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A pilot scale assessment of phycoremediation technology in handling effluent from a leather industry, Kanpur, India

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Abstract

After a preliminary laboratory screening and selection of a consortium of micro algae (*Chlorella vulgaris*, *Chlorococcum vitiosum, Chlorococcum humicola, Chroococcus turgidus, Dactylococcopsis raphides, Desmococcus olivaceus, Scenedesmus dimorphus, Scenedesmus incrassatulus,* and *Oocystis borgei*) a pilot plant was set up in one of the leather industries in Kanpur, India and assessment of the efficiency of phycoremediation technology was done using the effluent after bar screen, oil and grease trap, equalization tank, followed by primary settling tank. Colour removal and reduction in COD were monitored and the results are discussed.

Keywords: leather industry, phycoremediation, micro algae, COD, BOD, colour removal

Introduction

Phycoremediation technology is well established and more and more industries are coming forward to adopt this eco-friendly technology (Sivasubramanian, 2015, 2016 and 2019). Existing conventional systems of ETP can be improved with proper intervention through phycoremediation technology for pH correction, colour and odour removal, sludge reduction and reduction of BOD and COD without using any chemicals saving operation cost to a great extent and finally saving the environment. World's First largescale phycoremediation plant was set up by PERC, Chennai at SNAP alginate industry during the year 2006 (*Sivasubramanian et. al*., 2009).

Kanpur is famous for its leather goods from early times. In fact, leather industry is the oldest industry in Kanpur. The consumption demand of the growing European community reshaped the nature of local production. Pre-industrial artisanal manufacture in Kanpur also developed in response to the European consumption demands. Even before the establishment of factories leather goods were manufactured by the village craftsman as cottage industry used to meet the local demand for carriage, harness, saddlers and pots. Once renowned as an export powerhouse, Kanpur's tanneries are perceived to be the primary source of industrial pollution in the Ganga. Inadequacy of proper treatment plants and inefficiency of the old conventional ETP systems have created a huge environmental crisis and the industries are struggling to survive. It is typically characterized as pollutants generated industries which produce wide varieties of high strength toxic chemicals. It is recognized as a serious environmental threat due to high chemical levels including salinity, organic load (chemical oxygen load or demand, biological oxygen demand), inorganic matter, dissolved, suspended solids, ammonia, total kjeldahl nitrogen (TKN), specific pollutants (sulfide, chromium, chloride, sodium and other salt residues) and heavy metals etc. (Cooman *et al*., 2003). The present report is about a successful case of phycoremediation technology based pilot plant set up in one of the biggest industries which tan their own leathers, make full boots, shoes, and leather accessories.

Materials and Methods

Micro algae

Micro algae employed in the present work (*Chlorococcum vitiosum, Chlorococcum humicola, Chroococcus turgidus, Dactylococcopsis raphides, Desmococcus olivaceus, Scenedesmus dimorphus, Scenedesmus incrassatulus,* and *Oocystis borgei)* were obtained from the micro algae culture collection of PERC (Phycospectrum Environmental Research Centre), Chennai, where the laboratory screening of the effluent was also done. Cultures were maintained in Bold Basal Medium (Nichols and Bold, 1965).

Leather industry effluent

Leather industry in Kanpur manufacturing full boots, shoes and leather accessories was selected and the effluent after bar screen, oil and grease trap, equalization tank, followed by primary settling tank was obtained for the study.

Analyses

Analysis of BOD and COD were done at the industry site as per APHA (2005).

Pilot plant

An 8 KL treatment tank with a slope surface (3.4 m x 2.3 m x 1.1 m (H). Roof 2.3 x 1.7 m) with a motor circulating the effluent loaded with micro algae over the roof which is exposed to sunlight and also fitted with LED lamps for night illumination was installed at the industry premises (Fig 1). Fig 2 shows the ETP set up at the industry and where algal intervention is planned.

Fig 1 Showing 8 KL slope tank at leather industry

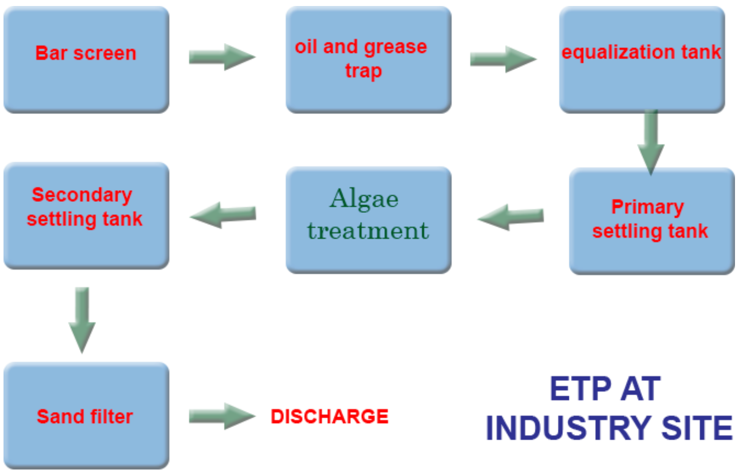

Fig 2. Shows the ETP at leather industry site in Kanpur

Results and Discussion

Laboratory screening of leather industry effluent

Laboratory screening of the effluent was done by inoculating selected micro algae cultures into raw effluent taken in test tubes. The cell count was made every day and based on this growth rates were determined and the results are shown in Fig. 3. Micro algae exhibiting rapid division rates were selected to make a consortium to be tested in pilot plant. Algae growth also reduced the colour considerably (Fig 4)

