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Research Article

ESTIMATION OF IMPACT OF *CHLORELLA VULGARIS* ON CHEMICAL OXYGEN DEMAND (COD) AND TOTAL PHOSPHATE (TP) IN WASTE AND RIVER WATER

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ABSTRACT. Waste water treatment by the use of non-micro algal or physiochemical methods often result in being exhaustive and inefficient ways. Microalgae have the ability to take up nutrients while thriving in water bodies. Phosphorous, nitrogen and other trace elements are present in waste water which the algae need for their growth. Algae which was obtained from waste water was inoculated in waste and river water for a period of 14 days as testing for chemical oxygen demand and total phosphate was carried out on a weekly basis along with the observance of absorbance by the use of a spectrophotometer. A decrease in the content of total phosphate and chemical oxygen demand was observed. The average efficacy of COD reduction was 60% for waste water and 77.2% for river water and the average efficacy of total phosphate reduction was 87% for waste water and 13% for river water. Similarly a decrease in absorbance and increase in transmittance was observed in both water samples. The average efficacy of absorbance reduction was almost 100% for both samples. But due to the sudden increase in concentrations it was revealed that due to the lack of aeration and a carbon source, the algae had died and started to decompose. This study demonstrates that algal treatments are achievable as an eco-friendly alternative and that algal bioremediation could be incorporated with other methods of treatment or adopted as the single method for the treatment of wastewater.

Keywords: *Algae, water treatment, chemical oxygen demand, total phosphate, absorbance*

INTRODUCTION

Microalgae are a diverse group of microorganisms which can be found in soil, water, trees, air bark microhabitats [1].

Compared to wheat, corn, palm sources microalgae are the most preferred plant source due to its property which initiate an efficient reduction of phosphorus and nitrogen, high rates of photosynthesis in mitigation of CO2, and also the possibility of growing easily in wastewater [2]. It is also classified as a unicellular microscopic alga which can continue growing and sustain even in harsh surroundings with limited nutrient concentration [3].

An algae-based wastewater treatment system is a way to reduce the amount of quantity of carbonaceous material, along with phosphorus and nitrogen in the water. It's also a sustainable alternative to current methods. Due to the presence of large concentrations of these components result in a deleterious effect on the environment. In developed and developing nations the need for the achievement of improved ecological sources of water bodies is an emerging focus, more specifically aiming at the reduction of phosphorous and nitrogen content [4] Due to the increasing number of cities, the need for more efficient and well-treated wastewater treatment has become one of the most environmental challenges. Urban wastewater treatment can be achieved at various stages, such as primary, secondary, and tertiary. Primary treatment involves the removal of solid components which can result in operational problems in advanced treatment steps. Secondary treatment is a biological process that involves the consumption of dissolved organic matter. Tertiary treatment is an advanced step which is involved in the removal of nitrates, phosphates and trace organic compounds. The elimination of-nutrients such as phosphates and nitrates are one of the main criteria for treatment. The removal of nitrogen results in it being converted into N2 and does not undergo further recycling. Nitrogen and phosphorus can potentially be removed in a considerable amount of time by the use of algal growth cultures. By using this method, nitrogen and phosphorus can be taken up by the algae, and in turn result in a valuable algal biomass. The biomass can be further used as biofuel, feedstock or fertilizer [5].

The aim of the project was the reduction of total phosphate and chemical oxygen demand in waste and river water.

Objectives of the project are as follows:

- To inoculate algal strain in wastewater and river water.
- To observe the decrease in chemical oxygen demand (COD) and total phosphate of thewater samples within a time period of 14 days.

To observe the decrease in absorbance and increase in transmittance of the water sampleswithin a time period of 12 days.

MATERIALS AND METHODS

Algal samples were obtained from a water body in a residential area at Rawal Chowk, Islamabad. After collection, the sample was placed in a freezer at 4°C to allow the debris to settle and to stop microbial activity, for an approximate of 24 hours. After which it was defrosted through natural sunlight and inoculated in waste water which was collected from a water body in Sohan, Islamabad and river water which was collected from River Soan, Islamabad, in 500mL conical flasks. Algae grows ideally in 600-700 nm as it is the best wavelength for photosynthesis, a table lamp was used as a light source since the wavelength of visible light is from 400-700 nm [6]. The levels of COD and total phosphate were measured within a period of two weeks by the use of kits alongside absorbance and transmittance which were measured by the use of mass spectrophotometer.

