Chemicals and Nutrients Removal Efficiency of Duckweed (*Spirodelapolyrrhiza*) in Improving the Quality of the Louhajang River Water, Tangail, Bangladesh

Israt Jahan Tonny*
Kaniz Fatema*
Rezuana Afrin*
Md. Younus Mia**

Abstract

This study involved a laboratory experiment on the efficiency of Duckweed (Spirodelapolyrrhiza) in improving the quality of the Louhajang River Water, Tangail. The efficiency was tested by measuring some of the physicochemical parameters of the river's waste water after each 7 days until 21 days. All the parameters (pH, TDS, EC and nutrients such as phosphate, nitrate, ammonia) showed considerable rate of reduction. Duckweed effectively removed approximately 13% of pH, 46% of EC, 70% of ammonia, 98% of phosphate and 93.7% of nitrate at the end of 21 days. These results were very much useful in understanding the efficiency of Duckweed, in removing of pollutants from the waste water.

Keywords: Phytoremediation, Removal Efficiency, Duckweed, Louhajang River

Introduction

Most water conditions across the world can provide organism with adequate nutrition and do not require fertilizer for a complete life cycle. However, man can artificially modify water through the addition of fertilizer to promote vigorous growth and increase yield. During the last 2 decades, the word "eutrophication" has been frequently used to denote the artificial and undesirable addition of plant nutrients to water bodies (Jizeater and Bigfag, 1989).This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can frequently cause other water biota (fish in particular) to die. Nutrients can come from many sources, such as, fertilizers applied to agricultural fields, suburban lawns, and deposition of nitrogen from the atmosphere, erosion of soil containing nutrients and sewage treatment plant discharges. Eutrophication denotes the decreasing aspect of the water quality (Henry, 1993).

* Students, Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Bangladesh
** Professor, Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Bangladesh

Excessive nutrient present in water bodies causing eutrophication can be remediated by phytoremediation process using various aquatic plant such as duckweeds, water hyacinth etc. Any fast growing aquatic plant of high nutritive value is an excellent candidate for bio-remediation of waste water. Ran *et al.* (2004) points the advantages of using duckweeds due to its high production rate, easy manual harvest from the surface, high protein and low fiber content. Besides, duckweeds are floater plants, which reduce suspended solids by blocking light penetration. Thus, light availability causes algae to die off, which consequently settle or disintegrate.

The Louhajongriver, is a distributor of Jamuna which cross Basail and Mirjapur and flows into the Turag river. Recently the water of this river is polluted by various anthropogenic activities. Waste from household, municipalities, industries are responsible for the degradation of the quality of water of this river.The present study aims at determining the effectiveness of Duckweed(*Spirodelapolyrrhiza*)to act as a phytoremediant for removing some physicochemical parameters (pH, DO, EC, TDS, PO_4, NO_3 and NH_3-N) from river waste water.

Materials and Methods

Phytoremediation potential of Duckweed(*Spirodelapolyrrhiza*) in the removal of some pollutants in refinery waste water was determined in laboratory experiment.

Sample collection

Surface water sample was collected with the help of sampling bottles (plastic)from Kagmari point of the Louhajongriverand the total amount of collected water was 40litres.Samples of matured Duckweed (*Spirodelapolyrrhiza*)were collected from a natural pond of Santosh region, Tangail, Bangladesh.

Treatment process

For initial analysis, 4 litres of water was separated in a bucket. Another 36 litres of water was further divided into three parts, each of which contained 12 litres and taken in 3 separate buckets for phytoremediation. Then the surfaces of the waste water of these 3 buckets were covered by Duckweed (*Spirodelapolyrrhiza*). Then the 1st bucket was exposed in open air for 7 days, 2nd was for 14 days and 3rd was for 21 days.

Study of water quality parameter

During the study period the water quality was determined by analyzing physicochemical parameterslikewater temperature (°C), pH, Dissolved Oxygen (mg/L),Electrical Conductivity(µS/cm), Total Dissolved Solids(ppm),PO_4 (mg/L), NO_3 (mg/L), NH_3-N (mg/L)after 7 days, 14 days and 21 daysof phytoremediation with the Duckweed (*Spirodelapolyrrhiza*). Also the collected waste water was analyzed initially before phytoremediation.Thevalues of pH, DO, EC and TDS were measured by a portable Multi-parameter (Sension 156^{TM}). Another parameters including PO_4 (mg/L), NO_3 (mg/L) and NH_3-N (mg/L) were measured by Spectrophotometer (Dr-2800). In case of each parameter three samples were analyzed and average values are presented in the Table.

Analysis of Water Removal Efficiency

The value before Phytoremediation experiment was noted as initial value, while the value recorded after the Phytoremediation experiment was indicated as final value. Pollutants removals were considered as the reduction (%) in concentration according to:
(A-B) / A ×100%
A= Initial concentration (before experiment)
B=Final concentration (after experiment).

Results and Discussions

The efficiency of Duckweed(*Spirodelapolyrrhiza*)in scavenging contaminants indicatesthat the presence of themacrophyte was an important element for removing contaminant in wastewater.The values before and after the phytoremediation and removal efficiency in this study are shown in Table 1.

