Original Article

A Study of the Environmental Characteristics of the Alhagi plant and its Ability to Withdraw Cadmium from the Soil of Baquba District - Diyala Governorate

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Abstract

The current study is carried out from 01/Sep./2021 to 27/Sep./2021 in four sub-districts, which are Buhruz, Kanaan, Muhammad Sukran and Khan BaniSaad belonging to Baquba district inDiyala governorate. It is conducted by collecting three samples of Alhagi plant with its soil from agricultural and non-agricultural lands, and three compound soil samples from virgin, uncultivated lands for each site. The aim is todetect the concentration of cadmium (Cd) in both, the soil and the Alhagi plant to determine some environmental characteristics, which are the bio-concentration factor (BC), translocation factor (TF), and bioaccumulation coefficient (BAC).Where the plant plays an important role in maintaining the ecological balance by participating in the nutrient cycle, as well as providing a huge root and leaf space to repel, absorb and accumulate heavy elements. The results showed that there were significant differences between the treatments of the site, as the bioconcentration coefficient of cadmium recorded the highest average in the third site and the treatment of non-agricultural soil by 0.118 ± 0.921 and 0.084 ± 0.931, respectively. As for the transmission coefficient, the highest average was recorded in the first site and the treatment of non-agricultural soil with 0.095 ± 1.0576 and 0.067 ± 1,147, respectively. As for the bioaccumulation coefficient of cadmium, the highest average was recorded in the first site and the non-agricultural soil treatment was 0.121± 1.345 and 0.086 ± 1.030.

Keywords: Bio-concentration Factor, TransferFactor, Bioaccumulation Coefficient, cadmium.

INTRODUCTION

Heavy metal pollution is one of the biggest environmental problems resulting from various human activities in the environment. Environmental pollution with heavy metals comes at the forefront of the problems, as it is considered more toxic because heavy elements are not degradable and remain in the soil as long as possible without any chemical change to it (Tahseen, 2019).

Plants such as the Salsolaimbricataplants and Alhagi play an important role in withdrawing pollutants or elements from the environment by a process called phytoremediation. Thesearetwo of the most prominent plants that spread in the saline areas and wet areas in Iraq in general and in the south in particular. The climatic conditions in those areas are also used as bio-indicators of pollution (Al-Jurani, 2013).

The bio-concentration factor (BCF) refers to the efficiency of the plant in accumulating pollutants in its tissues. The bio-concentration factor is calculated as the ratio of the concentration of the pollutant in the harvested plant to its concentration in the soil (Wu et al., 2018). A (BCF) value greater than one indicates that the plant is an over-accumulator, while a value less than one indicates that the plant is not an accumulator (Roudposhtiet al., 2016).

The Translocation Factor (TF) represents the ability of the plant to transfer pollutants from the roots to the aerial parts of the plant. It is calculated as the ratio of the concentration of the heavy element in the aerial parts of the plant to the concentration of the heavy element in the root system of the plant (Mireckiet. al., 2015).The value of TF determines the efficiency of the plant in the transfer of heavy elements from the root to the branch. The transfer factor is higher than one and this is due to the effective transport system of elements. However, values of the transfer factor of less than one indicate ineffective transport of elements, which indicates that the accumulation of elements in the roots is more than in the buds or leaves (Purwaning and Takarina, 2022). As for the bioaccumulation factor, it is the concentration of heavy elements in plant buds divided by the concentration of the heavy element in the soil. The phenomenon of accumulation of heavy elements is one of the natural phenomena in plants that have the ability to accumulate heavy elements in their tissues without the appearance of toxic symptoms on it. It is called accumulating plants when the percentage of element accumulation in the vegetative group to the root system is greater than one.On the other hand, the non-accumulated plants have a percentage of accumulation of the element less than one (Ouda and Nasir, 2021).

