Plant Archives Vol. 21, Supplement 1, 2021 pp. 1658-1664 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.261

TREATMENT OF SOME CONTAMINANTS OF WASTE WATER BY USING *CERATOPHYLLUM DEMERSUM*

Fatimah Hassoon Yaseen* and Atheer Saieb Naji AL-Azawey
College of Environmental Sciences, Al-Qasim Green University, Iraq
*Email: fatmaa88774545@gmail.com

ABSTRACT

The current study included the possibility of *Ceratophyllum demersum* to reduce some of the pollutants present in the waste water from Al-Yahodiya drainage. The experiment included placing aquatic plants in 20-liter glass basins containing waste water. Physical and chemical properties were performed by taking water samples every 4 days for a period of 20 days. The results showed that all plants raised the pH value to the basic side. On the other hand, the current plants were not efficient in reducing the values of total dissolved solids and electrical conductivity, while the chemical properties showed reduction during the current study. The present study showed that *C. demersum* recorded efficacy by reduction, starting with a small percentage and then increasing with the progression of treatment time. *C. demersum* plant recorded an increase in the element concentration after using the plant for water treatment compared to the control plant. The current study proved the role of aquatic plants under study in reducing the concentrations of the element lead, and the reduction ratios were continuous throughout the treatment period.

***Keywords*:** *Ceratophyllum demersum,* total dissolved solids (TDS), nitrite, nitrates**,** total hardness, pH, EC.

Introduction

The problem of environmental pollution has received wide attention at the global, regional and local levels in order to protect the environment and its natural resources and to lay the correct foundations for economic development and the development of various areas of life. Therefore, water pollution is defined as a set of physical, chemical or biological changes of water that lead to a change in its quality and make it. Harmful to the environment and is dangerous or a nuisance to the recipient (Ambedkar, 1999; Gesamp, 1993). Studies in the field of polluted water treatments have confirmed that biological treatment is superior to physical and chemical treatments because it is a healthy, simple and cost-effective method (Kroiss and Muller, 1999). The process of removing or reducing pollutants by plants is called phytoremediation, which represents one of bioremediation forms, which is use of living organisms (plants, animals, or microorganisms) to remove the toxicity of pollutants in various environments. (Bhatnagar *et al.*, 2013). Phytoremediation is the use of certain plants that have the ability to reduce pollution levels. The path of metabolic mechanisms by the plant that leads to the removal, seizure, or analysis of pollutants (Al-Sanjari, 2011).

Aquatic plants contribute to the purification and improvement of water by providing it with the oxygen necessary for the life of aquatic organisms and preparing the means for the life of aquatic organisms and works to reduce the speed of water flow and the accumulation of alluvial substances at the bottom, as well as contribute to the collection of some polluting materials such as heavy elements through bio-absorption and storage of these elements or by transferring it to the bottom through its simple roots or through adsorption on the surfaces of its leaves (Graneli and Solander, 1986). The diversity of aquatic plants and their wide spread in water bodies and their tolerance to variable environmental conditions, has encouraged many researchers to study the possibility of using them as biological evidence of pollution. Al-Saadi and Al-Mayah (1983) mentioned that aquatic plants are sensitive evidence of the environmental conditions in which they live, as they are affected by a number of environmental factors, so the flourishing of a specific plant growth in a special environment and conditions is considered as evidence of the existence of those environmental conditions (Prasad, 1998). Therefore, interest has increased in recent years in using aquatic plants to remove pollutants and treat water from pollution, especially from heavy metals.

Materials and Methods

Sample Collection

The water *C. demersum* plant was collected from the drainage of Haji Ali, west of Babel Governorate- Abi Gharq district. The plants were placed in large plastic bags and when they arrived at the laboratory they were washed and cleaned well, with clean water to get rid of suspended matter and mud from the roots, and stay in this water for two weeks to adapt it.

Treating polluted water with plants

Water plants were collected using large-sized nylon bags, were marked and a little water was added from the same sites from which the plant was collected And when it reached the laboratory, the plants were washed well with tap water and brush several times, then warm water to remove the algae and the sticking materials and put them in plastic tanks with dimensions (35×30×70) And the plants were left for two weeks for the purpose of localization, as well as to discard the pollutants suspended from them from their original origin Then put the plants 10 g /L with the addition of 20 liters of contaminated water in each basin (Three basins for *C. demersum* with control basins). Whereas, this polluted water was collected by 20-liter polyethylene containers separately, and a quantity of water was withdrawn every 4 days to day 20 for the purpose of conducting measurements of physical and chemical properties and estimating heavy metals (Taha *et al*., 2011)

Experimental part

pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Total hardness (TH), Calcium hardness, Magnesium Hardness, Nitrite and Nitrates were examined.

Determination of some heavy metals in waste water samples

The concentration of heavy metals was examined based on the APHA method (1998), from which the sample was taken (500) ml in a beaker and then placed on a hot plate. Then it evaporated and its volume reached (50) ml, then was 15 ml of nitric acid added. Then it evaporates to dryness and a colored precipitate is added, then distilled water is added to the sample and completed to a volume of (50) ml of distilled water. The samples are kept in plastic packages until the measurement. Using the Atomic absorption spectrophotometer and taking the standard curve for each metals (Pb, Cd), from the equation, the concentration of each metals is expressed and the final results are expressed in mg / liters unit.

