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Review on degradation of Textile Dyes using Algae

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Abstract

Wastewater is a major environmental impediment for the growth of the textile industry besides the other minor issues like solid waste and resource waste management. Textile industry uses many kinds of synthetic dyes and discharge large amounts of highly coloured wastewater as the uptake of these dyes by fabrics is very poor. This highly colored textile wastewater severely affects photosynthetic function in plant. It also has an impact on aquatic life due to low light penetration and oxygen consumption. It may also be lethal to certain forms of marine life due to the occurrence of component metals and chlorine present in the synthetic dyes. So, this textile wastewater must be treated before their discharge. In this article, different treatment methods to treat the textile wastewater have been presented along with cost per unit volume of treated water. solid waste and resource waste management. Textile industry uses many kinds of synthetic dyes and discharge large amounts of highly coloured wastewater as the uptake of these dyes by fabrics is very poor. This highly colored textile wastewater severely affects photosynthetic function in plant. It also has an impact on aquatic life due to low light penetration and oxygen consumption. It may also be lethal to certain forms of marine life due to the occurrence of component metals and chlorine present in the synthetic dyes. So, this textile wastewater must be treated before their discharge. In this article, different treatment methods to treat the textile wastewater have been presented along with cost per unit volume of treated water. The removal process is the need of hour to remove contaminants from wastewater which are obtained from industries, residential or commercial buildings or sludge and recycle it into an effluent in an environmentally friendly manner which cause minimum impact to the environment. The textile waste water from the industries can be considered as one of the major threat to the environment Modern textile effluent treatment involves costly process to meet the pollution control board standards. This article is focused the utilization of the algae for the treatment of the textile dyes. The algae species like *Chlorella vulgaris, Scenedesmus* sp., *Sphaerocystis schroeteri, Cosmarium species, Scendesmus quadricauda, Lyngbya lagerlerimi, Nostoc lincki, Oscillatoria rubescens, Elkatothrix viridis and Volvox aureus* were discussed in this this review in three main topics as bioremediation , biodegradation and bioadsorption.

Keywords: Bioremediation, biodegradation, bio adsorption, waste water treatment, Algae.

Introduction

Textile wastewater carries large variety of dyes, chemicals and bleaching powder which is hazardous to the environment. Mainly dyeing and finishing process are responsible to produce large amount of toxicity to the environment. In order to treat these textile effluent microalgae can be used to degrade the dyes. Owing to growth of environ-tech and huge creative production in biotechnology field, microalgae has always been favoured. Since microalgae have been used in multiple technologies and due to its inexpensive growth requirements, it has become suitable for eco-friendly technologies. For managing the excessive toxic characteristics of metals, a fully-fledged

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array must be developed using microalgae. They are made as suitable in practical applications of wastewater bioremediation due to their extensive amount and their potential to develop and focus on heavy metals. Prevalent to the physiochemical processes which worked out to be in the eliminating the toxicity in heavy metals, microalgae are affirmed to be superior in uptake of heavy metals also. It is necessary to develop a reproving analysis to fill in the loopholes and for estimating their ability[1].

The toxicity of wastewater upon the variety of the fibre used in the textile and hence the wastewater characteristics may vary. Manufacturing process involves both dry and wet processes. Sizing, de-sizing, sourcing, bleaching, mercerising, dyeing, printing and the finishing techniques are involved in the textile manufacturing process[4 &29]. Many chemicals are added to the fibres and can be of two types such as natural and synthetic dyes. They can be categorized based upon their molecular structure and their mode of application. The discharged dye effluents from the textile wastewater is high in pH, chemical oxygen demand (COD), Biochemical oxygen demand (BOD), heavy metals (HM), temperature and total suspended solids (TSS). The textile wastewater constituents depend upon the type of the manufacturing process, the fibre used and the season[41].

