Impact of aquatic plant *Lemna minor* L in removing of chloride ion

Khadijah . K.Hareeb

Marine Biology/ Marine Science Center/University of Basrah/ Iraq

Kdkm75@yahoo.com

Abstract

Three weights of chloride (5,11.5and15.5gm) in the form of KCl ,each of them was dissolved in one liter of tap water, with two replicates for each treatment , two hundred grams of aquatic plant (*Lemna minor* L.) were aqua cultured in each water aquarium, then the same above mentioned weights of KCl were dissolved in the same quantities of water but without adding aquatic plants to these aquaria, in order to know the remained quantity of chloride ion in these solutions and to compare it with the one of aqua cultured plant aquaria. Chlorine in all aquaria was evaluated within standard periods . Tap water characteristics with chlorine before use were measured. It was noted the elevation of chloride concentration with increasing addition of solution and also with the time. In first treatment, in water aquaria the concentration raised by 1.5 time increase than it was in the first four days, while chloride concentration in the third treatment, increased after twelve days by 1.7 time increase than it was in the first four days . An increase in chloride concentration was also noted in aquaria of aquatic plants that accompanies the first increase . The increase in chloride concentration accompanies the increase in added chloride increase and accompanies the first increase but there is difference in increase rates in aquatic plant aquaria, since the chloride concentration in first treatment , in the first four days was more than its concentration after twelve days by more than half (0.66) where as in the second treatment, chloride rates approximated during twelve days , they were less than the ones in third treatment in which it was noted an increase in chloride concentration, but with approximation of chloride level after eight days and minor elevation after twelve days, but in aquatic plant treatment, in the first and second concentrations (T_1 and T_2) during the first four days , chloride concentration raised, whereas it decreased after eight days, it means there was a decrease by 12.97% ,whereas after twelve days , the chloride level decreased by 31.2%. But in treatment T_2 , the chloride level decreased during all twelve days of the experiment while the largest decrease occurred after twelve days, it was by 34.08 %.While in treatment $T_{3,}$ in aquaria of aquatic plants, the reduction rate in chloride ion increased by 40.83% during eight days , and by 42.6% after twelve days, but there was an increase in chloride ion level by 12% in the first four days.

Introduction

Chloride is widely distributed in nature, generally in the form of sodium (NaCl) and potassium (KCl) salts; it constitutes about 0.05% of the earth's outer crust as well as the greatest amount of chloride found in the environment is in the oceans and these chloride ions are frequently deposited as salt underground where they are mined for variety of industrial and domestic purposes as well as its uses in the road salt for winter accident prevention ,besides that sodium chloride is also widely used in the production of industrial chemicals such as caustic soda (sodium hydroxide), chlorine, soda ash (sodium carbonate), sodium chlorite, sodium bicarbonate, and sodium hypochlorite, as well as potassium chloride use in the production of fertilizers, in addition to other sources of chloride the environment include dissolution of salt deposits, effluents from chemical industries, oil well operations, sewage, irrigation drainage, refuse leachates, sea spray, and seawater(Nagpal and Levy, 2003).

Chloride is one of the major anions commonly found in ambient and wastewater, Chloride may enter surface water from several sources such as wastewater from industries and municipalities, effluent wastewater from water softening, road salting, agricultural runoff; and produced water from oil and gas wells, (Iowa DNR, 2009) .The chloride ion is negatively charged and typically is not involved in adsorption on soils and as result, it is transported along water pathways, but when reaches deep soil it disperses in water and dilutes(Jones et al, 1976) . Chloride does not seem to have any direct impact on soils, although studies find evidence in laboratory tests suggesting that it can contribute to the release of heavy metals in soils.39 Little field data to support this laboratory evidence have been found, however.Guntner and Wilke (1983) evaluated the effect of chloride on soil microbial activity. They detected a general decrease in microbial activity, but the effects were temporary, it was concluded that reductions of enzyme activity were due to decreases of microbial activity not to inactivation of enzymes (Guntner and Wilke , 1983), Mount *et al.* (1997) states that the toxicity of fresh waters with high dissolved solids has been shown to be dependent on the species ionic composition of the water ,but integrative parameters such as conductivity, TDS, or salinity are not robust predictors of toxicity for a range of water qualities. Mount *et al*. (1997) developed regression models to predict the toxicity attributable to major ions such as K+, HCO3-, Mg2+, Cl-, and SO42, their study found that the presence of multiple cations tended to be less toxic than comparable solutions with only one cation it also, as the hardness increases, TDS toxicity may decrease, hence their study mentioned that the regression models provided highly accurate predictions for Ceriodaphnia dubia toxicity, but over predict the toxicity for Daphnia magna and fathead minnows.Weber-Scannell and Duffy (2007) reported that TDS causes toxicity through increases in salinity, changes in the ionic composition of the water, and toxicity of individual ions. Increases in salinity have been shown to cause shifts in biotic communities, limit biodiversity, exclude less-tolerant species, and cause acute or chronic effects at specific life stages and changes in the ionic composition of water can exclude some species while promoting population growth of others while concentrations of specific ions may reach toxic levels for certain species of life history stages**.** Chlorides are the natural substances which are found in the water bodies in varying amounts, their concentrations are significantly low , but the industrial, domestic and agricultural wastewaters that are generated from the human society may contain large amount of chlorides, which can cause significant disruption in the ecological balance (Apte *et al.*, 2011).