Results and Discussion

Contaminated Waste Water Before Treatment

In table (1) the physical and chemical characteristics of polluted water before biological treatment

Measured Factors	Contaminated water
pH	7.5
TDS mg/l	2398
EC µs/cm	3470
Total hardness mg$CaCo_3$/l	1216
Nitrite mg/l	0.19
Nitrate mg/l	0.06

pH

The pH is one of the most important characteristics that affect the metabolism and phylogeny of aquatic organisms if it affects the readiness of the metals and nutrients (Lawson, 2011), figure (1) shows the pH values of contaminated water, as *C. demersum* was recorded (the lowest value was 7.8 on day 5 and the highest value was 8.6 on day 25). As for the control treatment, it was recorded (the lowest values were 7.6 on day 20 and the highest value was 8.1 on day 15). The statistical results showed that there was no significant difference (p≤0.05) in the pH values in the polluted water.

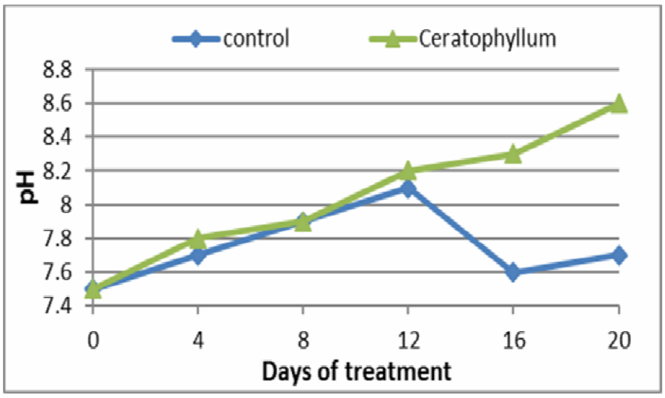

Fig. 1 : Variation of pH values of during current study

The results showed that the pH values of the treated water increased in the baseline trend. The slight increase in the pH values was recorded by other studies such as the study by Wendeou *et al.* (2013) which showed that the pH values increased slightly when treated. It is due to photosynthesis that consumes CO_2 gas and raises the pH. It produces a little carbonic acid (Selvarani *et al.*, 2015). Al-Asadi (2014) pointed to the high pH values when treated with the two plants of the Nile herb and L. minor, and indicated that this has desirable effects because it contributes to reducing the toxicity of some heavy metals and reduces their readiness in those waters (Shelef *et al.*, 2013). explane (Mukherjee and Chatterjee, 2014) that the treatment of industrial water with *H. verticillata* raised the pH values so that it tended to the alkalinity. Al-Janabi (2013) also recorded a gradual increase in the pH values when treating the industrial water of the Furat General Company for Chemical Industries with a group of plants, including plants. *C. demersum.*

Total dissolved solids (TDS):

The Dissolved solids TDS are substances produced from the dissolution of compounds that produce positive and negative ions (WHO 1996). It represents the sum of dissolved solid materials and salts and is an important indicator in water treatment plants (Al-Asadi, 2014), and there is a strong relationship with electrical conductivity, (Moore *et al*., 2008). The values of total dissolved solids of polluted water treated and the percentages of their reduction are shown in figure (2) as the plant under study did not show efficiency in their reduction throughout the study period. The results of the statistical analysis indicated that there was no significant difference (p≤0.05) in the values of total dissolved solids in the water.

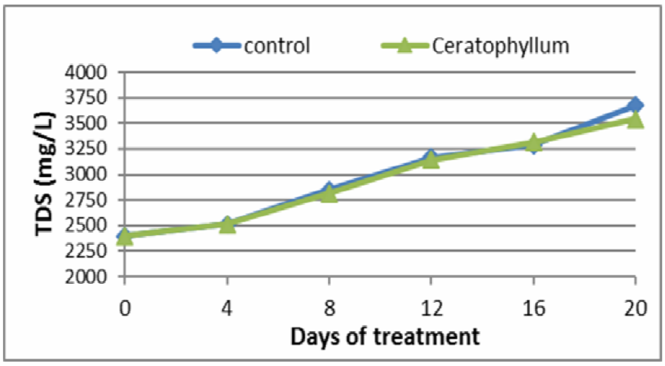

Fig. 2 : Variation of TDS values of during current study

The results showed that the plant under study did not show efficiency in reducing TDS values, but they recorded lower values than the control plant. This means that the decomposition processes were high above the ability of plant to reduce them, especially since the current results indicate the weakness of the plants under study in reducing the values of each of magnesium chloride, which is a basic component of dissolved solids. These results are consistent with previous studies such as the study of (Abouel-kheir *et al.*, 2007) which showed that the Lemna sp plant recorded a slightly reduced TDS values on the second day, after which the values increased to exceed the actual values at the time Zero. (Wendeou *et al.*, 2013) reported that TDS values in wastewater treated with *Lemna* sp have increased to high values after treatment.

