African Journal of Biotechnology Vol. 9(14), pp. 2125-2128, 5 April, 2010
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB09.1698
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Analysis of pollution removal from wastewater by *Ceratophyllum demersum*

M. Foroughi[1], P. Najafi[2]*, A. Toghiani[3] and N. Honarjoo[2]

[1]Department of Soil Sciences, Islamic Azad University, Khorasgan Branch, Isfahan, Iran.
[2]Department of Soil and Water Sciences, Islamic Azad University, Khorasgan Branch, Isfahan, Iran.
[3]Department of Soil Sciences, Islamic Azad University, Khorasgan Branch, Isfahan, Iran.

Accepted 6 January, 2010

Water is one of the most stable and abundant complexes on nature that can be polluted with natural and human factors. Polluted water is harmful to human health and need to purify. One of the economic and rapid methods for elements removal is displacement of metals by biosorption. Two treatments in four replications for the purpose of purifying wastewater by *Ceratophyllum demersum* were designed. The treatments included raw municipal wastewater (RMW) and treated municipal wastewater (TMW). The experiment was performed at the open air of Khorasgan University area for 18 days without aeration. Result of the COD indicated that the COD of RMW and TMW were decreased from 664 to 152.75 mg/l and 260 to 64.5 mg/l, respectively. Also, this investigation demonstrated that the amount of ammonium in RMW and TMW decreased from135 to 15 meq/l and 90 to 10 meq/l, respectively. The amount of nitrate in RMW and TMW had a similar decreased from 60 to 30 meq/l as well as 4.48 to 0.53 meq/l, respectively and the amount of phosphorous in RMW and TMW declined from 13.68 to 1.15 meq/l and 4.48 to 0.53 meq/l, respectively. It could be concluded from these results that a significant amount of these macro elements were absorbed by *C. demersum*. The other factor that was measured in this study was the electrical conductivity (EC). Results of this factor indicated that the EC of treated municipal wastewater (from 1.34 to 0.95 ds/m) and the EC of raw municipal wastewater (from 2.68 to 2.12 ds/m) were reduced. The variation for NH_4, NO_3, COD and EC were < 5%. Therefore it was concluded that *C. demersum* can be used for refining wastewater.

Key words: Pollution, *Ceratophyllum demersum*, nitrogen, phosphorous, COD.

INTRODUCTION

By far the greatest volume of waste discharged to the marine environment is sewage. Sewage effluent contains industrial waste, municipal wastes, animal remains, slaughterhouse wastes, water and wastes from domestic baths, utensils and washing machines, kitchen wastes, faecal matter and many others. Huge loads of such wastes are generated daily from highly populated cities and are finally washed out by the drainage systems which generally open into nearby rivers or aquatic systems. Sewage effluent entering coastal waters contains a variety of harmful substances including viral, bacterial and protozoan pathogens, toxic chemicals such as organochlorines, organotins and heavy metals and a variety of other organic and inorganic wastes (Islam and Tanka, 2004).

Cloern (2001) described two broad responses of nutrient loadings in coastal waters: direct responses such as changes in chlorophyll, primary production, macro and micro algal biomass, sedimentation of organic matter, altered nutrient ratios, harmful algal blooms and indirect responses such as changes in benthos biomass, benthos community structure, benthic macrophytes, habitat quality, water transparency, sediment organic matter, sediment biogeochemistry, dissolved oxygen, mortality of aquatic organisms, food web structure, among others. Blooming and finally collapse of algae may lead to hypoxia/anoxia and hence mass mortality of benthic invertebrates and fish over large areas. Sensitive species may be eliminated and major changes in ecosystem may occur. Increases in nutrient concentration, phytoplankton biomass

*Corresponding author. E-mail: payam.najafi@gmail.com.

