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# PHYCOREMEDIATION OF INDUSTRIAL EFFLUENT FROM TANNARY IN PERANAMPATTU AND AMBUR AREA OF PALAR RIVER

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## ABSTRACT
The leather industry represents an important economic sector in many countries. On the other hand, it generates large amounts of wastewater containing ammonium ion, sulphides, surfactants, acids, dyes, sulfonated oils and organic substances including natural or synthetic tannins agents. Tannery wastewater treatment is very complex, due to the addition of large number of chemicals in several concentrations. The treatments of these effluents using physical - chemical methods alone are quite expensive technologies. Hence the present work is focused on biological treatment to reduce the pollutants of tannery effluents and through micro algal treatment process taken from the tannery industries Peranampattuand AmburPalar River effluents, Tamil Nadu, India. The effluent samples were characterized by measurements of Physico – chemical properties, such as, BOD, COD, etc.,. In our findings we observed that the consortium of Microalgal species such as Chlorella vulgaris andScenedesmusdimorphusat various ratios (Control, 100:400, 200:300, 250:250, 300:200, 400:100 of algae and effluent concentration respectively) effectively reduces the TDS, COD and BOD level of effluents which was confirmed by the Physico-Chemical measurements at regular interval of 7 days for a period of 21 days. The concentration of algal consortium and effluent 250:250 was found to effectively reduce TDS, BOD and COD levels when compared to individuals. Hence this technology avoids use of chemicals and the whole process of effluent treatment is simplified to make it and eco-friendly & economical.

**KEYWORDS:** Leather Waste water, Biological Treatment, Consortium, Chlorella vulgaris, Scenedesmusdimorphus.

## INTRODUCTION
In India tanning industry occupies an important position in export earnings. Tanneries are a very important industry in Tamil Nadu. The total production capacity is expected to increase 2 or 3 times in the coming years in order to achieve 10% global market share (Subramanian and Sastry, 1999).A wide variety of both organic and inorganic pollutants are present in effluents from tanneries, paper and pulp mills, steel industries, sugar factories, fertilizer, dyeing and textile units etc.,(Amin,1990).Phycoremediation is the use of macroalgae or microalgae for the removal or biotransformation of pollutants, including nutrients and xenobiotics, from wastewater and CO2 from polluted air (Olguin, 2003).Microalgae have received more attention in recent years, especially in tropical and subtropical regions, as an alternative biosystem for wastewater treatment (Fallowfield& Garrett, 1985; de la Noueet al., 1992).Algal systems have traditionally been employed as a tertiary treatment process (Lavoie & de la Noueet al., 1985; Oswald, 1988) and have recently proposed as a potential secondary treatment system (Tam & Wong, 1989). Algal systems are further credited by their potential biomass production as sources of fine chemicals or animal feed (Borowitzka&Borowitzka, 1988). Regardless of the operating system or the level of wastewater treatment concerned, the success of an algal system relies on the ability to take up inorganic nutrients such as N and P from the wastewater and assimilate them for their growth.Microalgae offer a low-cost and effective approach to remove excess nutrients and other contaminants in tertiary wastewater treatment, while producing potentially valuable biomass, because of a high capacity for inorganic nutrient uptake (Bolan et al., 2004; Muñoz and Guieyssea, 2006). In a study by Zhang et al., (2008), Scendesmussp. showed high removal efficiency for inorganic nutrients from artificial and real domestic secondary effluents. In addition, microalgae play an important role during the tertiary treatment of domestic wastewater in maturation ponds or the treatment of small to medium -scale municipal wastewater in facultative or aerobic ponds (Aziz and Ng,

1993; Mara and Pearson, 1986; Oswald, 1995).Using microalgae in continuous treatment processes would be of great advantage, because most industries are in direct exigency for implementing cost-effective continuous treatment processes. Algal species are relatively easy to grow, adapt and manipulate within a laboratory setting and appear to be ideal organisms for use in remediation studies (Dresbacket al., 2001).Hence the present work is focused on biological treatment to reduce the pollutants of tannery effluents through micro algal treatment process taken from the leather industries.

