Phytoremediation Mechanisms of Mercury (Hg) between some plants and soils in Baghdad City

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Abstract: The phytoremediation is a natural plant for the treatment of heavy metals in soil polluted, which is a few of its kind in the city of Baghdad, where the current study was carried out by collecting three types of plants (*Eucalyptus camaldulensis*, *Dodonaea viscosa* and *Cynodon dactylon*) with soil samples for each region (soil surrounding the plant and far soil). In addition to a control soil sample from the University of Baghdad College of Engineering to identify soil contaminants in public parks and roads with Mercury and choose ten regions (5 regions of Karkh - 5 regions of the Rusafa side) with control, and determine the physical properties pH and soil texture. Results showed that there was a positive correlation between plant type and Mercury absorption in the study areas depending on absorption capacity in three dominant plants respectively: *C. dactylon*> *E. camaldulensis*> *D. viscosa,* (0.44, 0.31 and 0.16) ppm respectively in positive correlation coefficients P values greater than 0.050 (P= 0.46). Soil pH was measured for all studied samples with alkaline ranges (7.35 - 7.8). High pH values in urban soil were due to the high percentage of carbonate, ash and waste from human activity. High pH in irrigation could contribute to alkaline soil increase which in turn leads to restrict the movement of heavy metals, which affect the solubility of soil and retention of minerals was also measured soil texture of the samples studied and showed that most of the soil was sandy loam. Bioconcentration Factor determines the movement of lead from the roots to the aerial parts of the plant.

Keywords: Phytoremediation, Bioconcentration, plants and soils

1. Introduction

Baghdad is the capital of Iraq (33°14'-33°25'N, 44°31'-44°17'E), located in the alluvial plain of Mesopotamian. Tigris River distributes in this city into a left (Risafa) and right (Karkh) sides with a flood direction from north to south. The source of the soil in Baghdad city from river origin and consisted of deposits of Tigris River. It contains a large variety of sediment sizes It is a soil that is not homogeneous in its properties. its affected by the desert climate, the city witnessed strong dust storms coincided with high temperatures and attributed to global warming, the high carbon component, and the city suffers from several problems such as desertification, soil erosion and drought (Al shukargie and Al khzai, 2011).

A soil is a large reservoir for contaminants to able binding various chemicals. These chemicals can occur in different forms in soil, variability of soil and some environmental properties such as climate influences may change stability found in soil and cause discharge of heavy metals strongly bound to the soil particles (Dube, *et al.*, 2001). The main source of soil pollution come from chemical, mining and processing industries. These wastes contain varieties of chemicals from heavy metals, organic and non-metals (Asati *et al.*, 2016). The soils composed essentially of a mixture of resources different from those in forest areas or adjacent agricultural presenting a surface layer more than 50 cm, and transformed deeply by human activity concluded mixing, exporting material and importing by contamination (Christian, *et al.*, 2000) . Basic main pollutants and chemicals components have a tendency to stick to the environment such as cadmium, lead, mercury or copper and others. Minerals in the biotic environment originate from two separate sources of geological processes related to metal fillings geological formations and human resources. Primary contaminants cannot be degraded more so they can undergo different reversible changes in belonging depending on the chemical environment (Campbell et al; 2006).Many elements are necessary for life functions (Mertz, 1981), and plants and animals possess different mechanisms for accumulating sufficient amounts of elements from their environment also facilitate the treatment of non-essential minerals (Ballatori, 2002;Zalups and Ahmad, 2003).

Eucalptus (Class: Magnoliopsida, Family: Myrtaceae, Gens: *Eucalyptus Sp).*

This genus is diverse of shrubs, flowering trees and evergreen, there are more than 700 species native to Australia (Butcher, *et al.*, 2009). Range of which many eucalypts can be planted in the temperate zone is constrained by their limited tolerance, featured these species desirable traits fast-growing sources, producing oil that used for cleaning and as a natural insecticide and an ability to be used to drain swamps and thereby reduce the risk in nature (Hirakawa, *et al.*, 2011) .

Cynodon (Class: Magnoliopsida, Family: Poaceae, Genus: *Cynodon Sp*.)

Widely grown in warm climates all over the world. It is fast-growing. It is a highly desirable turf grass in warm temperate climates, particularly in those regions where its heat and drought tolerance. About

Dodonaea ***(***Class:Magnoliopsida,Family: Sapindaceae, Genus: *Dodonaea Sp)*

Easily occupies open areas and secondary forest, and is resistant to salinity, drought and pollution. It can be used for dune stabilization, remediation of polluted lands and for reforestation. The plant is tolerant to strong winds, and therefore is commonly used as hedge, windbreak, and decorative shrub (Felger and Moser, 1985).