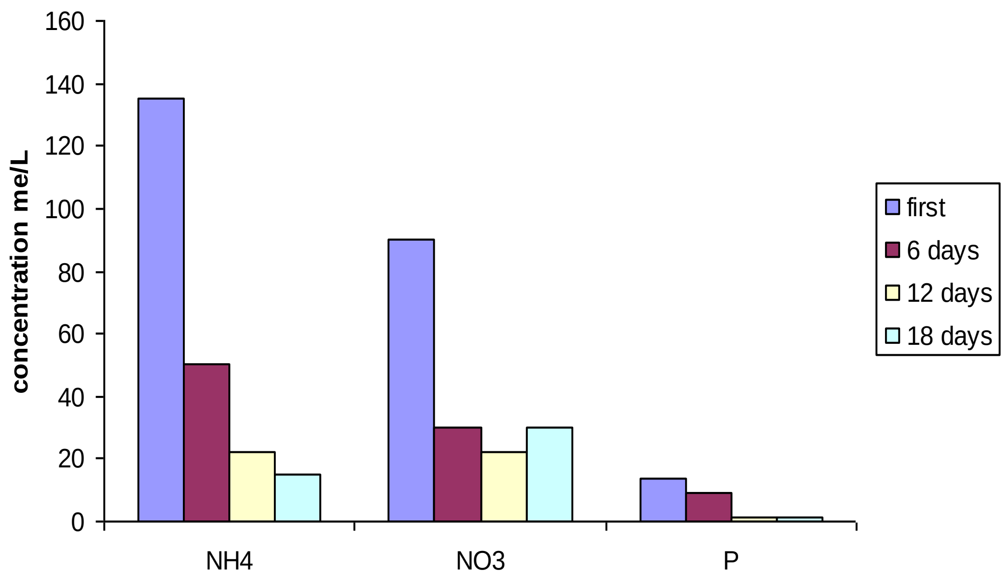

Figure 1. Removal of nutrient from RMW.

and productivity, alternation of nutrient ratios, change of species composition and large scale hypoxia/anoxia affecting hundreds and thousands of km^2 have been reported in many areas all over the world (Sheppard, 2000).

The problems of aquatic pollution are likely to exacerbate and pose significant ecological/public health risk in the coming years, especially in developing countries (Islam and Tanka, 2004). Recently, particular attention was paid to metal ions binding by non-living (biosorption) and living biomass (bioaccumulation). The majority of studies usually focus on bioremoval of metals from wastewater (Pagnanelli et al., 2001; Naja and Volesky, 2006; Miretzky et al., 2006; Keskinkan et al., 2004).

Submerged aquatic vascular plants are known to absorb nutrients, such as nitrogen (N) and phosphorus (P), far in excess of their normal metabolic requirements (Wilson, 1972). Thus, considerable amounts of nutrients can be stored in plant dominated littoral areas of aquatic ecosystems. Nutrient uptake and storage by aquatic plants is an integral part of the biogeochemical cycle of both natural wetland ecosystems (Mitsch and Gosselink, 2000) and treatment wetlands (Kadlec and Knight, 1996; Reed et al., 1995). Because some species of submerged aquatic vegetation (SAV) assimilate nutrients directly from the water column, this community may play an important role in maximizing nutrient removal in treatment wetlands (Gumbricht, 1993).

Ceratophyllum demersum L. (*Ceratophyllaceae*, horn weed or coontail) grows in shallow, muddy, quiescent water bodies at lowlight intensities. It is a submerged, rootless, free floating, perennial and it is cosmopolitan in distribution. This submerged macrophyte has a high capacity for vegetative propagation and biomass production even under low nutritional conditions, which removes excess nutrients and cadmium from stagnant waters (Best, 1977; Pomogyi et al., 1984). It is useful as an oxygenate or for use in the closed equilibrated biological aquatic system (CEBAS) (Ornes and Sajwan, 1993; Aravind and Prasad, 2005).

This paper presents the results from a study of pollution removal by *C. demersum* from sewage and waste water.

MATERIALS AND METHODS

C. demersum plants were collected from Zayanderood River in spring season of 2009 (Isfahan, Iran, 32° 38' 30'' N, 51° 39' 40'' E). Samples were thoroughly washed with tap water to remove any soil/sediment particles attached to the plant surfaces. The plants were then placed in urban wastewater and Khorasgan University's sewage water in 8 bottles (volume 6 l). The experiment was performed at the open air of Khorasgan University area under natural daylight for 18 days without aeration. Samples were collected for three periods of six days and compared with primary sample (before using *C. demersum*). No_3 and NH_4 were measured according to standard method (keeney and Bremner, 1996). Phosphorous (P) was determined according to the estimation of available phosphorous in soil (Olsen et al., 1954). Electrical conductivity (EC) was measured according to comparison and extracts with saturation extracts (Hogg and Hurey, 1984) and COD was measured by COD meter. All of the data collected during this experiment were analyzed with Statistical Package for the Social Sciences (SPSS) software (version 16.0) and were compared with the Duncan's multiple range test.

RESULTS AND DISCUSSION

The concentration of NH_4 in RMW and TMW decreased from 135 to 15meq/l and from 90 to 10meq/l, respectively, for each three periods of six days (Figures 1 and 2).

