chemosphore*, **68** 323 (2007).
12. P. Varnay, C. Gauthier-Moussard, and A. Hitmi, *Chemosphore*, **68**, 1563 (2007).
13. A. Zubair, H. N. Bhatti, M. A. Hanif and F. Shafqat, *Water*, *Air and Soil Pollution*, **191**, 305 (2008).