Annals of Plant Sciences 6.12 (2017) pp. 1918-1921

ANNALS OF PLANT SCIENCES
ISSN: 2287-688X
OPEN ACCESS
www.annalsofplantsciences.com

Research Article

Studies on phytoremediation of municipal waste water with reference to aquatic plant *Ceratophyllum demersum*

Mohan J., Narendra Babu Shakya, Narendra K. Shukla & Vishnu Kumar
Department of Botany, DAV College, Kanpur, India.

Received: 10/20/2017; **Revised:** 10/29/2017; **Accepted:** 11/13/2017

Abstract: *C. demersum* is a cosmopolitan submerged aquatic varieties that has presumably as of now attacked a large portion of its potential intriguing extent. It has the upsides of being a perpetual surviving great overwinter in more profound water and by becoming both by asexual reproduction of broken or finish stems and by sexual reproduction of a lot of seeds. It has a wide biological resistance and becomes moderately quick. Unsettling influence of the water body brings about increments in development through changes in supplement accessibility yet in addition in quicker dispersal around water bodies permitting more noteworthy rivalry with less overwhelming species.

Keywords: *Ceratophyllum demersum,* phytoremediation, Aquatic plant

Introduction

The interest for aquatic plants, principally marine full scale green growth has expanded exponentially finished the previous couple of decades. Worldwide harvests of aquatic plants in 2009 were approximately 17 million tons with marine algae growth involving > 85 percent of this aggregate. Kelp has generally been the class of marine green algae growth collected in the best volume with top harvests happening from 2004 to 2009 at > 6 million tons. Anyway in 2009, the gather of red green growth outperformed kelp by around 2 million tons. Nations contributing the lion's share of wild collected full scale green growth incorporate China, Chile, Norway, Japan, and Russia (FAO, 2010). Macroalgae generation because of aquaculture is most noteworthy in China took after by Indonesia, the Philippines, Korea, Japan, Malaysia and Vietnam (Bixler & Porse, 2011; FAO, 2010; McHugh, 2003; Sculthorpe 1967).

Description

Ceratophyllum demersum, normally known as hornwort, inflexible hornwort, (BSBI List 2007) coontail, or coon's tail, (*Ceratophyllum demersum* on the Global Invasive Species database, 2006) is a species of *Ceratophyllum.* It is a submerged, free-drifting amphibian plant, with a cosmopolitan circulation, local to all landmasses aside from Antarctica. It is an unsafe presented weed in New Zealand (Ceratophyllum demersum on the Global Invasive Species database, 2006).

An aquatic plant, *Ceratophyllum demersum* has stems that achieve lengths of 1–3 m (3–10 ft), with various side gives influencing a solitary example to show up as an expansive, ragged mass. The leaves are developed in whorls of six to twelve, each leaf 8– 40 mm long, basic, or forked into two to eight string like fragments edged with sharp teeth; they are firm and weak. It is monoecious, with isolated male and female blossoms delivered on a similar plant. The flowers are little, 2 mm long, with at least eight greenish-dark colored petals; they are created in the leaf axils. The natural product is a little nut 4– 5 mm long, generally with three spines, two basal and one apical, 1– 12 mm long. Plants with the two basal nut spines short are here and there recognized as *Ceratophyllum demersum* var. apiculatum (Cham.) Asch., and those with no basal spines at times recognized as *Ceratophyllum demersum* var. inerme Gay ex Radcl. -Sm (Flora of China; Flora of North America; Flora of NW Europe; Blamey & Grey-Wilson, 1989; Huxley, 1992; USDA, 2011) It can shape turions: buds that sink to the base of the water that stay there in winter and frame new plants in spring.