Materials and methods

Three concentrations of potassium chloride (KCl) were used by dissolving 5,11.5and15.5gm of KCl in one liter of tap water, with two duplicates for each treatment and two hundred grams of aquatic plant (*Lemna minor* L.) were aqua cultured in each water aquarium, then the same above mentioned weights of KCl were dissolved in the same quantities of water but without adding aquatic plants to these aquaria, in order to know the remained quantity of chloride ion in these solutions and to compare it with the one of plant aqua cultured aquaria. The period of experiment continued for twelve days and during this experiment the remained chloride ion concentration in all aquaria was evaluated within standard periods of intervals each of four days. Tap water characteristics with chloride ion concentration before use were measured.

1-Temperature.
2-Salinity.
They were measured by using Ysi apparatus , model 556.
Chemical analyses
1- Dissolved oxygen
2-pH
3- Chloride ion concentration.

The amount of dissolved oxygen was measured according to Azide modification in Winkler' s method and described by Lind(1979) and the product was expressed in mg/ L.

pH was measured by using Ysi apparatus , model 556.

Chloride ion concentration was evaluated by titration with silver nitrate ,according the method described by(APHA,2005).

Statistical analysis was done by using SPSS for analysis of data, the mean of T_1 reached to 5590.67 ,with standard deviation of ± 2909.307, while the mean of T_2 was 6898.83 ,with standard deviation of ± 306.o7. whereas T_3 reached to 10153.oo , with standard deviation of ± 368. 927 .There were significant differences among the treatments –test value at ($P\leq0.05$) in first treatment 3.328,in second treatment was39.041,in third treatment was 47.607 and in control t value was 7.608.

Results

Physical measurements

Table (1) illustrates the physicochemical characteristics of tap water before the experiment.

Samples	Dissolved oxygen	pH	Salinity	Temperature (C^o)
Tap water	6.7	6.5	3.9	25

Table (2) illustrates the first measurement of the physicochemical characteristics of water aquaria .

Samples	Dissolved oxygen	pH	Salinity	Temperature (C^o)
Control	6.5	5.5	3.7	21.7
2.5	5	5.1	19.2	21.2
5.5	5	5.4	27	21.2
7.5	4.8	4.8	37	21.7

Table (3) illustrate the second measurement of the physicochemical characteristics of water aquaria .

Samples	Dissolved oxygen	pH	Salinity	Temperature (C^o)
Control	4.5	5.6	4.8	22.7
2.5	5.5	5.2	17	22.7
5.5	5.3	5.4	32	22.7
7.5	5	5.5	47	22.7

Table(4) illustrates the third measurement of the physicochemical characteristics of water aquaria .

Samples	**Dissolved oxygen**	**pH**	**Salinity**	**Temperature C ^{o}**
Control	5.8	5.6	5.9	23
2.5	5.5	5.8	20	23
5.5	5.4	5.7	34.6	23
7.5	4.8	5.7	53	23

Table (5) illustrates the first measurement of the physicochemical characteristics of water aquaria that included *L. minor* and after four days of addition of potassium chloride

