Bioremediation of Oil Refinery Effluent
By Using Scenedesmus Obliquus

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ABSTRACT: The contamination of groundwater, surface water and air with hazardous and toxic chemicals is one of the major problems in the industrialized world faces today. One among many new technologies to deal with this major problem is bioremediation. Bioremediation, the use of microorganisms or microbial processes to degrade environmental contaminants. Present investigation focuses on the bioremediation of oil refinery effluent by using micro algae. In order to select organism for the treatment process, micro algal populations were collected at different places from where the effluent was collected; isolated and identified by using the standard manual and were maintained in Bold Basal Medium (BBM). To study the role of micro algae in oil refinery effluent, the following protocols were employed. i) Effluent treated with Scenedesmus obliquus and ii) Effluent without Scenedesmus obliquus (control). Various physicochemical parameters such as pH, alkalinity, hardness, iron content, COD, BOD and free ammonia were estimated. It is observed that Scenedesmus obliquus proved to be an efficient removal of most of the parameters including COD and BOD. Results obtained for various parameters are critically analyzed and compared with those of similar investigations reported by various researchers. [The Journal of American Science. 2009; 5(4): 17-22].

Keywords: Refinery effluent, Bioremediation, *Scenedesmus obliquus*

1. INTRODUCTION

Industrialization has long been accepted as a hallmark of civilization. However, the fact remains that industrial emanations have been adversely affecting the environment. Industrial effluents containing toxic and heavy metals drawn into river, which is often source of drinking water for another town downstream. Corporation/Municipal water treatment facilities in most of the developing countries, at present are not equipped to remove traces of heavy metals, consequently exposing every consumer to unknown quantities of pollutants in the water they consume. The main sources of heavy metal pollution are mining, milling, petro chemical industries, discharging a variety of toxic metals into the environment. Although the removal of toxic heavy metals from industrial waste waters has been practiced for several decades, the cost effectiveness of the most common physico-chemical processes such as oxidation and reduction, chemical precipitation, filtration, electrochemical treatment, evaporation, ion-exchange and reverse osmosis is limited. The need to remediate these sites has led to the development of new technologies that emphasize the destruction of the pollutants rather than the conventional approach of disposal. Bioremediation, the use of microorganisms or microbial processes to degrade environmental contaminants, is among these new technologies. Bioremediation has numerous applications, including clean-up of ground water, soils, lagoons, sludges, and process-waste streams.

Micro algae are used in wastewater bio-treatments (Oswald, 1992), as food for humans and animals (Becker, 1992), as feed in aquacultures Lora-Vilchis et al., 2004), for the production of pigments (Johnson and An, 1991) and in agriculture (Metting, 1992). Bioremediation, the use of microorganisms or microbial processes, is one among the new technologies. The bioremediation has been proven successful in numerous applications especially treating petroleum contaminated soils Gazyna et al., 2005). Bioremediation strategies for typical hazardous wastes are illustrated by Satinder et al. (2006). Petrochemical plants generate an aqueous effluent containing various conventional pollutants as well as specific petrochemicals and intermediates. The present study focuses on the bioremediation of oil refinery effluent by using a micro alga.

Present investigation focuses on the bioremediation of oil refinery effluent by using micro algae. In order to select organism for the treatment process, micro algal populations were collected at different places from where the effluent was collected; isolated and identified by using the standard manual and were maintained in Bold Basal Medium (BBM). To study the role of micro algae in oil refinery effluent, the following protocols were employed. i) Effluent treated with Scenedesmus obliquus and ii) Effluent without Scenedesmus obliquus (control). Various physicochemical parameters such as pH, alkalinity, hardness, iron content, COD, BOD and free ammonia were estimated. It is observed that Scenedesmus obliquus proved to be an efficient removal of most of the parameters including COD and BOD. Results obtained for various parameters are critically analyzed and compared with those of similar investigations reported by various researchers.

2. MATERIALS AND METHODS

Oil refinery effluent was collected from Ennore, a suburb of Chennai, India. In order to select organism for treatment process, micro algal populations were collected at different places from where the effluent was collected, isolated and identified by using the standard manual and were maintained in Bold Basal Medium (BBM) (Nichols and Bold, 1965).

The taxa collected and identified as *Chroococcus, Oscillatoria, Lyngbya, Scenedesmus, Scytonema and Spirulina* sp indicates the polluted status of the water body. Among various micro algae, *Scenedesmus obliquus,* have alone acclimatized well with oil refinery effluent. For the present investigation, *Scenedesmus obliquus* was selected for treatment process. To study the role of micro alga in oil refinery effluent, the following protocols were employed. i) The effluent treated without *Scenedesmus obliquus* (control) and ii) The effluent was treated with *Scenedesmus obliquus*. These experiments were conducted in duplicate and repeated three times.