Electrical Conductivity (E.C)

Electrical conductivity is a numerical value indicating the ability of water to carry electric current and is a good indicator of total dissolved salts and increases in areas that are under the influence of agricultural and industrial activity (APHA, 1976), and it is an indicator of water salinity (Lind, 1979). They are increased by the presence of cations such as sodium, potassium, calcium, magnesium and anions such as carbonate, bicarbonate, nitrates, chlorides and sulfates (Maiti, 2004). The plant under study did not record efficiency in reducing the electrical conductivity values in the polluted water, as shown in figure (3). The results of the statistical analysis indicated that there was no significant difference ($p \leq 0.05$) in the values of electrical conductivity in the water.

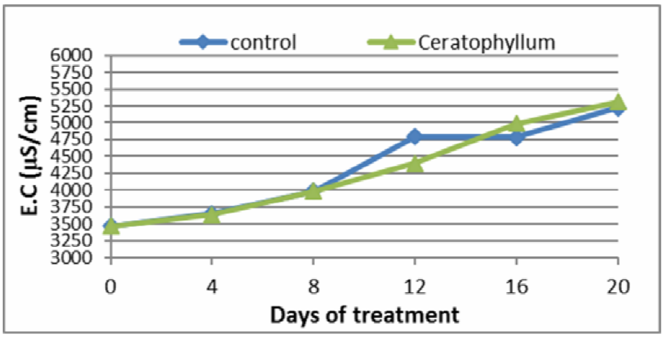

Fig. 3 : Variation of E.C values of during current study

The results indicate the inability of the plant under study to reduce conductivity values throughout the treatment period. This may be due to the presence of high concentrations of some ions such as chloride (Hutchinson, 1957), especially since the plant failed to reduce it. This was recorded in previous studies such as Abouel-Kheir *et al.* (2013) that the electrical conductivity in wastewater began to increase significantly, especially after the sixth day of the experiment, and showed that increasing the conductivity values in connection with the phenomenon of evaportranspiration may be due to an increase in mass plant in ponds. As shown by (Al-Sanjari, 2011), the electrical conductivity values increased after the use of the reed plant in treating polluted wastewater. Certain in soluble ionic form have the ability to conduct electricity, which in turn increases the electrical conductivity depending on the concentration and quality of the dissolved ions (Al-Wahaibi, 2007).

Total Hardness

Hard water is water that contains high concentrations of polyvalent ions, especially calcium and magnesium ions, and causes many problems in factories such as cracking boilers and cooling towers, in addition to it causing problems in homes as it leads to not forming foam with soap (Sivasubramanian *et al*, 2012). Other ions, such as barium, iron, manganese, strontium and zinc, share high hardness, and these ions are often formed from the erosions of neighboring soils (Gupta *et al.*, 2009). figure 4 shows that *C. demersum* plants did not record any reduction ratios throughout the treatment period. As for the control treatment, high concentrations were recorded throughout the treatment period compared to water treated with plants, and no reduction ratios were recorded. The results of the statistical analysis indicated no difference. Significant ($p \leq 0.05$) in total water hardness values.

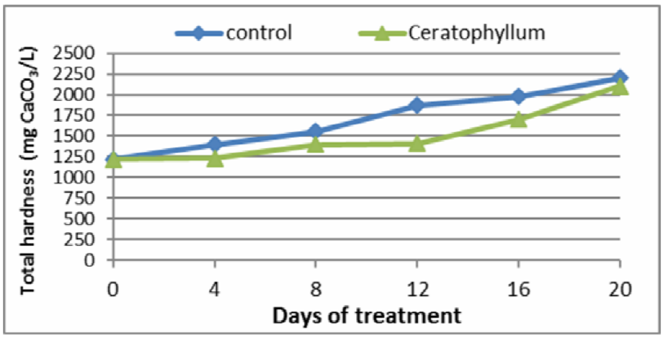

Fig. 4 : Variation of Hardness values of during current study

Calcium plays a role in maintaining the functional and structural integrity of plant membranes, stabilizing the cell wall, in addition to regulating and transferring ions and activating cell wall enzymes (Ashraf, 2004). As for magnesium, it is included in the composition of the chlorophyll molecule, (Kupper *et al*, 1998). Calcium hardness concentrations of domestic water treated with plants are shown in figure 5 *C. demersum* showed capacity for reduction from day 10 until day 25 and recorded higher. Reduction rate of 15.1% for days 10, 15 and 20. The control treatment did not record any calcium reduction ratios throughout the treatment period. The results of the statistical analysis indicated that there were no significant differences ($p \leq 0.05$) in the reduction of calcium concentrations in the water.