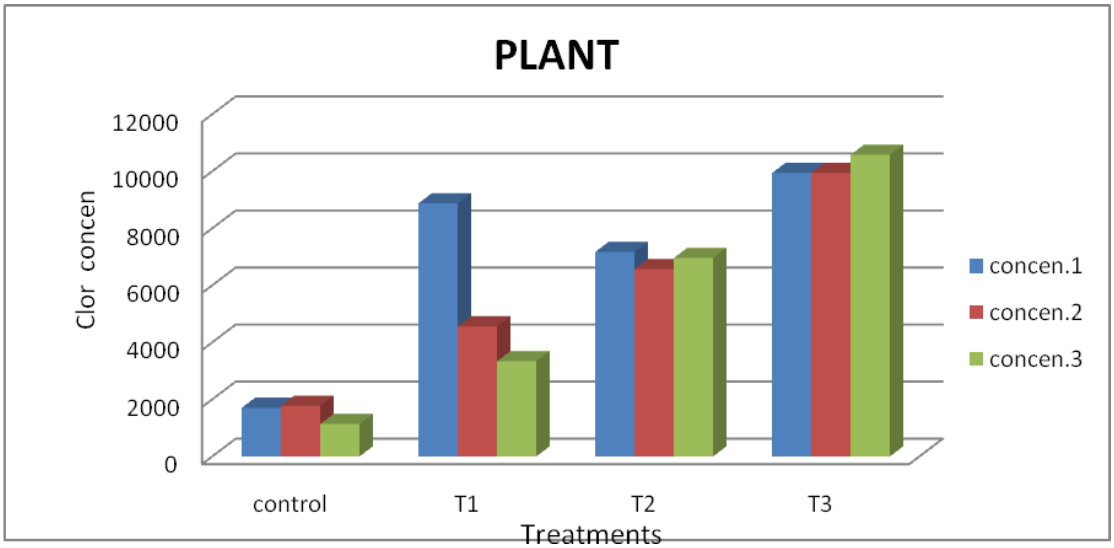
Samples	Dissolved oxygen	pH	Salinity	Temperature (C^{o})
Control	6.5	6.5	4.5	28
2.5	1	5.8	14	28
5.5	1.4	5.8	28	28
7.5	1.7	6	33	28

Table (6) illustrates the second measurement of physicochemical characteristics of water aquaria that included *L.minor* and after eight days of addition of potassium chloride

Samples	**Dissolved oxygen**	**pH**	**Salinity**	**Temperature (C ^{o})**
Control	5.2	6.1	4.29	27
2.5	5.5	4.8	10.31	27.4
5.5	2.5	5	19.7	27
7.5	2.5	5.6	31	27

Table (7) illustrates the third measurement of physicochemical characteristics of water aquaria that included *L.minor* and after twelve days of addition of potassium chloride

Samples	Dissolved oxygen	pH	Salinity	Temperature(C^o)
Control	5.7	5.85	3.7	23
2.5	1.7	5.22	17	20.5
5.5	2.4	5	24	20.5
7.5	2	5.4	54	21



Figure(1) illustrates the remained chloride in plant aquaria.