Table 1:Physicochemical parameters of the Louhajang river water measured after 7, 14 and 21 days of treatment using Duckweed(*Spirodelapolyrrhiza*)

Parameters	Initial results	After 7 days of treatment	Removal efficiency (%)	After 14 days of treatment	Removal efficiency (%)	After 21 days of treatment	Removal efficiency (%)
pH	7.96	7.42	6.8	7.29	8.4	6.93	13
TDS(ppm)	422	288	31.75	247	41.46	243	42.41
EC (µS/cm)	975	623	36	545	44	522	46
Phosphate (mg/L)	0.98	0.11	88.7	0.09	91	0.01	98
Ammonia (mg/L)	0.012	0.01	16.66	0.0062	48.33	0.0036	70
Nitrate (mg/L)	6.4	1	84.4	0.5	92	0.4	93.7

pH

The study showed that the pH values were decreased from 7.96 to 6.93 (Table 1) in the presence of Duckweed during 21 days. This may be due to respiration by Duckweed plants. The pH was reduced from 6.8 to 8.4% between 7 days to 14 days of treatment. Further the pH was reduced from 8.4 to 13% between 14 days to 21 days of treatment. Duckweed(*Spirodelapolyrrhiza*)is able to reduce pH value of domestic wastewater from 8.74 to7.8 during 10 days of treatment(Vanitha*et al*., 2013). In Bangladesh, *S. polyrrhiza* has been reported to grow best at a pH between 6.5 and 7.5 (Khondker*et al.*, 1993).

DO

In the presence of Duckweed, the DO value initially decreased from 1.30 to 1.22 mg/Land then increased to 2.80 mg/L, respectively, after 7 and 14 days of treatment. The reduction of DO may be due to the decomposition of organic matter by aerobic bacteria. Later, the DO started to increase. A case study was done by Patel and Kanungo(2010) where the higher percentage of increase was >100% for DO only in the month of February, while other months have very fluctuating value from 38.5 to 96.2% for DO. So, it shows that the previous result is highly varied with the present result (53.04 to 74.50%) of DO. This may be due to (1) Supply of oxygen by Duckweedplants and (2) Atmospheric diffusion.

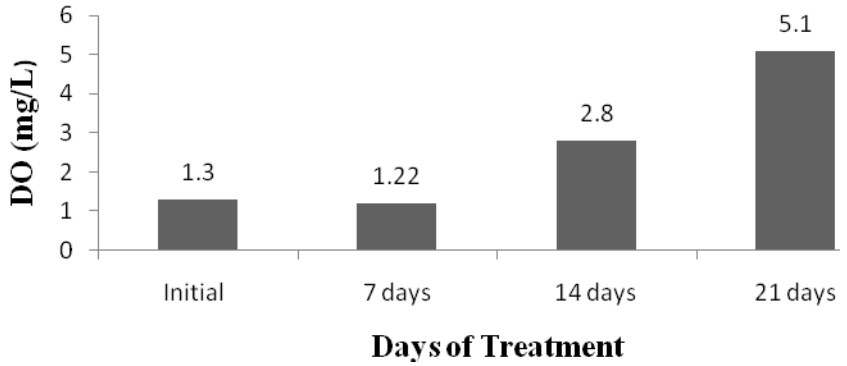

Figure 1.Weekly changes of DO of water under the experimental condition.

Temperature

This study was conducted in the month of February for 21 days. During the experiment, water temperature had range between 23.5ºC to 26.5ºC. A study done by Culley*et al*. (1981) represented that the temperature was hammering around between 24ºC and 29ºC which was very near to the present study. The temperature ranges depending on the sunlight and the temperature of water of the present study was within the tolerance limit (34ºC) for duckweed growth. So, it didn't affect the duckweed to uptake nutrient during the study period.

TDS

Results in Table 1 revealed that Total Dissolved Solids (TDS) recorded their minimum values of 288 mg/L (31.75 % reduction) after 7 days,247 mg/L (41.46% reductions) after 14 days and 243 mg/L (42.41% reduction) after 21 days of treatment. This decreasing rate was due to the plant's capacity to uptake some organic and inorganic ions.

EC

Conductivity is a measure of how well a solution conducts electricity. Water with absolutely no impurities (which really does not exist) has very poor conductivity. Duckweed (*Spirodelapolyrrhiza*) plants were used to treat wastewater and it reduced EC from 975 to 522

µS/cm.Results of the present study (Table1)showed that the EC was reduced from 36 to 44% between 7 days to 14 days of treatment. The reduction was reached 46% after 21 days of treatment.

Phosphate

The phosphate removal in river water and in the presence of Duckweed after 7, 14 and 21days was measured as 88.7, 91 and 98%, respectively. The phosphate removal was more with the presence of Duckweed due to the following reasons (1) this may be due to phosphate uptake by Duckweed plant and assimilation into plant protein; (2) adsorption on plant leaves; (3) chemical precipitation and (4) microbial uptake.

Nitrate

The nitrate removal in the river water and in the presence of Duckweed after 7, 14 and 21days was measured as 84.4, 92 and 93.7%, respectively. The results demonstrated that the duckweed efficiently removed nitrate from wastewater and incorporated into its biomass, where its concentration reached from 6.4 to 0.4 mg/L after 3 weeks later (Table 1) that was attributed to the plant's capacity to provide suitable conditions for nitrate reduction.

Ammonia

The ammonia removal in river water and with the presence of Duckweed was about 16.66, 48.33 and 70% after 7, 14 and 21 days of treatment, respectively. The results indicated that the Duckweed plant does not completely remove ammonia but can remove it efficiently.

Conclusion

Duckweed (*Spirodelapolyrrhiza*) is capable of removing phosphate and nitrate very effectively from the rivers' wastewater. Ammonia is also removable by this treatment process. The removal to a great extent efficiencies of EC and TDS in the treated effluent were not much satisfactory but not negligible.Moreover, Duckweed(*Spirodelapolyrrhiza*)showed its ability to survive in high concentrations of nutrients. So, the use of duckweeds can help to reduce the influence of eutrophication effects in receiving streams and can consequently improve the water quality. Treatment of polluted water using duckweed also proves to be cost effective and eco-friendly.

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