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Micro algal technology to correct pH and reduce sludge in an acidic effluent from a detergent industry.

V Sivasubramanian[1], B Sankaran[2], R. Murali[1] and V V Subramanian[3]

[1]Vivekananda Institute of Algal technology (VIAT), R K M Vivekananda College, Chennai 600004.

[2]Presidency College, Chennai – 600005.

[3]Phycosepctrum Environmental Research Centre (PERC) 52 A, AK Block, 7th Main road, Annanagar, Chennai – 600040.

Abstract

Ultramarine and Pigments Ltd, Ranipet, is a detergent manufacturing company which produces pigments and surfactants. The sulfonation plant of the factory generates 60 to 70 KL of highly acidic (pH < 1) effluent every day. It also has very high TDS (Total dissolved solids > one lakh). Conventionally the industry has been correcting the pH with lime and the neutralized effluent has been evaporated using SEPs (solar evaporating ponds). Present study deals with development of microalgae based technology (Phycoremediation) to correct pH (without lime) and reduce sludge. After preliminary feasibility studies in the laboratory, *Chlorococcum humicola* has been selected for field trials using a slope tank, designed and constructed at industry's premises. Effluent addition to the slope tank was done through a continuous flow arrangement. Optimization of effluent addition was achieved through regular monitoring of pH and micro algal growth. Effective pH regulation associated with considerable amount of sludge reduction was achieved and based on the data collected recommendations for scaling up were given to the industry.

Keywords: *Chlorococcum humicola*, effluent treatment, pH correction, phycoremediation

Introduction

Phycoremediation, as defined in a broad sense, is the use of macro algae or micro algae for the removal or biotransformation of pollutants, including nutrients and xenobiotics from wastewater and CO2 from waste air (Olgu'in, 2003). Microalgae play an important role during the treatment of domestic wastewater (Abeliovich, 1986 and Oswald, 1988). Vivekananda Institute of Algal technology (VIAT), Chennai is an organization doing pioneering works in Phycoremediation. They have successfully implemented micro algae based technology in treating different types of industrial wastewater. The first ever phycoremediation plant with *Chroococcus turgidus* has been working from September 2006 at SNAP industry very successfully (Sivasubramanian *et al*, 2009).

Industrial wastewaters are conventionally treated using chemicals for pH correction, sludge, colour and odour removal. Micro algal technology prevents the use of chemicals in treatment and also the process is simplified.

The present study is on the phycoremediation of effluent from Ultramarine and Pigments limited, situated at Ranipet, Tamilnadu, India. The company is involved in manufacturing pigments for detergents and surfactants. Their liquid effluent is acidic and has a very high TDS ranging from 75000 – 150000. The industry has to release the effluent after neutralizing it with Lime, slaked. Industry was also using solar evaporation ponds to evaporate the effluent to leave out final solid sludge.

Preliminary laboratory experiments proved that *Chlorococcum humicola* a chlorophycean micro alga has the potential to correct pH and reduce total dissolved solids (sludge).

Materials and Methods

Ultramarine and Pigments limited is one of the largest pigment and surfactant manufacturing company. They have two factories in South India. One of them is situated in Ranipet, an industrial town 110 kilometers northwest of Chennai. It specializes in the manufacture of inorganic pigments and organic surfactants with international quality standard. The company commits itself to prevention of pollution through seeking and adopting techniques and process that reduce energy consumption and reduce damage to the environment.

The company produces a chemical called Ultramarine blue. It is a very safe chemical, non-hazardous blue pigment with a variety of applications worldwide. Its synthetic manufacturing process and possibility for close control over its physical, chemical, and colour characteristics enable the production of several types of this blue pigment, which are readily accepted by plastic, printing ink, paint, cosmetic and many other industries due to advantages over other organic pigments and dyes. Besides, Ultramarine blue is an environment friendly pigment available to the industry today.