*Corresponding Author:
J. Mohan,
Department of Botany,
DAV College, Kanpur, India.
E-mail: jmohansaxena@gmail.com

Distribution and habitat

Ceratophyllum demersum develops in lakes, ponds, and calm streams with summer water temperatures of 15-30 °C and a rich supplement status. In North America, it happens in the whole US and Canada, aside from Newfoundland. In Europe, it has been accounted as far north as at a scope of 66 degrees in Norway (ISSG database, 1997) Other announced events incorporate China, Siberia (at 66 degrees North), Burkina Faso (Africa), Vietnam, and New Zealand (presented). *Ceratophyllum demersum* develops in still or moderate moving water. It is particularly supported by nitrate-rich conditions where it develops in more noteworthy plenitude (Goulder and Boatman, 1971; Toetz, 1971; Best, 1980; Kulshreshta, 1982). It is a cosmopolitan species. Despite the fact that the plant is viewed as rootless, it bears a few appendages which help with postponing development around the shallower edges of lakes affected by, for instance, wind fetch.

Ecology

C. demersum has allelopathic characteristics as it discharges substances that repress the development of phytoplankton and blue green algae. Its thick development can outcompete local submerged vegetation, prompting loss of biodiversity. In New Zealand, it has caused issues with hydroelectric power plants.

Chemical composition

Herb is rich in Protein, Calcium and Magnesium, It also contains Ferredoxin and Plastocyanin

Uses:

1. The paste of the herb is applied externally over pile mass and burning sensation in the external opening of anal region

http://dx.doi.org/10.21746/aps.2017.6.12.18

2. Fresh juice of C. demersum L. is given in a dose of 10-20 ml in condition of fever excessive thirst and burning sensation of body to relief the features.
3. Cold infusion prepared from herb is given in a dose of 50-60 ml to relief diarrhoea associated with blood.
4. In condition of fresh wound associated with pain and swelling, the paste is applied over the affected area to relief pain.
5. The paste is mixed with butter and leaf paste of Shirisha and Haridra can pacify scorpion bite poisoning and pain associated.

Environmental Impact:
At the point when water is bothered, it is very normal for local species to expand their development and turn into a danger to human utilization of the water body. Much of the time, aggravation comes about because of an expansion in the trophic level of the water or the substrate. *C. demersum* has turned out to be locally troublesome on a few events (Cook, 1990). It is one of the 26 sea-going vascular plant species that Cook (1985) portrayed as 'extremely boundless'. Production of fish is also affected in Thailand (Chomchalow and Pongpangan, 1973).

A few reports demonstrate that *C. demersum* may apply allelopathic consequences for its condition. Mostly researchers have contemplated the impacts of plant separates and regularly have not considered whether these allelopathic substances really leave the live plants and apply their belongings in situ. For instance, watery concentrates indicated inhibitory impacts on seed advancement of test plants, for example, *Lepidium sativum* (Kleiven and Scepanska, 1988) and on seedling radicle development of lettuce cv. Dark Seeded Simpson (Elakovich and Wooten, 1989). Natural sulfur has been appeared to be available inside the plant and, on discharge, can be exceptionally poisonous to, for ex., periphyton (Wium-Andersen *et al.,* 1983). On the other hand, *C. demersum* was touchy to the nearness of *Hydrilla verticillata* in its neighborhood (Kulshreshta and Gopal, 1983).

Plants as phytoremediators
The foremost use of phytoremediation is for gently polluted soils and waters where the material to be dealt with is at a shallow or medium profundity and the zone to be dealt with is vast (Berti and Cunningham, 2000). For both planting and gathering, phytoremediation makes agronomic strategies efficient and material (Kochian, 1996). Phytoremediation rehearses utilize a portion of the plants: water hyacinths (*Eichornia crassipes*); alpinepennycress (Thlaspica erulescen) (Baker and Walker, 1990; Reeves and Brooks, 1983) poplar trees (Populus spp.); scavenge (Kochia spp) (Paz-Alberto et al, 2007); Ipomea snow capped (Baker and Walker,1990) Haumaniastrum robertii (Brooks, 1977); Scirpusspp, coontail (*Ceratophyllum demersum* L.); American pondweed (Potamogeton nodosus); and the emanant regular ar-rowhead (Sagittaria latifolia) among others. Mangroves created one of a kind body includes keeping in mind the end goal to adapt up to unforgiving condition (Zheng *et al.,* 1997).