RESULTS AND DISCUSSION

The duration of treatment has a significant effect on the efficiency of treatment, as the time increases; the algal biomass is able to absorb more nutrients from the water sample. In the current study treatment time, the levels of the nutrient content were observed and a decrease resulted in the concentration of chemical oxygen demand and total phosphate from day 1 to day 7.

It was observed that reduction became constant on 5^{th} to the 7^{th} day. Algal species are widely applied for the treatment of wastewater and have shown potential for the removal of nitrogen, phosphorus, and chemical oxygen demand (COD) with different retention times ranging from 10 hours to 42 days [7].

The nutrient reduction depends on the quantity of nutrients present in wastewater and extent of these nutrients absorbed by the algae for incorporation into algal tissues [8]

Chemical Oxygen Demand and Total Phosphate Testing

The following results were obtained regarding chemical oxygen demand and total phosphate concentrations (Table 1 and 2).

Table 1. *River water COD and TP results in a span of 14 days*

Days	COD (mg/L)	TP (mg/L)
Day 1	180	4.70
Day 7	41	4.10
Day 14	140	34

Table 2. *Waste water COD and TP results in a span of 14 days*

Days	COD (mg/L)	TP (mg/L)
Day 1	110	41.20
Day 7	44	4.95
Day 14	121	58

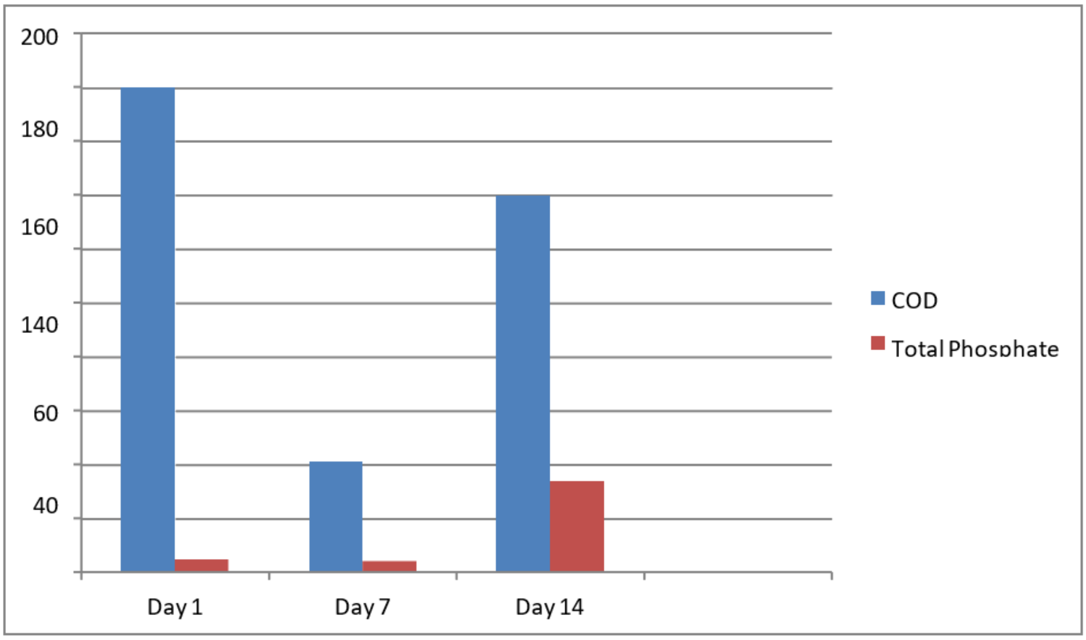

Fig 1*. Graphical Representation of River Water COD and TP results*

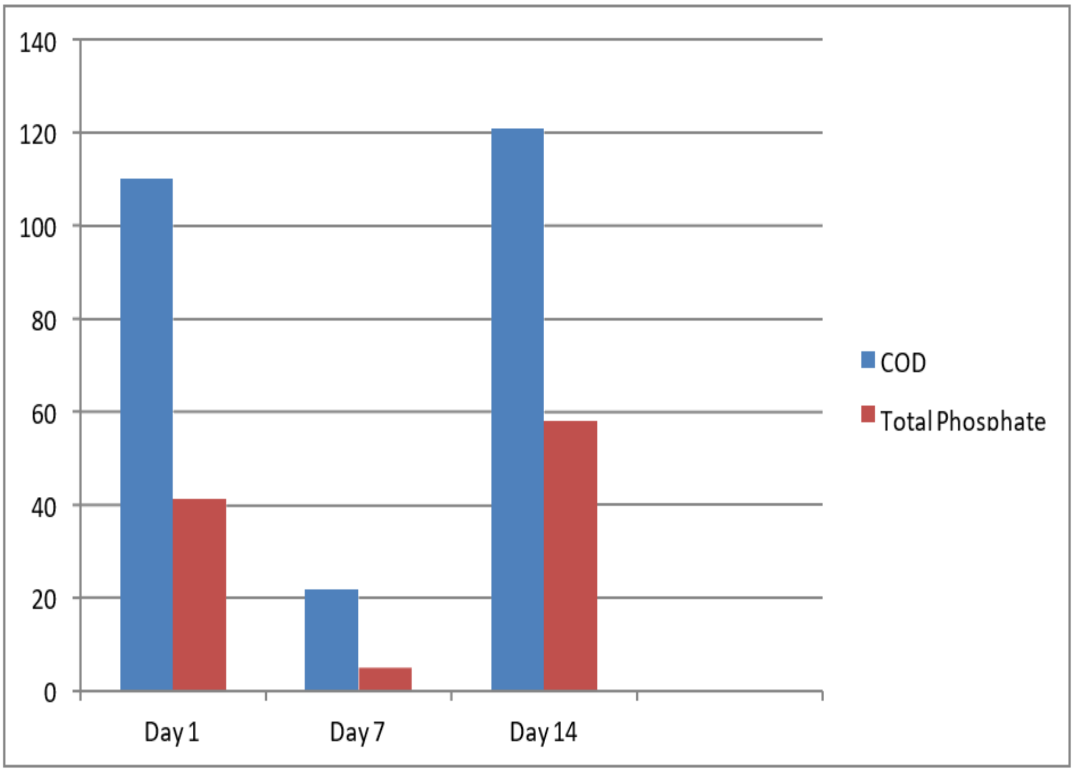

***Fig 2**. Graphical Representation of Waste Water COD and TP results*

Calculation of percentage reduction in COD and TP after algal treatment

% Reduction in COD for wastewater

= [(initial value of COD-final value of COD)/initial value of COD]*100

Eqn. 1

= (110–44/110)*100

= 60%

% Reduction in COD for river water

[(initial value of COD-final value of COD)/initial value of COD]*100

Eqn. 2

= ((180–41)/180)*100

= 77.2%

% Reduction in TP for waste water

[(initial value of TP-final value of TP)/initial value of TP]*100

Eqn. 3

= ((41.20–4.95)/41.20)*100

= 87%

Reduction in TP for river water

[(initial value of TP-final value of TP)/initial value of TP]*100

Eqn. 4

= ((4.70-4.10)/4.70)*100

= 13%

Treatment Performance

In accordance to the results, the COD and TP concentrations of river water at the day of algal inoculation were 180 mg/L and 4.70 mg/L, which in a time period of 7 days reduced to 41 mg/L and 4.10 mg/L respectively.

