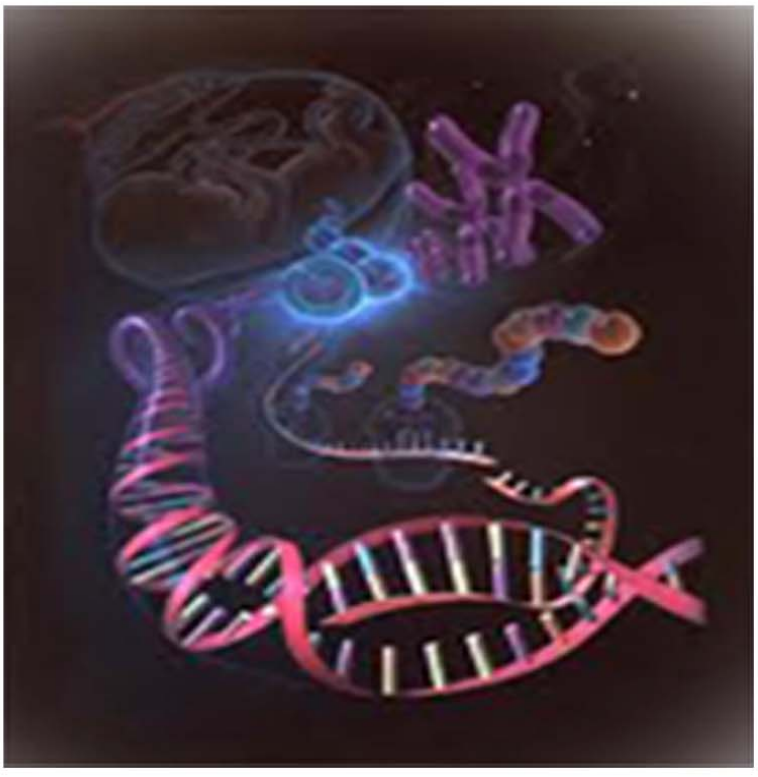
IJLBPR

ISSN 2250 - 3137
Vo1. 2, No. 3, July 2013

International Journal of

Life Sciences Biotechnology and Pharma Research



International Journal of Life Sciences Biotechnology and Pharma Research
Hyderabad, INDIA

www.ijlbpr.com

Email : editorijlbpr@gmail.com or editor@ijlbpr.com

International Journal of Life Sciences Biotechnology and Pharma Research

ISSN 2250-3137 www.ijlbpr.com
Vol. 2, No. 3, July 2013

Research Paper

BIOREMEDIATION OF WASTEWATER BY USING MICROALGAE: AN EXPERIMENTAL STUDY

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Autotrophs play an important role in remediation of wastewater particularly domestic waste through it photosynthetic ability. To investigate the role of algae in wastewater treatment algal samples were collected from polluted water. These samples were used to isolate most dominant and pollution tolerant algae such as *C. vulgaris* and *S. quadricauda* cultures in BBM and used for the treatment. The domestic wastewater samples used in this study were collected from sewage wastewater treatment plant Bopodi from Pune city. To study the role of microalgae in wastewater, the following protocols were used, (i) Wastewater treated with culture of *C. vulgaris* and *S. quadricauda;* and (ii) Wastewater treated without culture of *C. vulgaris* and *S. quadricauda* (Control). Samples were periodically (every 5th day) analyzed for physico-chemical parameters such as pH, phosphate, nitrate, BOD and COD using standard methods. *C. vulgaris* shows the best removal capacity of nitrate and COD while *S. quadricauda* shows BOD and phosphate reduction. Present investigation focuses on the bioremediation of wastewater by using micro algae.

Keywords: Bioremediation, Wastewater, Microalgae, Physico-chemical parameters

INTRODUCTION

The world is facing problems with a wide variety of pollutants and contaminates from various developmental activities. The population explosion in the world has resulted in an increase in the area of polluted water. The concern on the quantity and quality of waste generated and discharged into natural water bodies has recently indicated the need for different strategies to address water quality challenges in the regions. Bioremediation uses naturally occurring microorganisms and other aspects of the natural environment to treat wastewater of its nutrients. Bioremediation can prove less expensive than other technologies that are used for cleanup of hazardous waste (Vidali, 2001).