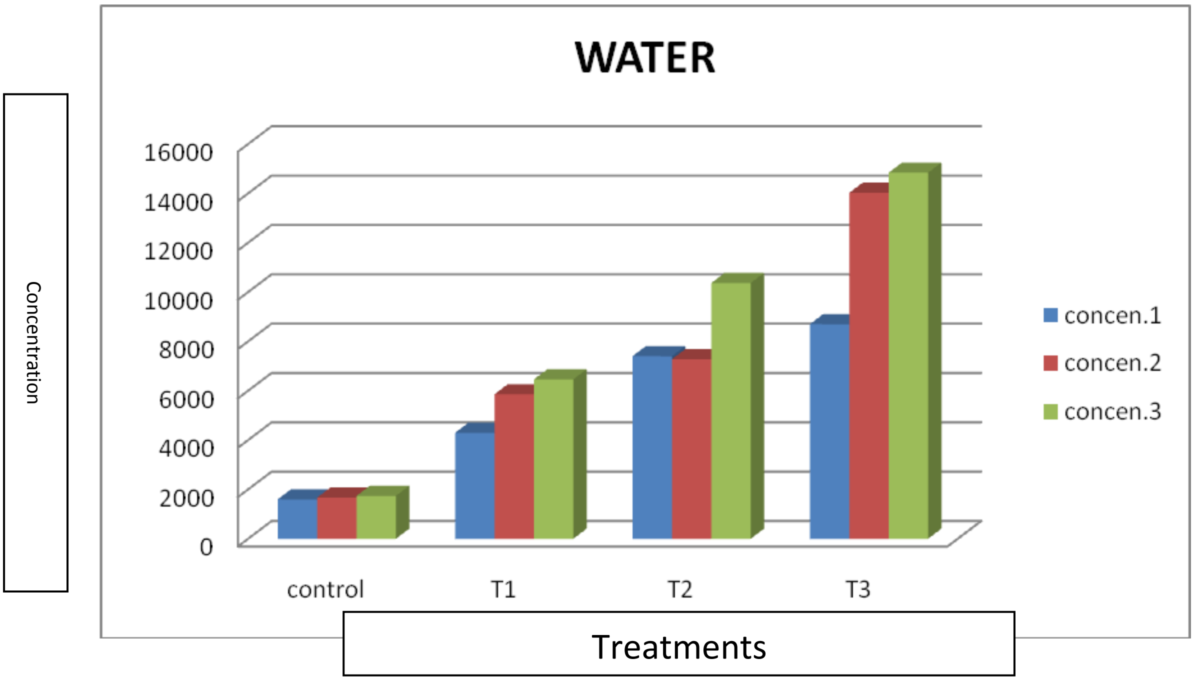
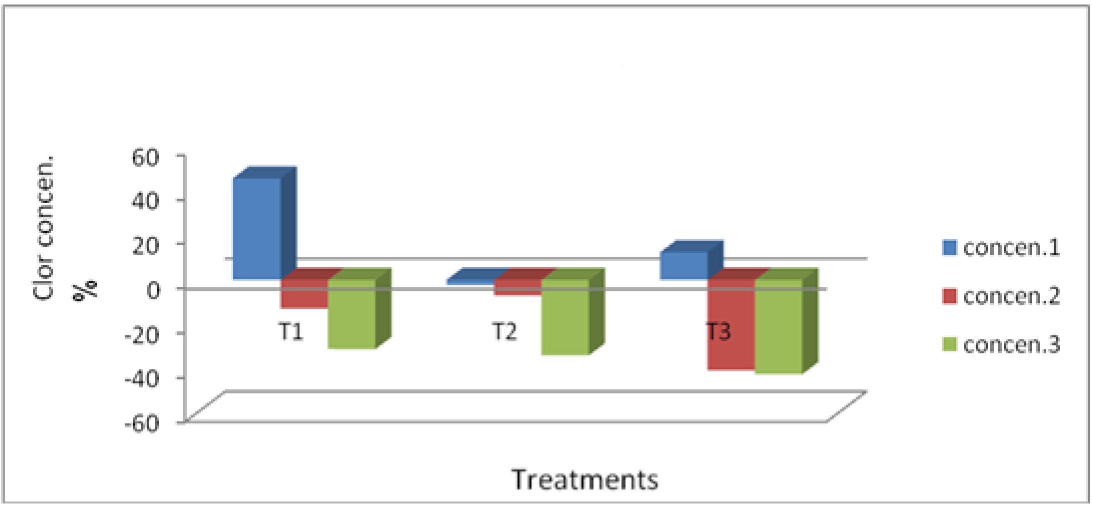


Figure (2) illustrates the remained chloride in water aquaria



Figure(3) illustrates the increase and decrease in chloride ion concentration in the three treatments.

Discussion

The tables(2,3,4) concerned with aquaria of water and dissolved chloride only without aquatic plant. These aquaria did not show any reduction in chlorine concentration but instead of that chlorine concentration increased due to evaporation of water from the aquaria, where as the tables (5,6,7) concerned with aquaria of water, chlorine as well as aquatic plant (*L. minor*),showed a reduction in chlorine concentration in the two aquaria that contained 2.5 and5.5 g/L of chlorides, while the aquarium that contained 7.5 g/L did not show any reduction in chloride concentration.