In plants accumulators survive despite concentrating contaminants in their aerial tissues, biodegrade the contaminants into inert forms in their tissues the excluders restrict contaminant uptake into their biomass. Plants have evolved highly specific and very efficient mechanisms to obtain essential micronutrients from the environment, even when present at low ppm levels. Plant roots, aided by plant-produced chelating agents and plant-induced pH changes and redox reactions, are able to solubilize and take up micronutrients from very low levels in the soil, even from nearly insoluble precipitates. Plants have also evolved highly specific mechanisms to translocate and store micronutrients. These same mechanisms are also involved in the uptake, translocation, and storage of toxic elements, whose chemical properties simulate those of essential elements. Thus, micronutrient uptake mechanisms are of great interest to phytoremediation (Tangahu, *et al*., 2011). Transport mechanism is likely to take up a range of ions. A basic problem is the interaction of ionic species during uptake of various heavy metal contaminants. After uptake by roots, translocation into shoots is desirable because the harvest of root biomass is generally not feasible. Little is known regarding the forms in which metal ions are transported from the roots to the shoots (Tangahu, *et al*., 2011).

2. Materials and Methods

Eleven basic stations were chosen in this study of Baghdad province between the sides of Karkh and Rusafa with control, of each area were labeled it depending coordinates these locations were determined by the (GPS/ Geko 201, Taiwan).

1- Environmental Samples: Soil Samples were collected by using cleaned polyethylene bags from 10 cm in depth.

2- Biological Samples: Plants were surveyed this area and selected most common plants**,** collected in cleaned polyethylene bags. Three basic species of plants were chosen *Eucalyptus camaldulensis, Dodonaea viscosa* and *Cynodon dactylon.*

Plants samples were collected and then rinsed thoroughly with deionized water and dried in the outdoor in room temperature for (3-5) days then ground with an agate mortar to be ready before analysis, selected with surrounding soil for each plant type from the same area, and collected a one sample of soil far the plants as the same area, becomes the total samples three types plants, three soil surrounding it as well as soil far from the plants (Three plants, Four soil for one area).

Preparing Experimental and Analysis:

Mechanical Working of Milestone's Direct Mercury Analyzer (DMA-80)

Directly analysis to any sample solid or liquid at the same time without need to preparation of sample liquid or solid sample into metal boat or quartz and then transfer sample from DMA-80 to the analytical balance need five minutes for one sample, no need acid digestion. Sample boats loaded on to instrument auto sampler, first dried then thermally decomposed in furnace oxygen. Mercury and combustion products released from the sample and carried to the catalyst section furnace, where sulfur oxides and nitrogen. Mercury (Hg) is flown by the transferor gas into path of the spectrophotometer where it is quantitatively measured. All systems of information are kept on a Windows-based computer and software, providing simple and intuitive, Sample parameters including method profile, furnace temperatures, absorbance signals. The results and calibrations are saved information is easily transferred by using a USB memory to Laptop Laboratory (USEPA, 2006).

Method validation was used as certificate reference material CRM as in Table (2-1) (Gaithersburg, MD, USA, 2013) was utilized to assess the accuracy of the method. Developed spike recoveries were performed on this material as well as samples according (Ataro *et al*., 2008 and Nascimento *et al*., 2008). This principle was used for all sample analysis. This typically contains an automatic sampler, quartz furnace, cobalt-manganese oxide catalyst, gold-coated sand amalgamator and an atomic absorption detection cell with three different path lengths (120,165 and 4mm). The method for solid sample analysis consists of placing a known amount of milled sample in a nickel or quartz boat (Sample holder). The sample is introduced in the quartz furnace, where it is heated up to 200 °C (drying temperature) for 600-1000 C, Maximum temperature allowed by the software of equipment about 105 which set a limit mercury volatilization and reduction of Oxygen O2 (99.99%) (CEM Corporation, Matthews, USA, 2013).

Table (2-1) Method validation was used as certificate reference material CRM

Wavelength	Step	Time	CRM and SRM	Type
Gas Flow (L min-1)	150	12 min	IAEA-140TM	Plants
Plasma 15	170	16 min	TORT-2	Mollusk
Auxiliary 0.2	100	15 min	DORM -2	fish
Nebulizer 0.8	100	10 min	0	blank
Read delay (s) 75	200	25 min	NIST 2709	soil
Replicates 5	175-200	One time to each	SRM-1974b	water
Probe in sample (n)	100	10	0	blank
Rinse (n)	100	10	0	Blank

A-PH: Measure the pH values of a suspended solution from the soil with the pH meter. Prepare the suspended solution from the soil by taking 50 g of the sample of the previously dehydrated and dehydrated soil. Add 50 mL distilled water. Mix the solution well and leave for 30 minutes stirring every few minutes. After leaving the solution suspended for a full hour, after the expiration of the full hour was well blended (Icarda, 2001).