Algae are universally acknowledged as playing a very important role in natural water purification

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process (Han *et al*., 2000; Olguin, 2003). Thus, the use of microalgae for removal of nutrients from different wastes has been described by a number of authors (Benemann *et al*., 1977; Gupta and Rao, 1980; Williams, 1981; Kunikane *et al*., 1984; Senegar and Sharma, 1987; Tam and Wong, 1989; Gantar *et al*., 1991; De la Noue, 1992; De-Bashan *et al*., 2002; Queiroz *et al*., 2007; Rao *et al*., 2011).

The present work aimed to examine the efficiency of microalgae strains in removal inorganic nutrient to prevent further deterioration of water quality of domestic wastewater. Present investigation focuses on the bioremediation of wastewater by using culture of *C. vulgaris* and *S. quadricauda*.

MATERIALS AND METHODS

Collection of Wastewater

The domestic wastewater samples used in this study were collected from sewage wastewater treatment plant Bopodi from Pune city.

Analytical Methods

The wastewater was analyzed for pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), phosphate and nitrate were before and after using algae for treatment using the standard techniques described by (APHA, 1998).

Microorganism Selection

The algal species used in this study were isolated from water from river Mula, Pune. Firstly most dominant algal strain selected which survival in the highly polluted water of river Mula such as *Chlorella vulgaris* Beijerinck and *Scenedesmus quadricauda* (Turpin) Breb. (Kshirsagar and Gunale, 2011; Kshirsagar *et al*., 2012) were used as test organisms for the treatment of domestic wastewater.

Experimental Set-up

To study the role of microalgae in wastewater treatment, the following method was employed (i) Wastewater treated with culture of *C. vulgaris* and *S. quadricauda;* and (ii) Wastewater treated without culture of *C. vulgaris* and *S. quadricauda* (Control). Experiments were conducted in triplicates.

2 ml of uniform suspension of *C. vulgaris* and *S. quadricauda* as initial inoculums (9 days old culture) in each flask containing 200 ml wastewater sample. The initial total count of the *C. vulgaris* and *S. quadricauda* were 7.32×10^4 cell/ml and 3.46×10^4 cell/ml respectively. The experiment was conducted under controlled conditions (Temp 27 ± 2º C) for a total duration of 20 days. Samples were periodically (every 5^{th} day) analyzed for physico-chemical parameters such as pH, phosphate, nitrate, BOD and COD using standard methods (APHA, 1998).

RESULT AND DISCUSSION

All physico-chemical parameters were quantified for 0^{th}, 5^{th}, 10^{th}, 15^{th} and 20^{th} days, respectively. The initial pH of wastewater was 7.41 ± 0.10 (Table 1). When the wastewater treated with *C. vulgaris* and *S. quadricauda* then the pH was increased as compared to control. Similar observation recorded by Rajasulochana *et al*. (2009).

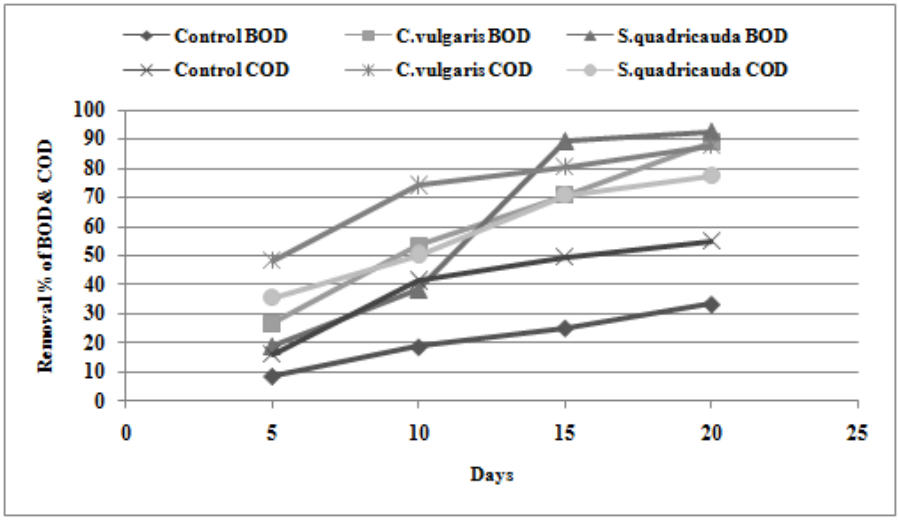
BOD and COD levels of treated effluent were reduced significantly (Figure 1). The BOD is an indicator measurement of substances that can be degraded biologically, consuming dissolved oxygen in the treatment upto15^{th} days. The BOD