Advantages and Disadvantages of Phytoremediation:

Advantages	Disadvantages
Less need of equipment	Time-consuming method
Aesthetically pleasing	With plant based systems of remediation, it isn't conceivable to totally keep the filtering of contaminants into the ground water.
Cost effective	Climatic condition
The opportunity of the revitalization and reuse of precious metals.	plant survival is pretentious by the toxicity of the land contaminated and general status of the soil.
The plants can be easily examined as plants can be easily grown	Possible bio accumulations of contamination which is entered into the food-chain
Less disruptive than techniques	Majorly eliminates only those contaminants which occur around the root zone.
Method is environmental friendly	The contaminant concentration
Applicable for wide range of contaminants	Enough land is required to grow plants

Phytoremediation of nutrients using *Ceratophyllum demersum* L.
Temperature: Temperature regulates the growth of plant, solubility of gases and salts in water. Temperature of domestic wastewater is influenced by the environment. The domestic wastewater temperature after phytoremediation was ranged from 22.8-33.6°C. Similar observation was recorded by Rai *et al.,* (1995). Olga and Alenka (1989) found the luxuriant growth of aquatic plants in domestic waste water favored by a temperature range of 26-35°C.

pH: Das (2005) had recorded increase in pH of municipal sewage on exposure of aquatic macrophytes after seven days. Percentage increase in pH value was 2.39-12.81%. An increase in pH value supports the growth of aquatic plant Vermaat and Hanif (1998).

Turbidity: Turbidity was noted in the range of 6.1-27.4 NTU after the phytoremediation with *Ceratophyllum demersum* L. Similar values were obtained by Shobha and Harilal (2005) for the aquatic bodies of the country. The percentage reduction in the value was 15.17- 40.78%.

Salinity: Salinity values were varying after the phytoremediation with *Ceratophyllum demersum* L. from 0.330-0.822 ppm. Higher values were obtained due to greater solubility of solids in higher temperature of summer. Salinity influences the growth of aquatic vegetation was studied by Haller *et al.,* (1974). The percentage reduction in the value of salinity was 8.46-19.56%.

Electrical Conductivity: EC value had ranged from 529.20- 926.50 µ mhos/cm for the domestic wastewater after the phytoremediation. Increasing trend in EC value was observed from February to May. The values were higher during summer and lower during the winter. The value of Electrical conductivity was lowered after the culture due to dissolved solids absorption by *Ceratophyllum demersum* L. during phytoremediation.

Total dissolved solids: TDS varies from 261.40 to 563.80 ppm after the phytoremediation with *Ceratophyllum.* EC and TDS were found closely related hence, exhibited same trend of variation in value. Higher values were obtained in summer due to excessive evaporation and lower values due to dilution of wastewater during rainy months. The percentage reduction in value was 2.36-20.94%.

Total alkalinity: The total alkalinity values were varying from 170.0-277.5 $mgCaCO_3$/L after the phytoremediation with *Ceratophyllum demersum* L. The decrease in total alkalinity value after the phytoremediation was due to partial absorption of bicarbonate ions by the experimental aquatic plant. Percentage reduction in total alkalinity value had exhibited a change (reduction) from 13.95-32.20%.

Chloride: The variation in chloride content after the phytoremediation with *Ceratophyllum demersum* L. was 70.93-133 mg/L. Chloride value had recorded random variation during the study. Percentage reduction in chloride content was 2.64-5.78%. The percentage reduction in chloride value was lower as the chloride content has no significant role in the metabolism of plant hence, absorbed in very low amount.

