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Review Article

Recycling and reuse of azo dye polluted water for agriculture through bioremediation-A microbial perspective

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ABSTRACT

Recycling water for irrigation is necessity of the day. Industrial effluents are huge in amount so its recycling becomes countable. Textile industries are one of the main domains of whole industrial sector. The textile hubs are with increasing risk of dye contaminated effluent pollution to the water reservoirs. This is a direct risk to ecosystem through crops. Textile effluents should be treated before expelling to environment; there are many methods amongst which bioremediation through bacteria are reported most sustainable, non-toxic and cheaper. Studies reveals about azo dye degradation and detoxification of such effluents through bacterial bioremediation. It's a need to gaze on the issue as a need of the day; as through water and crops such pollutants may bio-magnify and can have hazardous effects.

Key words: Water recycling, Bioremediation, Irrigation, Textile industry, Azo dye

Since the beginning of the human civilisation, people have been using colours. Mauveine, the first synthetic dye was discovered by Perkin who patented his invention and set up a production line in 1856 (Hunger *et al.*, 2002). In the beginning of 20th century, synthetic dyestuff had almost supplanted natural dye (Van der Zee and Villaverde, 2005). In the textile industry,azo dyes are the largest group of dyes, constituting 60-70% of all dyes produced (Carliel*et al.*, 1995). The effluents of such industries are polluting water reservoirs and through that crops are affected (Khan and Malik, 2018). Today agriculture has different challenges. Water crisis and interruptions in rain water due to climate change affects agriculture yields (Hassan *et al.*, 2013). Water recycling can become the answer to these problems; hence studies towards textile industrial water bioremediation are needful.

Textile Industries- A reservoirs of Azo dyes

The textile industries use various dyes in greater extent in processing units which are liberated directly in natural water bodies as an industrial effluent. The textile industry is one of the largest industries which are significantly contributing economies globally. The textile manufacturing process has thumping consumption of potable water that generates significant amount of effluent with complex pollutants and their mixture viz. heavy metals, chlorinated compounds, dyes and dyestuffs (Islam and Mostafa, 2018). Toxic industrial effluents and textile dyes pose a potential threat to both the environment as well as human kind (Chu and Phang, 2019; Yagnik 2012). Hence, it is essential to remediate such pollutants to protect the environment.

Dyes and Azo Dye

Dye is any coloured substance with affinity towards the substrate it is applied onto. Majority of dyes are water soluble and used as aqueous solution which sometimes requires a mordant that intensify onto the substrate (Purwar,

2016).Azo dyes are widely used on industries, it is have an azo bond (R_1-N=N-R_2). Azo dyes are scarcely biodegradable organic compounds due to their high stability to light and resistant to microbial attack. These dye are resistant to conventional biodegradation, however under anaerobic condition; they have been associated with the generation of metabolites. According to Saratale and coworkers there are some species of microorganisms that under certain environmental condition, are able to completely mineralize several type of azo dye (Sartale*et al.*, 2011). Azo dyes have high water solubility. This property makes dye a potent toxic consumable of biotic component upon expelled to environment through textile industries (Talarposhti*et al.*, 2001). Majorly such pollutants are least biodegradable and get incorporated to food chain through crops. Even studies reports that water holding capacity of agricultural soil decreases due to irrigation activities carried out using untreated effluents. Thus raises a major concern for recycling of dye polluted water (Rawat *et al.*, 2016).

Biological Methods of textile effluent treatment

A major paradigm shift in environmental science research is seen and microbial clean-up is the front runner and is adjudged as Bioremediation. It is a general approach for microbes to get acclimatizes to the surrounding including toxic wastes. In due course of time, newer strains may develop by genetic exchange methods which resist the toxic and harmful substances in environment, utilize it as substrate and eventually degrade them and render them non-toxic several such reports regarding biotransformation reactions are very well documented (Saratale*et al.*, 2011). Degradative biotransformation which includes various enzymes of microbial origin such as tyrosinase (Zhang and Flurkey, 1997), lignin peroxidase, laccase (Hatvani and Mecs, 2001), aminopyrine N-demethylase, NADH-DCIP reductase (Bhosale *et al.*, 2006), hexane oxidase are well reported in the past researches (Saratale*et al.*, 2011).

Microbial transformation or bioremediation of textile dyes using enzymatic treatment confer advantages as it is cost effective,eco-friendly, follows complete degradation, reduces the amount of sludge produced and recycle water used in treatment processes (Saratale*et al.*, 2011). A diverse group of microbes have been tried and tested for their capacities to decolorize a range of dyes which includes bacteria (Jadhav *et al.*, 2010). Bacterial cells represent an inexpensive and promising tool for the removal of various azo dyes. Bacteria play an important role in transforming toxic compound into non-toxic or less toxic and degrading.

