A COMPARATIVE STUDY ON THE TREATMENT OF INDUSTRIAL AND MIXED EFFLUENT BY ALGAE

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ABSTRACT: The current study was carried out to assess the pollution load in industrial effluent located at Hudiara drain and municipal wastewater collected from sewage drain passing through Shadman, Lahore and its treatment with heterogeneous species (*Microspora sp.*, *Rhizoclonium sp.*, Diatoms, *Lyngbya sp.*, Dinoflagellates) of fresh water algae. Various compositions of industrial and municipal wastewater (20:80, 40:60, & 50:50) were prepared and phycoremediation process for effluent treatment was done in ponds of different dimensions to find out the optimum conditions i.e. wastewater composition (40:60) and pond size (P2). Accumulation of nitrogen (22.98 mg/g) and phosphorus (10.4ppm) in algal biomass. The maximum percent reduction for biological oxygen demand (99.8%), chemical oxygen demand (98.6%), total suspended solids (93.9%), total dissolve solids (96.5%), total kjeldhal nitrogen (97.7%), total phosphorus (99.2%), phosphate (99.2%), nitrate (98.9%) and dye (99.2%) was achieved.

Key words: Phycoremediation, biological oxygen demand, chemical oxygen demand, total suspended solids and total dissolve solids.

INTRODUCTION

In the industrial sector, the paper and textile industries are of particular importance because they produce considerable amount of wastewater effluents that have a very harmful affect when discharged into the natural environment without treatment (Peralta-Zamora *et al.,* 2003). Pollutions of groundwater, sediments, air surface water and soils with toxic and dangerous chemicals constitute important troubles for both environment and the human health (Ansari and Malik, 2007). In developing nations such as Pakistan which discharged wastewater in rivers directly without any treatment.

Algae can be used to treat both municipal and industrial wastewater. Algae play a major role in aerobic treatment of waste in the secondary treatment process. Current technology for algal wastewater treatment uses facultative ponds. However, these ponds have low productivity (Sponza and Ulukoy, 2005). In this study various composition of industrial and municipal wastewater were prepared for analysis of various parameters (BOD, COD, color removal, TSS, TDS, TKN, TP, NO_3^-, PO_4^{3-} and water evaporation rate). Reduction in dye concentration in various ponds was another focus of the study.

MATERIALS AND METHODS

Wastewater and Algal Sampling*:* Industrial and sewage wastewater were collected from Hudiara drain and Satukatla drain respectively. Algae were collected from the ponds of Punjab Department of Fisheries, Lahore and Baradari from River Ravi. Algal species were identified as *Microspora sp.*, *Rhizoclonium sp.*, *Diatoms*, *Lyngbya sp.* and *Dinoflagellates*

Sample Analysis: Physical and chemical properties of the untreated wastewater samples such as pH, Temperature, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Kjeldahl Nitrogen (TKN), Total phosphorus TP, Phosphate (PO_4), Nitrate (NO_3) and Dye concentration were measured by methods prescribed by APHA (1998) standard methods for wastewater. Post-experimental analysis was carried out for the determination of properties of the treated wastewater after every experiment.

Experimental Design for Wastewater Treatment: Ponds having dimensions of 0.15 x 0.15 x 0.3 m (P1), 0.3 x 0.3 x 0.15 m (P2) and 0.9 x 0.15 x 0.45 m (P3) with final capacity 6.75 L, 13.5 L and 60.75 L respectively were used for experimental purpose. Seven liter pure industrial wastewater was treated with 300g of algae in square shaped pond (P2). Wastewater quantity was changed to 9L, 7L, 5L and 3L with 40-60% ratio of municipal and industrial wastewater in separate ponds (P1, P2 and P3).

RESULTS AND DISCUSSION

Laboratory Analysis: Laboratory analysis of mixed effluent samples along with maximum reduction achieved in comparison to National Environmental Quality Standards (2000) revealed that Table 1. Before treatment all parameters were higher than NEQS (2000) limit. After treatment all parameters were found within the limits of NEQS. In this study the temperature of water was ranged from 31-35 oC and pH was noted to be 7.2. However, Nwani et al. (2013) measured the temperature of water ranged from 24.70 to 26.10 0C and pH was ranged from 7.00 to 7.29. Aktan and Ozan (2012) investigated that temperature was highest in autumn while pH value was highest in summer and lowest in winter (Table 1).

Table 1: Laboratory analysis of mixed effluent samples along with maximum reduction achieved in comparison to National Environmental Quality Standards (2000).