Figure (2) illustrates the chloride ion concentrations in water aquaria during the period of study in the different treatments and it was noted the elevation of chloride ion concentration with increasing addition of solution and also with the time. In first treatment, in water aquaria the concentration raised from 4295.5mg/L to 6461mg/L by one and half time increase than it was in the first four days, while chloride ion concentration in the third treatment, increased from 8697.5mg/L in the first four days to 14839 mg/L after twelve days by 1.7 time increase than it was in the first four days. This elevation in concentration of chloride ion with time may be due to evaporation because the aquaria were opened so there was a possibility of an increase in chloride ion concentration after eight and twelve days than it was in the first four days. An increase in chloride ion concentration was also noted in aquaria of aquatic plants that accompanies the first increase. The increase in chloride ion concentration accompanies the increase in added chloride ion increase but there is difference in increase rates in aquatic plant aquaria, since the chloride ion concentration in first treatment , in first four days was more than its concentration after twelve days by more than half time (0.66) where as in the second treatment, chloride ion rates during the four ,eight and twelve days were approximated , they were less than the ones in third treatment in which it was noted an increase in chloride ion concentration, but with approximation of chloride level in the four and eight days and small elevation after twelve days.

Metabolism may raise chloride level in the solution ,in the first and second concentrations (T_1 and T_2) during the first four days ,it raised from 4293.5mg/L to 8875mg/L whereas it decreased after eight days from 5857.5mg/L to 4580mg /L ,figure (3) in aquatic plant treatment , it means there was a 1297.2 mg/L decrease, in another word by 12.97% ,whereas after twelve days , the chloride ion level decreased by 31.2%. But in treatment T_2 , the chloride ion level decreased during all the twelve days of the experiment while the largest decrease occurred after twelve days, it was 34.08 %.While in treatment $T_{3,}$ in aquaria of aquatic plants, the reduction rate in chloride ion increased by 40.83% after eight days and by 42.6% after twelve days, but there was an increase in chloride ion level by 12% in the first four days as shown in figure (3) . Bere (2007) mentioned that aquatic plant (*L. minor*) remove the nutrients from polluted water, is regarded as highly efficient aquatic plant in removing pollutants. The effects of contamination are of particular concern when high concentrations of components (1)accumulate in localized areas (such as end points of runoff drainage channels) and groundwater supplies; (2) increase biochemical oxygen demand; (3) accelerate eutrophication; (4) alter pH level ;and (5) stratify water bodies.

These conditions can have a variety of effects on aquatic biota, ranging from reducing their growth and reproduction to causing mortality in water bodies vulnerable to high concentrations of deicing materials include shallow groundwater drinking supplies adjacent to roadways, small rivers and streams adjacent to roadways, and small lakes and wetlands that have only seasonal outflow and/or partially closed or closed basins(Judd and Steggall, 1982)

Chloride is one of the major anions commonly found in ambient and wastewater, Chloride may get into surface water from several sources, including wastewater from industries and municipalities, effluent wastewater from water softening road salting agricultural runoff, and produced water from oil and gas wells. Iowa DNR(2009). Chloride tends to accumulate in tissues, particularly leaves, of some plants to toxic levels. Chloride accumulation in plants is closely related to chloride concentration in the external solution and the genotype. (Hajrasuliha , 1980). Mount *et al*.(1997) stated that the composition of specific ions determined toxicity of elevated TDS in natural waters, found relative ion toxicity was K+ > HCO3- = Mg2+ > Cl- > SO42-. Ca2+ and Na+ did not produce significant toxicity. For C. dubia and D.magna , toxicity of Cl-, SO42- and K+ were reduced in solutions containing more than one cation.

In freshwater, natural background concentrations of chloride are on the order of 1 to 100 mg/L, with maximum observed surficial concentrations in B.C. in the range of 13 to 140 mg/L (Bright and Addison , 2002). High concentrations of chloride, related to the use of road salt on roads or released from storage yards or snow dumps, have been measured in ground water adjacent to storage yards, in small ponds and water courses draining large urbanized areas, and in streams, wetlands and lakes draining major roadways, while the highest concentrations of chloride are usually associated with winter and spring thaws, elevated chloride concentrations have also been measured during summer low flow (Nagpal and Levy, 2003).