The cost of textile waste treatment has been considered a serious problem for long time. Technologies are being developed so that products recovered from the wastewater areconverted to socially acceptable and economically viable products. Microalgae can be used for wastewater treatment because it has potential to remove the nutrients effectively from wastewater and to reduce the electrical energy used in the treatment systems. The great advantage of using microalgae is that they are available free of cost in nature and they can easily remove the existing organic matters in the wastewater which further leads to eutrophication. The main challenges in applications of algae in wastewater are process of culturing algae, since they require an optimal condition and control in their biomass composition. The need of the desired species in the wastewater management process with transition from laboratory to the pilot scale is a bit tedious one. But the favouring point is algae can easily grow with the help of solar energy which is abundant in nature followed by a small investment. Due to the positive characteristics of algae-based treatment, it has become an advantageous method especially in places where there is a lack of infrastructure for wastewater treatment systems. Algae can be cultivated in open air systems which permits for low cost investment, no cost solar energy and minimal amount of energy providing no control in temperature and lightning[1]. Algae can also be grown in a closed photobioreactor system where the temperature and lightning can be systematically controlled[36]. Algae are also grown in a sustainable bio film system but there is insufficient data regarding the performance of the system, its sustainable development and cost effectiveness[11]. Algae growth medium can be BG 11 medium[2] and can be maintained in Bold's Basal medium under the same conditions[7&9]. The textile wastewater contributes a major portion of pollutants to the environment and in order to reduce the pollutant there must be a suitable treatment.

Bioremediation

Bioremediation is a method to treat the polluted sites with microorganisms or with their enzymes. There are several processes where algae can be utilized for bioremediation of dyes and the process includes the usage of large algal biomass[32]. It has been suggested that some species of algae have the capacity to break down the compounds of dyes into simpler compounds[39]. For the removal of reactive yellow 22 which is in an azo dye in textile wastewater, *Spirogyra* sp. is the commonly used green algae especially for the discoloration of this dye by breaking down the dye molecules into simpler compounds[31&27]. *Chlorella Vulgaris* and *Oscillatoria tenuis* also can degrade azo dye using azoreductase enzyme[39]. For the treatment of Triphenylmethane dye and malachite green dyes a green microalgae *Cosmarium* sp., has been suggested[12]. Under thermophiles, *Phomidium* sp. can decolorize 50 to 80 % of textile dyes[17]. By stimulating algal growth algal dye removal ability can be enhanced. The plant regulator triacontanol hormone was added to the *Synechocystis* sp. and *Phormidium* sp. to increase their dye removal activity[22]. It is reported that about 91% of malachite green has been decolourised by *Oscillatoria sp.*, and it has also decolourised about 75% of congo red and 23% of Nigrosin dyes at 0.05% of dye concentration[20].

An experiment conducted by using central composite design for the treatment textile effluent with *Chlorella vulgaris*[14]. Bold's Basal medium were used as the growth medium for *C. vulgaris*. The concentration of the wastewater and sodium bi-carbonate was taken as two variables for the central composite design where the polynomial equation was obtained to find the maximum cellular concentration in eight commercial dyes. A cell concentration C_{max} (270,009 cells per ml), specific growth rate l_{max} (0.53 per density) were obtained in less concentrations. The wastewater concentration was moderately added to the culture media used for cultivation of the microalgae in about 5% and 8.5% which showed both COD removal (69.25 and 69.90%) and color removal (75.68%) at larger rates.

