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Effect of salinity and pH on the absorption of cadmium in *Lemna minor*

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Abstract: This work was conducted to study the effect of salinity and pH on the absorption and accumulation of cadmium by the aquatic plant *Lemna minor*. Different concentrations of salinity (0, 1, 2 and 3 ppt) and pH (6.2, 7 and 8.4) were used. The results showed a decrease in the absorption of cadmium with increasing salinity, and the highest concentration of cadmium absorption at pH 6.2.

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Introduction

Aquatic plants are an important part of aquatic ecosystems due to providing an important source of organic matter and maintaining biological balance in the circulation and organization of nutrients. In addition, they provide ground for living, reproduction and nutrition for fish and other aquatic organisms (Caraco and Cole, 2002). In recent years, global interest has increased in using aquatic plants as a biological index for heavy metal pollution due to their ability to accumulate these elements in their tissues (Coleman et al., 2001). They have also been used as a biological monitor for heavy metal levels in the aquatic environment (Mal et al., 2001).

Furthermore, aquatic plants are used as phytoremediation of heavy metals (Al-Edani et al., 2019). The process of heavy elements absorption by plants may be affected by several factors, including pH, temperature, salinity and the concentration of heavy elements in the surrounding water (Pettersson, 1999). Salinity is one of the main limiting factors of the growth and productivity of aquatic plants. The effect of high salinity on plants can be observed through decreased productivity or plant death or photosynthesis, protein synthesis, energy conversion and lipid metabolism (Agastian et al., 2000), and salinity also has a significant role in the abundance and distribution of plant species (Littles, 2005). The effect of salinity comes through its impact on the growth rate of plants as well as their ability to absorb heavy elements through the toxic effect of sodium ion and chloride ion (Parida and Das, 2005), as the sodium ion releases cadmium from sediments into the water, which leads to an increase in cadmium concentration (Greger et al., 1995). It was found that the aquatic plant *Potamogeton pectinatus* grows with high concentrations of salinity, contains low concentrations of cadmium, as increased salinity led to a decrease in cadmium absorption by the plant (Noraho and Gaur, 1995). Munda and Hudink (1988) pointed out that the ability of aquatic plants to absorb copper decreases with increasing salinity. Leblebici et al. (2009) found that the ability of aquatic plants to absorb heavy metals decreases when salinity levels increase in water.

It is known that Iraqi waters are alkaline (Richardson and Hussain, 2006), i.e. the pH values of the southern marshes range between 7-8.5. The pH can decrease during the summer and autumn seasons due to the decomposition of organic matter, which increases by rising temperature (Lateef et al., 2020). The dense plant growth leads to carbon dioxide consumption during the winter and spring seasons, which leads to high pH values (Neghamish and Ali, 2005). The pH is a limiting factor for the growth of

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plant communities, as its value is less than 6, which can limit the growth of aquatic plants (Hutchinson, 1995). It was found that the pH in rivers in which there are species of the family Lemnaceae was between 5.6-8.5, and they die when the pH reached 1.2 (Hicks, 1933).

Cadmium is one of the important toxic trace elements in the environment due to its high mobility and toxicity at low concentrations for plants (Ye et al., 2003) and its ability to transfer through the food chain (Hiroyuki et al., 2002). Cadmium enters the air, soil and water from industrial works, burning coal, household waste, phosphate fertilizers containing cadmium, sewage and pesticides. (Wu et al., 2004). Cd accumulates in fish and plants from the environment (ATSDR, 2012). The aquatic plant *Lemna minor* is one of the efficient plants used for water purification, and it grows at a pH ranging between 5-8.5 (Littles, 2005). Experiments have shown that this plant can consume many elements, including boron, aluminium, manganese, iron and copper, and it can absorb lead, in addition to removing phosphorous and nitrogen from water (Miranda and Liaugovan, 2004). It also tolerates salt up to 2.5% (Haller, 1974). Based on the above-mentioned background, the purpose of this study is to investigate the effect of salinity concentrations and pH on the ability of *L. minor* to absorb cadmium for the possible application of this plant as a biological monitor.

Materials and Methods

Samples of the *L. minor* were collected from the ponds near the Basrah University, Karmat Ali, Iraq. They were washed with pond water to remove suspended matters and placed in clean bags until reaching the laboratory. Aquaria with a capacity of 20 liters (25x25x29 cm) were used for the experiments. A fluorescent light source was provided with a luminous intensity of 130-150 microenstein m^2/sec with a period of 14:10 hours light: dark. For aeration, an air pump was added to each of the aquarium. The aquaria were filled with distilled water of 10 liters; then the collected *L. minor* plants were placed into them at a rate of 100 g.