Dissolved oxygen: Dissolved oxygen values were recorded 5.3-8.3mg/L after the phytoremediation with *Ceratophyllum demersum* L. D.O. value had an opposite trend as compared to other parameters. An increase was observed in the dissolved oxygen content after the phytoremediation. Summer months had recorded lower value due to higher rate of consumption of oxygen in decomposition and respiration. The percentage increase in D.O. value ranged from 42.6-278.6%. Moorhead and Reddy (1988) noticed an raise in level of oxygen after aquatic plant culture in domestic wastewater because of exchange of oxygen to root zone from aerial tissue.

Total hardness: Total hardness, Ca & Mg total hardness, Ca and Mg values were found to range from 157.14-287.12, 97.02-174.24, 37.29-69.83 and 11.77-53.65 mg/L respectively for the domestic wastewater after the phytoremediation. All the four parameters had exhibit same outline of change in values through phytoremediation study. The qualities for every one of the parameters brought down after the phytoremdiation, because of usage of Calcium and Magnesium by the tested aquatic plant for their body arrangement and advancement during the culture. Rate decrease in an incentive after the phytoremediation was found to extend from 14.45, 28.57, 14.58-26.73, 14.74-26.74 and 11.77-53.65% for Total hardness, Calcium hardness, Calcium and Magnesium respectively. Das (2005) also reported decrease in Ca and Mg content in sewage after the 7 days' culture of aquatic plants.

Nitrogen: All the three forms of nitrogen ammonical, nitrite and nitrate nitrogen values were decreased in domestic wastewater after the culture. Ammonical, nitrite and nitrate forms of nitrogen value had ranged from 2.77-22.85, 0.133-0.362, 13.72-37.38 mg/L respectively, after the phytoremediation of domestic wastewater with *Ceratophyllum demersum* L. The higher value of ammonical nitrogen was found lower to the value obtained by Hosetti and Patil, (1986). Ammonical nitrogen value had a less difference before and after the phytoremediation, this was due to quick transformation of ammonical form of nitrogen in to stable nitrate form in domestic wastewater. Nitrite had recorded comparatively lower value than ammonical and nitrate form of nitrogen because it was an intermediate form of both oxidations of ammonia and reduction of nitrate. Nitrate is the stable form of nitrogen, hence recorded higher value than the other two forms; however, higher values were obtained due to higher rate of oxidation. Nitrogen was found to be absorbed as nitrate, hence exhibited lower values after the phytoremediation. Shen *et al.,* (2006) had recorded similar observations for duck weed plant. Percentage reduction of nitrogen as ammonia, nitrite and nitrate after phytoremediation was found to ranging from12.75-57.58, 24.74-58.35, and 35.47-65.61 % respectively

Phosphorous: Phosphorous content was estimated as Total ortho, Acid hydrolysable, Total and Organic phosphate and value recorded after the phytoremediation of domestic waste water with *Ceratophyllum demersum* L, was found to change from 0.209-0.631, 0.141-0.332, 0.732-1.204 and 0.171-0.613 mg/L respectively. Except total phosphate all other forms of phosphorus recorded <1 mg/L throughout the study period. All the forms of phosphate were reducing after the phytoremediation due to absorption of phosphorus as a phosphate. Similar variation was noted in monthly value of all the forms of phosphate during the study. Percentage change in Total ortho, Acid hydrolysable, Total and Organic phosphate value was found to varying from 29.26-67.23, 16.05-43.94, and 27.34-51.98 and 18.47-59.73% respectively. Reddy *et al.,* (1990) studied that accumulation of various nutrients by aquatic plants depend on relative population in aquatic environment

Conclusion

In conclusion, to investigate its potential and other amphibian macrophytes in the treatment of maladies by utilizing disconnected mixes with negligible or no reactions. All the more in this way, guaranteeing the protected utilization of these plants ought to be strived more. This plant needs successful use keeping in mind the end goal to influence a trademark through entire ailments to fix and shabby regimen to be accessible for conventional populace versus helping indeveloping potential biopharmaceutical item. Likewise, to accomplish far reaching improvement of plant genomics, despite everything we have to do inquire about in foundation and advancement of hereditary change frameworks.

