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Research Article

Determination of Cadmium in Roadside Soil and Plants in Erbil, Iraq

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Abstract: In recent years the number of cars has been growing rapidly due to which the pollution load in soil is increasing gradually. Generally, heavy metal contamination of the soil has raised concerns in recent years due to its potential effects not only on human health but also on the plant system. To knowledge the consequences of Cadmium (Cd) on plant systems, in the current study, we collected the soil samples and *Hordeum*, *Triticum* and *Vicia faba* plants from two different highway sides (Erbil-Altun Kupri and Erbil-Koya). The results of statistical analysis of variance show that there were no significant differences between distances ($P < 0.003$) as well as between plant samples ($P < 0.000$), while the interaction between plant samples, distance and locations is opposite ($P > 0.33$). Vehicle emission could cause mitotic irregularities consisting of anaphase bridges, chromosome breaks, stickiness, and micronuclei. The intensity of Cd effects is basically relying on the Cd concentration and plant type.

Keywords: Cadmium, Traffic emission, Soil contamination.

1. Introduction

Almost all plants need at least sixteen mineral elements for their nutrition. These mineral nutrients are classified into two groups: the macronutrients and micronutrients (White and Brown, 2010; Rahmatollah and Mahbobeh, 2010). Scientists agree that carcinogenic concentrations in roadside plants and soils are the third most important factor impacting heavy metal accumulation in roadside ecosystems (Wang and Zhang, 2018). The heavy metals in many cases are proved to be potential carcinogens and mutagens in plants (Somashekar and Arekal, 1983). Vehicle emissions, leakage of oils and wear out of tires, have become the primary source of heavy metals in the urban environment (Siddiqui, 2015). Pollution by micronutrients of water, air, and soil has negative impact on human, animal and plant health (Ogundele *et al.*, 2015; Rouached and Tran, 2015). Soil and water close to industrial areas, highway roads and waste sites typically contain higher concentrations of Cd. This is due to industrial and vehicle emissions are selectively absorbed by edible plants, consequently, the levels of Cd is much higher than those in the surrounding soils (Huff *et al.*, 2012).

Cadmium is the third major contaminant with the greatest environmental hazard after mercury and lead. It is released into environment by urban traffic and mining industries (Benavides *et al.*, 2005). According to Zhang and Yang (1994), Cd is neither an essential micronutrient for the growth of plants nor participates in the process of cell metabolism. But if a large amount of Cd accumulates in plants serious symptoms will occur, for instance, chlorosis leaf rolls are the main and easily visible symptoms (Haghiri, 1973).

In the current research, we collected and analyzed soil and plant samples from two different highways, in order to understand the concentration of Cd in roadside plants.

2. Material and Methods

2.1 Study area

Erbil-Koya highway is located in the northeast of Erbil city and Erbil-Altun Kupri is located in the middle of the Erbil-Kirkuk highway, KRG Governorate. The distance routs about 60 and 55 km long respectively. Soil and plant samples were taken every 25 km. For each point we collected three samples, then we observed mean to minimize the error. There are no industrial activities are conducted around the Erbil-Koya highway, however, around Erbil-Altun Kupri highways there are industries and the proportion of agricultural land use is large. There is also an urban

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area less than 3% and 7% around Erbil-Koya and Erbil-Altun Kupri highways respectively of the total area. Thus, traffic emissions are almost the only source of pollution from heavy metals in the area. Control samples have been collected in cultivated areas, which were about 3 to 5 km far from the sampling area.

2.2 Soil

Soil samples were collected at different depths at 5cm intervals to a depth of 20cm. Soil samples were air-dried in an oven at 60°C for two hours and ground to pass from 0-5mm mesh sieve for chemical analysis. 1 gram of soil samples was weighed into a 125ml beaker and digested with a mixture of 2ml, 4ml, and 25ml each of concentrated H_2SO_4, $HClO_4$ and HNO_3 respectively. After digestion, the samples were cooled and 50ml of deionized distilled water was added and then the samples were filtered. The samples were made up to 100ml with deionized distilled water, eventually concentration of Cd determined by AAS Model.

