MICROBIAL DEGRADATION OF TEXTILE DYES: A REVIEW

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Abstract: The earth holds several natural resources in itself. Water is the most important resource in them. However extensive use of water in many anthropogenic activities is leading to its pollution. The major concern is of textile industry where the consumption of water is maximum. The way the water is discharged into the water body is of main concern as no proper treatment is done in many cases or one can say that non proper facility is developed for the same. In this review we aim at the bioremediation of textile dyes. The main focus of review is on the microbial use for degrading the dyes that are discharged into the water bodies. Although several techniques are available for dye degradation but the bioremediation is most promising as it is easy to alter and more economical when applied to commercial scale. The bioremediation is also sustainable solution which can be harness at large scale and for several generations. However, the combination of microbes with certain new biotechnological application as bio nanotechnology can give more better result. Still very less literature is available on this. Microbes are very strong option when it comes to dye degradation as several bacteria and fungus have the capacity to degrade many acidic and basic dyes within few minutes to hours. The effluent obtained in the end of process is also not having and tertiary effect which makes these microbes an efficient choice for the dye degradation.

Keywords- Bioremediation, Microbes, Dyes, Biomagnification, Nanobiotechnology

I. INTRODUCTION

Textile industry is a giant player when it comes to economic aspects. After Agriculture it is the second biggest industry in terms of employment provider. If we see the current figure this industry globally has emerged as a trillion-dollar industry. One of the reports from WHO (World Health Organization) states that nearly 18 to 20% of water population is alone contributed by textile residues from the textile industries. The reason is the use of several synthetic dyes which are available at cheaper rate but from environment point of concern they possess no benefit and potential to be seen as a sustainable approach.

Various synthetic dyes are used nowadays which are readily available in the market and fits in the pocket of industries. Some of them are Toluidine Blue, Neutral Red, Safranine O, Eosin Yellowish, Coomassie Brilliant Blue, Methyl Violet, Malachite Green, Methyl Green. These dyes when released either untreated or undertreated are a cause of great environmental concern. Serious threats to ecosystem like aquatic water pollution, biomagnification is resultant of these. Such dyes which are insoluble in water remains and suspended particles and they tend to enter inside the living system of aquatic fauna. This cause the accumulation of these compounds into their system which is also thus responsible for threats like tumor formation as discussed in the review.

Bioaccumulation of such toxic compounds in water can have potential threats and be hazardous not for aquatic species but for human and other animals too which are indirectly linked to water bodies. Bioremediation is one of the best and suitable method for overcoming this problem. However, in every case it doesn’t fits the best but certain improvements in this method with incorporation of new technology can make this technique reach its optimum potential providing relief from the water pollution.

II. MICROBES USED FOR DYE DEGRADATION

There are several classes of microbes that are used for the degradation of dyes. The focus is given to those microbes in this paper which are economical and easy to culture. At the same time importance is given to those microbes which don’t produce any secondary or tertiary by product after the reaction is done with the dyes. Bacteria like Brevibacillus is effective in degrading the Toluidine Blue. This was confirmed using 16S rRNA sequencing followed by morphological or enzymatic assays (Huda, Muhammad Et.al). Study shows that textile industrial effluents which are removed by microbial use has sufficient amounts of BOD levels to meet the standard criteria (Shanooba, Dhiraj Et.al). Also, the nitrogen and carbon content can be also treated using the same. Bacterium P. azoreducens is used for degradation. The BOD parameter fit for commercial and environmental concern is generally set at 30mg/l. With help of this bacteria the target of this standard can be met easily. It is often seen that natural dyes can provide alternative to harsh synthetic dyes.

III. NATURAL DYES AS SAFE ALTERNATIVE

To avoid the harmful effects of synthetic dyes natural dyes obtained from natural sources can be a great alternative. Natural dyes can be animal based, herbal or mineral too. Most of them are mordant dyes very few are basic and direct dyes. Some natural dyes options include Calendula or pot marigold. Yellow colour dye is obtained from this. Aiding certain mordants to it other colour
like brown and orange can be obtained too. Other natural dye example includes the one obtained from Juglans Regial (walnut tree). Sambucus Nigra and Querus Ithaburensis are some other options (Dr. Sateesh, Ramachandran Et.al).