To prepare the cadmium nitrate solution, 2 mg/liter of cadmium was added to each experimental aquarium. NaCl was used to make different salt concentrations, including 0, 1, 2 and 3 ppt and other aquaria for the experiment used for pH (6.2, 7 and 8.4) experiments. For this purpose, the acidity was adjusted using sodium hydroxide and hydrochloric acid.

The experiment was performed for 40 days, and the concentration of Cd was measured in the treatments every ten days. For this measurement, the samples were dried in an electric oven at 70°C for 24 hours, crushed and passed through a laboratory sieve with a mesh of 40 µ. Then, the samples were prepared for the extraction and measurement of the heavy metals according to APHA (2005). One g of the crushed aquatic plant was put in glass flasks with 25 ml capacity and added a certain volume of nitric and pyrochloric acids in a ratio of 3: 1. The samples were left for 24 hours under vacuum, and the flasks were placed in a water bath for 1 hour to speed up digestion. The flasks were taken out, and 2-3 ml of the distilled water were added and placed on a hot plate at a temperature of 70°C until the volume reached 2 ml. After centrifuge filtration and completion of the filtered sample to 50 ml of distilled water, the samples are measured with a flame atomic absorption spectrometer (Pye Unicam Sp9 Air Acetyline). The result is expressed as µg/l dry weight.

Results and Discussions

Based on the results, the plant's ability to absorb Cd at high salinity levels decreases or almost stops, in agreement with the findings of Witham et al. (1971). The rise of salinity leads to an increase in the available forms of Cd and its uptake by the wheat crop (Norvell et al., 2000; Khoshgoftarmensh et al., 2002). The study also showed that the Cd in salinity of 0 and 1 ppt were higher absorption than those with higher salinity i.e. confirming that the increase in salinity caused a decrease in accumulation of the heavy metals in aquatic plants (Fritioff et al., 2005). Mahmoud (2008) and Hanaf (2016) found that heavy metals accumulate with increasing salinity. As for *L. minor*, the increase

Table 1. Concentration of cadmium (µg/g dry weight) in *Lemna minor* in different salinities during 40 days.

Cadmium concentration (µg/g dry weight)				
Salinity (ppt) / Time (day)	0	1	2	3
10	43.1	58	56	13.8
20	99.2	58.3	45.7	10
30	131.2	78.5	33	11.9
40	146.8	98.1	30.7	12

Table 2. Concentration of cadmium (µg/g dry weight) in *Lemna minor* at different pH during 40 days.

Cadmium concentration (µg/g dry weight)			
pH / Time (day	6.2	7	8.4
10	89.9	67.3	55.9
20	156	88.9	66.1
30	188.9	88.6	66.8
40	199	99.3	76.1

in the salinity led to a decrease in the accumulation of Cd, and this was in agreement with the results of Leblebici et al. (2009). Table 1 shows the concentration of Cd in *L. minor* at different salinities during 40 days' experiment. The reason for this may be due to the complex structure between the chloride ion and metals (Forstner, 1979), or increased competition with the sodium ion for the adsorption sites in both the cell and plasma walls due to the high salinity, which led to a decrease in the absorption of elements by the plant (Noraho and Gaur, 1995). Salinity may increase the release of heavy metals from the sediments into the water column (Yureki et al. 2001).

The pH plays a fundamental role in the transfer of the heavy metals between the liquid and solid phases, as the low pH increases the solubility of some heavy elements in water, which causes an increase in their spread and availability to living organisms in the water (Addy et al., 2004). The results of the current study (Table 2) showed that the highest concentration of cadmium in *L. minor* was at pH 6.2 compared to the concentration of cadmium in the same plant at pH 8.4, this was also noted by Puranik and Paknikar (1999) in their study on the use of some aquatic plants in the removal of heavy elements (lead, copper, zinc and cadmium) by the influence of some factors, including pH. While Jafari and Akhavan (2011) found an increase in the concentration of some heavy metals with increasing pH, the reason for this may be because *L. minor* grows in this range of pH (Littles, 2005), as the ability to take up and absorb increases during the plant growth period, which leads to an increase in binding and thus an increase in accumulation, and this was confirmed by Ekval and Greger (2002) in a study they conducted on the influence of biomass production factors in two types of the aquatic environment on the ability to take some elements. This was also found by (Hanaf, 2016), as she noticed the correlation of the productivity of phytoplankton and aquatic plants with the concentration of some heavy metals. Several studies have indicated that the aquatic plant *L. minor* can accumulate heavy metals and remove them from polluted water with high efficiency. This was also found by the current study, which agreed with Athbi et al. (2018).

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