B- Soil Texture: Hydrometer method was used to measure the content of silt and clay according to (Icarda, 2001). The soil size of the soil was dehydrated and precipitated. The size distribution of the soil components was generally determined for the sand particles (0.05-2mm), the clay particles (0.002-0.05mm) and clay particles (0.002mm <). Solutions used prepare to dissolve (40 g) of Sodium hexameta phosphate (Na Po3) 13 and (10 g) of Sodium carbonate (Na2Co3) in distilled water, and complete the volume to 1 liter with distilled water and the method of work to take the weight (40 g) of the soil,, 60 mL of solution A was added, and the solution was left after 24 hours of coverage, then placed in the blender Distilled water was added to about three quarters the size of the blender cup, blending for 3 minutes Then take the resulting suspension solution and leave for 1 minute, then transfer to a liter of hydrometer cylinder and complete volume with distilled water.

The statistical analysis was performed according to the AOAC Protocol (Thompson, 2006) was assessed using different measures of statistical and coefficient of determination correlation coefficient, mean prediction error concentration of component standard method. The coefficient of determination, r^2, was calculated where N is the total number of paired observations. A value of $r^2 = 1$ indicates 100% precision between the methods.

3. Results and Discussion

Physical Properties of Soil:

PH: The results showed that the PH values for all the studied soils samples were alkaline and ranged between (7.35-7.80) .This finding is similar to (Madrid *et al*, 2002), where the pH of the soil of the city gardens (Seville) is between 7.3-8.0 and also close to that of (Kafoor, *et al*., 2014), when it was found that the pH To irrigate the Erbil Gardens ranges between (7.26-8.23) that the high values of pH of urban soil is due to the high percentage of carbonates, ash and waste resulting from activity (Ge, *et al.,* 2000; Lu *and Bai,* 2010), where it was found that in the soils, heavy metals bind with carbonates and this restricts their movement (Kabata-Pendias, 2011). as well as alkaline components in the atmosphere that can be deposited (Kim, *et al*., 1996). In soil soils, higher uptake of heavy metals occurs due to an increase in the number of negatively charged soil particles, which leads to slow or determined mineral movement in the soil. Also, the high pH of the water Irrigation may contribute to increased alkalinity of soil, where some researchers reported that irrigation water leads to increased pH of the soil (HCO3), salinity and nutrients (Chen, *et al*., 2005), where the ability of soils to restrict the movement of heavy metals increases with the elevation of the pH, under equal conditions to the base chromium is highly moving while cadmium, zinc and to non-moving respectively (Chopra, *et al.,* 2009). Soil acidity has a higher effect on soil solubility and mineral retention, where higher mineral retention and solubility occurs when soil pH is higher (Skrbic, *et al.,* 2002).

Texture Soil: The soil granules were measured for the studied areas of the gardens of the city of Baghdad and it was found that most of the soils were Sandy Loam and as shown in Table (1). This is due to an interaction between the size particle infractions and plays a role in the different findings in soil, the sand very important of skeleton while silt and clay particles primarily coat the surfaces of the sand grains and act as bridges between them (Davey, 1978; Chenu, *et al*., 2001). In unsaturated soils, the parameter that determines water phase connectivity is the pore size distribution, which is in turn controlled by bulk density and particle size distribution (soil texture). Pore size and shape determine the relative magnitudes of capillary, viscous and gravitational forces, thereby controlling the water content and configuration within a pore. The location of a microhabitat in the three-dimensional pore network is of utmost importance in determining the hydrologic regime it experiences. In moist soils (e.g., those at field capacity), water films in larger pores are held by surface tension (capillary forces) in crevices on the surfaces and at the edges of pores where soil grains meet. Smaller pores in which capillary forces are stronger may be saturated at field capacity.

Table (1) Shows PH concentrations and Texture soil in the study areas

Station	PH	Texture
S.1	7.8	Sandy Loam
S.2	7.53	Sandy Clay Loam
S.3	7.45	Sandy Loam
S.4	7.57	Sandy Loam
S.5	7.61	Sandy Loam
S.6	7.39	Sandy Clay Loam
S.7	7.59	Sandy Clay Loam
S.8	7.72	Sandy Loam
S.9	7.35	Sandy Loam
S.10	7.47	Sandy Loam
S.11	7.33	Sandy Clay Loam

Mercury (Hg) Concentrations in Plants Types and Soil:

Results showed presence of Mercury concentration in all plants but differ from one to other depending on the ability to absorb this element and content in three dominate plants species, Consecutively: C. dactylon> E. camaldulensis> D. viscosa, that's mean used it as a positive indicator of mercury pollution in study areas in Baghdad.