IV. SYNTHESIS OF DYES

Synthesis of 2-Amino-5-bromo benzoic acid(2a):

For this dye glacial acetic acid is used and amino benzoic acid is dissolved followed by cooling at 16 °C. Bromine is also added with stirring for 2-3 hours vigorously. Solid mass obtained is boiled using water and HCL. The filtrated is cooled and precipitates of 2-amino-5bromobenzoic acid are obtained.

Synthesis of diazonium salt of 2-Amino-5-bromobenoic acid:

For this dyes 2-amino5-bromobenzoic acid is suspended in water, HCL which is added dropwise. The solution obtained is cooled in ice bath. Cooled solution of sodium nitrate is added slowly followed by diazo used for coupling.

When acid dyes are used fabric are given certain pre-treatment like ammonia solution. Certain pH adjustment is made followed by certain dyeing procedure. In most cases Glauber’s salt solution is used for dyeing procedure.

V. EXTRACTION OF DYES

To extract dyes several protocols are there. For instance, to extract methyl red, xylene can be used as extractant. The solution needs to be aqueous with anionic methyl red present in it. Various parameters can then be studied like pH, loading capacity, equilibration time, temperature etc. The liquid-liquid extraction method is dominantly used for the extraction purpose where in one liquid target molecule is present and another is having a carrier for the former (Muthuraman and Teng). Practically this method is suitable in industrial scale too and results don’t deviate much from the laboratory solution.

VI. BIOREMEDIATION OF TEXTILE DYES

Textile industry is very giant industry with market capitalization in billions. In our country too it holds major economic part. Use of hazardous chemicals in form of dyes can be a great theft to the environment. Microbes are great alternative to chemicals when it comes to dye degradation. As compared to general practice where one microbe is used, the use of more than one microflora is more promising protocol especially when it comes to azo dyes degradation. (Sarkar, Banerjee et.al). Similarly, for Congo Red bacteria like Bacillus thuringiensis RUNI is popularly used. This is a dye decolorizing bacterium. However, this bacterium is capable to degrade some other dyes namely Reactive blue 13, Reactive red 58 and reactive yellow 42 (Olukanni, Osuntoki et.al).

The bacteria yield important enzymes for biodegradation like azoreductase, laccase etc. Other highly reactive dyes like species Red HE3B can be degraded by bacteria like Providencia sp. And Pseduomonas aeruginosa strain (Swapnil, Dayanand et.al). Effluents of dyes are the one of major pollutants of water. In case of dyes the azo dye, class dominate the segment. Being the large class, it has variety of colours which are highly soluble in water and can easily escape treatment systems without any impact are certain problems which are of great concern. So, one of the majorly and effectively used method is of bioremediation in which microbes are used as mentioned earlier. Use of microbes is economical and effective just it is of a drawback that less literature is available for the same. Microbes from class bacteria, fungi, yeast have the capability to clean the effluent water. In fungus species like Phaeorochaete chrysoporum are highly capable to metabolize several xenobiotics compounds.

Another popular microbe used is Pseudomonas aeruginosa ETL-1. This bacterial species is capable of decolorizing triarylmethane dyes (Maulin, Kavita, et.al). For the same dye another bacterial strain namely Aeromonas hydrophila is also effective. The operational parameters are generally decolorization efficiency of the bacterium (Chimezil, Thomas et.al). When it comes to azo dyes the concern to degrade dyes rises as mentioned earlier azo dyes form the largest class of dyes. One of novel fungus used for degradation is Aspergillus oryzae (Caolus, Ana et.al). It is observed that this fungus species has capability to decolorize and remove toxicity of reactive textile dyes like PR-HE7B and PV-H3R. However, productivity is achieved when the fungus is in pellet form or is having dead biomass. The fungus class is capable to remove the metals like copper and chromium from mixed waste water streams. It is important to consider metal waste also as majority of textile industry effluents had residual metal as well as dye in waste effluents (Mishra and Malik). For metal degradation A. lentulus and A. terreus are popular. These fungus shows high productivity even in presence of mixed pollutants. Mixed pollutants are generally known to exhibit high toxicity (Mishra and Malik 2013). Several new techniques are evolving daily. Bio nanotechnology is also emerging. Several industrial effluents are treated with help of nanoparticles like Fe, Au, Sn, Ag etc. Like Zno nanoparticles effectively degrade Rhodamine B which is a colorant (Nandhini, Rajesh et.al).