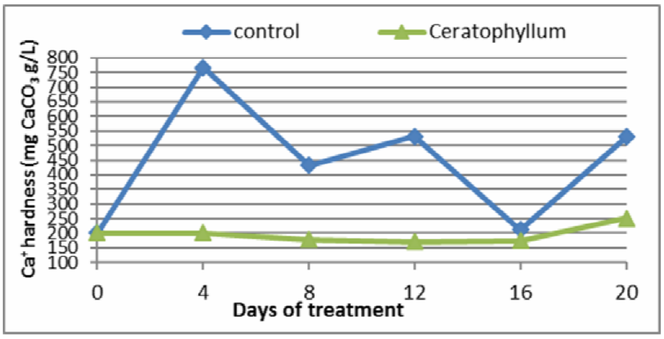

Fig. 5 : Variation of Calcium hardness values of during current study

The current study showed that *C. demersum* did not record any reduction ratios throughout the treatment period. As for the inefficiency of the plant by reduction, this may be due to the fact that the water is loaded with organic materials in high concentrations as well as the conversion of large quantities of calcium into soluble bicarbonate leading to an increase in total hardness (Salman, 2006). This came in accordance with the study (Al-Sangari, 2011), which showed that the hardness increased after using the reed plant to treat polluted water in some sites and attributed this to the presence of polyvalent metal ions (Mustafa, 2009). Also, *C. demersum*, are less efficient in reducing the disinfection causes of calcium and magnesium compared to root plant such as reed and sedge (Kopittke and Menzies, 2006). The plant did not record any reduction ratios of magnesium concentrations throughout the treatment in water. The control treatment also did not record efficiency in reduction throughout the treatment period, and its concentrations were high compared to water treated with plants figure 6. The results of the statistical analysis indicated that there was no significant difference (p≤0.05) in reducing the magnesium values in the water.

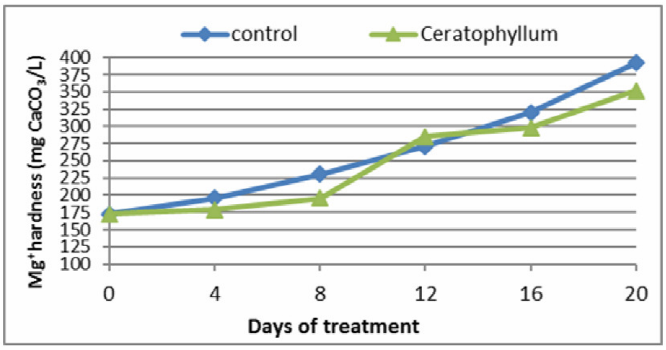

Fig. 6 : Variation of magnesium Hardness values of during current study.

As for magnesium, the results indicate the inefficiency of plants in reducing magnesium in water except for *C. demersum* plant, which recorded simple reduction ratios limited to day 4. This is confirmed by the study of (Abouel-Kheir *et al*., 2007), which showed that the lentil plant was able to reduce Calcium and magnesium on the second day of treatment, but the concentrations increased after the eighth day, to be higher than those before treatment. Patel and Kanungo (2010) indicated that *C. demersum* reduced calcium and magnesium concentrations when domestic raw water was treated on the seventh day, and then no treatment. This may be due to the fact that some ions present in the water, such as calcium and magnesium ions, may be expelled out of the plant body because the plant does not need them or need them in small quantities (Argo, 2003). As between (Kupper *et al*., 1998) the magnesium in the chlorophyll molecules may be replaced Ions of heavy metals such as copper, cadmium, lead, and nickel, which lead to excretion in the outer medium.

Nitrite

Nitrogen is present in the environment in several oxidative states and is transformed from one form to another depending on the availability of oxygen. As ammonia is biologically oxidized by nitrification process to nitrate by two types of autotrophic bacteria which are very sensitive to pH values, temperature, heavy metals, and chemical compounds released (Hockenbury and Grady, 1977). The unstable form of the nitrogenous form that turns into ammonia as a nitrate, meaning that it has the highest oxidative potential compared to the rest of the nitrogen forms (Maiti, 2004). figure (7) shows the nitrite concentrations in the water treated with plant, which indicates that *C. demersum* plant started treatment after day 10 until the end of treatment and recorded a higher Reduction rate of 89.4% at day 25. Compared to the control treatment, which recorded high concentrations, and its reduction ratios were limited to days 20 and 25, it reached 73.6%. The statistical results showed that there was no significant difference (p≤0.05) in the reduction of nitrite in water.

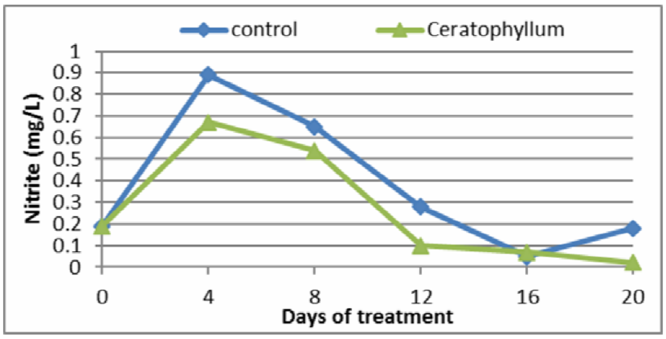

Fig. 7 : Variation of Nitrites values of during current study.