## MATERIALS AND METHODS

### Isolation and culturing of microalgae

Chlorella vulgaris andScenedesmusdimorphus, were isolated from the tannery industries Peranampattuand AmburPalar River effluentsusingserial dilution, standard plating, colony isolation and culturetechniques. The algae were identified with the help ofstandard monographs and recent available literature(Philipose, 1967), (Butcher 1959).

### Source of raw wastewater

The wastewater used in the present investigation was obtained from a tannery processing raw skins intosemi finished leather. The steps involved in the process are soaking, liming, pickling and tanning. Thewastewater from soaking and pickling operations were collected in a separate drain. The coarse solidssuch as fleshing, trimmings and hair are screened through a metal screen of aperture 5mm. Thescreened effluent was collected in a tank.

### Experimental Design

Chlorella vulgaris andScendesmesdimorphus was grown in appropriate medium(Kanz T, Bold HC, 1969), along with the consortiums of these algae by altering pH slightly. On reaching the exponential phase the culture was transferred with the different Concentrations of the effluent in the ratio of 100:400, 200: 300, 250: 250, 300:200 and 400:100 respectively.

### Physico-chemical analysis of the wastewater

The wastewater samples were analysed for pH, BOD (biochemicaloxygen demand), COD (chemical oxygen demand),total organic carbon and total dissolved solids, in accordancewith standard methods of analysis of wastewater (AmericanPublic Health Association 2000).

### Stastistical Analysis

Values of all data are expressed as mean ± SD. The one-tailed paired Student's t-test was used to determine statistical significance between the untreated and treated parameters at $P < 0.05$. All analyses were carried out in triplicate.

## RESULTS

Among the physico-chemical parameters studied in leather industrial effluents treatment TDS, TSS, BOD, COD, Nitrogen, Phosphorus, Chloride, Sulphate, Sulphide, Calcium, Sodium and Chromium (Table 2, 3)showed reduced concentrations significantly; whereas pH and dissolved oxygen showed increased concentration after the treatment with microalgae and its consortium.

The high level tolerance of various pollutants and large surface area offered by the tiny cells make microalgae highly suitable for effluent treatment.

In the present study it was observed that the selected microalgae with its consortium treated effluents showed the reduction of various physico-chemical parameters.

The complete breakdown of organic and inorganic matter should be the desired outcome to avoid persistence of potentially hazardous compounds in the environment (Bumpus, 1987). The breakdown of organic matter which directly leads to the reduction of total dissolved solids in the Tannery, Peranampattu, Tamil Nadu, India and AmburPalar River treated effluents. The present study reveals the significant reduction in the total dissolved solids of the effluents treated with the microalgae and its consortium. The equal concentration of tannery, Peranampattu algae and effluent system shows the highest reduction of TDS in all the treatment flasks. About 25.03%, 46.31%, and 65.09% of reduction in Chlorella vulgaris treated effluents on $7^{th}$, $14^{th}$ and $21^{st}$ days respectively. Scenedesmusdimorphus shows 13.65%, 43.84% and 58.81% reduction. Above all 28.35%, 49.54% and 67.37% reduction were recorded in the consortium of these algae (Table 1 and Fig 1). The equal concentration of AmburPalar River algae and effluent system shows the highest reduction of TDS in all the treatment flasks. About 23.48%, 46.25%, and 66.54% of reduction in Chlorella vulgaris treated effluents on $7^{th}$, $14^{th}$ and $21^{st}$ days respectively. Scenedesmusdimorphus shows 12.80%, 43.90% and 58.90% reduction. Above all 30.48%, 57.32% and 67.67% reduction were recorded in the consortium of these algae (Table 2 & Fig 2). Hence this study has demonstrated the successful reduction of TDS by using algal cultures to remove nutrients from industrial effluents.