Table 1: Analysis of pH from wastewater using *C. vulgaris* and *S. quadricauda*

Initial pH	7.41±0.10		
Days	Control	*C. vulgaris*	*S. quadricauda*
5th	7.69±0.07	7.64±0.06	7.72±0.04
10th	7.08±0.06	8.40±0.27	7.75±0.20
15th	7.66±0.14	7.77±0.07	7.76±0.06
20th	7.73±0.06	7.75±0.19	8.10±0.13

Note: Values represent the mean ± SD of three replicates.

Figure 1: Removal % of BOD and COD of Wastewater Using *C. vulgaris* and *S. quadricauda*



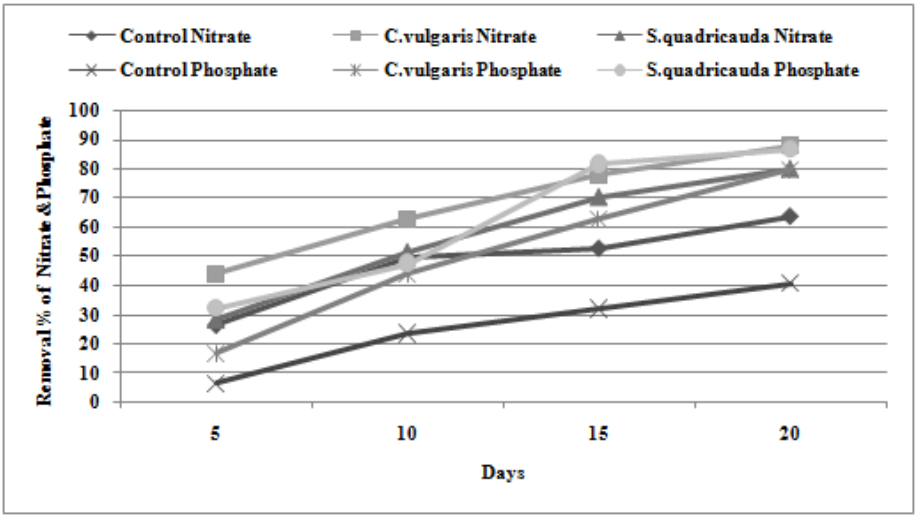
level was reduced to 70.91 % by *C. vulgaris* and 89.21 % by *S. quadricauda* up to 15th days. Aziz and Nag (1993) studied the feasibility of using an activated-algal process to treat wastewater and found that it was able to remove 80-88 % of BOD, 70-82 % of COD with a retention period of 15th days using *C. vulgaris*.

During present study, the COD level was higher reduced to 80.64% and 70.97% by *C. vulgaris* and *S. quadricauda* upto 15th days respectively (Figure 1). *C. vulgaris* showed the best removal capacity of COD from wastewater. Valderramna *et al*. (2002) obtained 61% removal efficiencies for COD by *C. vulgaris* in the treatment of diluted ethanol and citric acid production industry wastewater. *C. vulgaris* induced progressive reduction in both BOD and COD values of the effluent and this could be attributed to the high algal growth rate and intense photosynthetic activity (Colak and Kaya, 1988). In a study by Zhang *et al*. (2008) *Scendesmus* sp. showed high removal efficiency for inorganic nutrients from domestic effluents. COD and BOD removal efficiency were 88 and 89.60%, respectively using *C. vulgaris* (Azeez, 2010).

In the same experiment, removal of nitrate using *C. vulgaris* and *S. quadricauda* from wastewater was determined. Removal of nitrate from wastewater was 78.08% and 70.32% when treated with *C. vulgaris* and *S. quadricauda* upto 15th day. *C. vulgaris* shows best reduction capacity of nitrate from wastewater than *S. quadricauda*. High levels of nitrogenous compounds in wastewater can be effectively removed only by algae (Tam and Wong, 1990). A study by Narkthon (1996) on the efficiency of nitrogen and phosphorus removal from swine wastewater by *C. vulgaris* showed that 77-86 % of nitrogen and 53-75% of phosphorus was removed with a retention period of 8 days. Gonzales (1997) found that *C. vulgaris* and *Scenedesmus* sp removed 95% of ammonium-nitrogen and 50% of phosphorus in wastewater.