The results indicate the high efficiency of plants in reducing nitrite values with the superiority of *C. demersum.* This efficiency may be due to the fact that the submerged vascular plants absorb large amounts of nitrogen and phosphorous in excess of the natural metabolism requirements (Wilson, 1972). These plants represent the nutrients directly when absorbed from the water column and thus play an important role in their maximum removal from the treated water (Gumbricht, 1993). Foroughi *et al.* (2013) indicates that denitrification by plants depends on growth rate and tissue nitrogen content. Korner and Vermaat (1998) show that removing nutrient forms such as P, N is due to their consumption by the new developing tissues and not by increasing the nutrient content in old tissues.

Nitrate

Plants showed higher efficiency in reducing nitrate concentrations in water, as *C. demersum* recorded a reduction rate of 96% on day 25, but its treatment was limited to days 20 and 25. Day 25 compared to the control treatment in which the treatment was limited to days 20 and 25 only, and the highest reduction rate was recorded on day 25 of treatment, figure 8. The results of the statistical analysis indicated that there was no significant difference (p≤0.05) in the reduction of nitrates in water.

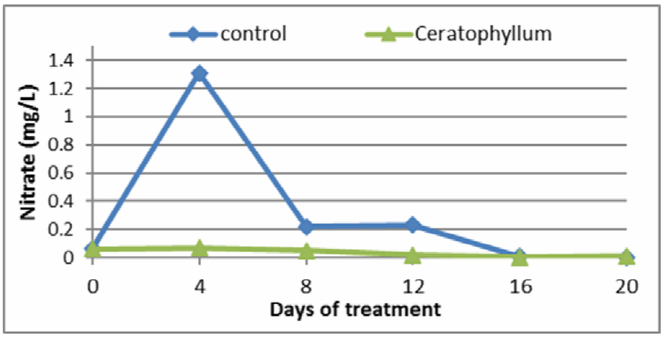

Fig. 8 : Variation of nitrate values of during current study.

It is one of the forms of nitrogen present in the environment. The current study showed the effective role of plants by reducing nitrates in water, as plants mostly prefer ammonia first, then nitrate as a nutrient source, whereas nitrite is considered an intermediate state (Selvarani *et al.*, 2015). This is in line with the study of Foroughi *et al.* (2010), which recorded the best reduction of nitrates when treating wastewater at the beginning of the treatment, however, the reduction ratios decreased as the treatment time progressed. Wetzel and Manny (1972) indicated that quantities of organic compounds, including dissolved nutrients, are continuously excreted by living aquatic vascular plants. Godbold and Kettner 1991 showed that lead uptake by plants reduces the absorption and transport of certain nutrients. Also, by increasing the pH values, a reduction occurs in the intake and transport of nitrogen to the plant (Saygideger *et al.*, 2004). Foroughi *et al*. (2013) pointed out that the age of plants has a role in reducing metals, as young plants are more efficient than the old by the process of reduction. In addition, if plants are not harvested in a timely manner, nutrients from the plant body may return in the opposite direction to the water (Ayyasamy *et al.*, 2009). The efficacy of the plants under study in reduction is in agreement with many studies, such as Patel and Kanungo (2010), study which indicated the efficiency of *C. demersum* plant in reducing large quantities of nitrite and nitrate with superior nitrite reduction because it represents an intermediate state between ammonia oxidation and nitrate reduction processes. When used in wastewater treatment, Al-Janabi, (2013) indicated the role of a group of aquatic plants, including *C. demersum* plant, in reducing nitrite and nitrate concentrations with the variation in the reduction efficiency in industrial water and attributed this to the role of plants in producing oxygen in the process of photosynthesis and thus converting Quantities of nitrite into nitrate by the nitrification process (Al Saadi *et al.*, 1999). As indicated by (Foroughi *et al*., 2013) *C. demersum* was efficient in reducing both nitrates and ammonia completely when treating wastewater. Patel and Kanung (2012) indicated that *H. verticillata* reduced large amounts of nitrate when treating water.

Cadmium

Cadmium is one of the unnecessary metals that causes many plant sides affects such as reduced growth rate and nutritional imbalance as a result of interference with nutrient absorption and photosynthesis enzymes (Bradl, 2005). In figure (9) shows the cadmium element concentrations for water treated with plants, where L. minor showed efficiency by reduction, which started with a few percentages and then increased to reach 45.7% on day 25. As for *C. demersum* plants, they recorded reduction ratios of 65% on day 15. As for the control treatment, it was It has slight reductions compared to the treated water, and the highest percentage of reduction is 34.1% at day 25. The results of the statistical analysis showed no significant difference ($p \leq 0.05$) in the reduction of cadmium in the water.

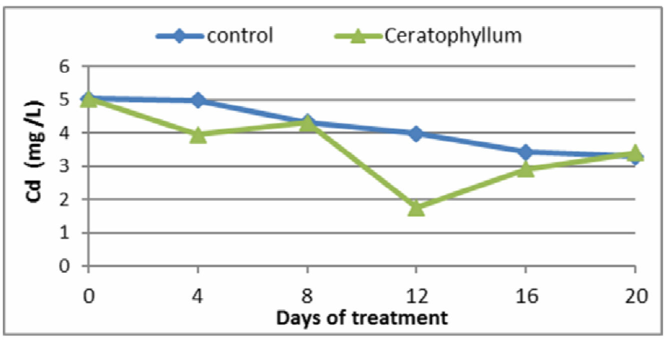

Fig. 9 : Variation of cadmium values of during current study.