2.3 Plants

Leaves from *Hordeum*, *Triticum* and *Vicia faba* plants were washed thoroughly in running tap water. After drying leaves at 60°C in an oven to a proper weight, then samples were reduced to fine powder with a grinder. 1.0 gram each of the finely powdered samples was weighed into a flask and digested in a mixture of 4ml, 25ml, 2ml and 1ml of concentrated $HClO_4$, HNO_3, H_2SO_4 and 60% H_2O_2 respectively. The resulting solution was left overnight and made up to 100ml with deionized distilled water, finally concentration of Cd determined by AAS Model.

3. Results and Discussion

Soil and plant samples have been taken from two toll points for each highway (Erbil-Altun Kupri and Erbil-Koya). Since no guidelines on Cd in roadside soils and plants have been advised by authorities in Iraq, therefore our results were compared with the maximum permissible limits prescribed by Motsara & Roy (2008) and WHO (2002). According to them the critical limit of Cd in soil is 0.5≥ μg g^{-1}. In this study, multi-way analysis of variance (ANOVA) was employed to assess significant differences between locations, distance and plants. In our data, the mean concentrations of Cd in soils varied in a wide range between 1.17 and 4.17 μg g^{-1} (Table 1). Thus, the mean concentrations of the Cd in all analyzed soils are much higher than the recommended maximum permissible level. Roadside soils in Erbil-Altun Kupri are excessively polluted with Cd while roadside Soils in Erbil-Koya is slightly less polluted (Fig. 1). This may be due to Altun Kupri highway has been witnessed rapid increase of heavy and light vehicles for the last two decades that caused environmental pollution by heavy metals such as Cd.

Table 1: Mean concentrations of Cadmium (μg g^{-1}) in two different roadside soils.

Locations	Distance	Soil Sample	Mean
Erbil-Altun	D1	Control	0.53
		1	4.17
		2	3.80
	D2	Control	0.53
		1	3.73
		2	2.83
Erbil-Koya	D1	Control	0.47
		1	2.40
		2	0.90
	D2	Control	0.23
		1	1.73
		2	1.17

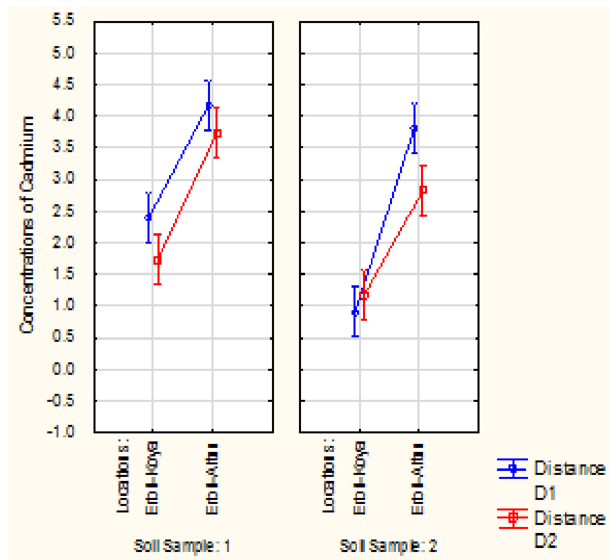

Fig. 1: Mean concentration (μg g^{-1}) of Cd in both highway roadside soils.

The mean concentrations of Cd in plants have been found between 0.87-2.83 μg g^{-1}**.** Referred to previous references, the threshold value of Cd for plants is 0.2-0.4 μg g^{-1}. According to our data, there were no significant differences between distances ($P < 0.003$) as well as plant samples ($P < 0.000$); however there was a highly significant difference between plant samples, distance and locations ($P > 0.33$). In general, the results of the analysis showed that Cd concentrations in the Erbil-Altun Kupri roadside plants were relatively higher than those of Erbil-Koya highway (Fig. 2). Also, higher Cd concentrations of both highway roadside plants were observed in D1 samples near the highways as compared to those obtained in D2. This is maybe due to the fact that the D1 are always jammed with the heavy and light vehicles while in the D2 there are relatively less, also this is referred to many urban populations are located in D1. Therefore, high amount of Cd in roadside plants is highly related to traffic emission as reported by Suryawanshi *et al.*, (2016) and Madrid *et al.*, (2002). Furthermore, the data analysis is given in fig. 3 shows that Cd level in *Vicia faba* is higher than

Hordeum and *Triticum*. This is due to *Vicia faba* has long and large number of roots. People may encounter these contaminants if they are working in contaminated soil or consuming food that has grown in contaminated soil. In some cases, exposure to soil contaminants may increase the risk of disease, especially in children (Johns Hopkins Center for a Livable Future, 2014). For the last two decades, the toxicity of heavy metals to plants has drawn the attention among many environmental scientists, notably, because plants represent the main route of entry of heavy metals into the food chain, presenting a threat to human health (Chen *et al.,* 2009). Thus, accumulation of heavy metals requires a detailed study to predict serious health effects that may increase in the short term, especially with an increasing number of cars.