In the present study *C. vulgaris* removed 62.73% of phosphate in wastewater during the 15th days, while the maximum capability of removal was 79.66% on 20th day of experiment. Such a high percentage of removal was found 81.34 % for *S. quadricauda* during 15th day (Figure 2). These results similar to that reported by Granter *et al*., (1984) who concluded that *Chlorella* and *Scenedesmus* were the most efficient algal strains to eliminate phosphate from mixtures of municipal and refinery wastes. Phosphate was efficiently removed from the wastewater by *S. quadricauda* within 15th days. The wastewater treatment using *S. quadricauda* found higher removal rates of phosphate. Similar observation recorded by Chevalier and Noue (1985). Kim *et al*. (2007) observed over 83% removal of phosphorus by *Scenedesmus* in fermented swine wastewater with phosphorus concentration of 120 mg/l. Phosphate removal by *C. vulgaris* during remediation is due to the utilization of phosphorus for growth (Rao *et al*., 2011). *C. vulgaris* removed 58.7% of phosphate in wastewater while the maximum capability of removal was 91.9% on 20th day of experiment while such a high percentage of removal was found 80.0 % for each of *S. abundanse* and *S.*

Figure 2: Removal % of Nitrate and Phosphate of Wastewater Using *C. vulgaris* and *S. quadricauda*



quadricauda during the 6th and 15th day, respectively (Granter *et al*., 1984; Kassim, 2002).

Garrett and Allen (1976) have shown that accumulation of phosphorus accounts for 96% of that removed during the growth of a strain of *C. vulgaris* on animal slurry. Doran and Boyle (1979); Tam and Wong (1990) have reported over 90% removal in total phosphorus within 10th days of algal cultivation due to chemical precipitation. Lau *et al*. (1997) mentioned that 38% phosphate uptake by free cells culture of *C. vulgaris* and 94% by alginate immobilized cells after 24 h. Studies in *Chlorella* and *Scenedesmus* indicated efficiency to remove phosphate from mixture of municipal and refinery waste (Gupta *et al*., 1980).

The results showed that the removal efficiencies of COD, BOD, nitrate and phosphate of wastewater were 80.64%, 70.91%, 78.08% and 62.73%, respectively using *C. vulgaris* upto 15th days. While using *S. quadricauda* the removal efficiencies of COD, BOD, nitrate and phosphate of wastewater were 70.97%, 89.21%, 70.32% and 81.34%, respectively upto 15th days. Biological treatment processes accomplish oxidation of organic materials in wastewater by microbial activity such as activated sludge, lagoons or anaerobic processes and photosynthesis of micro algae which are being used to reduce some physico-chemical parameters such as pH, BOD and COD (Tarlan *et al.,* 2002; Goel, 2006).

CONCLUSION

From this study it was clear that when the growth rate of *Chlorella vulgaris* and *Scenedesmus quadricauda* in the wastewater increases, the rate of reduction of different pollutants or nutrients. *Chlorella vulgaris* showed the best removal capacity of nitrate and COD while *Scenedesmus quadricauda* showed best result for BOD and phosphate reduction. Unicellular green algae such as *Chlorella* and *Scenedesmus* have been widely used in wastewater treatment as they have fast growth rates and high nutrient removal capabilities.

Therefore, it was found that the remediation using *Chlorella vulgaris* and *Scenedesmus quadricauda* of wastewater provides an effective and environmentally acceptable option for wastewater remediation, which not only recycles valuable nutrients but also improves water quality. These experiments confirm that *Chlorella vulgaris* and *Scenedesmus quadricauda* may be considered efficient nutrient removers.

ACKNOWLEDGMENT

Dr. Ayodhya D. Kshirsagar is grateful to the University Grant Commission (UGC), New Delhi for financial assistance through the UGC Research Fellowship. The author thanks to Dr. V R Gunale. The author also thanks to Prof. N S Nikam, Principal of C T Bora College, Shirur, Pune, Pin 412210.

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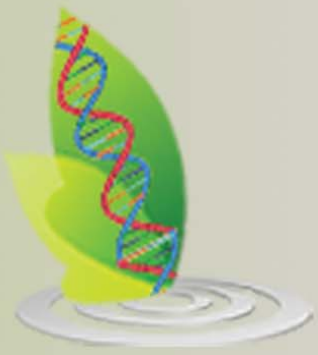

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ISSN 2250-3137