Abdel-Wahab (2020) indicates in a study of agricultural soils and four types of field plants, namely sunflower, turnip, carrot and Indian mustard in Diyalagovernorate that the bio-concentration factor is recorded as the highest value for Indian mustard, followed by turnip, sunflower and carrot for each of the cadmium, copper, nickel, and lead elements, respectively.

El- Sherbinyet al. (2019)has conducted a study in a cement factory in the city of Rabigh in the western part of the Kingdom of Saudi Arabia, where 20 samples of surface soil with a depth of 20 cm and 20 samples of ZygophyllumcoccineumL.are collected for each of the chromium, nickel, lead and zinc elements. They show that the biological concentration has had the highest values of 1.19, 0.50, and 0.31 for zinc, copper and nickel, respectively, as the Z. coccineum L.plant is considered an accumulation of zinc only.

Farhan and Al-Jubouri (2019) in a study of four sites in Wasit Governorate, namely the power plant in Zubaidia, the licorice plant in Aziziyah, the textile factory in Kut and the brick factory show that the Translocation Factor (TF) of the chard plant for the elements cadmium, zinc and copper is recorded in values that range between 0.92 - 1.82, 0.64 - 1.49, 0.55 - 1.28, respectively, while the average TranslocationFactor (TF) of zinc in the Malvaparviflora (khobiza) plant is 0.744.

In a study by Chaouaet al. (2016) in Marrakesh, Morocco, sewage samples and 15 soil samples are collected from a depth of 0-20 cm. Moreover,a number of vegetable samples are also collected, namely broad beans, durum wheat, soft wheat, oats, nettles, broad plantain and alfalfa. They mention that the average TranslocationFactor ranges from 0.277-0.801, 0.134-0.905, 0.319-0.922, 0-0.744 for each of the zinc, copper, lead, and cadmium elements, respectively.

In another study in Kosovska, southern Serbia, Mireckiet al. (2015) have taken 25 plant samples and 6 compound soil samples with a depth of 0-20 cm. The TranslocationFactor in all samples has recorded values ranging between 0.5-0.1 for cadmium and 0.001-0.2 for lead, when compared with the control plants having the TranslocationFactor values ranging from 0.001-0.1.

Farhood (2019) in a study using the sedge plant Cyperuspapyrus in southern Iraq as an indicator of the bioaccumulation of some heavy elements, namely lead, copper and cadmium has indicated that the concentration of these elements is affected by the changing seasons, human activity and climate factors, as the sedge plant has a great ability to accumulate heavy elements and considered a good biological marker for this type of pollution.

In a study conducted in the Tanta Directorate - Egypt, which include three types of urban, agricultural and industrial sample soils taken from the middle of the Nile Delta with a castor plant sample, Eltaheret. al.(2019) have indicated that the bioaccumulation factorhas recorded values less than one for the castor plant and for all elements, as follows: Zinc > Lead > Copper >cadmium.

In a study performed by Islam et al. (2020) near Buriganga River in Bangladesh, a variety of vegetables are collected, namely red amaranth, spinach, jet, squash, green mustard and water spinach from six different locations. They have foundthat the bioaccumulation factorhas recorded values greater than one and for all heavy elements, namely chromium, nickel, copper, zinc, cadmium and lead in all plants. This indicates that they are all accumulating plants.

Material and Methods:

First: Description of the Studied Area

Baquba district is one of the Iraqi districts with its center in the city of Baquba, and is regarded as the largest district in terms of population in the governorate.It consists of an area of 580 km2, and includes several sub-districts: Al-Farrasub-district, Muhammad Sakransub-district, Buhruzsub-district, Kanaansub-district, Khan BaniSaadsub-district, and Ghalibiyasub-district. This study is conducted in Buhruz, Kanaan, Muhammad Sukran and Khan BaniSaadsub-districts / Diyala governorate (Muhammad et al., 2021).