Several sulphate reducing bacteria (SRB) are found to be effective in azo dye degradation. They are also beneficial in mineralization of intermediates when given anaerobic conditions (Mirjan, Nawaz Et.al). Beside bacteria fungus are also employable. Like Trichoderma harzianum in semi solid medium is capable to degrade dye which is seen by the parameter of decolorization. Fungal mycelium exhibit colour which is indication of dye when so present (Lokendra, Ved Et.al). Another fungal species Aspergillus flavus is reported to degrade bromophenol blue (Lokendra, Ved Et.al).

VII. OTHER METHODS TO DEGRADE DYES

Beside bioremediation several processes are capable of dye degradation one of them is photo-Fenton catalysis. In this process monoliths of Fe3O4and TiO2 are prepared using ammonium hydroxide, ferrous nitrate and other solutions. In presence of light the electrons jump to higher energy state and photogenerates holes leads to oxidation of water molecules which eventually degrade the waste water (Jawinder, Surbhi Et.al). UV illumination is another promising technique to degrade industrial dyes. Panos
extract is used as structure directly agent to synthesis ZnO/QNF. The resultant has the capability to photocatalyzed MB, EY and MG dye when UV is used as a source of light. The potential of dye degradation by this method is 90-35 mins for EY dye and 110-90min for MG dye during time of contact (Lalitha, Jang Et.al).

Nowadays nanotechnology is also emerging. In many studies it is found that the nanostructures can be employed for dye degradation. Cu-doped TiO₂ nanostructures are used to degrade RhB dye. The photocatalytic activity proves that the dye is degraded when the nanostructures are used (Gajanan, Sudhir Et.al). Several electrochemical oxidation methods are also floating in research to degrade dyes. Dual electro-oxidation protocols are employed in comparison to traditional single chamber method. It is done to treat the hydrogen gas which is produced at the cathode end (Raghu, Chang Et.al). Titania nano cubes are reported to be effective in dye degradation as they offer more surface area (Suprabha, Haizel Et.al). These surface passes high photocatalytic activity which promotes more dye degradation either by illuminating UV or other light source over the target. Another famous nanoparticle used is of copper ferrite which has great photocatalytic activity (Niyaz Mohammad). Certain elements like Praseodymium when doped with Cadmium tungstate and used as nanoparticles are effective in degrading dyes like Remazol Black B by increasing the electrical conductivity which in turn enhances the soloactivity (Shahin, Abbas Et.al).

VIII. ENVIRONMENTAL IMPACT

Majority of industrial effluents are forced to be have harmful pollutants consisting of heavy metals too. Many azo dyes and found to have toxic effect on the microbial population (Glenda, David, Et.al). The microbes in some cases uses the carbon sources of dye as energy medium but the sorbed dyes have the tendency to move in the food chain which can lead to infection of other organism in the ecosystem.

In case of woolen industries several bleaching operations uses oxidizing chemical including peroxidases and hypochlorite. Only this portion has nearly 10% contribution in total pollutant lead in the end stage (Rajendra Singh, Yogita Yadav). It is seen that use of synthetic dyes become famous after industrial revolution. This also leads to pollution, harming the ecosystem. Generally, when the dye gets mixed in water the light entering capacity of water is reduced causing imbalance in water ecosystem.

Several benzidase based azo dyes are observed as carcinogenic and very allergic to skin (Sarkar, Banerjee, Et.al). Several textile dyes like blue HFRL have anti-estrogenic activity. It is highly disappointing that several industrial dyes are endocrine disruptive agent (Bazin, Hassine Et.al) Many harmful dyes are also liked to promotion of tumor generation. The toxicological analysis is very important when it’s come to dye degeneration. Test like “Allium Test” are used for such analysis “Mitotic index” is of great concern in such tests. Rice in mitotic index indicates tumor formation, rapid and uncontrolled cell division. (Swapnil, Dayanand Et.al) Comet assay is used to test the genotoxic potential of industrial dyes.

Conclusion

The review basically focuses on the microbial use for degrading the dyes which are highly used in the textile industries. There are several species of microbes that can degrade the dyes and their efficiency highly appreciable. When the use of microbial load is combined with the nanotechnology the results are more effective. In near future the good combination of both the aspects may provide more efficient methods for the problem of dye degradation.

REFERENCES