Golenkinia radiate was used to treat the non-sterile textile wastewater[40]. The textile wastewaters from raw wastewater collection effluent (CE), equalization tank effluent (SE), active sludge effluent (ASE) and the effluent (E) where subjected for the study. From the equalization tank with the trail of 1.23 ± 0.83 per day, the highest specific growth rate was obtained. The physiochemical parameters were found to be high in CE when it is compared with SE, ASE and E. The highest range of physiochemical parameters were temperature 32^o C, pH was found to be at 9, DO 7 (mg/L), COD 7000 (mg/L). *G radiata* showed toleration in various conditions and was not affected by changing in temperature, DO and pH. Various algae and sludge were treated which was also having a similar structural relationship for treating the heavy load printing and dyeing wastewater under solar energy[28]. The effects of aeration rate (0.1-0.15,0.4-0.5 and 0.7-0.8 L/min) and hydraulic retention time (HRT) (12h,16h and 20h) on conventional activated sludge (CAS) and algal-bacterial symbiosis (ABS). When compared with the treatment of printing and dyeing, waste water results of the experiment from the ABS system showed the highest performance in the removal of total phosphorus (TP) at higher rate of 10.5%, ammonia nitrogen (NH_4 + -N) at the incremental rate of 23.1% and chemical oxygen demand (COD), has increased by its removal rate at 12.5%, and also the colour has reduced by 80 times. Since the growth of the algae can be increased in low amount of dissolved oxygen it can also provide more dissolved oxygen for ABS. The ABS system has a stable particle size distribution so a stable treatment can be guaranteed from this system. Further decrement of colour and COD can be made sure by having longer HRT and a condition of having no outer source of carbon. Higher amount of dissolved oxygen was produced by adding algae which in turn provided a stable and larger amount of removal rate of nutrients by the ABS system.

Biodiesel from bioremediation of textile wastewater using microalgae were produced successfully[18]. One of the disadvantages in large quantity of micro algal cultivation is the nutrient and water requirement extensive amounts. Textile wastewater itself has many requirable nutrients as nitrates, phosphates, micronutrients etc. It also includes the organic dyes which is the potential carbon source for the cultivation of algae. This process can be used potentially for improvising the production of biodiesel and treatment of wastewater. An environmentally friendly approach, for higher effective products has been designed from *Chlorella variabilis* and also enhancing a maximum utilization of effluents from textile wastewater as a nutrient medium.As a source of nutrient, the productivity of biomass was at the rate of 74.96 ± 2.62 gram per m^2 per day and lipid production at the rate of 20.1 ± 2.2% with respect to the dry biomass. In order to transform the microalgal biomass carbohydrates into reducing sugars for the fermentation of microbes an integrated process was developed based on the type of detergents. The data obtained from the experimental research showed an amount of about 109.4 grams of total lipids was obtained from a microalgal of biomass 495grams. The lipids were extracted from the mass of 34.65 grams of γ-linolenic acid and about 1.3 grams of pure ε-polylysine was obtained from 36.68 g of reducing sugars. With 74% recovery a bi-step effective eco friendly process was build with ethyl ammonium nitrate for obtaining ε-polylysine. A remediation of about 100% was obtained in aluminium and cobalt, and a highest range of about 82.72% boron, 45.6% of calcium, 42.1% of sodium, and 14.5% of potassium and of about 0.1% magnesium using *C. variabilis* was obtained. From the total phosphate the detrimental range of about 78.17% and with respect to this total phosphate inorganic phosphate showed a decrease of about 25.22% in the effluent which was identified as other valuable product. Unreacted dyes and high concentration of salts are one among the most critical issues concerning the environment with respect to the textile sector mainly in their effluent disposal aspects. The effluent from the textile wastewater consists of an important substrate which has higher amount of bicarbonate salt concentration which is useful for *Chlorella*.sp. growth. According to this study, 40% of textile wastewater effluent was used for growing the *Chlorella* species at a scale of 100 L in the open tanks, producing biomass which also includes nutraceutical ,γ-linolenic acid, which can be especially used in cooking oils. About an amount of 495 g of biomass was obtained from 34.65 g of γ-linolenic acid. Owing to the preparation of 1.3 g ε-polylysine, of about 36.68 grams of fermentable sugars were extracted from the de an oiled micro alga which has beneficial effects in the pharma industries for various biomedical applications[6].

