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10. Treatment Options of Textile Industry Wastewater with Special Reference with Solar and Algal Treatment Combination

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Abstract:

The textile industries are the major culprits for producing huge amount of toxic chemicals to the hydrosphere. These toxic chemicals are nothing but various types of carcinogenic dyes. These dyes are highly harmful compounds and can cause allergy, dermatitis, skin irritation critical diseases like cancer and mutation in human body. Recent treatments of textile industry wastewater involve physical, chemical and biological methods, but the factors like effluent composition, treatment cost and operational feasibility determine the practical and financial applicability of these treatment methods. Various physical and chemical methods including adsorption, precipitation, coagulation, filtration, ozonolysis, advanced oxidation and membrane separation etc have been scrutinized for these effluents.

These methods have potential for dye removal but some serious concerns like toxicity, high energy input, high expenditure, generation of secondary pollutants make them unfavorable for this industrial operation. Therefore, innovative and cost-effective technologies are required to achieve cost effective and efficient treatment of textile industry wastewater. Therefore, uses of the renewable energy based treatment system with energy saving and cost effective options are taken as a prime objective of this review associated with pros and cons of existing treatment options.

Index Terms:

Textile industry wastewater, toxicity, potential treatment options, renewable treatment system

10.1 Introduction:

Colors are one of most important aspect of human society. These colors are nothing, but typical dyes that have been used in various industrial sectors for the manufacturing of different textile products. Whenever these toxic dye come in contact with surface water possess high challenge for the survival of aquatic organisms [1, 2]. These days are highly toxic/carcinogenic compounds and have huge potential to create critical diseases in human body. Their discharges into water bodies possess extensive supply of contamination due to their disobedience character. It gives objectionable color to the aquatic resources, minimizes the intensity of solar radiation to pass in, and creates obstacles for the natural phenomenon like photochemical and biological of aquatic flora and fauna [3, 4].Statistically it is estimated that worldwide more than10,000 tonnes/year dyes are being consumed with the same time with an average of 100 tonnes/year of dyes are being released in return [5].These dye productions are not single way process, but the connection of so many processes for the production of final dyes and during these processing phases huge amount of wastewater are generated (illustrated in figure 10.1).

Fig.10.1. Flow diagram of textile manufacturing processes [1]

The treatment of this dye stuff is a major concern due to its high persistence levels, because out of 84% of total dyestuff only 47% of dyes are biodegradable [5]. The major treatments available for the treatment of textile industry wastewater have been discussed in the following section:

10.2 Availbale Treatment Technologies:

On the basis of toxic chemical compound its treatment possesses immense challenges to environmental experts. The treatment system of dye wastewater can be broadly classified into two categories such as: Conventional Treatment Technologies (CTT) and Modern Treatment Technology (MTT). CTT includes all the traditional treatment options like physical, chemical & biological methods. MTT includes advanced applications of recent developed techniques like use of nonmaterial, treatment through ion exchange, reverse-osmosis, biomass-based treatment and solar-energy-based treatment technology etc [6, 7]. The major advantages and disadvantages of these treatment technologies have been illustrated in table-10.1.

Table 10.1 advantages and Disadvantages of Availbale Treatment Technologies [4, 6, 7 & 8]

Methods	Description	Advantages	Disadvantages
Adsorption	Pollutant and color removal with the help of solid support	Excellent reduction of pollutants as well as a wide variety of dyes	Difficulties in restoration and the disposal of adsorbent is difficult
Membrane filtration	Separation physically from the sources	Mostly remove all types of dyes	It is very costly and produces concentrated Sludge
Ion exchange	ion exchange resins based treatment	It is a very easy for restoration	Though is very effective, it is not effective for all types of dyes
Electro-coagulation	The treatment is based on cathode and anode,	It is very effective process of dye removal	It is not cost effective and the reliability of electrode is very less
Coagulation and flocculation	This process is based on the coagulants and flocculants additions	It is a very cost effective process and very effective for dye removal	This process generates large amount of sledges
UV/O_3	This process is totally based on radiation and its effect	It is effective for many types dyes and reactive dyes are most favorable	It depend on pH and various dyes are non-effective with this process
UV/H_2O_2	This process is totally based on radiation and its effect	It is effective for many types dyes and no generation of sludge and best suitable for short term process	This process not effective for all type of dyes and suspended solids requires separation and suffers from UV light interaction