The consistent reduction in the BOD levels were recorded in the Tannery, Peranampattu and AmburPalar River algae treated effluents. The equal concentration of OMHT algae and effluent system shows the highest reduction of BOD in all the treatment flasks. About 48.26%, 77.08%, and 90.71% of reduction in Chlorella vulgaris treated effluents on $7^{th}$, $14^{th}$ and $21^{st}$ days respectively. Scenedesmusdimorphus shows 42.01%, 70.76% and 88.81% reduction. Above all 56.25%, 78.61% and 91.60% reduction were recorded in the consortium of these algae (Table 3 and Fig 3). The equal concentration of AmburPalar River algae and effluent system shows the highest reduction of BOD in all the treatment flasks. About 41.20%, 72.75%, and 89.65% of reduction in Chlorella vulgaris treated effluents on $7^{th}$, $14^{th}$ and $21^{st}$ days respectively. Scenedesmusdimorphus shows 28.77%, 65.44% and 86.78% reduction. Above all 45.52%, 73.92% and 90.58% reduction were recorded in the consortium of these algae (Table 4 and Fig 4). Hence this study has demonstrated the successful reduction of BOD by using algal cultures to remove nutrients from industrial effluents.

The consistent reduction in the COD levels were recorded in the Tannery, Peranampattu and AmburPalar River algae treated effluents. The equal concentration of tannery, Peranampattu algae and effluent system shows the highest reduction of COD in all the treatment flasks. About 58.94%, 80.13%, and 93.57% of reduction in Chlorella vulgaris treated effluents on 7$^{th}$, 14$^{th}$ and 21$^{st}$ days respectively. Scenedesmusdimorphus shows 59.01%, 79.87% and 93.96% reduction. Above all 64.86%, 81.39% and 94.30% reduction were recorded in the consortium of these algae (Table 5 and Fig 5). The equal concentration of AmburPalar River algae and effluent system shows the highest reduction of COD in all the treatment flasks. About 55.02%, 77.77%, and 93.33% of reduction in Chlorella vulgaris treated effluents on 7$^{th}$, 14$^{th}$ and 21$^{st}$ days respectively. Scenedesmusdimorphus shows 56.29%, 81.43% and 93.40% reduction. Above all 63.75%, 83.14% and 94.03% reduction were recorded in the consortium of these algae (Table 6 and Fig 6). Hence this study has demonstrated the successful reduction of COD by using algal cultures to remove nutrients from industrial effluents.

**Table 1. Total Dissolved Solids of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

| CONCENTRATIONS Algae:Effluent Ml | *Chlorella vulgaris* | | | *Scenedesmusdimorphus* | | | Consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 2890.1±4.40 | 2610.16±4.0190 | 2301.43±4.001 | 2900.10±4.0 | 2680±4.161 | 2491.26±6.110 | 2888.41±5.682 | 2584.20 ± 7.2 | 2301.94 ± 6.01 |
| 200:300 | 2699.2±4.52 | 2250±4.5086 | 2098±5.000 | 2840±5.00 | 2080±4.501 | 1907±4.500 | 2600±5.00 | 2183±4.508 | 1842±6.0270 |
| 250:250 | 2459±5.00 | 1761±5.0001 | 1145±5.506 | 2832±5.47 | 1842±5.001 | 1351±4.505 | 2350±5.033 | 1655±5.506 | 1070±4.0071 |
| 300:200 | 2600±5.45 | 2030±4.5090 | 1434±5.000 | 2843±2.85 | 1890±4.504 | 1443±4.502 | 2580±4.040 | 1943±5.505 | 1376±5.0000 |
| 400:100 | 2483±4.53 | 1961±5.0001 | 1750±4.5090 | 2900±3.60 | 1851±4.0411 | 1581±6.0270 | 2379±5.1315 | 1750±6.0272 | 1578±4.5091 |