Six microalgae were isolated for their ability to bio remediate the textile wastewater. Since the wastewater treatments are expensive, usage of algae has been increasing for textile wastewater cleaning purpose. For each algae strain biomass was generated in which deionised water was used for dilution purpose and the dry weight of algae was obtained at the rate of 0.4-1.65 gram per litre. An elemental analysis was carried out for the present phase and future phase of cultivation of algal strains and their amount of dye colour removal rate were also obtained. The supernatant was obtained after harvesting the biomass and with respect to that the removal /reduction of heavy metals like Se, Al, V and Cu were shown. At a lambda max of 558nm, in the textile wastewater chromogenic substances were present and they showed a decrement ranging about 47.10-70.03%. Hence with the addition of producing microalgae biomass and improvising the treated wastewater quality while coupling the treatment process of textile wastewater with algal farming it was a complete successful process. Ignoring the impacts which are negative, while using wastewater from textile industry it has paved a way to obtain biofuels from the biomass of the microalgae[34].

Biodegradation

Biodegradation is described as the biologically mediated breakdown of chemical compounds; it is an energy-dependent process and involves the breakdown of dye into various byproducts through the action of various enzymes[25]. Biodegradation of synthetic dyes not only results in decolorization of

Table 1 Efficiency of algae in biodegradation process (3)

Algae	Dye (conc.)	Decolorization (%)	Incubation period (days)	References
Chroococcus minutus	Amido Black 10B (100 mg L−1)	55	26	Parikh and Madamwar (2005)
Phormidium ceylanicum	FF Sky Blue (100 mg L−1)	80	26	Parikh and Madamwar (2005)
Gloeocapsa pleurocapsoides	FF Sky Blue (100 mg L−1) Acid Red 97	90 83	26	Parikh and Madamwar (2005)

the dyes but also in fragmentation of the dye molecules into smaller and simpler parts (breakdown products). Decolorization of the dye occurs when the chromophoric center of the dye is cleaved[25].

Usage of Algae for Biodegradation

C. vulgaris was used for the treatment of tectilon yellow 2G (TY2G), which is a mono azo dye. Efficiency of COD was increased at the rate of 88% in the concentration of 50 mg/L, at the rate of 87% with respect to the concentration of 200 mg/L and 89% for the concentration of about 400 mg/L by the acclimation of *C. vulgaris*, which had initial COD efficiency removal of about 69%, 66% and 63% at the same initial concentration as mentioned above. The absorbance spectral analysis profile were obtained for algae which is unacclimated, showed that the first stage of (initial) peak was produced at 45 nm vanished and the another peak at 220 nm showed a detrimental line and it showed another peak at 350 nm, which showed the transition of tectilon yellow 2G dye to an another product. It was verified as aniline using the analysis performed by HPLC. There was no end product aniline formation in acclimated algae. Degradation was the main mechanism in case of acclimated algae and bioconversion for unacclimated algae. Moreover, in shorter time higher COD removal efficiency, the higher initial algal concentration was achieved. Acclimatized *C. vulgaris* showed a higher efficiency in treatment with tectilon yellow 2G dye. In the initial stage of concentration TY2G never showed a significant removal range. The mechanism which was adopted by the TY2G dye was bioconversion or degradation, as concerned it did not show adsorption process on the biomass of algae. Degradation of the TY2G dye was observed in unacclimated algae due to their prolonged exposure, and aniline was obtained as an end product. However, aniline was not produced in acclimated algae. Comparing to untreated TY2G the toxicity levels has been decreased due to usage of non acclimated algae. A substrate was produced by the product aniline for the activated sludge microorganisms which also stimulates their rate of growth[1].