Waste water treatment results showed a similar pattern as the COD and TP concentration which was initially 110 and 41.20 reduced to 44 and 4.95 within a time span of 7 days

An average 87% and 13% of P removal efficiency was achieved, within an average of 7 days as the micro-algae were cultured in a free living state.

The majority of inorganic P removal was attributed to assimilation by the micro-algae and other microorganisms in the wastewater.

Phosphate removal during remediation is due to the utilization of phosphorous for growth [9].

Initially COD levels were very high in both the water samples, indicating a greater

This meant that more oxidizable organic material was present in the samples. The algae without the use of chemicals had a proven ability to treat and stabilize the wastewater, content of organic material within the samples decreased, the COD levels also eventually started to decrease.

An average 60% and 77.2% of COD lowering efficiency was achieved, within an average of 7 days.

Comparing both samples, as the nutrient concentration in the waste water was high it resulted in rapid and increased levels of reduction in total phosphate and chemical oxygen demand. River water although not being as contaminated as waste water, still had a considerable amount of pollutants due to discharge of contaminants in the surrounding area, the nutrient concentration was efficiently lowered by the algae.

Contrasting the results obtained with previous studies for the evaluation of growth of *Chlorella* sp. on wastewaters sampled from a local municipal wastewater treatment plant, and how effective the treatment would be regarding the reduction of micro and macronutrients. The study indicated removal rates of NH4–N were 74-82%, phosphorus 83-90% and 50-83.0% COD. There was also indication of the removal of metal ions which were present in the water sample [10].

Another study was conducted; investigations were done regarding the nutrient removal efficacy of *Chlorella vulgaris.* In the study it was observed that after cultivating the microalgae in waste water, the chemical oxygen demand (COD), total phosphorous, total Kheldjal nitrogen, and ammonia were reduced by 70.0, 77.7, 82.2, and 99.0% within a period of 15 days, respectively [10].