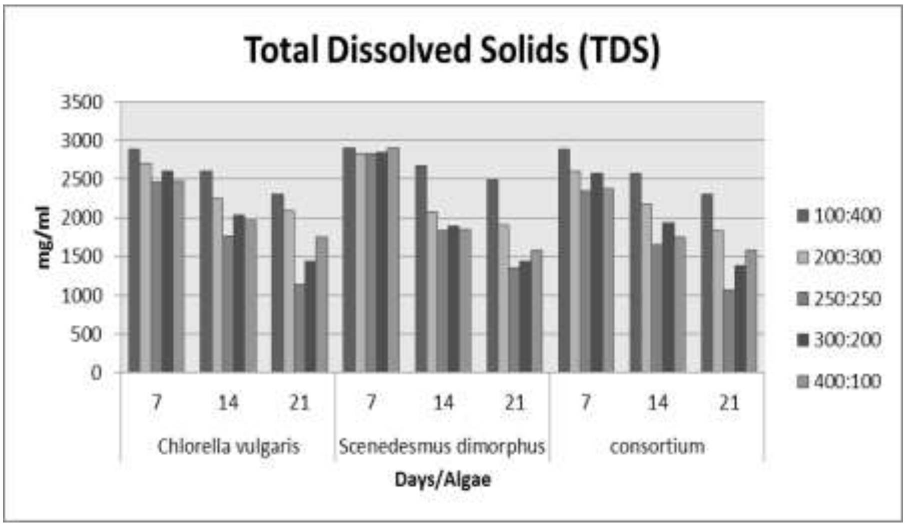


**Fig:1. Total Dissolved Solids of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

**Table 2. Total Dissolved Solids of Treated Effluent in different concentrations (AmburPalar River)**

| CONCENTRATIONS Algae:Effluent Ml | *Chlorella vulgaris* | | | *Scenedesmusdimorphus* | | | consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | TDS (mg/ml) DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 2788.5±4.35 | 2433.45±4.009 | 2163.66±4.000 | 2801.07±4.17 | 2597.01±4.120 | 2375.63±5.500 | 2791.33±5.43 | 2437.01±5.93 | 2278.81±6.55 |
| 200:300 | 2589.20±4.35 | 2199.0±4.4029 | 2001.1±4.930 | 2790±5.00 | 2329±4.350 | 1802±4.287 | 2574±5.00 | 2037±4.007 | 1739±5.9901 |
| 250:250 | 2372±5.00 | 1666±5.0033 | 1037±5.303 | 2703±5.30 | 1738±5.000 | 1274±4.500 | 2155±5.001 | 1323±5.009 | 1002±4.0028 |
| 300:200 | 2549±5.39 | 2100±4.5000 | 1333±4.9907 | 2694±2.91 | 1745±4.500 | 1327±4.041 | 2399±4.941 | 1823±5.005 | 1205±5.0010 |
| 400:100 | 2355±4.23 | 1831±5.0900 | 1566±4.0071 | 2830±3.33 | 1741±4.0012 | 1327±5.9277 | 2237±5.0500 | 1637±5.9370 | 1478±4.5001 |