Batik effluent was carried out treatment using *Chlorella* sp. which was immobilized in alginate, starch and carboxyl methyl cellulose and growth was carried in batch culture mode. Using alginate as an immobilized matrix, higher range of decolorization was obtained in the batik effluent, at 77.9%. Box-Behnken design approach was used, for the optimizing the effects of microalgae bead concentration, light intensity, and pH, which were done by alginate- *Chlorella* sp immobilized for decolourization and removal of total nitrogen (TN). The decolourization of highest range 80% in the batik effluent was obtained by favouring the following conditions as at the concentration ranging of 150 micro algal beads, at the light intensity of 1000 and the pH of about 12. The bead concentration being 150 at the pH level being 7, the highest removal of total nitrogen 7% was being obtained at the light intensity 1000 lux. The higher range of potential is shown by the immobilised alginate *Chlorella* sp. for the treatment of batik effluent despite of its direct discharge into the environment. This method is also considered to be an effective and efficient method, both in terms of quantity and quality[23].

A methodology has been obtained for bio decolourization using microalgae from wastewater which was low-cost and effective treatment and also to be greenery approach. For the treatment two kinds of microalgae *Sphaerocystis schroeteri* and *C. vulgaris* was used. For this study purpose yellow colour dye was used at various concentrations of 1 mg/L, 5 mg/L, 10 mg/L and 20 mg/L. A 14 days experiment was conducted using this dye solution at the above mentioned concentrations and the absorbance was recorded. The highest range of decolourisation was obtained at the concentration of 10 mg/L by *S. schroeteri* and *C. vulgaris* at the percentage of about 43.12. By this study the decolourisation ranges, irrespective of their dye concentration and algae were obtained. The decolourisation ranges both the algae as *C. vulgaris* showed the maximum decolourisation of 43.12% and minimum decolourisation of 19.42%, while the *S. schroeteri* showed the maximum level of decolourisation of about 45.03% and minimum decolourisation of 24.27%. Though, the dye concentration and the decolourisation were interdependent whereas comparatively, the percentage decolourization has no significant difference between the two microalgae. To the conventional treatment method an alternative measure was provided using algae as sorbent for the treatment of coloured wastewater. Based on economic and market analysis, effort is needed for the selection of suitable algae and commercialization of algae as sorbent. Therefore, an environmentally friendly and sustainable management can be achieved by using algae as sorbent for effluents colour removal before discharge into the water bodies[37].

Cosmarium species which is green algae is used for the treatment of Malachite Green (MG), which is a triphenylmethane dye. The concentration of the algae in various parameters like pH, dye concentration and temperature on the decolourisation of the dyes were analysed. The optimal level pH was 9. To understand the relationship between the concentration of the dye and its decolourisation kinetics of Michaelis-Menten was derived. V_{max} was in the range of 7.63 mg dye g/cell/hour and the K_m was in the range of 164.57ppm which was considered as the optimal kinetic parameters of this study. According to the study it has been revealed that the concentration of the dye, concentration of the algal species their temperature and pH was considered as the independent factors. According to the model of Michaelis-Menten the decolourisation of the specific dye depends upon the concentration of the dye. In case of the increase in the temperature of about 5- 45 °C the decolourisation rate can be increased[12].

The consequences of the indigo dye effluent were studied on the freshwater microalgae *Scendesmus quadricauda*. ABU12 which was found in freshwater but studied under controlled laboratory conditions. For about 100 to 175 times the dye effluent was diluted in the bold basal medium and the microalga was used in different concentrations. The effluent dye concentration and the microalgae growth rate showed were always inversely proportional. The rate of growth of the algae was decreased ($p<0.005$) as increase in the concentration of the dye. The factor of dilution was found to be 155 in EC_{50}. Dye effluent concentrations were significantly correlated with the changes in size of *Coenobia*. Due to the shift of the sizes of Coenobia (the size varied from large to small) there was an increase in the concentration of the dye effluents. The number of cells of the coenobium was reduced during the study. The structure of Coenobium of the genus *Scenedesmus* was affected due environmental stress; this also conveyed further for toxicity testing and was observed as an influential biomarker. Thus, the toxic characteristic of the effluent affecting the microalgae *S. quadicauda* at various concentrations were confirmed. Therefore, there is big risk of disturbing the food chain of the primary aquatic organisms by releasing the untreated effluents of indigo dye[10].