Although chloride is an essential element for maintaining normal physiological functions in all aquatic organisms but elevated or fluctuating concentrations of this substance can be detrimental and specifically when the exposure to elevated levels of chloride in water can disrupt osmoregulation in aquatic organisms leading to impaired survival, growth, and/or reproduction and because excess chloride is most frequently actively excreted from animal tissues via the kidneys or equivalent renal organs to achieve osmoregulatory balance, the bioaccumulation potential of chloride is low but several factors such as dissolved oxygen concentration, temperature, exposure time and the presence of other contaminants influence chloride toxicity. However, few studies have systematically evaluated the influence of confounding variables on chloride toxicity in aquatic environments (Nagpal and Levy, 2003). The basic concept of a duckweed polluted water treatment system is to farm local duckweeds on the polluted water which needs to be treated. The rapidly growing plants act as a nutrient sink, absorbing primarily nitrogen, phosphorus, calcium, sodium, potassium, magnesium, carbon and chloride from the wastewater (Leng *et al*, 1995). A variety of techniques have been found to be extremely suitable for the removal of chlorides. Some of these include ion exchange (Giyeon and Buchanan, 2006), reverse osmosis, norcure, etc. However, these techniques though effective, are not feasible from the cost perspective. Many techniques have been adopted in order to reduce the amount Of chlorides in wastewater like demineralization , reverse osmosis, agulation, precipitation, electrodialysis and so on , these techniques are physico – chemical in nature, and are cost consuming capital cost wise as well as maintenance cost wise but biological alternative was used for the removal of chlorides from wastewater for instance *Parthenium* sp. as a sorbent for chloride removal (Apte *et al*.,2011).

The major impact that chlorides impart on the receiving waters is the permanent hardness increase the rate of sedimentation and thereby decreasing the water column depth besides that chlorides tend to initially percolate some distance, but over a period of time, they cause surface salt formation, thereby causing increased alkalinity of the soil, hence resulting in loss of soil fertility where as in plants, chlorides tend to accumulate in the tissues, especially the leaves and chloride accumulation in plants is closely related to the chlorine concentration in the external solution and the genotype (Hajrasuliha, 1979). It was also noted that when sodium and chloride, when supplied via landfill leachate irrigation, is accumulated in high concentrations in the tissues of many plants like *Populus* (Zalesny *et.al.* 2007).

References

Amrhein, C. and Strong, J. E. (1982). Effect **of** Deicing Chemicals on Major Ion and Trace Metal Chemistry in Roadside Soils (1990b). in Goldman, Environmental Impact of Highway Deicing (symposium); D. T. Long and E. E.Angino, "Mobilization of Selected Trace Metals from Shales by Concentrated Aqueous Solutions: Shales as a SourceRock," Economic Geology , 77646-77652.

-APHA, , AWWA and WEF (2005).Standard methods for examination of water and wastewater ,21th ed,Washington,D.C.

-Apte Sagar. S.; Apte Shruti S., 1Kore V. S., 1Kore S. V.(2011). Chloride Removal from Wastewater by Biosorption with the Plant Biomass Journal of Environmental Research and Technology , Volume 1, Issue 4: 416-422.

-Bere,T.(2007). The assessment of nutrient loading and retention in the upper segment of Chinyka river ,Harare (implication for eutrophication control),Dept . of Biological Sciences,Univ. of Zimbabwe. Water SA,33 (2);279-284.

-Bright, D.A. and J. Addison. 2002. Derivation of matrix soil standards for salt under the British Columbia Contaminated Sites Regulation. Royal Roads University. Prepared for BC Ministry of Water, Land and Air Protection, BC Ministry of Transportation and Highways, BC Buildings Corp., and the Canadian Association of Petroleum Producers. Victoria, BC.

-Guntner, M. and Wilke, B. M.(1983). " Effects of De-Icing on Soil Enzyme Activity," Water, Air, and Soil Pollu., 20(2),pp 211- 220 .

-Hajrasuliha, S. (1980): Accumulation and toxicity of chloride in bean plants, J. Plant and Soil, 55(1) ,pp133-138.

-Hanes, R. E. (1976). Effectsof De-Icing Salts on Water Quality and Biota, Transportation Research Board, National Research Council (Washington,D.C.).

-Iowa DNR(2009). Water Quality Standards Review:Chloride, Sulfate and Total Dissolved Solids, Iowa Department of Natural Resources Consultation Package,pp3-6.

-Jones, P. H., Jeffrey, B. X. , Watler, P. K. and Hutchon, H.(1986). Environmenral Impact of Road Salting-State of the Art, Research and Development Branch, Ministry of Transportation and Communications ,Ontario.

-Judd, J. H. and. Steggall, J. W. (1982). Reevaluation of the Effects of Deicing Salt Runoff on a Small Urban Luke,Office of Water Research Technology (Washington, D.C).

-Leng,R.A.,Stambolie,J.H. and Bell,R. (1995). Duckweed - a potential high-protein feed resource for domestic animals and fish, J. **Livestock Research for Rural Development , 7(1);** 1-11.

