

## Reduction of Pollution Load in Sewage Water using Aquatic Macrophyte *Lemna minor* L. (Duck Weed)

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**Abstract** The study involved a laboratory experiment on the use of *Lemna minor* L. as an alternative cost effective natural biological tool in the reduction of pollution load in sewage water. The physiochemical characteristics of the waste water i.e; biological oxygen demand (BOD), electrical conductivity (EC), temperature, chloride ion concentration, dissolved oxygen (DO), hardness, alkalinity and pH were determined before and after the treatment. The experiment lasted for three weeks and the rate of reduction was recorded. The highest rate of mean reduction following treatment was observed in BOD (87.7%), EC (24.6%), temperature (29.1%), chloride ion concentration (72.1%), DO (60.9%), hardness (36.1%), alkalinity (72%) and ph

(14%). The percent increase in fresh and dry weight were recorded as 12.44 and 32.0 respectively. *Lemna minor* L. is a suitable tool for effective phytoremediation of sewage water.

**Keywords** *Lemna minor*, Sewage water, BOD, Pollution alkalinity.

### Introduction

Nutrient rich effluents when discharge into water bodies cause eutrophication, leading to algal blooms, which deplete oxygen and make the water unfit for beneficial use. Physical, chemical, and biological technologies have been developed to reduce the pollution load and restore environmental quality. However their costs are high most of them are difficult to use under field conditions [1]. Viewing this fact, phytoremediation was assumed as an innovative, ecofriendly and efficient technology in which natural properties of plants are used in engineered system to remediate hazardous wastes through physical, chemical and biological processes from wastewater and sewage [2, 3]. Phytoremediation is the utilization of plants accumulation capabilities to remove contamination from water, soil and air. Aquatic treatment systems con-

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**Table 1.** Effect of aquatic treatment with *Lemna minor* L. on temperature and electrical conductivity of sewage water. T<sub>0</sub> = sewage water, T<sub>1</sub> = 10 g of plant, T<sub>2</sub> = 20 g of plant, T<sub>3</sub> = 30 g of plant.

Treatments	Temperature (°C)				Electrical conductivity (µm hos/cm)			
	0 day	7 day	14 day	21 day	0 day	7 day	14 day	21 day
T <sub>0</sub>	40.3	41.8	43.2	43.9	359.3	364.2	369.9	373.5
T <sub>1</sub>	40.6	39.5	36.4	32.7	357.1	345.8	335.4	326.2
T <sub>2</sub>	40.6	37.2	34.9	32.4	358.3	340.1	327.3	309.8
T <sub>3</sub>	40.4	35.4	32.4	31.1	356.6	298.6	290.3	281.5
CD (p=0.05)	1.430				12.217			

sist of one or more shallow ponds in which one or more species of water tolerant vascular plants such as water hyacinths or duckweed are grown. Water hyacinth systems are capable of removing high levels of BOD, suspended solids (SS), nitrogen and trace organic matter. various duckweed species have been used for the treatment of municipal and industrial waste waters. Duckweed is a floating aquatic macrophyte belonging to the botanical family *Lemnaceae*, which can be found world-wide on the surface of nutrient rich fresh and brackish waters [4]. The *Lemnaceae* family consists of four genera (*Lemna*, *Spirodela*, *Wolffia* and *Wolffiella*) and 37 species. The habitat requirements of duckweed vary between species, but all share the need for sheltered still water. Duck weed species are adapted to wide variety of geographic and climatic zones. However most are found in moderate climates of tropical and temperate zones. The most favorable habitat is water with decaying organic matter that provides a steady supply of growth nutrients and trace elements. A striking feature of duckweed species is their enormous reproductive capacity. Under favorable conditions they have been reported as doubling their

biomass every 16 to 48 h. The main form of reproduction is vegetative, through the production of daughter fronds. Duckweed daughter fronds do not stay attached indefinitely, but rather break and form new colonies. The nutrients taken up by duckweed are assimilated into plant protein. Compared to other plants, duckweed has low fiber content (about 5%), since it does not require structural tissue to support leaves and stems. The application of *Lemna minor* L. (duckweed) in waste water treatment is hypothesised to be very effective in the removed of nutrients, soluble salts, organic matter, heavy metals and in eliminating suspended solids, alga abundance and total fecal coliform densities.

This study was designed to evaluate the applicability of common duckweed (*Lemna minor* L.) for reduction of pollution and to assess it's efficiency in removal of from the waste water.

## Materials and Methods

### Experimental method

The study was carried out in the laboratory of de-

**Table 2.** Effect of aquatic treatment with *Lemna minor* L. on chloride ion concentration and biological oxygen demand of sewage water. T<sub>0</sub> = sewage water, T<sub>1</sub> = 10 g of plant, T<sub>2</sub> = 20 g plant, T<sub>3</sub> = 30 g of plant.

Treatments	Chloride ion concentration (mg/l)				Biological oxygen demand (mg/l)			
	0 day	7 day	14 day	21 day	0 day	7 day	14 day	21 day
T <sub>0</sub>	137.6	143.1	152.1	157.5	284.83	291.83	295.60	302.37
T <sub>1</sub>	138.7	96.8	83.2	70.5	284.60	221.07	191.33	154.63
T <sub>2</sub>	138.6	88.16	73.0	51.6	287.57	193.77	155.30	101.50
T <sub>3</sub>	140.1	80.6	57.9	43.8	288.13	150.83	119.57	36.90
CD (p=0.05)	13.089				24.000			

**Table 3.** Effect of sewage water on fresh and dry weight of *Lemna minor* L.

Treatments	Fresh weight (g)	Dry weight (g)
T <sub>1</sub>	166.533	16.16
T <sub>2</sub>	186.300	18.93
T <sub>3</sub>	190.200	23.8
CD ( $p=0.05$ )	10.334	1.844

partment of biological sciences, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad. There were four treatments i. e; control, 10, 20 and 30 g of *Lemna* keeping three replications per treatment with the sampling frequency of 7 days. *Lemna minor* L. was kept on a filter paper to remove excess water and then transferred into plastic troughs of 45 cm diameter and 25 cm depth filled with sewage water. Before transferring the test plant into the trough containing the water sample, the water characteristics were determined by analyzing some physiochemical parameters like temperature, electrical conductivity, BOD, chloride ion concentration, dissolved oxygen, hardness, alkalinity, pH and also the fresh weight of test plant was determined. The same parameters were assessed after treatment.