The acidic waste water was neutralized with lime, slaked by the industry, settled to remove the total suspended solids and evaporated on solar evaporation ponds (SEPs). The dried solids were recovered from the SEP and stored in a secured landfill. Improvised CFTRI Medium (Venkataraman LV, 1985), Bold Basal Medium (Nichols H W, 1965) was prepared for laboratory cultivation of microalga.

Microalgae

Chlorococcum humicola maintained in the VIAT lab which was earlier identified following the monograph of Philipose, 1967. *Chlorococcum* is a fresh water green alga. It was maintained in the laboratory at 24±1°C in a thermostatically controlled room and illuminated with cool white fluorescent lamps (Philips 40W, cool daylight 6500K) at an intensity of 2000 lux in a 12:12 light dark regime. All the physical and chemical parameters were analysed according to APHA Standard methods (APHA, 2000).

Sloping pond - pilot scale

The pilot scale sloping pond was constructed in Iron and was designed with a dimension of 3 m (L) × 1.5 m (W) × 0.3 m (depth) with a sloping angle of the evaporating surface of 45°. The dimension of the sloping area was 4 m2. The holding capacity of the tank was 1500 l. The flow rate of the effluent was at 500 l/h. The plant was run during the day for about 8 h.

Sloping pilot plant tank built in the industries premises for field trials of phycoremediation. Aeration, agitation, temperature and growth of the microalgae were the factors that influenced sloping tank treatment. Outdoor treatment was comparatively more effective than the indoor treatment. The factor behind this might be the sunlight, with the light intensity between 15 and 75 Klux (morning – 25 Klux, noon – 75 Klux and evening – 15 Klux); whereas the artificial illumination in indoors were between 2000 and 4000 lux. The aeration was too better in the outdoors due to frequently altered wind movement.

The experiment has been planned to first grow the algal culture in the tank and then add the effluent for treatment. The sloping tank used for the pilot culture study was found best for phycoremediation. This is because of better aeration and expediency of periodical mixing. Aeration and agitation improved the growth of algae and this has been achieved by rhythmic circulation of the effluent in a sloping pond. This in addition increased the rate of evaporation too. The principle of the sloping design is to create a turbulent flow while the algal suspension flows through sloping surfaces. A pump returns the algal suspension from the lowest point to the top. The turbulence is produced by gravity, according to the flow speed of the liquid given by the slope of the surface. The flow rate of the effluent was at 500 LPH. The running time of the plant during day-time was 8 hrs.

The tank has been filled with 1000 L of raw water. The nutrients Sodium bicarbonate, NPK fertilizer, super phosphate and magnesium sulphate have been added to water in the tank because, the growth of the microalgae to be grown would be absolutely reliant upon the availability of nutrients. The quantity of chemicals added to the tank has been based on the improvised CFTRI medium suggested by CFTRI, Mysore for outdoor cultivation.

The fresh *C. humicola* culture taken to the industry for the purpose of phycoremediation has been added to the nutrient mixed water in the pilot culture tank. The tank has been kept undisturbed for 10 days. The luxuriant green micro algal culture of *C. humicola* was found ready for the phycoremediation study.

The experiment has been started with the algal culture by adding 50 L of effluent to it with a variant acidic pH (5 – 6.5) and TDS in the range of 75000 to 150000 mg/L. The supplementary quantities of 10 L have been added every day to study the effect of microalgae on the effluent. The physical parameters like the pH, temperature, TDS have been analysed every day. Cell count and the evaporation rate of the tank have also been studied.

The cell count of the *C. humicola* reduced significantly during every addition of raw effluent due to inadequate nutrients. Hence, the nutrients such as $NaHCO_3$ and NPK have been added periodically to enhance the cell count of *C. humicola*.

Results and Discussion

The raw effluent was analysed for its physic-chemical parameters and the results are shown in Table 1. The TDS was very high (90846 mg/l). The levels of sodium and sulphate were very high. The chloride levels also very high. The conventional method of neutralizing with lime, slaked was followed and the effluent was allowed to evaporate in solar evaporation ponds. The physic-chemical parameter of treated effluent showed a very good reduction in sodium and chloride.