The reason for decrement in the decolourisation capacity of diatoms and cyanobacteria green algae were inspected, when there is a variation with respect to the molecular structure and functional groups of monoazo dye and diazo dye. The study proved that there is a decrease in the removal capacity of the green algae in azo dyes at the time rate of six days , but in turn has the rapid rate of decolourisation at the initial stages of study (for three days). The decolourisation capacity was found to be maximum at the rate of 5 ppm after the period of six days in incubation of Tartrazine dye along with the species *N. muscourm* and *S. bijugatus*. The structure of the dyes and the species used for the treatment were found to be similar. The culture of the diatom *Nitzschia perminuta* reached its death phase after the period of two days in incubation. From the study it was made sure that the conversion of the azo dyes into aromatic amine is made by breaking the azo dye linkage with the main enzyme azo reductase which is present in algae. In IR spectra the azo band reduction was found at the range of 1642 – 1631 per cm and a new peak formation at 3300 per cm. The Langmuir isotherm model was used for testing and to observe the algae behaviour regarding the sorption properties. The environmental issues are raised due to the intense colour formation in the effluents. It can be said from these experimental studies that the dyes can be removed with greater potential, effectively and efficiently at lower concentrations of the micro algal culture. In addition to that it can also be said that this biosorption property of algae can be concluded as the cost effective approach for dye decolouration and it can also be taken as an eco-friendly treatment[33].

The discoloration of methyl red, G-Red (FN-3G), basic cationic orange II, and basic fuchsin dyes were reported using *C. vulgaris*, *Lyngbyala gerlerimi, Nostoclincki, Oscillatoria rubescens, Elkatothrix viridis and Volvox aureus*. According to the algae species the efficiency of the colour removal varies and even according to their properties such as molecular structure and its rate of growth it may vary from 4% to 95%. The decolourisation of the orange II and G-Red by *C. vulgaris* showed algal activity to remove 43.7 and 59.12, whereas about 5.02 and 3.25% of dyes were removed by *V. aurreus* respectively[15].

Bioadsorption

Bioadsorption is defined as the property of certain biomolecules to bind and concentrate selected ions/other molecules from aqueous solution[19]**.**

Usage of Algae for Bioadsorption

The algae used for this biosorption process were selected in such a way that they could degrade the dyes used by the process of biosorption. Moghazy, (2019) The removal of methylene blue (MB) has been repored,which is an aqueous solution of the absorbents such as *Chlamydomonas variabilis* which is the activated biomass and raw biomass of green microalgae was used. In order to get the adequate algal biomass *C. variabilis* was obtained and cultivated. The biomass was oven dried and further H_2SO_4 added for activation of the algal biomass. The optimum adsorption was observed in methylene blue by using the *C. variabilis* algae at the conditions such as, 30 mins of contact time, pH at 7, 1.5 gram per litre for dried biomass as dosage of the biosorbent and 1 gram per litre for activated biomass. The zero discharge point was observed at the range of pH of about 6.8 for dried biomass and 6.9 was recorded for activated biomass, respectively. The highly active biosorbent was observed in activated biosorbent when compared to the dried bio sorbent. The highly active biosorbent where also confirmed by using Langmuir and Freundlich models in which a good fit was given by the activated biosorbent when compared to the dried biosorbent. According to the kinetic data model the pseudo-second-order equation was better than the pseudo-first-order one for the methylene blue adsorption. The experimental data also assured that the activated and the raw biosorbents are the efficient biosorbent of the green alga *C. variabilis* for methylene blue. Thus, the biosorbents of the *C. variabilis* has been considered as a promising tool for bioadsorption of methylene blue[30].

