**4. Microalgal Treatment of Textile Wastewater**

Textile wastewater comprises complex compositions of dyes, heavy metals, reagents, salts, acids, alkalis, amines, etc. (. Various unit processes such as sizing, desizing, bleaching, mercerizing, dyeing, and printing, produce high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, dissolved solids, alkalinity, PH, and strong odorous condition in the effluent [4]. For the removal of dyes, and their associated metabolites from textile effluents, various treatment methods have been proposed. These methods include physical techniques, chemical and biological methods [5]. Physical methods for textile effluent treatment such as ozonation and photocatalysis may produce end products with increased toxicity [16]. Among these, biological methods are the simplest, most efficient and inexpensive of all [6]. A wide range of biological methods have been used to effectively treat textile effluents. Several bioreactors are available, which can be operated in anaerobic [7], anoxic and aerobic conditions using activated sludge process [8].

Aerobic treatment applied to textile effluents results in efficient removal of organic load, but not accompanied by an equally efficient removal of dyes and colors. Traditional and advanced chemical methods of decolourization are expensive and not reliable in microbial decolourization [9]. Compared to anaerobic system, aerobic system achieve greater removal of soluble biodegradable organic matter and the biomass generated is well flocculated resulting in lower effluent suspended solids concentration [10].

Among all the given processes, anaerobic process seems most promising as a first stage of treatment due to its less operational cost and low investment [9]. It generates a relatively small volume of sludge when compared with aerobic treatment and no aeration is needed unlike in aerobic treatment, given the high BOD levels involved. In Anaerobic reactors, the best feature for textile effluent treatment is the decolourization of many dyes under reducing conditions. Another major advantage is that its ability to treat waste streams with high organic loads such as the effluents from desizing and scouring operations within textile manufacturing industry [11]. Under aerobic conditions, dyes are generally resistant to degradation [12] whereas reduction of azo dyes can be achieved under the reducing conditions prevailing in anaerobic bioreactors.

Recently, microalgae treatment have received great attention due to its ability to fix CO2 and bioremediation of textile effluents [13]. Microalgae are known to perform efficient removal of dyes by bio adsorption, biodegradation and [bioconversion](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/bioconversion).  It degrades dye for nitrogen sources by removing nitrogen, phosphorous and carbon from water [26]. Microalgae consumes N & P present in the wastewater as a nutrients source to support their growth [28] and transform them into value-added bio products including biodiesel [29]. Microalgae produce oxygen through photosynthesis, which can metabolize organic carbon and remove COD [30].The most promising microorganisms for wastewater treatment are isolated from sites contaminated with dyes or from the sludge of treatment plants because they have adapted to survive in severe conditions [14]. Textile wastewater contains dyes and nutrients that are consumed by microalgae for its growth. The microalgal treatment of textile waste water occurs in two ways: bioconversion or bioaccumulation process and biosorption process. Microalgae consume dyes as carbon source and convert them into metabolites during bioconversion process. It can also work as bio sorbent by adsorbing the dyes on its surface [15]. The mechanism of microbial decolouration occurs from adsorption, enzymatic degradation or a combination of both. Microbial degradation process involves both reductases and oxidases. Microbial treatment is carried out to decolourize and detoxify the dye contaminated effluents [14]. The microorganism’s biosorption capacity is attributed to the cell wall’s heteropolysaccharide and lipid components, which has different functional groups, including amino, carboxyl, hydroxyl, phosphate and other charged groups, leading towards strong attractive forces between the azo dye and the cell wall [17-18]. Therefore, microalgae result in high sorption capacity due to great surface area and high binding affinity towards the azo dyes [19]. Both living and dead microalgae can be used for these phenomenon. However, the dead microalgae can effectively participate in the adsorptive removal of dyes [20]. The advantage of dead cells as bio sorbents over living cells is that they do not require nutrients, can be stored and utilized over extended periods and can be regenerated using organic solvents [14]. Microalgae species such as *Chlorella Vulagris*, and *Chlorella Pyrenoidosa* degrade azo dyes into simple aromatic amines and decolorize dye wastewater [21]. These microalgae’s are capable of degrading azo dyes through an induced azoreductase to break the azo bonds, resulting in the production of aromatic amines [22-23]. An alternative to decolourization are immobilised microalgae. For example, *Chlorella Vulgaris* [24] immobilised on alginate can remove a greater percentage of colour from textile dyes than suspended algae [25]. El-Kassas and Mohammad observed that *Chlorella Vulgaris* cultivated in textile wastewater could reduce COD up to 70% [26]. Another study observed that Chlorella Vulgaris could degrade 63-69% mono-azo dyes into simple aromatic components [27]. The bioremediation of textile effluents and dyes employing different microalgal species is given in the Table 1.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Microalgal species | Target | Biosorption capacity (mg/g) | Decolourization (%) | Biomass Productivity (mg/L day) | Nutrient Removal | References |
| Chlorella pyrenoidosa  Chlorella Sp. | MB  MB  MO | 21.3  - | > 90  99.9 | -  - | -  - | (Pathak et al., 2015)  (Seo et al., 2015) |
| Chlroella vulgaris | Tectilon yellow 2 G | - | 63–69 | - | - | (Acuner et al., 2004) |
| Chlorella pyrenoidosa | DR31 | 30.53 | 96 | - | - | (Sinha et al., 2016) |
| Chlorella vulgaris | RTWW | - | - | 3.08 per cathode | Zn 98% | (Logroño et al., 2017) |
| Chlorella pyrenoidosa | TWW | 20.8 | 80 | 8.114 | NO3  −1 82% | (Pathak et al., 2015) |
| Chlorella vulgaris | TWW | - | 77 | 0.0019 | COD 69.9% | (Wu et al., 2017) |
| Chlorella sp. G23 | TWW | - | 75 | 0.00005 | COD 75% | (El-Kassas et al., 2014) |

**Table 1**: Bioremediation of textile wastewater by using microalgae

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