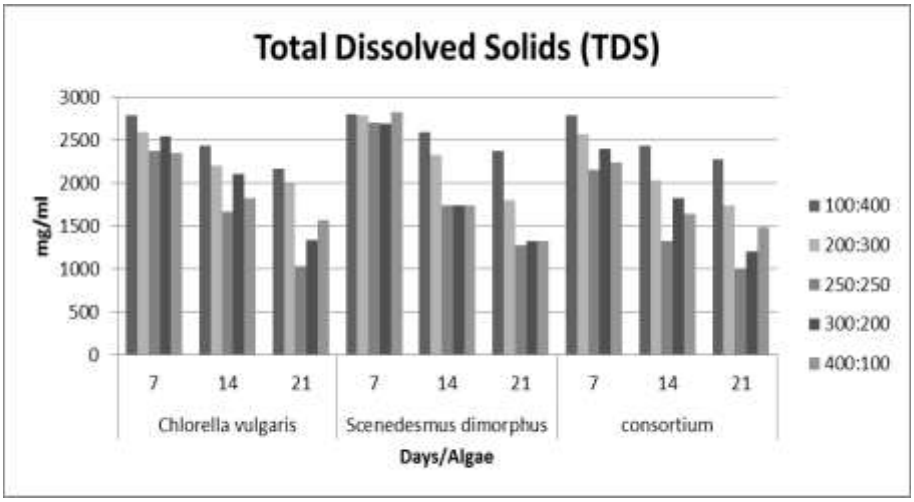


**Fig 2. Total Dissolved Solids of Treated Effluent in different concentrations (AmburPalar River)**

**Table 3. BOD of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

| CONCENTRATIONS Algae:Effluent Ml | *Chlorella vulgaris* | | | *Scenedesmusdimorphus* | | | Consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | BOD (mg/ml)DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 294.1±5.4 | 183.3±5.3 | 114.6±5.0 | 253.61±5.04 | 181.0 ±4.50 | 124.65±5.50 | 274.65±5.50 | 162.1±5.50 | 56.31±5.01 |
| 200:300 | 254.33±5.04 | 119.34±5.501 | 46.00±5.01 | 260.0±5.50758 | 148.34±5.50760 | 105.33±5.03222 | 229.34±5.03333 | 106.6±5.50757 | 45.01±5.00000 |
| 250:250 | 248.3333±4.50926 | 110.0001±5.0010 | 44.5556±5.13180 | 278.3334±5.50758 | 140.3222±5.50758 | 53.6666±4.04145 | 210.0010±5.56786 | 102.6666±5.50758 | 40.3133±4.00000 |
| 300:200 | 258.0000±7.00000 | 147.3±4.5 | 56.0010±10.58001 | 257.6567±5.0333 | 150.3223±12.66229 | 69.33±3.51189 | 249.6667±6.02770 | 138.3322±5.03233 | 58.1233±5.03333 |
| 400:100 | 225.3313±5.50756 | 130.3333±4.72583 | 57.3323±6.02770 | 252.3333±5.03323 | 183.3333±4.50824 | 90.3323±5.50756 | 230.6657±5.0333 | 156.0001±6.0000 | 64.0000±6.00000 |