The adsorption of Astrazon red were evaluated by *Scenedesmus obliquus* and activated carbon. Activated carbon which was mainly used for this treatment was selected based upon its pore size and surface area distribution, as they determine the efficiency of the activated carbon. The treatment of the activated carbon where judged by comparing the results of before and after using activated carbon. The main reasons for the determination of the experimental results were due to the enlargement of the specific area surface and their total volume of the pore by their activation chemically. The higher range of adsorption was observed in activated carbon at the rate of 181.82 mg per gram at the temperature of about 25 ºC, these results were obtained from the Langmuir isotherm model[8].

The bioadsorption of the dye Basic Red (BR 46 by green)has been demostrated by macro algae *Enteromorpha sp.* For the biological decolourisation process the optimisation was carried out using the model central composite design. The variables which are used for the investigation are temperature, reaction time, initial dye concentration and algal biomass initial dye concentration. For carrying out the central composite model the value which is been predicted should be correlated with the values obtained from the experiment (R^2 =0.988, Adj R^2 =0.978). Under optimal conditions about 83.45% of biological dye removal was achieved in the time of reaction of about 5 hours at the temperature of about 25 °C[24].

Bioadsorption has been carried out using the prokaryotic algae (*Phormidium animale*) and eukaryotic algae (*Scenedesmus* sp.) to treat the acid dye P-2BX(ARP-2BX) . Since this dye has been one of the extensively used and found in larger quantities in textile waste water, the constituents such as pH which may range from 2-10, type bioabsorbent used such as ash or dries, dosage level of the bio absorbent, dye concentration at their initial levels, the temperature and the contact time was obtained. *P. animale* removed the dye to the maximum concentration of about 99.70 ± 0.27 %. In the treatment pH range varied for both the species, *Scenedesmus* sp. had the optimal biosorption activity at the pH 8. For *P. animale* pH range was at 2 and the removal rates were four times higher in dried bioabsorbent. The biosorption concentrations of *P. animale* was 97.35 ± 0.65 % at 25 °C. *P. animale* has increased the biosorption rate of the dye ARP-2BX at the temperature of 45 °C to 99.70 ± 0.27 %. *P. animale* was declared as the favorable biosorbent by the FTIR elemental analysis for removal of P-2BX[21].

Desmodesmus sp. has been isolated from the textile dying unit for dye degradation and lipid production. Microorganisms uses light energy to carryout various activities of metabolism. The capability of microbes to associate with its environment is shown by Extracellular Electron Transfer (EET). To form a graphene oxide/ algae bio nanocomposite an efficient nano biotechnological approach was done in which *Desmodesmus sp.* with extracellular electrons was combined with graphene oxide nano sheets on its region where the electron rich draper is found to be present. *Desmodesmus sp.* was used for the suitable eco friendly and sustainable approach in which the azo dyes are reduced in addition to which the production of lipids is also done, which in turn can be helpful for the generation of biodiesel. These reductions and by products information were taken from the electrochemical tests which are carried using graphene a nano biocomposite material along with the algal species *Desmodesmus*. Hence to produce biofuel and remediation of the wastewater a reusable, eco-friendly, sustainable and economical approach was developed by the material which is to be a nanocomposite. Due to the over usage of the dyes which are in nature in the textile industries and releasing them without treating into the streams makes the water bodies to get affected at the high levels which in turn also affects the environment. Owing to this affects of dyes a coupling method was introduced in which the coupling takes place between the green algae *Desmodesmus sp.* which has an property of being electrogenic and the transporter of the electron graphene oxide is been used here for the decolourisation of the textile dye DR31 and it also helps in the generation of lipids which in turn is made as biofuel feedstock. Under aerobic conditions the isolated species of *Desmodesmus* algae shows the decolourisation at higher rate of about 36 % which also had the maximum capacity of being bioelectric. Further its decolourisation efficiency and electro genetic property was enhanced by successful amalgamation of graphene oxide sheen on to *Desmodesmus* sp. Thus, under visible light in 150 mins 90 % of DR31 dye was successfully removed in 150 mins by graphene oxide / algae bio nano composite. After decolourisation of the DR31 dye the lipid content was at 9% only from the algae which was increased by graphene oxide / algal bionanocomposite at the range of 11%. For 40mgL^{-1} of aqueous solution of DR31 dye graphene oxide/algal bionanocomposite can be completely reused up to three times. Thus, for water treatment the usage of bionanocomposite is proved to be economic, eco-friendly, reusable and a sustainable solution[5].