-Lind,O.T.(1979).Handbook of utilization of aquatic plants.A review of world literature.FOA Fisheries Technical paper,No.187.

-Mount, D .R . , Gulley, D .D ., Hockett, J .R., Garrsion, T .D, and Evans,, J .M. 1997. Statistical Models to Predict the Toxicity of Major Ions to Ceriodaphnia dubia, Daphnia magna and Pimephales promelas (Fathead Minnows). Environ Toxicol Chem 16(10):2009-2019.

-Nagpal , N.K., Levy , D.A., and MacDonald, D.D.(2003). Ambient water quality guidelines for chloride, overview report, Environmental Protection division,British Columbia ,Canada.

-Weber-Scannell, P.K., and L.K.Duffy. 2007. Effects of total dissolved solids on aquatic organisms: a review of literature and recommendation for Salmonid Species. American Journal of Environmental Sciences. 3(1): 1-6.

-Zalesny, Jill. A., Zalesny, Ronald S. Jr., Wiese,Adam. H., Sexton, Bart, Hall, Richard. B. (2007):Sodium and chloride accumulation in the leaf,wood, and root tissue of *Populus* after irrigation with landfill with leachates, Env. Poll. xx ,pp 1-9.

تأثير نبات عدس الماء *Lemna minor* L في ازالة ايون الكلورايد

خديجة كاظم حريب

مركز علوم البحار/جامعة البصرة /العراق

المستخلص

استخدمت ثلاثة اوزان من الكلور وهى 5 ، 11,5 و5, 15 غرام بصورة KCl حيث اذيب كل منها فى لتر واحد من ماء الاسالة و بمكررين لكل معاملة واستزرع نباتات عدس الماء فيها بوزن 200 غم لكل حوض واذيبت نفس الاوزان المذكورة اعلاه من كلوريد البوتاسيوم فى نفس مقادير الماء مع عدم اضافة النباتات الى الاحواض لمعرفة مقدار المتبقى من ايون الكلورايد فيها ومقارنته مع مقداره فى الاحواض المستزرعة . قدر الكلور بفترات قياسية ، كما قيس مواصفات ماء الاسالة مع قياس الكلور قبل الاستعمال ، لوحظ ارتفاع تركيز الكلورايد مع زيادة الاضافة فى المحلول كذلك لوحظ زيادة التركيز مع الزمن ففى المعاملة الاولى ارتفع التركيز بمقدار مرة ونصف عن الاسبوع الأول اما فى المعاملة الثالثة فقد ارتفع تركيز الكلورايد فى الاسبوع الثالث بمقدار7 ,1 مرة عن الاسبوع الاول . بينما اظهرت الاحواض المتضمنة عدس الماء زيادة فى الكلورايد ترافق الزيادة فى زيادة الكلورايد المضافة ومترافقة مع الزيادة الاولى الا ان هناك تباين فى نسب الزيادة فى احواض النبات ففى المعاملة الاولى فى الاسبوع الثالث، لوحظ انخفاض الكلورايدعن الاسبوع الاول بمقدار اكثر من النصف (66, 0 مرة) فى حين فى المعاملة الثانية ، تقاربت نسبة الكلورايد خلال الاسابيع الثلاثة وكانت اقل من المعاملة الثالثة التى لوحظ فها زيادة فى تركيز الكلورايد مع تقارب مستوى الكلورايد خلال الاسبوعين ،الاول والثانى و ارتفاع طفيف خلال الاسبوع الثالث . ولكن فى معاملة النبات ، فى التركيزين ، الاول والثانى(T_1 و T_2) فى الاسبوع الاول ارتفع نركيز الكلورايد فى المحلول فى حين انخفض تركيزه خلال الاسبوع الثانى بنسبة 12,97٪ و انخفض بنسبة 31،24 ٪ فى الاسبوع الثالث .اما فى المعاملة T_2 فقد انخفض تركيز الكلورايد فى جميع الاسابيع وأكثر انخفاض حدث فى الاسبوع الثالث وهو بنسبة 34،08 ٪ وزاد الانخفاض فى المعاملةT_3 فى احواض النبات بنسبة 40،83 ٪ خلال الاسبوع الثانى ، 42،6 ٪ فى الاسبوع الثالث الا انه كانت هناك زيادة في تركيز الكلورايد بنسبة٪ خلال الاسبوع الاول فى احواض النبات.