Absorbance and Transmittance

Absorbance measurements were used to quantify the algal sample in the wavelength range of 550 nm [2].

The aim of this part of the study was to determine whether organic and inorganic constituents present in river and waste water, such as natural organic matter and particles, would affect the spectrophotometric values of the samples.

The absorption rate of the algae was measured within a time span of 12 days.

The measurements obtained are mentioned in Table 3 and 4 respectively.

Table 3. *Transmittance and Absorbance measurements in River Water*

Days	Transmittance %	Absorbance
Day 1	64.5	0.190
Day 5	100	0.00
Day 7	100	0.00
Day 12	59.1	0.228

Table 4. *Transmittance and Absorbance measurements in Waste Water*

Days	Transmittance %	Absorbance
Day 1	54.1	0.267
Day 5	99.5	0.002
Day 7	99.5	0.002
Day 12	78.9	0.103

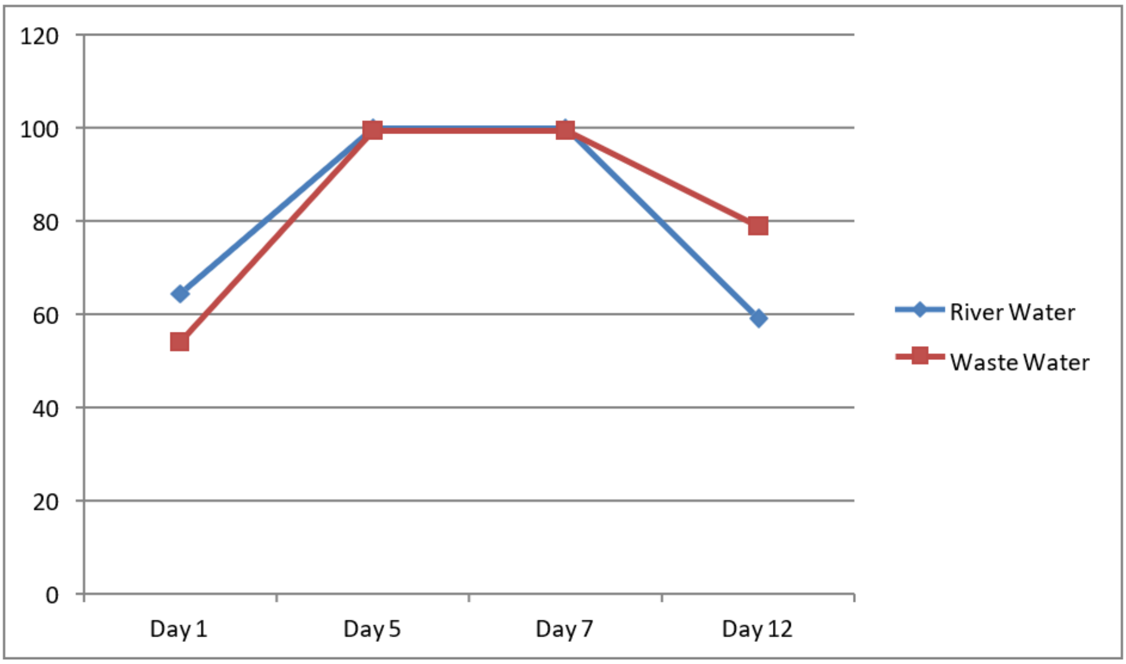

Fig 3. *Graphical Representation of Transmittance in River and Waste Water*

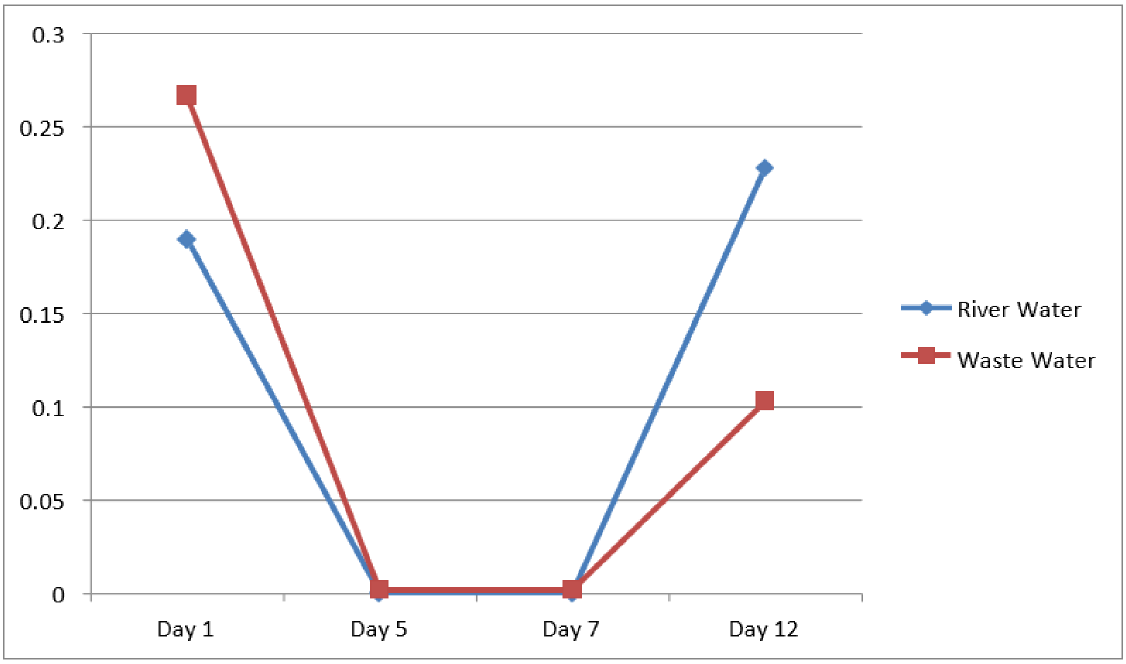

Fig 4. *Graphical Representation of Absorbance in River and Waste Water*

Percentage Reduction of Absorbance

% Reduction for wastewater

[(initial value of AU-final value of AU)/initial value of AU]*100

Eqn. 5

= (0.267–0.002/0.267)*100

= ~100%

% Reduction for river water

[(initial value of AU-final value of AU)/initial value of AU]*100

Eqn. 6

= ((0.190–0.00)/0.190)*100

=~100

Testing Performance

After the inoculation of the algal sample in the water cultures, an increase in transmittance and decrease in absorbance was been observed on day 5, and it remained constant till day 7.

As absorbance is directly proportional to the concentration of the substance, the higher the concentration, the higher its absorbance [2]. This is due to the proportion of light which gets absorbed is affected by the number of molecules that it interacts with.

The water samples before treatment were more concentrated and had larger number of molecules that interacted with the light that entered, thus resulted in increased absorbance.

The average reduction efficacy in both the water samples was approximately 100%, because in the treated samples the low absorbance is due to the presence of fewer molecules available to interact with the light.

Short comings