The temperature and EC of sample was recorded by using thermometer and digital EC meter respectively. Biological oxygen demand and dissolved oxygen of the water sample was determined by winkler method. Chloride ion concentration, hardness and alkalinity of sample were measured by titrimetric method. The fronds of *Lemna* were air dried after 21 days and then kept in oven for 24 h at 60°C for the estimation of dry weight. The pH of the sample

was measured by digital pH meter.

## Results and Discussion

### Temperature and electrical conductivity

Maximum temperature reduction was recorded by test plant at T<sub>3</sub> (31.1°C) compared to T<sub>0</sub> (43.9°C) (Table 1). The reduction in temperature is due to the increase in the biomass of plant [5]. High EC reduction was recorded by the test plant at T<sub>3</sub> (281.5µmhos/cm) compared to T<sub>0</sub> (373.5 µmhos/cm) (Table 1). This EC reduction is due to salt removal by the test plant uptake or root absorption [6].

### Biological Oxygen demand (BOD) and chloride ion concentration

High BOD removal was recorded at T<sub>3</sub> (36.9 mg/l) compared to T<sub>0</sub> (302.37 mg/l) (Table 2). The test plant *Lemna minor* contributes to the removal of organic compounds as well as the microbial degradation process of organic materials. BOD removal was higher in duckweed based pond than algae based pond [7]. Chloride ion concentration showed significant reduction in all the treatments with maximum reduction at T<sub>3</sub> (43.8 mg/l) compared to T<sub>0</sub> (157.5 mg/l) (Table 2). Electrical conductivity is positively correlated with TDS, Ca, Mg, Cl. Hence as the EC decreases, Cl ion concentration also decreases [8].

### Fresh and dry weight

The fresh and dry weight of the test plant increased with the maximum increase at T<sub>3</sub> (190.20 g and 23.8 g) compared to T<sub>0</sub> (166.533 g and 16.16 g) (Table

**Table 4.** Effect of *Lemna minor* L. on the dissolved oxygen and hardness of sewage water. T<sub>0</sub> = sewage water, T<sub>1</sub> = sewage water + 10 g of plant, T<sub>2</sub> = sewage water + 20 g of plant, T<sub>3</sub> = sewage + 30 g of plant.

Treatments	Dissolved oxygen (mg/ml)				Hardness (mg/ml)			
	0 day	7 day	14 day	21 day	0 day	7 day	14 day	21 day
T <sub>0</sub>	12.4	13	14.2	14.1	432.4	443.4	450.2	453.3
T <sub>1</sub>	12.8	9.1	8.3	7	433.9	376.9	345.6	326.7
T <sub>2</sub>	12.4	8.3	7	6.7	433.2	364.9	330.3	303.8
T <sub>3</sub>	12.7	8	6.5	5.5	432.1	350.8	324.8	289.6
CD ( $p=0.05$ )	0.961				100.469			

**Table 5.** Effect of *Lemna minor* L. on the alkalinity and pH of sewage water. T<sub>0</sub> = sewage water, T<sub>1</sub> = sewage water + 10 g of plant, T<sub>2</sub> = sewage water + 20 g of plant, T<sub>3</sub> = sewage + 30 g of plant.

Treatments	Alkalinity (mg/ml)				pH			
	0 day	7 day	14 day	21 day	0 day	7 day	14 day	21 day
T <sub>0</sub>	226.0	240.5	250.2	257.6	8.48	8.49	8.55	8.65
T <sub>1</sub>	226.2	179.6	163.5	133.5	8.48	8.15	7.9	7.78
T <sub>2</sub>	230.5	160.8	135.1	91.2	8.5	7.71	7.55	7.5
T <sub>3</sub>	227.7	143.8	103.8	70.1	8.47	7.56	7.47	7.42
CD ( $p=0.05$ )	20.018				0.136			

3). Waste water supported the higher growth rate of duckweed with increasing treatment periods [9].

#### Dissolved oxygen and hardness

The results showed that there was a significant reduction in the dissolved oxygen with maximum reduction at T<sub>3</sub> (5.5 mg/ml) compared to T<sub>0</sub> (14.1 mg/ml) (Table 4). There was a significant reduction in hardness of sewage water with the maximum reduction at T<sub>3</sub> (289.6 mg/ml) compared to T<sub>0</sub> (453.3 mg/ml) (Table 4).

#### Alkalinity and pH

The alkalinity showed a significant reduction in all the treatments with the maximum reduction at T<sub>3</sub> (70.1 mg/ml) compared to T<sub>0</sub> (257.6 mg/ml) (Table 5). The pH of sewage water showed significant reduction in all the treatments with the maximum reduction at T<sub>3</sub> (7.42) compared to T<sub>0</sub> (8.65). The alkaline pH (7.5) was most ideal for the establishment of duckweed system and optimum performance [8].

#### Conclusion

It may be concluded from the present study that *Lemna minor* L. at a concentration of 30 g can be used effectively for the treatment of the pollutant sewage water there by reducing the toxicity on the flora and fauna, since it is able to remove and degrade pollutants present in the sewage water to a sig-

nificant level.

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