Model organic cation: methylene blue sorption capacity has been tested using chemically modified *Sargassum muticum* biomass. The treatment was done in two stages as the carboxylic acid esterification process and the lipid extraction process. Due to the removal of lipid fraction from the algal species, the biomass of the algae is modified chemically so there is an increase in the capacity of sorption process. The extractions of lipids were carried out using reflux treatment. The biomass which is remaining after the reflux treatment has the maximum range of decolourisation of dye which was confirmed using Langmuir isotherm in which the value of dye is obtained as 860 mg per gram. The pH range was 4 to 10 of maximum uptake. At the time period of 30 min to 60 min the equilibrium was achieved which depends upon the pre-treatment of the algae. The above mentioned complete process follows the empherical model of pseudo first-order. In aqueous solution, *S. muticum* showed a high adsorption capacity. After the removal of lipids from the algal species by which the biomass was modified, the capacity of the sorption was increased. The methylene Blue gets affected by the solution pH. The pH ranges were found to be 4 to 10 for maximum uptakes and the adsorption of the dye methylene blue becomes lower at the range of pH below 4 as the solution becomes more acidic. Langmuir isotherm model is used to explain the sorption equilibrium. Depending upon the algae pre-treatment the equilibrium was achieved, which shows that the methylene blue kinetics of the are relatively fast timing range being from 30min to 60 min. The estimation of the specific surface is strongly affected by the covered area which has an uncertainty in their existence and for comparing among the different absorbents the results of the specific area can be useful but not in absolute sense[38].

Biosorption process were carried out in which the capacity of the sorbent is estimated using the Kinetic and equilibrium models. Many researchers have proved that biosorbents can be used as treatment which can be conventionally used, and it can also be carried out as an alternative process of treatment. As the cell surfaces of the algae are naturally attributed by the chemical groups such as phosphate, carboxylate, amino and hydroxyl, these chemicals are mainly used for the separation of the toxic materials from the wastewater. So, it is believed that the algae cell wall which consists of these chemicals can be used for the biosorption process. In this process both the complexation and attraction due to electrostatic plays a vital role. Due to the adsorption capacity most of the cells in algae were coated with mucilaginous layers. According to the analysis of the markets, cost analysis, pilot scale studies with actual waste waters and demonstration of the large scale systems research must be done to make this treatment commercially successful[13].

Conclusion

In order to assist the textile wastewater treatment microalgae can be used as an alternative for retarding the impact of the environment which are caused by the pollutants. The textile wastewater has been tremendously becoming a great environmental impact, owing to the high demand in textile products which is also increasing proportionally due to its wastewater release during the period of treatment. Due to the colour which is produced in the textile dyes which not only causes environmental affects but also due to their toxicity characteristics it affects human being in mutagenic way in case of breakdown of their products. Bioremediation is considered to be as alternative method for physio-chemical methods of treating textile wastewater .Various methods showed that treating the textile wastewater with microalgae is considered to be effective and sustainable method. The above mentioned methods also showed the variations in biological parameters which has proven that treatment of textile wastewater using algae is considered to be effective in removal of dyes. Future studies should investigate the behaviour of algal cells in real textile wastewater, which usually contains more dyes and several auxiliaries such as inorganic salts, detergents and fixing agents.

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