Parameters	Unit s	Wastewater characterization before treatment	Maximum reduction achieved (%)	Percent reduction in control	Existing NEQS 2000
pH		7.2	0.1*	0.4*	6-10
Temperature	^{0}C	33$\pm$2	10$\pm$3*	9$\pm$3*	$\geq$3 ^{0}C
BOD	mg/l	370$\pm$12	99.8	16	80
COD	mg/l	843$\pm$20	98.6	12	150
TSS	mg/l	317$\pm$14	93.9	4	150
TDS	mg/l	706$\pm$17	96.5	3	3500
TKN	mg/l	30.4$\pm$2.5	97.7	5	----
TP	mg/l	11.8$\pm$1.9	99.2	9	----
PO_4	mg/l	31.3$\pm$5.4	99.2	6	----
NO_3	mg/l	2.7$\pm$0.3	98.9	4	----
Dye	mg/l	1.9$\pm$0.15	99.2	17	----

*Total amount reduced

Pure Industrial Wastewater Setup: Laboratory analysis of industrial effluent sample has been done before and after treatment which showed that before treatment all wastewater parameters were higher than NEQS (2000) limit. During treatment time algae became dead and treatment process was not performed properly and values of parameter exceed from their original values (Table 2).

Table 2: Reduction in the concentrations of industrial effluent characteristics by treatment with algae.

		DAYS			
Parameters	**0**	**2**	**4**	**6**	**8**
BOD	620$\pm$18	480$\pm$10	600$\pm$16	640$\pm$21	680$\pm$27
COD	647$\pm$21	524$\pm$12	615$\pm$19	665$\pm$24	686$\pm$30
TSS	285$\pm$9	211$\pm$7	254$\pm$11	291$\pm$13	297$\pm$14
TDS	516$\pm$14	432$\pm$9	487$\pm$14	521$\pm$17	534$\pm$18
TKN	28.6$\pm$2.6	21.4$\pm$2.2	25.7$\pm$2.3	28.8$\pm$3.2	29.2$\pm$3.5
P	9.4$\pm$1.2	7.5$\pm$1.6	8.3$\pm$1.7	9.2$\pm$2.4	9.7$\pm$2.8
PO4	27.3$\pm$3.1	22.1$\pm$2	26.7$\pm$2.6	27.6$\pm$2.9	28.4$\pm$3.1
NO3	1.7$\pm$0.8	1.01$\pm$0.6	1.5$\pm$0.5	1.78$\pm$0.8	1.83$\pm$1
DYE	1.8$\pm$0.9	1.2$\pm$0.7	1.67$\pm$0.6	1.84$\pm$0.78	1.94$\pm$1.2

Reduction in Biological Oxygen Demand: Influence of wastewater quantity on BOD removal was measured with variation in retention time at constant algae quantity and pond size. BOD reduction was observed to be maximum with 5L of wastewater (99.7%) almost similar result was found with 7 liters of wastewater (98.8%) (Figure 1). Influence of P1, P2, and P3 on BOD removal was measured with variation in retention time at constant algae quantity and pond size. BOD reduction was observed to be maximum with P1 pond (99.8%) (Figure 4). Ahmad *et al.* (2013) observed BOD reduction of 98.69% from sewage wastewater using *C. vulgaris* as treatment organism.

Reduction in Chemical Oxygen Demand: Influence of wastewater quantity on COD removal was measured with variation in retention time at constant algae quantity and pond size. COD reduction was observed to be maximum with 3L of wastewater (99.08%) almost similar result was found with 5L and 7L of wastewater (98.22%) and (97.55%) respectively (Figure 1). Influence of P1, P2, and P3 on COD removal was measured with variation in retention time at constant algae quantity and pond size. COD reduction was observed to be maximum with P1 pond (98.6%) (Figure 4). COD reduction by *C. vulgaris* was measured to be 98.27% in municipal wastewater (Ahmad *et al.*, 2013)

Reduction in Total Suspended Solids: Influence of wastewater quantity on TSS removal was measured with variation in retention time at constant algae quantity and pond size. TSS reduction was observed to be maximum with 5L of wastewater (98%) almost similar result was found with 7L of wastewater (98.24%) (Figure 1). Influence of P1, P2, and P3 on TSS removal was measured with variation in retention time at constant algae quantity and pond size. TSS reduction was observed to be maximum with P1 pond (93.9%) (Figure 4). Zhang and Karahbakhsh (2007) reported TSS reduction 99%.