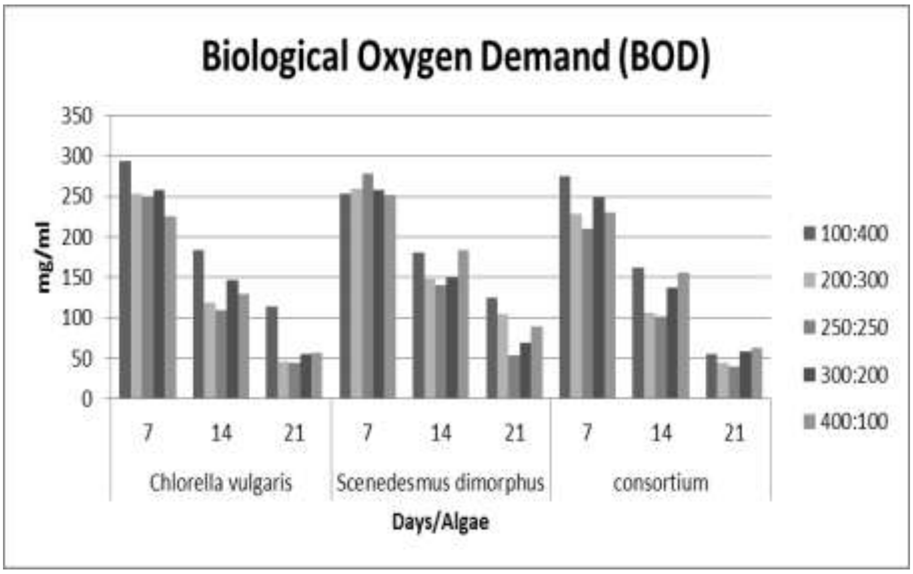


**Fig 3. BOD of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

**Table 4. BOD of Treated Effluent in different concentrations (AmburPalar River)**

| CONCENTRATIONS Algae: Effluent Ml | *Chlorella vulgaris* | | | *Scenedesmusdimorphus* | | | consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 285.3±5.1 | 163.7±5.0 | 111.5±5.01 | 247.80±5.02 | 160.2±4.10 | 116.37±5.20 | 264.07±5.50 | 144.06±5.50 | 93.08±5.07 |
| 200:300 | 249.01±5.0 | 115.55±5.305 | 43.33±4.97 | 253.5±5.307 | 135.70±5.0031 | 99.47±5.0521 | 205.18±5.0002 | 95.09±5.00301 | 41.37±5.00000 |
| 250:250 | 223.431±4.5341 | 103.531±5.000 | 39.3033±5.31322 | 270.6671±5.31031 | 131.3222±5.50000 | 50.2222±5.9900 | 207.001±5.3307 | 99.090±5.5055 | 35.7736±4.00135 |
| 300:200 | 251.3333±6.0099 | 138.43±4.02 | 53.3323±8.38880 | 248.5001±5.0000 | 139.6666±10.3333 | 60.73±3.90011 | 240.3631±6.0022 | 131.2222±5.00332 | 53.2333±5.00222 |
| 400:100 | 215.2222±5.5000 | 127.3333±4.5388 | 49.9850±6.0000 | 248.6666±5.0300 | 173.3302±4.40051 | 83.5556±5.50051 | 210.0500±5.0077 | 143.114±6.0237 | 60.2233±6.0003 |

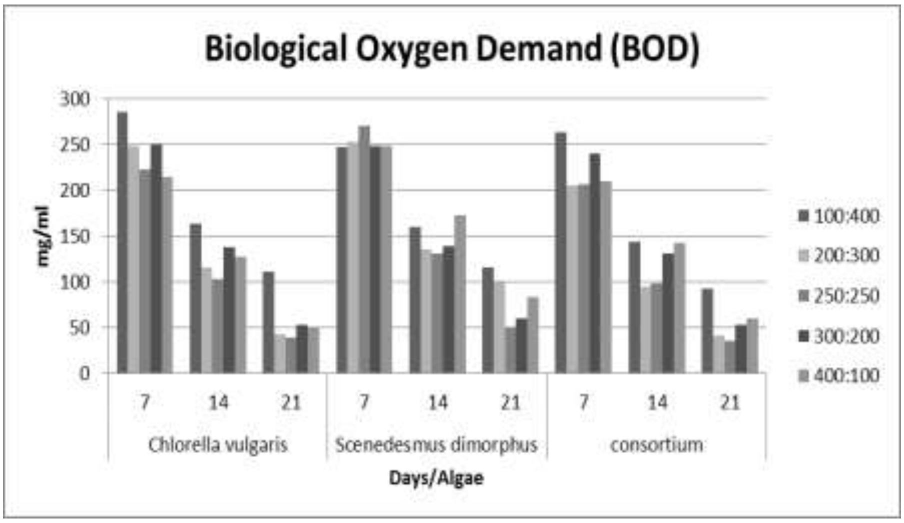


**Fig 4. BOD of Treated Effluent in different concentrations (AmburPalar River)**

**Table 5. Chemical Oxygen Demand (COD) of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

| CONCENTRATIONS Algae:Effluent Ml | *Chlorella vulgaris* | | | *Scenedesmusdimorphus* | | | Consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 655.66±5.4 | 406.1±6.0 | 248.56±4.4 | 624±5 | 461.4±5.2 | 264.30±5.5 | 1000±5 | 380.1±5.4 | 220.30±5.1 |
| 200:300 | 654±5.55 | 315±5.50 | 102.30±4.4 | 663.6±6.00 | 490±5.0 | 203.28±4.4 | 940±5.9 | 330.1±5 | 107.5±6.4 |
| 250:250 | 632.3±5.3 | 306±6.5 | 99±7.02 | 631.1±5.4 | 310±5.2 | 93.01±5.3 | 540.6±7.12 | 286.6±5.3 | 87.66±5.00 |
| 300:200 | 650±5.28 | 342.4±5.5 | 118±7.01 | 645±5.01 | 356.2±5.4 | 146.6±5.47 | 631.5±6.1 | 276.1±6.02 | 102.3±5.01 |
| 400:100 | 651±5.28 | 340.3±7.02 | 128.4±7.10 | 660.3±6.02 | 345.3±5 | 184.6±5.01 | 620.0±6.01 | 307.2±7.10 | 123.60±5.0 |