The principle of the slopping design is to create a turbulent flow while the algal suspension flows through sloping surfaces. A pump returns the algal suspension from the lowest point to the top. The turbulence is produced by gravity. The flow speed of the liquid increases with the slope of the surface. Effluent enriched with *C. humicola* was loaded into the slope pilot tank. The pH increase occurred after the micro algal treatment which was the most desired result of the experiment.

The pH of the untreated

Table 1. A comparison of physic-chemical parameters of raw effluent with the treated effluent

Parameters	Raw effluent	Treated effluent
Turbidity	14.1	74.6
Total dissolved solids (mg/l)	63510	54382
Conductivity (micromho/cm)	90846	77707
pH	3.8	6.7
Alkalinity pH mg/l	0	0
Alkalinity mg/l	Nil	Nil
Total Hardness mg/l	5800	2100
Calcium mg/l	1360	560
Magnesium mg/l	576	168
Sodium mg/l	18500	16100
Potassium mg/l	500	600
Iron mg/l	0.82	0.99
Manganese mg/l	Nil	Nil
Free Ammonia mg/l	0.37	16.28
Nitrite (as NO2) mg/l	2.67	2.58
Nitrate (as NO3) mg/l	11	12
Chloride (as Cl) mg/l	27400	24200
Flouride (as F) mg/l	0.97	0.84
Sulphate (as SO4) mg/l	2007	2920
Phosphate (as PO4) mg/l	3.38	73.84
Silica (as SiO2) mg/l	31.66	71.9
BOD mg/l	860	740
COD mg/l	2894	2512

effluent is 3.8 when compared to the treated effluent which was 6.7. The TDS also reduced from 63510 to 54382.

Effective pH regulation associated with considerable amount of sludge reduction was achieved and recommendations for scaling up were given to the industry.

Conclusion

The phycoremediation work carried out in the pilot plant scale using *C. humicola* was successful. The company requirement of pH correction and sludge reduction could be achieved without employing any chemicals. The recommendations were given to the industry to setup a scaling up plant to save a substantial amount of money on chemicals and the environment is saved from the dumping of hazardous solid waste.

References

Abeliovich A. 1986. Algae in wastewater oxidation ponds. In Handbook of *Microalgal Mass Culture*, edition. A. Richmond, 331-338. CRC Press, Boca Raton, FL.

American Public Health Association (2000) *Standard Methods for Examination of Water and Waste Water*, 21st edn, APHA, Washington DC.

Nichols HW, Bold HC (1965) *Growth media – Fresh water*. In: Stein JR (ed) *Handbook of Physiological Methods*, 7–24. Cambridge University Press, Cambridge.

Olguín EJ. 2003. Phycoremediation: key issues for cost-effective nutrient removal processes, Biotechnol. Adv., 22: 81-91.

Oswald WJ. 1988. Micro-algae and waste-water treatment. In Microalgal Biotechnology, edition. M.B.L. Borowitzka, 305-328. Cambridge University Press, Cambridge.

Philipose M T (1967) *Chlorococcales*, ICAR, New Delhi.

Sivasubramanian V, Subramanian VV, Raghavan BG and Ranjithkumar R. 2009. Large scale phycoremediation of acidic effluent from an alginate industry. *Science Asia*, 35: 220–226

Spolaore P, Joannis-Cassan C, Duran E. and Isambert A. 2006. Commercial applications of microalgae. *Journal of Bioscience and Bioengineering*, 101: 87-96.

Tadashi Matsunaga, Haruko Takeyama, Hideki Miyashita and Hiroko Yokouchi. 2005. Marine Micro algae. *Adv. Biochem. Engin./Biotechnol*. 96: 165–188.

Venkatraman LV. and Becker EW. 1985. In Biotechnology and utilization of algae – The Indian experience. Department of Science and Technology, New Delhi, India.