Two ml of uniform suspension of *Scenedesmus obliquus* was added as initial inoculums in each flask containing 1 liter of effluent. The experiment was conducted under controlled conditions (temperature $27 \pm 2°$ C) with a light intensity of 2000 lux, provided from overhead cool light white fluorescent tubes (16L+8D) for the total duration of 15 days. The samples were analyzed periodically on every 5th day for various physico-chemical parameters by using standard methods[1]. The results of the physico-chemical parameters were analysed using one way Analysis of Variance (ANOVA) followed by Tukey HSD test.

3. RESULTS AND DISCUSSION

All physico-chemical parameters were quantified for 0th, 5th, 10th and 15th day respectively are shown in Table 1. The following conclusions/observations can be made w.r.t Table 1.

In the present study, the colour of effluent treated with *Scenedesmus obliquus* changed from blackish to greenish yellow from the seventh day on wards and completed turned green. These changes in colour and odour of the oil refinery effluent may be due to the action of algae which decomposed the organic matter present in the effluent and made the water clear. These findings are in concordant with Verma and Madamwar (2002). There is no work reported on decolourization using micro algae.

The total dissolved solids (TDS) in the effluent treated with *Scenedesmus obliquus* were reduced to 6.10 percent. The TDS value of the oil refinery effluent was found to be exceeding the limit prescribed by CPCB (1995) in the raw effluent which could be attributed to various environmental factors responsible for the reduction of the diversity of aquatic life and oxygen depletion.

The electrical conductivity of the treated effluent was reduced to 7.43 percent by *Scenedesmus obliquus.* The higher level of electrical conductivity in the raw effluent could be attributed to the use of inorganic chemicals in oil refinery. Such low electrical conductivity could be attributed to the presence of organic compounds in the effluent.

Interestingly, the pH of the oil refinery effluent treated with *Scenedesmus obliquus* increased from 5.75 to 6.52. The present study shows that pH increased on the 3rd day itself. Manoharan and Subramanian (1992b, 1993) found a rise in pH value up to the tenth day of growth in paper mills wastewater. The values of pH in the effluent discharged indicated that it was well within the permissible limits of CPCB (1995). In the present study, pH was found to increase in the oil refinery effluent treated with the alga, whereas there was no change in the pH of the untreated effluent.

The alkaline nature of the effluent showed a gradual reduction. The alkalinity of the effluent was reduced to 44.0 percent by *Scenedesmus obliquus*. Alkalinity was found to be high which is harmful to aquatic organism (Nemerow, 1978). The

ability to utilize bicarbonate was also demonstrated with a variety of algae Beardall et al., 1976).

Hardness in the effluent would make it unsuitable for industrial purposes as it may cause the scaling of equipment (Goel, 2000). The total hardness was reduced to 6.34 percent by *Scenedesmus obliquus* with the result of an efficient nutrient uptake of micro algae. Saravanan et al.,(1998) reported that the total hardness was due to Na, K, Ca etc, and would affect the oil refinery wastewater treatment plants. Calcium and magnesium were reduced to 10.83 and 13.73 percent especially when the oil refinery effluent was treated with *Scenedesmus obliquus* with the result of an efficient uptake of alga. The reduction was noticed from the third day till the fifteenth day of growth and after was almost stabilized latter. Sengar et al.,(1990) in their study on purification of river water by algae found a reduction of 67.10 percent of calcium and 67.40 per cent of potassium.

In the present study, 39.27 percent of iron was removed when the effluent was treated with *Scenedesmus obliquus*.

The alga *Scenedesmus obliquus* was also more effective in the removal of (94.97 percent) free ammonia from the oil refinery effluent. The toxicity of ammonia is generally dependent on pH, oxygen concentration and temperature (Cote, 1976).

Chlorides are generally considered one of the major pollutants in the effluents which are difficult to be removed by conventional biological treatment methods. But it was also reduced (47.96 percent) by the experimental alga. Uma and Subramanian (1990) recorded a 30 percent chloride reduction under laboratory conditions by Halo bacterium and only an additional reduction of 12-17 percent with cyanobacteria in the ossein effluent.

The sulphate content in the effluent treated with *Scenedesmus obliquus* was found to be reduced to 26.02 percent. The reduction of sulphate in the effluent and its uptake by micro algae were reported by Mittal and Sengar (1989).

The phosphate and silica levels in the treated effluent were found to have increased to 78.02 and 41.92 percent respectively. The increase in the phosphate with all carbon sources was appreciably low at higher NH_4^+-N concentrations in the waste, but it was quite high at low concentration. Doran and Boyle (1979) reported that 90 percent of phosphorus removal by the activated algae was due to chemical precipitation. The increase of silica was due to the unavailable form of silica converted into the available form.