Unrooted submerged vegetation such as *C. demersum*

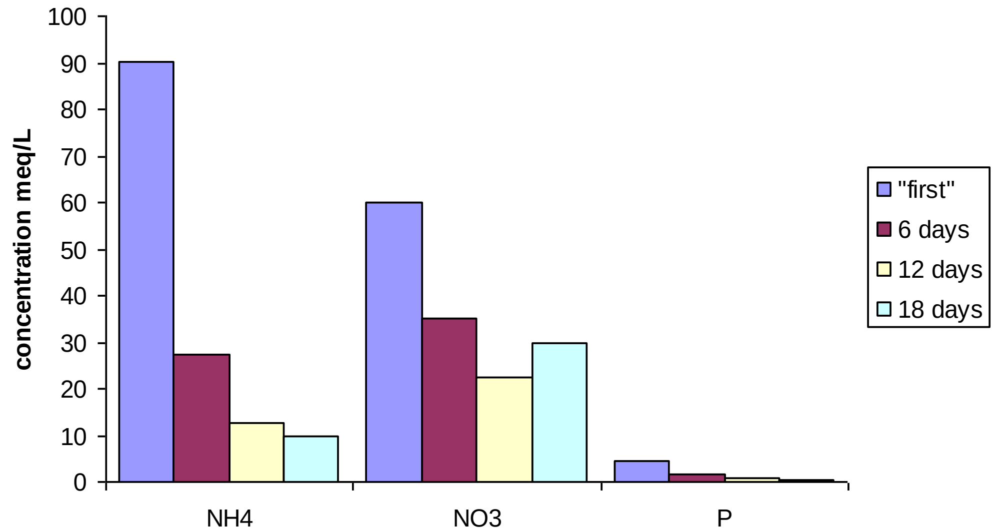

Figure 2. Removal of nutrient from TMW.

Table 1. Values of COD (mg/l) in samples of two treatments.

Treatment	COD (mg/l)			
	First day	6 days	12 days	18 days
RMW	664	257.25	231.50	152.75
TMW	260	230.50	164.25	64.50

Table 2. Changes process EC (ds/m) in samples of two treatments.

Treatment	EC (ds/m)			
	First day	6 days	12 days	18 days
RMW	2.68	2.32	1.88	2.12
TMW	1.34	0.91	1.14	0.95

requires nutrient uptake from the water (Mjelde and Faafeng, 1997). The concentration of P in RMW and TMW decreased from 60 to 30meq/l and from 4.48 to 0.53meq/l for each three periods of six days, respectively, (Figures 1 and 2). Submerged macrophytes could be used in reducing the P levels of nutrient enriched waters (Gao et al., 2009). Mjelde and Faafeng (1997) showed *C. demersum* development in shallow Lakes with high phosphorous load.

Analysis of NO_3 in samples showed that concentration of NO_3 in both treatments decreased from 135 to 15meq/l and from 90 to 22.5meq/l for the first two periods of six days, then concentration of NO_3 increased from 22.5 to 30 meq/l for the last period of six days (Figures 1 and 2).

It has been well documented in studies by Allen (1971), McRoy et al. (1972), Wetzel (1969), Wetzel and Manny (1972) and Wetzel and Allen (1972) that appreciable amounts of dissolved organic matter (DOM), including soluble nutrients, are continuously being excreted by living aquatic vascular plants.

The measured COD in RMW and TMW decreased from 664 to 152.75 mg/l and from 260.5 to 64.5 mg/l for all three periods respectively (Table 1).

Aquatic plants play a major role in the environmental conditions of stagnant and flowing waters. They produce organic matter and oxygen (Cedergreen et al., 2004). Zimels et al. (2009) showed that aquatic plants can be used for design calculations regarding expected removal of pollutants by aquatic floating plants and Tripathi and Shukla (1991) showed that they can decreased COD and increased dissolved oxygen.

Results of EC in two treatment indicated that the EC reduced from 2.68 to 2.12(ds/m) and from 1.34 to 0.95(ds/m) for all three periods of time (Table 2). Thus, considerable amounts of nutrients can be stored in plant dominated littoral areas of aquatic ecosystems (Kistritz, 1978). The variation for NH_4, NO_3, COD and EC were < 5%.

Conclusion

The data showed that nitrogen and phosphorous was removed from RMW and TMW as these were adsorbed by *C. demersum*. This experiment showed that the aquatic submerged plant *C. demersum* can be an effective biosorbent for nutrient as it decreased these elements in RMW and TMW. Also the data indicated that *C. demersum* increased oxygen dissolved in water and therefore COD decreased. EC decreased in polluted water by *C. demersum*. The aquatic plant *C. demersum* can play a major role in the environmental conditions of stagnant and flowing waters and this plant could adsorb elements and decrease pollution of sewage and waste-water. Therefore, it can be concluded that *C. demersum* can be used for refining wastewater.

REFERENCES

Allen HL (1971). Chemo organotrophy in epiphytic bacteria with reference to macrophyte release of dissolved organic carbon. In: Cairms JC (ed.) The Structure and Function of Freshwater Microbial Communities. Virgol. Polytech. Press, pp. 277-280.

Aravind P, Prasad MNV (2005). Modulation of cadmium induced oxidative stress in *Ceratophyllum demersum* by zinc involves ascorbate-glutathione cycle and glutathione metabolism. Plant Physiol. Biochem. 43: 107-116.