Second: Sampling Collection

The study samples are collected from four sites in Diyala Governorate / Baquba District, namely Buhruz, Kanaan, Muhammad Sukran, and Khan BaniSaad sub-districts from 01/Sep./2021 to 27/Sep./2021. They are three samples of the Alhagiplant with its soil from agricultural and non-agricultural lands and three compound samples from the soil of virgin lands. The samples are placed in polyethylene bags with the sample number and the name of the site written on it. The plant is then washed and the root separated from the stem and dried aerobically. After that, the samples are grounded, passed through a 2 mm sieve, collected in plastic boxes, and weighed at 5 g for each sample. Finally, they are transferred to the laboratories of the Ministry of Science, Department of Environment and Water to estimate the concentration of cadmium (Cd) by means of a Japanese spectrophotometerApsorptioAtomic absorption model AA7000.

Third: Sample Preparation

1. Estimating elements in the soil:

An amount of 0.5 gm of dry, ground soil is taken, placed in a beaker glass and 5 ml of concentrated nitric acid HNO_3 of %70 is added to it. Then, the sample is placed on a hot plate for an hour at a temperature of 105 °C. After that,the sample is cooled and 10 ml of distilled water is added. The sample is mixed well By a Rolex rotary device for 10 minutes, left to precipitate the solids, transferred to a centrifuge at a speed of 2000 rpm, and filtered with 0.45 Whattman filter paper. The volume is supplemented with distilled water up to 50 ml, and the sample is read using an atomic absorption spectrophotometer (Wodaje, 2017).

2. Estimating heavy elements in the plant:

An amount of2 gm of dry and finely grounded plant is weighed, and the sample placed in a glass beaker with 40 ml of sulfuric acid H_2SO_4added to it. The sample is left for 24 hours and the beaker is placed on a heating plate at a temperature of 105 °C for one hour. The sampleis cooled and 3 ml ofconcentrated perchloric acid $HClO_4$ is added to it. Then, the beaker is placed on a heating plate and carefully heated.The sample is cooled and 2 ml of HCL and 3 ml of distilled water are added to it, and the beaker is placed back on the heating plate at a temperature of 75°C for a period of one hour. The sample is cooled and filtered into a volumetric 25 ml vial. The volume is supplemented with distilled water to the mark, and the sample is read using an atomic absorption spectrophotometer (Wodaje, 2017).

3. Bio-concentration Factor (BCF):

The bio-concentration factor is used to determine the amount of heavy element absorbed by the plant from the soil. It is an indicator that shows the plant's ability to accumulate the heavy element in its tissues and is calculated using the following equation (Takarina and Purwaningdyah, 2019):

$$BCF = (Metals)\ root / (Metals)\ soil$$

4. Translocation Factor (TF):

It is an indicator of the plant's ability to transfer the element from the roots to the aerial parts of the plant. It is calculated using the following equation (Merecki et al., 2015):

$$TF = (Metals)\ shoot / (Metals)\ root$$

5. Bioaccumulation Coefficient (BAC):

It is the ratio of the concentration of the element in the vegetative system to the concentration of the element in the soil. It is calculated using the following equation (Qureshi et al., 2020):

$$BAC = (Metals)\ shoot / (Metals)\ soil$$

Results and Discussion:

First: Cd Bio-concentration Factor

The results of Table (1) show that there are significant differences between the treatments of the site. There are no significant differences between the treatments of agricultural and non-agricultural soil and the interaction between them. The bio-concentration factor recorded the highest average in the third site, with a value of 0.921 ± 0.118, while the first site recorded the lowest average, with a value of 0.789 ± 0.118. As for the soil treatment, the non-agricultural soil treatment recorded the highest average, with a value of 0.931 ± 0.084. The results of the current study do not agree with the results by the study of Wariset. al. (2022). The pH is an important property because the movement and availability of heavy metals that are toxic to plant uptake depends on the pH of the soil (Ashraf et al., 2010). As for the absence of significant differences between agricultural and non-agricultural soil treatments, it may be due to soil salinity, which leads to an increase in halides, especially chlorides, which have the ability to facilitate the movement of some heavy elements such as mercury, lead and cadmium in the rhizosphere and thus help absorb cadmium by the root system of the plant (Al-Khatib, 1998).