Addition of air into the water samples is required for the increase in pollutant degradation. Aeration helps in the removal of pollutants such as dissolved gasses, metals, ammonia, iron, and methane

Algae just like plants require CO_2 for its growth, a pound of algae needs two pounds of CO_2.

But since a carbon source was not provided to the algae and the water samples were kept in a static state it possibly resulted in the death of algae [11].

Due to the lack of a carbon source and additional supplements, the algae died and hence its remains were targeted by the microorganisms present in the water samples.

On day 14, the concentration of chemical oxygen demand and total phosphate had increased. The reason for this is that after the death of algae, it's physical and chemical decomposition takesplace due to the presence of bacteria and other microorganisms within the water, the decomposition of the chemistry of water also took place. Therefore as an increase the concentration of organic materials takes place the chemical oxygen demand eventually shows an increase as well.

Decaying algal debris results in a surge of phosphate release into the surrounding environment and an increase in total phosphate concentrations was observed [12].

On day 12, an increase in absorbance was observed. As concentration of the sample has a direct effect on the absorbance, the concentration of solution is increased due to algal death. It resulted in more molecules for the light to hit when it passed through, hence more light blockage.

CONCLUSION

Algae can significantly remove pollutants such as phosphate, nitrogen and trace elements from polluted water by using these nutrients for their growth provided a constant source of light and nutrients algae can further be used to improve quality of water bodies. A decrease was observed in COD and phosphate concentrations. In absence of stable source of external growth factors algae will eventually die and decompose resulting in increased concentrations

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Conflict of Interest. The authors declared that there is no conflict of interest.

Authorship Contributions. Concept: A.B., R.B., A.A.B., Design: A.B., R.B., A.A.B., Data Collection: A.B., R.B., Analysis or Interpretation: A.B., R.B., A.A.B, Literature Search: A.B., R.B., Writing: A.B., R.B.

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