References

1. Baker, A.J.M., Walker P.L. (1990) Ecophysiology of metal uptake by tolerant plants. In: A.J. Shaw Ed. Heavy metal tolerance in plants: evolutionary aspect, CRC Press Boca Raton FL, 155-177.
2. Berti, W.R., Cunningham, S.D. (2000) In Phytoremediation of Toxic Metals. Using Plants to Clean Up the Environment. (Ed. Raskin, I.). Wiley-Interscience, John Wiley and Sons, Inc. New York, NY, 71- 88.
3. Best EPH, 1980. Effects of nitrogen on the growth and nitrogenous compounds of Ceratophyllum demersum. Aquatic Botany, 8(2):197-206.
4. Bixler J H and Porse H (2011) A decade of change in the sea weed hydrocolloids industry. Journal of Applied Phycology 23(3): 321-335.
5. Blamey, M. & Grey-Wilson, C. (1989). Flora of Britain and Northern Europe. ISBN 0-340-40170-2
6. Brooks, R.R. (1977) Copper and cobalt uptake be Haumaniastrumspecies. Plant Soil, 48: 541- 544.
7. BSBI List 2007". *Botanical Society of Britain and Ireland. Archived from* the original*(xls) on 2015-01-25*. Retrieved 2014-10-17.

8. Ceratophyllum demersum on the Global Invasive Species database (2006).

9. Chomchalow N; Pongpangan S (1976). Aquatic weeds in Thailand; occurrence, problems and existing and proposed control measures. Aquatic weeds in S.E. Asia. Proceedings of a Regional Seminar on Noxious Aquatic Vegetation, New Delhi, 1973., 43-50.

10. Cook CDK (1985). Range extensions of aquatic vascular plant species. Journal of Aquatic Plant Management, 23:1-6.

11. Cook CDK (1990). Origin, autecology, and spread of some of the worlds' most troublesome aquatic weeds. In: Pieterse AH, Murphy KJ, eds. Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation. Oxford, UK: Oxford University Press, 31-39.

12. Das, A. K. (2005). Studies on bioremediation of municipal sewage with reference to macrophytes. Ind. J. Environ. and Ecoplan. 10(3): 965 - 971.

13. Elakovich SD; Woofen JW (1989). Allelopathic potential of sixteen aquatic and wetland plants. Journal of Aquatic Plant Management, 27:78-84.

14. FAO (2010) 2008 Fishery and Aquaculture Statistics. Rome, Italy, p 72.

15. Flora of China: Ceratophyllum demersum

16. Flora of North America: Ceratophyllum demersum

17. Flora of NW Europe: *Ceratophyllum demersum* [permanent dead link]

18. Goulder R; Boatman DJ, 1971. Evidence that the nitrogen supply influences the distribution of a freshwater macrophyte, Ceratophyllum demersum. Journal of Ecology, 59:783-791.

19. Haller, W. T., Sutton, D. L. and Barlowe W. C. (1974). Effects of salinity on growth of several aquatic macrophytes. Ecology. 55(4): 891–894

20. Hosetti, B. B. and Patil, H. S. (1986). Impact of Lemna minor on the effluent quality of sewage stabilization pond, Geobios. 13: 244-247.

21. Huxley, A., ed. (1992). New RHS Dictionary of Gardening. Macmillan ISBN 0-333-47494-5.

22. ISSG database, reports in Norway (based on Mjelde, 1997)

23. ISSG: distribution of *C. demersum*.

24. Kleiven S; Szczepanska W (1988). The effects of extracts from Chara tomentosa and two other aquatic macrophytes on seed germination. Aquatic Botany, 32(1-2):193-198.