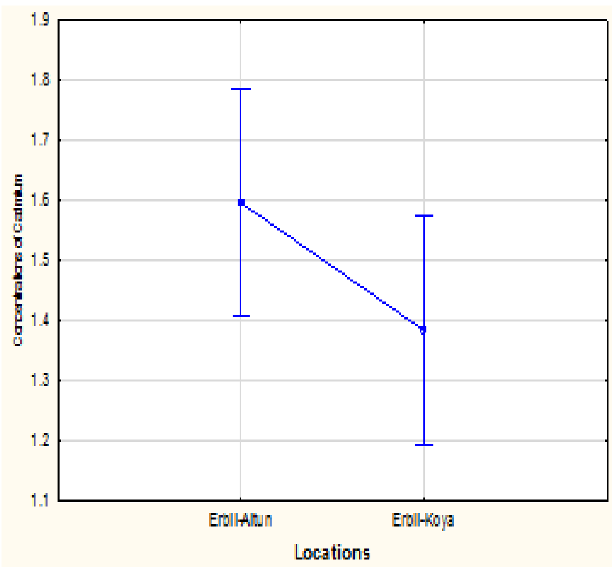

Fig. 2: Mean concentration (µg g⁻¹) of Cd.

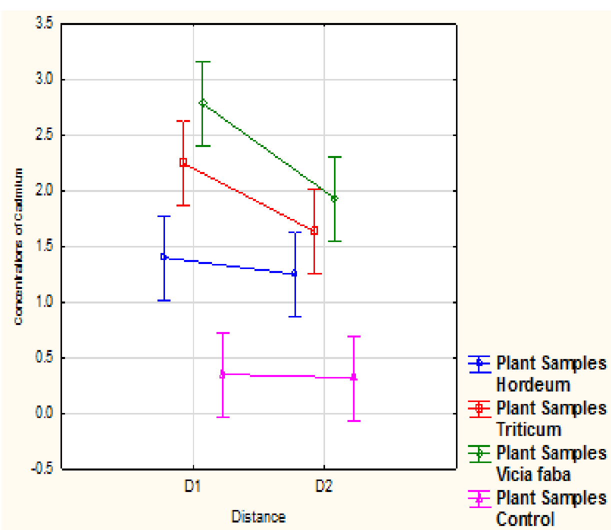

Fig. 3: Cd concentrations in first and second distance of both highway roadside plants of three different plant samples of both highways.

There is increasing evidence that metal toxicity is associated with oxidative stress as reflected by the increase in the concentration of hydroxyl radicals, nitric oxide and hydrogen peroxide. All of these changes physiological processes culminate finally in reduced crop yield and quality (Yan *et al.,* 2010). Chromosome bridges, stickiness and fragment as well as micronuclei can be seen if Cd concentration is higher than maximum permissible level in plant cells. This is indicated a cytological highly toxic effect and probably leads to inhibit root growth and eventually the death of the cells (Fiskesjö, 1985; Ruposhev, 1976). In plants, Cd affects different physiological processes, for instance, photosynthesis activity, nitrogen metabolism, nutrient uptake and cell elongation. At the biochemical level, excess metals like Cd has a deleterious effect on membrane function and inhibit enzymatic activities (Gajewska *et al*., 2009)

The last but not the least, It has been proven that the uptake of Cd by plants is much easier than other micronutrients (Levan, 1945). This study proved that species vary in their sensitivity to Cd. According to Gong *et al.,* (1990), various plants have various tolerances to same heavy metal. Upon this, Liu *et al.,* (1992) treated the root of *Allium cepa* with Cd, which resulted in only chromosome stickiness and c-mitosis. These results illustrate that our plant samples were more sensitive to Cd than *Allium cepa.*

4. Conclusion

It is concluded that Cd induces chromosomal aberrations in plants. It is established that vehicle emission increase cadmium concentration in soil and plants. The cytological disturbances caused by Cd vary from plant to plant. Further studies on the role of individual micronutrients may throw more light on their capacity in bringing about chromosomal aberrations.

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