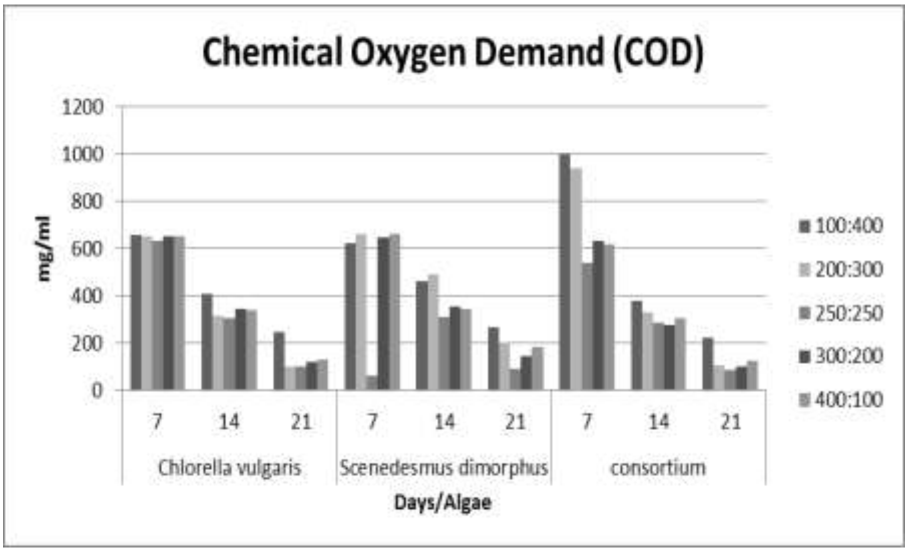


**Fig:5. Chemical Oxygen Demand (COD) of Treated Effluent in different concentrations Tannery, Peranampattu, Tamil Nadu, India.**

**Table 6. Chemical Oxygen Demand (COD) of Treated Effluent in different concentrations (AmburPalar River)**

| CONCENTRATIONS Algae: Effluent Ml | Chlorella vulgaris | | | Scenedesmusdimorphus | | | consortium | | |
|---|---|---|---|---|---|---|---|---|---|
| | COD (mg/ml) DAYS | | | | | | | | |
| | 7 | 14 | 21 | 7 | 14 | 21 | 7 | 14 | 21 |
| 100:400 | 605.33±5.05 | 390.2±5.96 | 213.14±4.01 | 612±5 | 399.3±5.01 | 203.33±5.33 | 834±5 | 347.01±5.01 | 215.50±5.2 |
| 200:300 | 590±5.51 | 293±5.05 | 101.3±4.01 | 620.5±6.00 | 420±4.9 | 202.12±4.1 | 920±6.90 | 301.2±5 | 103.3±5.9 |
| 250:250 | 607.2±5.0 | 300.1±6.1 | 90.0±6.9 | 590.0±4.9 | 250.7±4.8 | 89.02±5 | 489.3±7.0 | 227.5±5.1 | 80.53±4.5 |
| 300:200 | 600±5.01 | 313.2±5.0 | 99.0±6.09 | 611±5.0 | 313.01±5.0 | 126.3±5.01 | 621.3±5.9 | 232.2±6.0 | 95.01±5.0 |
| 400:100 | 613±5.05 | 297.5±6.9 | 123.5±7.1 | 623.8±6.0 | 313.7±5.0 | 123.9±5.0 | 590.1±6.1 | 292.2±6.9 | 102.3±5.0 |