Oil and grease, if discharged into treated effluents, can create unsightly floating matter and films on water surfaces. It may also interfere with biological life forms on surface water (Metcalf, 1991). In the present study, 99.85 percent of oil and grease was removed when the effluent was treated with *Scenedesmus obliquus*. In wastewater treatment, much of oil and grease floats can be generally removed by mechanical skimming. Though the amount of oil and grease is found to be in negligible, their continuous discharge into the aquatic ecosystem could also destroy the nursery ground of a variety of fishes.

The discharges of BOD in to receiving environments with the limited assimilative capacity sometimes reduce the dissolved oxygen concentrations to the levels below those required for aquatic biota, and it is in this condition that BOD is considered pollutant. The BOD and COD levels of the treated effluent were reduced significantly. In the present study the BOD level was reduced to 16.66 percent by *Scenedesmus obliquus*, and the COD level to 82.80 percent. It can be observed that the reduction in BOD was less compared to the reduction in COD. It is because the degradation sought was through biological activity and not through any chemical agent. Moreover, the presence of organic matter will promote anaerobic leading to the accumulation of toxic compounds in water bodies. This is in accordance with the work of Panneerselvam (1998) and Prabakar (1999). The reduction of BOD and COD levels might occur due to the removal of the dissolved organic compounds and derivatives to some extent from the effluent during the treatment process. The present investigation showed high levels of COD in both untreated and treated effluent, which would render the aquatic body unsuitable for the existence of aquatic organism (Goel, 2000) due to the reduction in the dissolved oxygen content.

4. CONCLUSION

The bioremediation of the pollution load of the oil refinery effluent with *Scenedesmus obliquus* can be used as an effective technology in the reduction of pollutants like inorganic and organic compounds. Furthermore, the better performance in field conditions gave positive indication of their usefulness in the treatment of oil refinery effluent. It is a simple, sensitive, biological, and rapid effluent treatment agent. The system, when standardized would not only be economical but also eco-friendly and sustainable. The information generated would help to scale up the process and moreover, to assess the economic feasibility of the technology.

Table 1 Physico-chemical parameters of oil refinery effluent

Parameter	Control	5th Day	10th Day	15th Day	F-Value	P-Value
TDS	1868±18.08^d	1833±10.77^c	1793±9.53^b	1754±6.81^a	100.717	0.0000**
Conductivity	2625±11.95 ^{d}	2565±13.34	2500±9.47 ^{b}	2430±10.7 ^{a}	322.163	0.0000**
pH	5.75±0.07 ^{d}	6.02±0.07 ^{c}	6.28±0.07 ^{b}	6.52±0.07 ^{a}	139.147	0.0000**
Alkalinity	100±3.91 ^{d}	85±4.94 ^{c}	68±6.23 ^{b}	56±4.00 ^{a}	94.370	0.0000**
Tot. Hardness	1025±7.24 ^{d}	1003±8.90 ^{c}	980±4.73 ^{b}	960±5.55 ^{a}	102.943	0.0000**
Calcium	240±1.41 ^{c}	240±1.41 ^{c}	228±4.98 ^{b}	214±3.16 ^{a}	94.639	0.0000**
Magnesium	102±2.61 ^{d}	98±1.41 ^{c}	93±2.61 ^{b}	88±1.41 ^{a}	50.340	0.0000**
Iron	4.71±0.07 ^{d}	4.11±0.06 ^{c}	3.50±0.12 ^{b}	2.86±0.08 ^{a}	558.969	0.0000**
Free Ammonia	8.96±0.14 ^{d}	6.13±0.25 ^{c}	3.21±0.19 ^{b}	0.45±0.12 ^{a}	2454.486	0.0000**
Chloride	492±9.55 ^{d}	414±8.65 ^{c}	332±13.91 ^{b}	256±13.11 ^{a}	469.691	0.0000**
Sulphate	196±4.69 ^{d}	179±4.20 ^{c}	161±6.57 ^{b}	145±6.23 ^{a}	96.223	0.0000**
Phosphate	1.58±0.10 ^{a}	3.34±0.20 ^{b}	5.21±0.09 ^{c}	7.19±0.16 ^{d}	1672.715	0.0000**
Silica	38±4.05 ^{a}	47.21±1.89 ^{b}	56.25±1.84 ^{c}	65.43±3.49 ^{d}	93.922	0.0000**
Oil & Grease	4±0.16 ^{d}	2.62±0.08 ^{c}	1.41±0.11 ^{b}	0.01±.0.00 ^{a}	1600.736	0.0000**
BOD	239.83±5.12 ^{d}	226±5.52 ^{c}	212±3.94 ^{b}	200±1.96 ^{a}	93.773	0.0000**
COD	407±11.81 ^{d}	295±8.29 ^{c}	180±8.42 ^{b}	70±14.17 ^{a}	1056.562	0.0000**

** Denotes significant at 1 % level; Different alphabet between days denotes significant at 5 % level

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