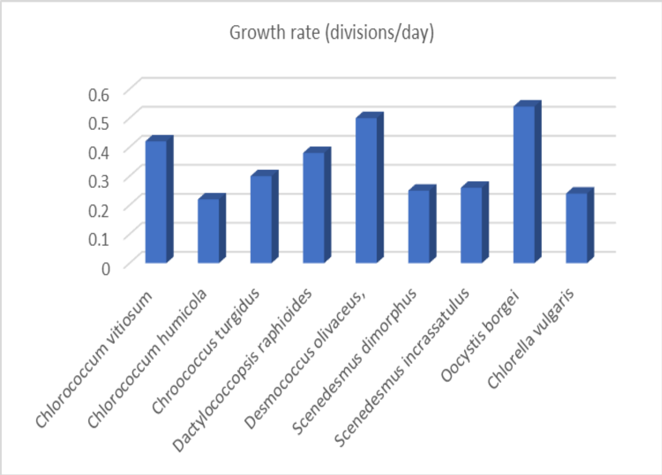

Fig 3 Showing growth of different micro algae in the raw effluent from leather industry.

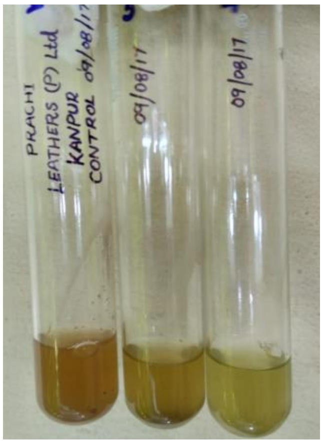

Fig 4 Showing growth of micro algae and reduction in colour of the raw effluent from leather industry

Pilot plant

Mixture of selected micro algae based on growth performance was prepared as a consortium and developed in the treatment tank. Once the desired algal density was achieved (@ cell density 250 – 300 x 10^4/ml) raw effluent with an average COD of 2400 after pre-treatment was added on daily basis (2 KL) after removing 2 KL from the tank which had 8 KL volume of culture (Semi-continuous mode of operation). Colour, COD were monitored for 32 days. The results are given in Fig 5. Tank COD after some initial fluctuations got stabilized after 10^{th} day and averaged around 700 with a 70% reduction in COD. The total COD added over a period of 32 days was 5,56,80,000. The colour was completely removed (Fig 6).

Elumalai *et. al.,* (2014) have reported a maximum of 94% reduction in COD in a batch mode laboratory experiment after 21 days of incubation with a consortium of *Chlorella vulgaris* and *Scenedesmus obliquus*. In the present study micro algae *Chlorococcum vitiosum, Chlorococcum humicola, Chroococcus turgidus, Dactylococcopsis raphides, Desmococcus olivaceus, Scenedesmus dimorphus, Scenedesmus incrassatulus,* and *Oocystis borgei* were mixed as a consortium and employed in the 8 KL pilot tank installed at industry premises with a semi-continuous addition and removal 2 KL per day and the effluent removed every day goes to secondary settling tank and sand filter before it is discharged or recycled.

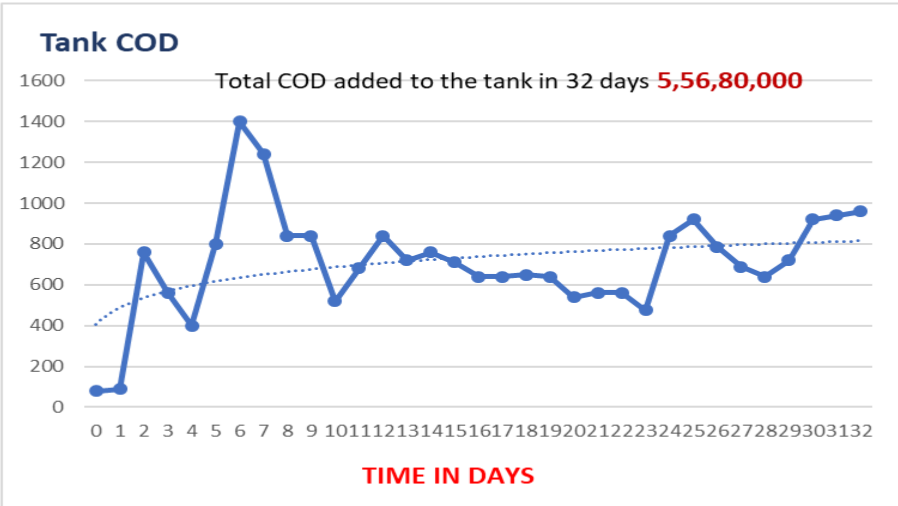

Fig. 5. The trend of COD of leather industry effluent over a period of 32 days in a semi-continuous addition of raw effluent into the treatment tank.

Fig 6 Showing colour removal by micro algae treatment in leather industry effluent

Conclusion

Leather industry in Kanpur treats its effluent with an existing conventional ETP which is not able to reduce colour and COD to the extent required for safe disposal. An intervention after primary settling tank was suggested to the industry and to prove the phycoremediation technology and its efficiency the present 8 KL pilot plant was set up and run successfully for 32 days with excellent colour reduction and a significant COD reduction which when scaled up will improve further. Phycoremediation technology is very efficient, robust, eco-friendly and cost effective and less energy intensive. The biomass generated can be good feedstock for bio-fuels or fertilizer based on the quality obtained.

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