The present study showed that *C. demersum* recorded efficacy by reduction, starting with a small percentage and then increasing with the progression of treatment time. *C. demersum* plant recorded an increase in the element concentration after using the plant for water treatment compared to the control plant. The efficiency of aquatic plants in bearing different concentrations of heavy metals while continuing to grow is due to the balance of both the enzymatic and molecular antioxidants, as well as the increased secretion of cellular metabolites such as cysteine and clutamine. Metal (Al-Wahaibi, 2006). Previous studies recorded the efficiency of plants by reduction, such as the study of Asadi (2014) which recorded a high efficiency of L. minor plant in reducing cadmium when treating industrial water and attributed the reasons for its success in reducing the element to the availability of ambient conditions such as temperature, pH and the age of the plant, in addition to the specific and physiological characteristics of the plant (Malec *et al.*, 2010). Other studies recorded high reduction ratios for the element using *H. verticillata,* which was efficient in reducing cadmium and to a lesser extent the copper element (Tawfiq and Al-Kubaisi, 2014). *C. demersum* plant also showed high efficiency by reducing cadmium. This may be due to the fact that cadmium is already low in water, on the one hand, and on the other hand, the absorption capacity of *C. demersum* plant is high (foroughi *et al.*, 2011).

Lead

It is a very toxic heavy element because it not only accumulates in individuals, but has the ability to enter the food chain, disrupt the human health system, and affect animals and phytoplankton, as it affects humans through direct absorption into the blood and stored in soft tissues and remains 95% in the bones and teeth It may affect the kidneys, the nervous system, and the brain (Singh *et al.*, 2012). Figure (10) shows the concentrations of lead in the water, as the plants recorded a reduction rate of 59.1% on day 25 for L. minor plants, and days 5 and 15 records 64.1 for *C. demersum* plants. As for the control treatment, it did not show efficacy with reduction, and its treatment was limited to day 10 only, which amounted to 11.3. %. The results of the statistical analysis showed a significant difference ($p \leq 0.05$) in the reduction of lead in water.

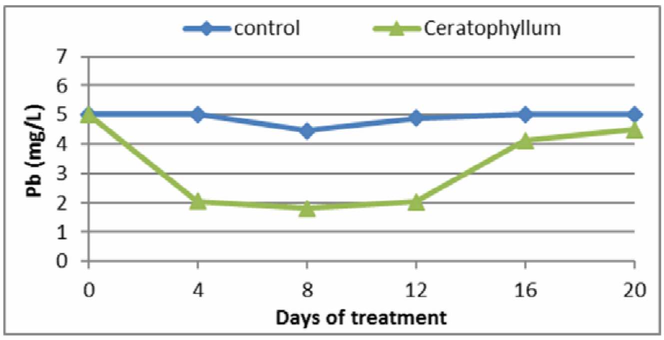

Fig. 10 : Variation of lead values of during current study.

The current study proved the role of aquatic plants under study in reducing the concentrations of the element lead, and the reduction ratios were continuous throughout the treatment period. As for the concentration of the accumulated element in the plant body, the study indicates that its concentration in *C. demersum* plants increased at the end of the treatment. The efficiency of plants in reducing the element of lead was recorded in several studies such as Abou el-kheir and others (2007), which recorded a reduction of heavy metals using L. minor, including the element lead, whose reduction ratios reached 100%. Minor when treating industrial water for Diwaniyah Textile Factory, and he attributed this to the ability of the plant to restrict metal immobilization, which is one of the mechanisms used by plants to withstand high concentrations. Foroughi *et al*. (2011) recorded an efficiency in reducing lead, which reached 100% after the sixth day of treatment with treated and untreated household wastewater, as the plant demonstrated a high ability to absorb lead compared to other metals.

Conclusions

The pH values of the treated water increased in the baseline trend where slight increase in the pH values was recorded. The results showed that the plant under study did not show efficiency in reducing TDS values, but they recorded lower values than the control plant. This means that the decomposition processes were high above the ability of plant to reduce them. The results indicate the inability of the plant under study to reduce conductivity values throughout the treatment period, this may be due to the presence of high concentrations of some ions. The current study showed that *C. demersum* did not record any reduction ratios throughout the treatment period. As for the inefficiency of the plant by reduction, this may be due to the fact that the water is loaded with organic materials in high concentrations as well as the conversion of large quantities of calcium into soluble bicarbonate leading to an increase in total hardness. The results indicate the high efficiency of plant in reducing nitrite values with the superiority of *C. demersum* this efficiency may be due to the fact that the submerged vascular plants absorb large amounts of nitrogen. The current study showed the effective role of plants by reducing nitrates in water. The current study proved the role of aquatic plants under study in reducing the concentrations of cadmium and lead, and the reduction ratios were continuous throughout the treatment period.