Table (1): The values of the bio-concentration factor of cadmium in agricultural, non-agricultural and study site soils

Average	Soil Treatment		Site
	Non-Agricultural	Agricultural	
0.118± 0.789	0.168± 0.958	0.168 ± 0.619	First
0.118± 0.901	0.168± 1.048	0.168± 0.753	Second

0.118± 0.921	0.168± 1.000	0.168± 0.842	Third
0.118± 0.820	0.168± 0.663	0.168± 0.710	Fourth
---	0.084± 0.931	0.084± 0.731	Average
Site: 0.358, Treatment: n. m, interaction: n. M			LSD

Second: Cd Translocation Factor (TF)

The results of Table (2) show that there are significant differences between site treatments, agricultural and non-agricultural soil treatments and the interaction between them.The translocationfactor recorded the highest average in the first site with a value of 1.576 ± 0.095, while the fourth site recorded the lowest average with a value of 0.536 ± 0.095.As for the soil treatment, the non-agricultural soil treatment recorded the highest average value of 0.067± 1.147. These results agree with the study conducted by Waris et al. (2022). The mobility and biological availability of heavy metals in the soil depends not only on their total concentration, but also on physical and chemical properties such as absorption, sedimentation and solubility (Almas et al., 2006). Referring to Table (1), it is noted that there is atranslocation of the cadmium element from the root to the vegetative system, especially in the third site and the non-agricultural soil treatment. It is noted that the translocationfactor recorded a value greater than one, which makes the Alhagi plant having the ability to withdraw the element from the soil.

Table (2): The values of the cadmium translocationfactor in agricultural, non-agricultural and study site soils

Average	Soil Treatment		Site
	Non-Agricultural	Agricultural	
0.095± 1.576	0.135± 2.057	0.135 ± 1.094	First
0.095± 0.753	0.135± 1.051	0.135 ± 0.454	Second
0.095± 0.905	0.135± 1.024	0.135 ± 0.785	Third
0.095± 0.536	0.135± 0.455	0.135± 0.617	Fourth
	0.067± 1.147	0.067 ± 0.738	Average
Site: 0.287, Treatment: 0.203, Interaction: 0.406			LSD

Third: Cd Bioaccumulation Coefficient

The results of Table (3) show that there are no significant differences between site treatments, agricultural and non-agricultural soil treatments and the interaction between them. The bioaccumulation coefficient recorded the highest average in the first site with a value of 1.345 ± 0.121, while the fourth site recorded the lowest average with a value of 0.435 ± 0.121.As for the soil treatment, the non-agricultural soil treatment recorded the highest average, with a value of 1.030 ± 0.086. The results of this study agree with the study by Boumaza and Chekushina (2021). The reason for this may be due to human activities resulting from throwing the waste of industrial stores in those soils (Odeh and Nasser, 2021). Since the bioaccumulationcoefficient is greater than one, this indicates that the Alhagi plant is a vital accumulator of cadmium.

Table (3): The values of the cadmium bioaccumulation coefficient in agricultural, non-agricultural soils and study site soils

Average	Soil Treatment		Site
	Non-Agricultural	Agricultural	
0.121± 1.345	0.172± 1.650	0.172 ± 1.039	First
0.121± 0.687	0.172± 1.024	0.172 ± 0.350	Second
0.121± 0.843	0.172± 1.023	0.172 ± 0.663	Third
0.121± 0.435	0.172± 0.425	0.172± 0.445	Fourth
---	0.086± 1.030	0.086 ± 0.624	Average
Site: G. M, treatment: G. M, interaction: G. M			LSD

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