Reduction in Total Dissolve Solids: Influence of wastewater quantity on TDS removal was measured with variation in retention time at constant algae quantity and pond size. TDS reduction was observed to be maximum with 5L of wastewater (99.23%) almost similar result was found with 7L of wastewater (98.76%) (Figure 2). Influence of P1, P2, and P3 on TDS removal was measured with variation in retention time at constant algae quantity and pond size. TDS reduction was observed to be maximum with P1 pond (93.9%) (Figure 5). Ahmad *et al.* (2013) measured the reduction TDS to be 98.21% from sewage water by treating it with *C. vulgaris.*

Reduction in Total Kjeldhal Nitrogen: Influence of wastewater quantity on TKN removal was measured with variation in retention time at constant algae quantity and pond size. TKN reduction was observed to be maximum with 3L of wastewater (97.79%) almost similar result was found with 5L and 7L of wastewater (95.56%) and (94.5%) (Figure 2). Influence of P1, P2, and P3 on TKN removal was measured with variation in retention time at constant algae quantity and pond size. TKN reduction was observed to be maximum with P1 pond (96.5%) (Figure 5). Bich *et al.*, (1998) reported TKN reduction 99.49%. Uptake of TKN was observed to be 55% by mixed algae culture from municipal wastewater by Ahmad *et al.* (2012).

Reduction in Total phosphorus: In this experiment effect of wastewater quantity on P removal was measured with variation in retention time at constant algae quantity and pond size. P reduction was observed to be maximum with 5L of wastewater (96.2%) almost similar result was found with 7L of wastewater (95.3%) (Figure 2). Influence of P1, P2, and P3 on P removal was measured with variation in retention time at constant algae quantity and pond size. P reduction was observed to be maximum with P1 pond (97.7%) (Figure 5). Total phosphorus removal was equal t0 96.2 % reported by Hammouda *et al.*, (1995).

Reduction in Phosphate: Influence of wastewater quantity on PO_4 removal was measured with variation in retention time at constant algae quantity and pond size. PO_4 reduction was observed to be maximum with 5L of wastewater (99.40%) almost similar result was found with 7L of wastewater (99.19%) (Figure 3). Influence of P1, P2, and P3 on PO_4 removal was measured with variation in retention time at constant algae quantity and pond size. PO_4 reduction was observed to be maximum with P1 pond (99.2%).

Reduction in Nitrate: Influence of wastewater quantity on NO3 removal was measured with variation in retention time at constant algae quantity and pond size. NO3 reduction was observed to be maximum with 5L of wastewater (99.75%) almost similar result was found with 7L of wastewater (99.34%) (Figure 3). Influence of P1, P2, and P3 on NO3 removal was measured with variation in retention time at constant algae quantity and pond size. NO3 reduction was observed to be maximum with P1 pond (98.9%) (Figure 6).

Reduction in Dye: Influence of wastewater quantity on Dye removal was measured with variation in retention time at constant algae quantity and pond size. Dye reduction was observed to be maximum with 5L of wastewater (98.41%) almost similar result was found with 7L of wastewater (97.91%) (Figure 3). Influence of P1, P2, and P3 on Dye removal was measured with variation in retention time at constant algae quantity and pond size. Dye reduction was observed to be maximum with P1 pond (99.2%) (Figure 6).

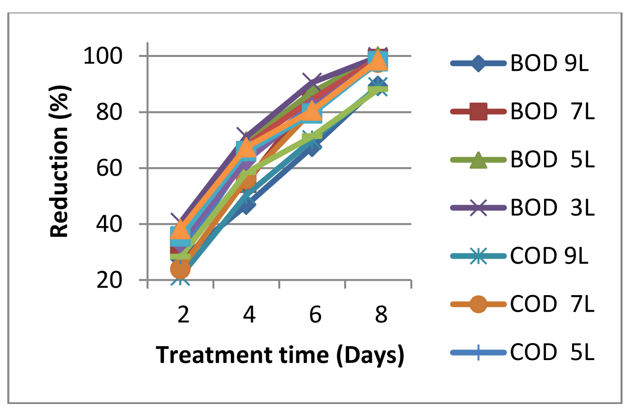

Figure 1: Effect of water quantity and treatment time on percent removal in BOD, COD and TSS with 300g of algae in P1.

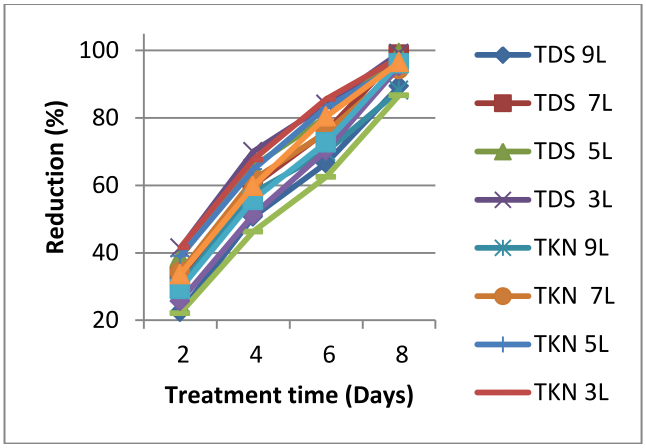

Figure 2: Effect of water quantity and treatment time on percent removal in TDS, TKN and TP with 300g of algae in P1.