References

Abouel-kheir, W.; Ismail, G.; Abou el-nour, F.; Tawfik, T. and Hammad, D. (2007). Assessment of the Efficiency of Duckweed (*Lemna gibba*) in Wastewater Treatment .Int. J. Agri. Biol., 9(5): 681- 687.

Al-Asadi, R.K. (2014). The use of some types of algae and aquatic plants in the biological treatment of water treatment plants in Diwaniyah city / Iraq. PhD thesis, Faculty of Education, Diwaniyah University, 106 pages.

Al-Janabi, Q.A.H. (2013). Phytotherapy of industrial wastewater of the General Furat Company for Chemical Industries in Babil Governorate-Iraq. Master Thesis, College of Science, University of Babylon.

Al-Saadi, H.A.; Al-Lami, A.A. and Kassim, T.I. (1999). Heavy metals in Qadisia Lake and its aquatic plants. J. Coll. Educ., 10(1): 281-292.

Al-Saadi, H.A. and Al-Mayah, A.R.A. (1983) Aquatic plants in Iraq. Publications of the Center for Arab Gulf Studies, University of Basra.

Al-Sanjari, M.N.F. (2011). A test of the efficiency of reed plants in the primary treatment of contaminated water. Tikrit Journal of Pure Sciences, 16(2): 123-127.

Al-Wahaibi, M.B.H. (2007). The phenomenon of accumulation of heavy elements in plants, Saudi Journal of Biological Sciences, Volume 14 (2).

Ambedkar, B.R. (1999). A study on water quality of river Yamania at Agra- India , J. Envir. Protec., 19(6): 44 - 41.

APHA (American public health association) (1976). Standard method for the examination of Water and Waste Water, 13th. Ed. New York.

APHA, (American Public Health Association) (1998). "Standard method for the examination of water and waste water". 20th .1015 fifteen street, N.W., Washington DC, USA.

Argo, B. (2003). Understanding pH management and plant nutrition part 2: water quality. Journal of the International Phalaenopsis Alliance 13(1): 1-15.

Ashraf, M. (2004). Some important physiological selection criteria for salt tolerance in plants"flora, 199: 361-377.

Ayyasamy, P.; Rajakumar, M.; Sathishkumar, S.M. ; Swaminathan, K.; Shanthi, K.; Lakshmanaperumalsamy, K. and Lee, S. (2009). Nitrate removal from synthetic medium and groundwater with aquatic macrophytes. Des alination 242: 286–296.

Bhatnagar, S. and Kumari, R. (2013). Bioremediation: A Sustainable Tool for Environmental Management–A Review. Annual Review and Research in Biology. 3(4): 974-993.

Bradl, H.B. (2005). Heavy metals in environment.1st ed., Elsevier, UK.

Foroughi, M.; Najafi, P.; Toghiani, A. and Honarjoo, N. (2010). Analysis of pollution removal from wastewater by Ceratophyllum demersum, African Journal of Biotechnology, 9(14): 2125–2128.

Foroughi, M.; Najafi, P.; Toghiani, A. and Honarjoo, N.(2011). Trace Elements Removal from Waster water by *Ceratophyllum demersum*. J. Appl. Sci. Environ. Manage, 15(1): 197-201.

Foroughi, M.; Najafi, P.; Toghiani, A. and Honarjoo, N. (2013). Nitrogen Removals by Ceratophyllum Demersum from Wastewater. Journal of Residuals Science & Technology, 10(2): 63-68.

Gesamp, H. (1993) IMO/FAO/UNESCO/WHO/IAEA/UN. Joint group of experts on the scientific aspects of marine pollution (GESAMP). Impact of oil and related chemicals and wasters on the marine environment. Reports and Studies No. 50, Imo, London, pp 180.

Godbold, D.L. and Kettner, C. (1991). Lead influences root growth and mineral nutrition of Picea abies seedlings, J. Plant Physiol., 139: 95–9.

Graneli, W. and Solander, D. (1986). Influence of aquatic macrophytes on phosphorus cycling in lake . Hydrobiol., 170: 245-366.

Gumbricht, T. (1993). Nutrient removal process in freshwater submersed macrophyte systems, Ecol. Eng. 2: 1–30.

Gupta, D.P.; Sunita and Saharan, J.P. (2009). Physiochemical analysis of ground water of selected area of Kaithal city (Haryana). India Researcher, 1(2): 1-15.

Hockenbury, M.R. and Grady Jr, C.P.L. (1977). Inhibition of nitrification-effects of selected organic compounds. Journal Water Pollution Control Federation, 49(5): 768–777.

Hutchinson, G.E. (1957). A treatise on limnology, vol. 1, Geography, Physics & Chemistry, New York.

Kopittke, P.M and Menzies, N.M (2006) . Effects of cu toxicity on growth of Cowpea (*Vigna unguiculata*).

Korner, S. and Vermaat, J.E. (1998). The relative importance of (*Lemna gibba*) bacteria and algae for the nitrogen and phosphorus removal in duckweed-covered domestic waste water. Water Res., 32: 3651-3661.