Through statistical analysis scored a significant between element and plants in percentage of corresponding (22% 0.19% 0.13) respectively, this is consistent with some of the researchers in the same element for plants C. dactylon between (2.14 –1.16) ppm in Spanish (Miguel Angel, et al., 2015). D. viscosa (3.4) ppm in Portugal (Naser, et al., 2012). Also in local studied (Ajmi, 2012) found E. camaldulensis between (4.3-16.9) ppm. This refers plants are known in accumulating metals from around it environment (Al-Haidary, 2009; Ajmi 2010). Table (2) showed the concentration of mercury in plants under study.

Table (2) Approach1 the concentration of mercury in all types plants in study area.

Study Areas	**Mercury in Samples (ppm)**		
	C. dactylon.	***E. camaldulensis***	***D. viscosa***
1	0.44	0.19	0.17
2	0.82	0.32	0.03
3	0.63	0.45	0.18
4	0.24	0.12	0.34
5	0.33	0.84	0.34
6	0.2	0.98	0.58
Average	0.44	0.33	0.19
SD	0.9	0.7	0.5
P-Value	0.008	0.013	0.024

After obtaining the results of mercury concentration in soil and plants , this study showed that level this element concentration between (0.951, 2.017) ppm . There was no significant correlation P-Value (0.001, 0.021). It was not of a critical level set by WHO and EUO (UNEP, 2001). Most concentrations of Mercury in analyses sigma plot were P-value < 0.05 and percentage 39% in Soil and (17 %) in plants compared to some researchers reported (Houserov´a, et al., 2007, Ullrich, et al., 2007). These results of Mercury concentration were relatively constant that may reflect that mercury input and deposition in sites under study and may be relatively constant during ten recent years, which reflects a fact that Hg concentration is not the only influencing factor this results agree with (Horvat, et al., 2003). May be some environment conditions such as nutrient and redox conditions depending on the specialty of this location, therefore the explanation of mercury vertical distribution in soil and plants were risk complex indirectly the biosphere by bioaccumulation and inclusion in the food chain, and transmission consecutively of healthy people.

Table (3) Percentage concentration of mercury in Soil and Plants in study area

Study Areas	*Groups1* Plants	*Groups2* Soil
1	0.96	1.9
2	0.58	2.2
3	1.39	2.5
4	0.79	2.3
5	0.88	1.2
6	1.07	2
7	0.99	2
8	1.92	0.82
9	0.33	1.22
10	0.28	0.35
11	0.82	0.56
Average	0.951	2.017
SD	0.274	0.454
P-Value	0.001	0.021

Mercury in samples can be used to compare different pollution in sites and essential to understanding the current risks to all organism in ecosystem a rapid distribution of development of urbanization and industrialization some plant species have the ability to grow and develop in metalliferous soils such as near to mining sites (Gardea-Torresdey, et al., 2005) .Such plants can be used to clean up heavy metal contaminated sites are examples of plants widely used to remediate heavy metal contaminated soils (Rylott and Bruce, 2008). Bioconcentration Factor (BCF) represents the ability to extract Mercury from the soil and plants species (*Cynodon dactylon, Eucalyptus camaldulensis, Dodonea viscosa*) respectively. BCF values of indicate movement element from the soil to the plant , concentration that is accumulated by plants and largely stored in the leaf of plants greater than one indicate translocation to the aerial parts of the plant and translocation factor of each metal under investigation at the respective sites to determine the transfer this concentration from roots to the aerial parts of the plant (Wuana and Okieimen, 2011).

4. Conclusion

Through the results of the Mercury concentration that have been obtained from analyzed samples were reached of the bioindication environmental and how to transition in ecosystem of the Baghdad city . The mercury accumulation in aquatic food chains Increasing gradually in soil and plants and that means the accumulated element through weathering and shelf of the river practical source through the seasons of the year. Average Mercury in soil of the surrounding environment would enhance the metabolism of the plants.

Recommendation

Strongly support the more intensive sampling to represent the spatial distribution of the risks of other elements in all Baghdad areas and focus on working spatial information about the idea of the relative risk between variables in environmental and biological factors in the food web by other new technologies such as Telescope and Remote Sensing to get a whole integrated database and allows users to evaluate potential policy options and poses better questions to decision makers seeking to protect susceptible populations community .

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