25. Kochian, L. (1996) In International Phytoremediation Conference, South borough, MA. May, 8-10.

26. Kulshreshtha M, 1982. Comparative ecological studies on two species of Ceratophyllum. Proceedings 6th EWRS International Symposium on Aquatic Weeds, 29-36.

27. Kulshreshtha M; Gopal B (1983). Allelopathic influence of *Hydrilla verticillata* (L.f.) Royle on the distribution of *Ceratophyllum* species. Aquatic Botany, 16(2):207-209.

28. McHugh D J (2003) A guide to the seaweed industry, Fisheries Technical Paper 441, Rome, Italy, pp. 105.

29. Moorhead, K. K. and Reddy, K. R. (1988). Oxygen transport through selected aquatic macrophytes, J. Environ. Qual. 17(1): 138-142.

30. Olga, U. B. and Alenka, G. (1989). The influence of temperature and light intensity on activity of water hyacinth (*Eichhornia crassipes*) (Mart) Salms). Aquatic Botany. 35: 403 - 408.

31. Paz-Alberto, A.M., Sigua, G.C., Baui, B.G., Prudente, J.A. (2007) Phytoextraction of LeadContaminated Soil Using Vetiver grass (VetiveriazizanioidesL.), Cogon grass (Imperata cylindrical L.) and Carabao grass (Pas- palum conjugatum L.)," Environ Sci Pollut., 14(7): 498-504.

32. Rai, U. N., Sinha, S. Tripathi, R. D. and Chandra, P. (1995). Wastewater treat-ability potential of some aquatic macrophytes: removal of heavy metals. Ecological Engineering. 5: 5-12.

33. Reddy, K. R., Agami, M. and Tuckker, J. C. (1990). Influence of phosphorus on growth and nutrient storage by water hyacinth (*Eichhornia crassipes* (Mart) Solms) plant. Aquatic Botany. 13: 355-365.

34. Reeves, R.D., Brooks, R.R. (1983) European species of ThlaspiL. (Cruciferae) as indicatorsof nickel and zinc. J. Geochem Explor., 18: 275-283.

35. Sculthorpe CD (1967) The biology of aquatic vascular plants. London, Edward Arnold, pp. 610.

36. Shen, G. X., Yao, F. and Hu, H. (2006). The Kinetics of ammonium and nitrate uptake by duckweed (*Spirodela oligorrhiza*) plant. Chin. J. Soil Sci. 3(37): 505-508.

37. Shobha, V. and Harilal, C.C. (2005). Influence of changing water quality on *Eichhornia crassipes* Solms. in the uptake pattern of various minerals & nutrients. Eco. Env. & Conserv. 11(1): 1- 6.

38. Toetz DW, 1971. Diurnal uptake of NO3 and NH4 by a Ceratophyllum periphyton community. Limnology and Oceanography, 16:819-822.

39. USDA PLANTS database on *C. demersum* as of 2011.

40. Vermaat, J. E. and Hanif, K. M. (1998). Performance of common duckweed species (Lemnaceae) and the water fern *Azolla filiculoides* on different types of wastewater. Water Res. 32: 2569-2576.

41. Wium-Andersen S; Anthoni U; Houen G (1983). Elemental sulphur, a possible allelopathic compound from *Ceratophyllum demersum*. Phytochemistry, 22(11):2613.

42. Zheng, W., Chen, X., Lin, P. (1997) Accumulation and biological cycling of heavy metal elements in Rhizophorastylosamangroves in Yingluo Bay, China.Mar. Ecol. Prog. Ser,159: 293-301.

Cite this article as:

Mohan J., Narendra Babu Shakya, Narendra K. Shukla & Vishnu Kumar. Studies on phytoremediation of municipal waste water with reference to aquatic plant Ceratophyllum demersum. *Annals of Plant Sciences 6.12 (2017) pp. 1918-1921.*

http://dx.doi.org/10.21746/aps.2017.6.12.18

Source of support: Nil.
Conflict of interest: Nil.