Methods	Description	Advantages	Disadvantages
Ozonation	Oxygen gas is used for this process	Process is altered in gaseous sate	This process has short half-life which is only 20 minute and it is very costly
Fenton reagents	H_2O_2-Fe(II) used for this process	This process very efficient in both soluble and insoluble dyes	Generation secondary pollutants
Photochemical Sonolysis	H_2O_2-UV used for this process	No extra sludge generation	It is very costly
Irradiation	This treatment is depended on the ionizing radiation	Very effective in lab scale	Very costly and not effective for all types of dyes
Photocatalysis	Radiation is the key factor	No generation of secondary pollutants, renewable based treatment	This shows limitations in penetration of light

The discussed treatments technologies are capable to degrade the textile dyes, but some serious concerns like treatment quality, generation of secondary pollutants, high energy inputs make them non-favorable. In this as regards, Enovation of highly advanced, cost effective, renewable based treatment technologies are required to solve these issues. So, combinations of more than one treatment system could be more effective in this perspective, so that the gap/limitations of one treatment system can be fulfilled. Modern industrialist and research scientists have categorized the available treatment options and their combinations for textile industry wastewater have been illustrated in figure 10.2.

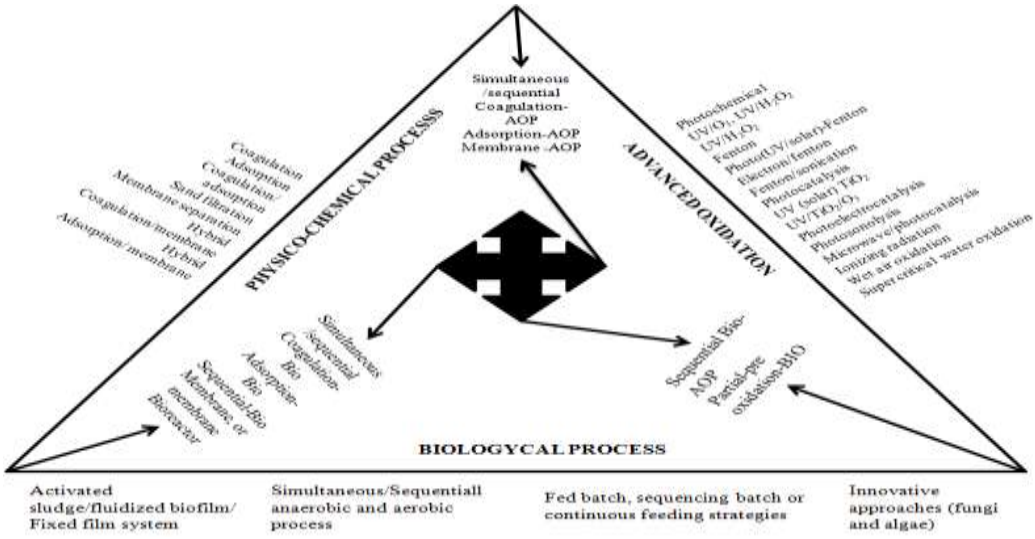

Fig.10.2: Simplified representation of various treatment processes and their combinations [1, 9]

Single treatment system for pollution reduction of textile dye wastewater is not fully capable to reduce as there are some specific limitations in specific treatment method. So, the idea of merging more than one treatment system could be a best option.

10.3 Proposed Hypothesis:

Recent studies on textile dye wastewater supports these innovative ideas coupling based treatments. In general, the merging more than system not only increases the treatment efficiency but also minimizes the generation of secondary pollutants as well.

In this perspective, solar energy and algal biomass-based treatment could be the ideal option. The basic idea behind the application of solar-energy-based-system is to substitute those treatment systems which run on fossil fuels-based technologies. Solar chemical applications can be of special relevance. The advantages of solar energy-based treatment have been discussed in table 2.

Table 10.2: Advantages of Solar Energy Based Treatment System [10, 11]

1. Solar radiation destroys the contaminants of textile industry wastewater.
2. Wastes are remained in one media only; hence they are not transferred to other media.
3. Solar radiation provides effective detoxification by denaturing the toxicants present in dye wastewater.
4. Solar radiation helps in elimination of organic contaminants from dye wastewater.
5. Solar energy is renewable hence, it reduces the treatment cost.