Best EPH (1977). Seasonal changes in mineral and organic components of *Ceratophyllum demersum* and *Elodea canadiensis*. Aquat. Bot. 3: 337-348.

Cedergreen N, Streibig JC, Spliid NH (2004). Sensitivity of aquatic plants to the herbicide metsulfuron-methyl. Ecotoxicol. Environ. Saf. 57: 153-161.

Cloern JE (2001). Our evolving conceptual model of the coastal Eutro phication problem. Mar. Ecol. Progress Series, 210: 223-253.

Gao J, Xiong ZH, Zhang J, Zhang W, Obono MbaF (2009). Phosphorous removal from water of eutrophic Lake Donghu by five submerged macrophytes, De salination 242: 193-204.

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

Hogg T, Hurey JL (1984). Comparision and extracts with the saturation extracts in estimating salinity in saskatchwan soils. Can. Soil Sci. J. 64: 699-704.

Islam MdSh, Tanaka M (2004). Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis, Mar. Pollut. Bull. 48: 624-649.

Kadlec RH, Knight RL (1996). Treatment Wetlands. Lewis Publishers, Boca Raton, FL.

Keeney DR, Bremner JM (1996). Comparison and evaluation of laboratory methods of obtaining an index of soil nitrogen availability. Agron. J. 58: 498-503.

Keskinkan O, Goksu MZL, Basibuyuk M, Forster CF (2004). Heavy metal adsorption properties of a submerged aquatic plant (*Ceratophyllum demersum*). Bioresour. Technol. 92: 197-200.

Kistritz RU (1978). Recycling of nutrients in an enclosed aquatic community of decomposing macrophytes (*Myriophyllum spicatum*). Oikos 30: 561-569.

McRoy CP, Barsdate RJ, Nebert M (1972). Phosphorous cycling in an eelgrass (*Zostera marina* L.) ecosystem. Limnol. Oceanogr. 17: 58-67.

Miretzky P, Saralegui A, Fernandez Cirelli A (2006). Simultaneous heavy metal removal mechanism by dead macrophytes. Chemosphere, 62: 247-254.

Mitsch WJ, Gosselink JE (2000). Wetlands, 3rd ed. John Wiley &Sons, Inc., New York, NY.

Mjelde M, Faafeng BA (1997). *Ceratophyllum demersum* Hampers phytoplankton development in some small Norwe Gian lakes over awide range of phosphorus concentrations and Geographic allatitude. Fresh Water Biol. 37: 355-365.

Naja G, Volesky B (2006). Multi-metal biosorption in a Wxed bed Xowthrough column. Colloid Surf. A 281: 194-201.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954). Estimation of ailable phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939. U.S. Government Printing Office, Washington D.C.

Ornes WH, Sajwan KS (1993). Cadmium accumulation And bioavailability in coontail (*Ceratophyllumdemersum*) plants. Water Air Soil Pollut. 69: 291-300.

Pagnanelli F, Trifoni M, Beolchini F, Esposito A, Toro L, Veglio F (2001). Equilibrium biosorption studies in single and multi-metal systems. Process Biochem. 37: 115-124.

Pomogyi P, Best EPH, Dassen JHA, Boon JJ (1984). On the relation between age, plant composition and nutrient release from living and killed *Ceratophyllum* plants. Aquat. Bot. 19: 243-250.

Reed SC, Crites RD, Middlebrooks EJ (1995). Natural Systems for Waste Management and Treatment, 2nd ed. McGraw Hill, Inc., New York, NY.

Sheppard C (Ed.) (2000). Regional Chapters: Europe, The Americas and West Africa. In: Seas at the Millennium: an Environmental Evaluation, Vol. 1. Pergamon, Amsterdam, Oxford. p. 934.

Tripathi BD, Shukla SC (1991). Biological treatment of wastewater by selected aquatic plants, Environmental Pollution, 69(1): 69-78.

Wetzel RG (1969). Factors influencing photosynthesis and excretion of dissolved organic matter by aquatic macrophytes in hard water lakes. Verh. Int. Verein. Limnol. 17: 72-85.

Wetzel RG, Allen HL (1972). Functions and interactions of dissolved organic matter and the littoral zone in lake metabo- lism and eutrophication. In: Kajak Z. Hillbricht-Il- kowska A (ed.). Productivity Problems of Freshwaters, pp. 333-347.

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

Wilson D0 (1972). Phosphate nutrition of the aquatic angiosperm, *Myriophyllum* exalbescens Fern. Limnol. Oce-anogr. 17: 612-616.

Zimels Y, Kirzhner F, Kadmon A (2009). Effect of circulation and aeration on wastewater treatment by floating aquatic plants. Separation and Purification Technology, 66(3&7): 570-577.