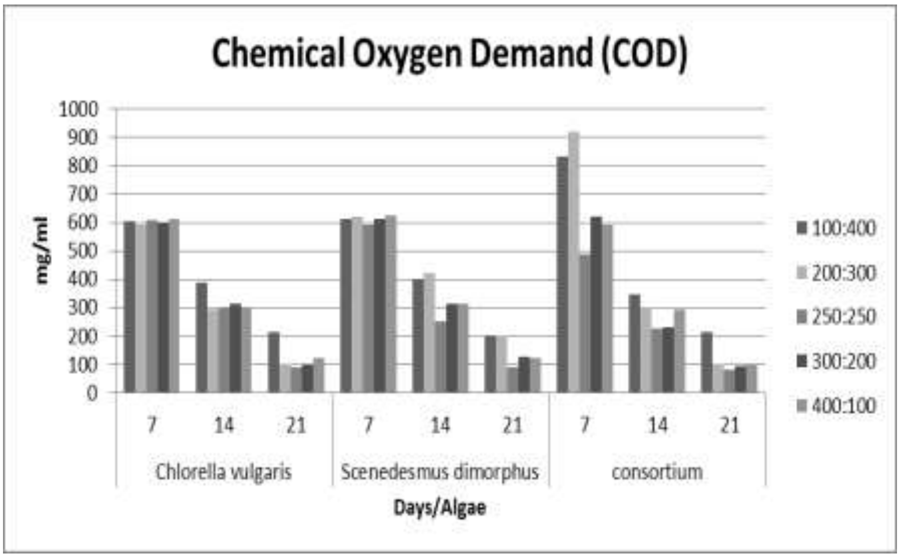


**Fig 6. Chemical Oxygen Demand (COD) of Treated Effluent in different concentrations (AmburPalar River)**

## DISCUSSIONS

In this study, Chlorella vulgaris and Scenedesmusdimorphus has been shown to possess excellent nutrient scavenging capability. Being treated alone in the effluents the consortium showed a very high rate on utilization of nutrients. During the Phycoremediation process, pH levels increased initially and thereafter remained around 9. The microalga reduces dissolved $CO_2$ concentrations through photosynthesis which, in turn, raises the pH level.The inorganic compounds normally used by the microalgae are $CO_2$ and bicarbonate (Borowitzka, 1998), the latter requiring the enzyme carbonic anhydrase to convert it to $CO_2$.

The total dissolved solids content of the effluent decreased upon treatment, which is due to the utilization of various nutrients by Chlorella vulgaris and Scenedesmusdimorphus from Tannery, Peranampattu and AmburPalar River. The quantification might project reduced reduction levels because there could be a conversion of the total suspended solids already present in the effluent into dissolved materials for algal uptake and assimilation.

During Phycoremediation using all these algae is a drastic reduction in magnesium levels and moderate decrease in potassium levels was observed. Although sodium levels did not show appreciable change, there was a significant reduction in calcium concentrations. This is aided by the carbonate ions, which not only decrease the crystallinity of calcium phosphates and promote the formation of amorphous calcium phosphates but also compete with phosphates in precipitating with calcium to form calcite ($CaCO_3$) at pH values above 8 (Arvin, 1983). However, sodium levels were reduced due to the tendency of the microalga for bioaccumulation. In addition, C. vulgaris and S.dimorphusinduced 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).

Many studies have demonstrated the success of using algal cultures to remove nutrients from waste waters rich in nitrogenous and phosphorus compounds (de la Noue and Proulux, 1988).The was a drastic reduction in the BOD and COD content of effluent treated with microalgae. As stated by Nandanet al., 1990 microbial methods are being increasingly used for the reduction of BOD and COD. More than 95% reduction of BOD has already been reported by Manoharan and Subramaniam, 1993 in ossein effluents and paper mill effluents by using Oscillatoriapsuedogeminitavargranulata. Similar results have been reported by Govindan (1983, 1984) using algal culture. He reported that there was considerable reduction of BOD & COD in soya, paper tannery, sugar and dairy mill effluents after treatment. A significant colour reduction was observed on $7^{th}$, $14^{th}$ and $21^{st}$ day of the Tannery, Peranampattu, Tamil Nadu, India and AmburPalar River treatment. On treating with Chlorella vulgaris andScenedesmusdimorphusthe acidic pH level in the tannery effluents was changed to neutral in the $14^{th}$ day and on the $21^{st}$ day it was changed to alkaline.

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