It is the most advanced treatment technology in recent era as it is capable to breakdown the highly toxic chemical compound also the cost effectiveness and renewable based approach makes it more suitable (figure 10.3a)

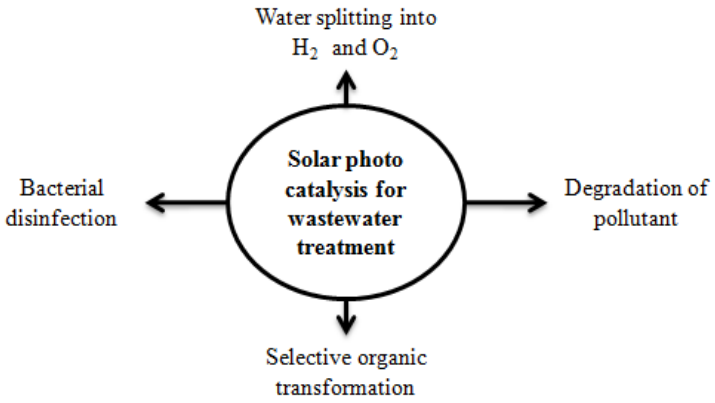

Fig.10.3 (a): Degradation by solar energy

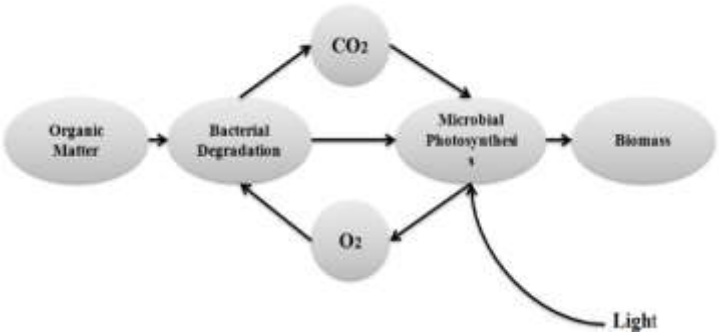

Fig. 10.3(b): Photosynthetic oxygen in bod removal process

The controlled use of algae over textile industry wastewater not only helps nutrient removal but also helps in degradation of organic matters. Algae also show potential for the reduction of heavy metals, other organic pollutants and provide oxygen for the heterotrophic aerobic bacteria which again degrades/ oxidizes the organic pollutants, using in reverse the carbon dioxide from respiration of anaerobic bacteria. This mechanism is utilized in photosynthetic aeration which reduces the treatment cost and also limits the volatilization of pollutants (figure 10.3b). Many researchers have stated the efficiency of solar energy and algal used for textile wastewater treatments. Rodrigues et al (2013) reported COD removal of 30.1 to70% while conducting experiment on optimization and economic analysis of textile industry wastewater under stimulated and artificial solar radiation [12]. Patil et al (2019) confirmed only 30% of COD reduction while treating wastewater by parabolic trough collector [13].

The effect of cultivated algal carbon Fe3O4 was studies by Foroutan et al (2019) and concluded cationic dye removal of above 98% from the test solution [14]. El-Kassas and Mohamed studied on Chlorella vulgaris and reported 75% dye removal efficiency from textile industry wastewater [15]. Chia et al (2014) while studying on Scenedesmus quadricauda reported 100% of dye removal from textile industry wastewater [16]. On the basis of literature, the textile industry wastewater is highly toxic and contains high load of complex non-biodegradable substances. The treatment technologies available have potential but need to be improved in many aspects. They show] gaps/ limitations in each treatment process. Therefore, in this context, the need for advanced, renewable and cost-effective treatment options are required which could able to fulfill these remaining gaps. So, as discussed above merging more than above treatments technology generate a positive hypothesis further research. Solar radiation is capable to break the complex chemical bonding and algal based treatment is capable to reduce high nutrient load. Hence, both the algal treatment system and solar energy based treatment system are showing synergetic effect to each other as well as helping in textile dye wastewater treatment. Therefore, the combination of both the treatment systems (solar-energy-based-treatment with algal treatment system) can fulfill the remaining gaps in a sustainable green approach.

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