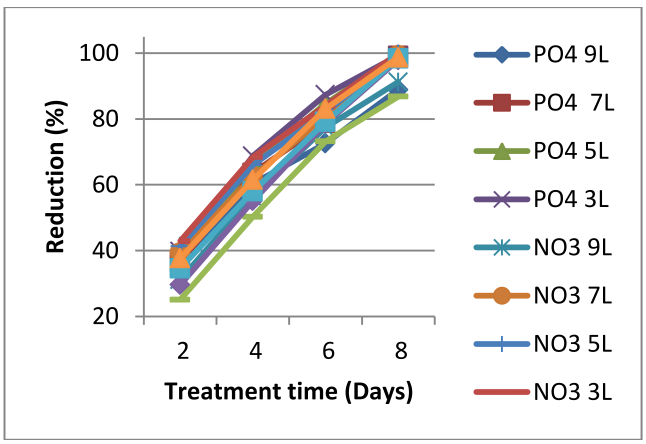

Figure 3: Effect of water quantity and treatment time on percent removal in PO4, NO3 and Dye with 300g of algae in P1.

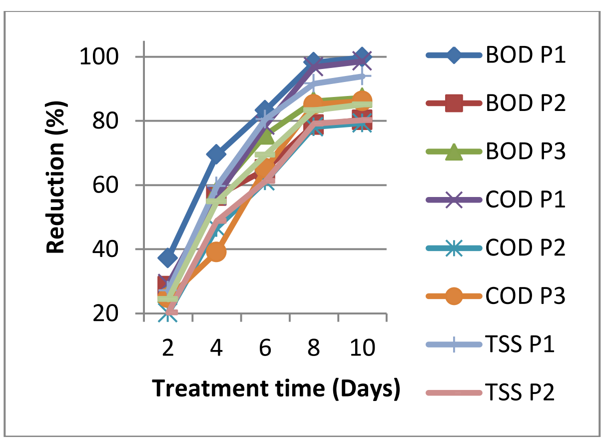

Figure 4: Effect of P1, P2, P3 and treatment time on percent removal in BOD, COD and TSS with 300g of algae in 7 liters water.

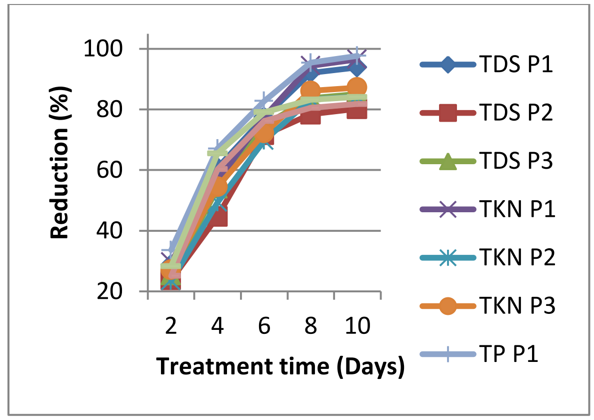

Figure 5: Effect of P1, P2, P3 and treatment time on percent removal in TDS, TKN and TP with 300g of algae in 7 liters water.

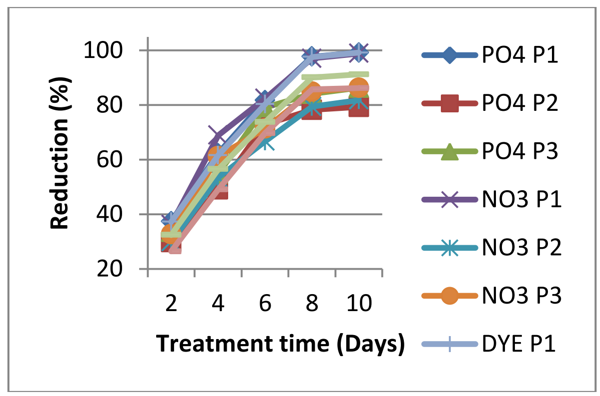

Figure 6: Effect of P1, P2, P3 and treatment time on percent removal in PO4, NO3 and Dye with 300g of algae in 7 liters water.

Conclusions: Algal treatment is an effective and cheapest method for reducing pollutants from sewage and industrial effluent. Algal growth was not luxurious in industrial wastewater but when it was mixed in a specific proportion to municipal waste water, it became a suitable medium for culturing it. High temperature in hot summer was harmful for algal growth particularly in an effluent with high concentration of industrial wastewater. Current study showed that phycoremediation process can be a cost-effective treatment method for mixed effluent. This treatment did not require any chemical and energy or power; therefore, it was proved to be inexpensive.

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