Kroiss, H. and Muller, H. (1999). Development of design criteria for highly efficient biological treatment of textile wastewater. J. WST, 40(45) : 399-407.

Kupper, H.; Kupper, F. and Spiller, M. (1998). In situ detection of heavy metals subtituted chlorophylls in water plants . Photosynthesis Research, 58(2): 123-133.

Lawson, E.O. (2011). Physico-chemical parameters and heavy metal contents of water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. Advan. Biol. Res., 5 (1): 08-21.

Lind, G.T. (1979). Handbook of common methods in Limnology, 2nd ed., London.

Maiti, S.K. (2004). Handbook of methods in environmental studies, Vol.1. ABD publisher, India.

Malec, P.; Maleva, M.G.; Prasad, M.N.V. and Strzalk, K. (2010). Responces *Lemna trisulca* L. (Duckweed) exposed to low dose of cadmium :thiols, metal binding complexes and photosynthetic pigments as sensitive biomarkers of Ecotoxicity. protoplasma, 240: 69-74.

Moore, R.D.; Richards, G. and Story, A. (2008). Electrical conductivity as an indicator of water chemistry and hydrologic processes. Streamline Watershed Management Bulletin, 11(2): 25- 29.

Mukherjee, S. and Chatterjee, S. (2014). Assessment of *Nelumbo nucifera* and *Hydrilla verticillata* in the treatment of pharmaceutical industry effluent from 24 Parganas, West Bengal. Internat. J. Sci. Eng., 7(2):100-105.

Mustafa, M.H. (2009). Tigris River Grey Water, Sources, Impact and Suggested Water Treatment Planets. 1st Scientific and Environmental Conference, March 30-31 2009, College of Environmental Science and Technology, The University of Mosul, Iraq.

Patel, D.K. and Kanungo, D.V.K. (2010). Ecological efficiency of *Ceratophyllum demersum* L. in phytoremedation of nutrients from domestic wastewater. Ecoscan-An International Quarterly Journal of Environmental Science, 4(4): 257-262.

Patel, D.K. and Kanungo, V.K. (2012). Treatment of domestic wastewater by potential application of a submerged aquatic plant Hydrilla verticillata Casp. Recent Research in Science and Technology, 4(10): 56-61.

Prasad, M.N.V. (1998). Metal-bimolecular complex in plants : Occurrence, functions and applications. Analysis Magazine, 26(6): 25-28.

Salman, J.M. (2006). An Environmental Study of Potential Pollution in the Euphrates River between the Al-Hindiya Bar and the Kufa-Iraq Ph.D. Thesis, Faculty of Science / University of Babylon, Iraq.

Saygideger, S.; dogan, M. and Keser, G. (2004). Effect of Lead and pH on Lead Uptake, Chlorophyll and Nitrogen Content of *Typha latifolia* L. and *Ceratophyllum demersum* L", International Journal of agriculture & biology, 6(1): 168–172.

Selvarani, A.J.; Padmavathy, P.; Srinivasan, A. and Jawahar, P. (2015). Performance of Duckweed (*Lemna minor*) on different types of wastewater treatment. International Journal of Fisheries and Aquatic Studies, 2(4): 208-212.

Shelef, O.; Gross, A. and Rachmilevitch, S. (2013). Role of plants in a constructed wetlands :Current and New perspectives. Water journal. 5: 405-419.

Singh, R.; Kirroliaa, A. and Bishnoia, N.R. (2012). Effect of shaking, incubation temperature, salinity and media composition on growth traits of green microalgae Chlorococcum sp. J. Algal Biomass Utln, 3(3): 46–53.

Sivasubramanian, V.; Subramanian, V.V.; Muthukumaran, M. and Murali, R. (2012). Algal technology for effective reduction of total hardness in wastewater and industrial effluents. Phykos, 42(1): 51– 58.

Taha, N.T.; Al-Razzaq, A.H.A. and Qasim, T.I. (2011). A test of the efficacy of Lemna spp. In reducing zinc and iron concentrations from wastewater when increasing biomass. Baghdad Journal of Science, 8(1): 471-477.

Tawfiq, R.K. and Al-Kubaisi, Abdul Rahman Abdul-Jabbar (2014). The use of the Hydrilla plant in the biological removal of copper and cadmium. Al-Mustansiriya Journal of Science, 25(3): 39-46.

Wendeou, S.P.H.; Aina, M.P.; Crapper, M.; Adjovi, E. and Mama, D. (2013). Influence of Salinity on Duckweed Growth and Duckweed Based Wastewater Treatment System. Journal of Water Resource and Protection, 5: 993-999.

Wetzel, R.G. and Manny, B.A. (1972). Secretion of dissolved organic carbon and nitrogen by aquatic macrophytes. Verh. Int. Verein. Limnol, 18: 162-170.

WHO (World Health Organization). (1996). Guideline for Drinking Water Quality Health Criteria and Other Supporting Information 2nd. Ed. Vol. 20.Geneva.

Wilson, D.O. (1972). Phosphate nutrition of the aquatic angiosperm, *Myriophyllum exalbescens* Fern, Limnol. Oce- anogr, 17: 612–616.