Biodegradation of Dye by Bacteria

There are presence of different chromophore groups like azo, triphenyl methane, phthalocyanine etc. are responsible for their structural diversity (Bakshi*et al.*, 1999). Azo dyes are electron-deficient xenobiotic compounds because they possess the azo and sulfonic electron-withdrawing group and are there for recalcitrant in nature however, many microorganisms are complete enough in biodegrading these dyes. Substantial work has been done and it is a proven phenomenon that majority of mono and di-azo dyes can be degraded by anaerobe, facultative anaerobes and certain aerobic group of bacteria. These bacterial groups adopt a robust mechanism of reductive cleavage of azo bonds via azo reductase enzyme. Under anaerobic conditions the resultant product is a colourless solution of hazardous aromatic amines (Van der Zee and Villaverde, 2005). Reactive sulphonated dyes are very soluble by structure but not all are used by textile fibres during the dyeing process and there for, are discharged as effluents from dyeing and printing units. Sulfonilic acid groups that are introduced to increase the water solubility of the dye and the azo group confer resistance to microbial attack, making them recalcitrant to oxidative decolorization (Coughlin *et al.*, 1999). There are some reports on aerobic desulfonation of sulphonated aromatic compounds but most of the sulphonated azo dyes are handily biodegraded under aerobic condition. Aerobic condition is required for complete degradation of the toxic intermediate compounds into harmless products (Kalme*et al.*, 2007). The Table 1summarizes the details of bacterial isolates varied environmental conditions of temperature,pH along with their treatment methodology that are used for decolourization of azo dyes.

Table 1: Dye decolorisation studies by bacteria in recent past (2014-2020)

Organism	Dye and CI number	Type of dye & Molecular weight(g/mol)	Time in hrs	% removal	Temp.& pH	Mechanism	Approach/ Technique	References
Bacillus halodurans MTCC 865	Acid Black-24 26370	Azo; 731.7	6	90%	37°C 9.0	Biodegradation	Alkaline aerobic treatment	Prasad and Rao (2014)
Acinetobacter baumannii YNWH 226	Congo red 22120	Azo; 696.7	16	99.1	37°C 7.0	Biodegradation	RSM based aerobic treatment	Ning *et al.*, (2014)
Geobacilluscatenulatus MS5	Congo Red 22120	Azo; 696.7	32	99	30-80°C 4.6	Enzymatic	Thermostable Laccase	Verma and Shirkot (2014)
Proteus. vulgaris P. mirabilis	Various mono azo and anthroquinone dyes	NA	12	>70 for all dyes individually	37°C 7.0	Biodegradation	Azo-reductase and consortia	Parmar and Shukla (2015)
Ochrobactrum sp., P. aeruginosa & Providencia vermicola	Textile Effluent NA	NA	16	>95 for consortia	37°C 7.0	Biodegradation Enzymatic	Aerobic treatment Consortia (coculture)	Vijayalakshmidevi and Muthukumar (2015)
Bacillus sp.	Acid red 14900, Remazol black 20505,Reactive blue 61200	Azo; 879.9; 991.8 ; 626.5	48	100	35°C 5.0-7.0	Biodegradation Enzymatic	Aerobic treatment Consortia	Dwivedi and Tomar (2017)
Bacillus fermus	Acid Blue-9 17560	Azo sodium salt792.9	72	97	37°C NA	Enzymatic	Aerobic treatment	Neeth*aet al.*, (2018)
Arthrobacter soli BS5	Reactive black 5 20505	Di-Azo 991.8	120	98	37°C 5.0-9.0	Enzymatic	NA	Khan and Malik (2018)
Bacillus sp. CF96	Indigo carmine Acid Blue 74	Azo 466.4	NA	90	60°C 8.0	Enzymatic	Laccase	Javadzadeh and Asoodeh (2019)
Shewanella sp. NIAB-BM15	Red-S3B 53000	Azo 1136.32	4	100	37°C NA	Enzymatic	NA	Shakeel *et al.*, (2020)
Pseudomonas stutzeri, AK6	Acid Blue 113 18777	Di-azo 681.7	96	86.2	37°C NA	Enzymatic	Azoreductase and laccase	Joshi *et al.*, (2020)

Bacterial remediation of textile effluent and Agriculture

Water crisis for drinking and agriculture purpose creates a demand for reuse of water; this makes industrial effluent treatment a must phenomenon in cheaper and sustainable way, which can be promising by bacterial remediation(Kabra*et al.*, 2012). A large amount of textile industrial effluent can be treated by potential dye decolorizing bacteria and such treated and detoxified effluent can be used for agriculture usages, this can fill the gap between demand and crisis of usable water (Islam and Mustafa, 2018).

Conclusion

Disposal of wastewater effluent generated by dye industries into environment without proper treatment negatively affect the soil and water and affects crops through them. This demands to invent sustainable approach to remediate the hazardous chemical compounds present in the textile effluent. Biological wastewater treatments through bacterial strains withcapabilities of dye degradation and turning it to non-toxic component are studied for reuse of such water for irrigation. In this regard, use of these bacteriacan enhance the process efficiency of degradation which is economically feasible,ecofriendly and easy to handle. This can lead a chain of recycle and better reuse of water, even agriculture which is facing a cut through of water crisis for irrigation can be made possible to decrease the dependency on rain water or other water resources in the area near textile industrial hubs.

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