INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 11, Nov – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 15/11/2020 Acceptance Date: 30/11/2020 Publication Date: 30/11/2020

Current trends of textile dyes on the Environment: A review

RIDDHI H. DAVE
Department of Microbiology,
Gujarat Arts and Science College, Ahmedabad -380006, Gujarat, India.
Email - DaveRiddhiH@gmail.com / riddhi.dave@outlook.com

Abstract: *Currently, covid-19 pandemic lock down surprised with the fresh air and water to part of the world, still some of the river are found unchanged. Textile dyes are made from organic molecules and growing industrialization demands it in foodstuff, paint, cosmetic, dying, paper, printing industries and various laboratories. These textile dyes are ultimately added to the environment which pollutes air, water and soil. They are harmful to human as well as surrounding natural bodies due to their toxic effects. Hence, the current review mainly focuses on the methods for the reduction of environmental waste. The physico-chemical treatments have been exploited for the treatment of industrial textile wastewater. Currently, the textile dyes remove by biological treatments from the industrial effluents offer potential advantages. This review provides a general idea of microbial treatments as it is applied to remove the textile dye waste from the water for the betterment of the environment. Nowadays, noteworthy attention is gained by microbial treatment because of nature-friendly and inexpensive usage.*

Key words: *microbe, environment, textile dyes, wastewater, decolorization, degradation.*

1. INTRODUCTION:

The major sources of toxic environmental pollutants are from the industries majorly textile dying industries which adversely pollute the surrounding and in terms affect health of living being. The India shares majors of dyes consume by textile dyes. Lavanya et al. (2014) acknowledged nearly 14% of the total industrial production of the country contributed by textile industry of the India (1).The ever increasing demand for the dyes by these industries estimated to loss approximately 10-15% in the waste water during the dyeing processes causes the high pollutant potential. Textile dyes nearly about 280,000 tons are released in the surrounding per year in the world (2).

The removal of dyes from water is becoming a serious problem because of its complicated chemical structure with various functional groups like azo, diazo, anthraquinone and metal complexes dyes. Moreover, the methods applied for dyeing are dependent on each other makes it more complicated. Rajaguru et al. (2002) and de Aragao Umbuzeiro et al. (2005) reported the azo colorants causing an increase in mutagenic activity of surface and ground water (3,4). When textile wastewater enters surface water, it causes serious harm to the soil fertility, nature's wealth and aquatic inhabitants. It is negatively influencing the value of water by altering pH, increasing the BOD, COD and TOD as recent attention specified by Ajaz et al. (2020) ultimately, it upsets authenticity of ecosystem (5).

Latest interpretations conducted by Lavanya et al. (2014) reported that the high concentration of dyes cause ulcerations of skin and mucous membrane, dermatitis, perforation of nasal septum, severe irritation of respiratory tract and on ingestion may cause vomiting, pain, hemorrhage and sharp diarrhea. This poses especially serious harm to human health (1,6).

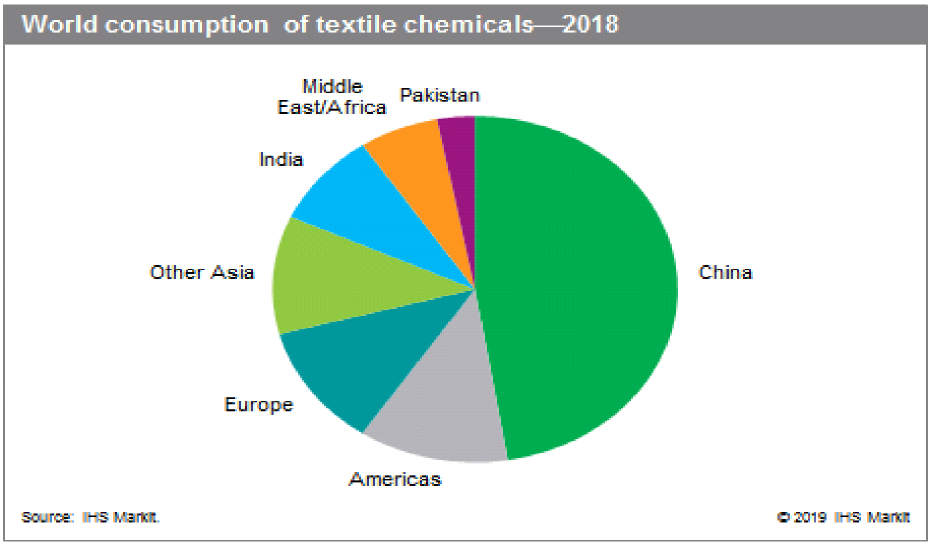
Different physical and chemical techniques such as adsorption, precipitation, oxidation, reduction etc. are used for the elimination of these colored compounds from textile wastewater (7-11). Still; these treatments are unfeasible and futile as these methodologies demanding outsized magnitude of energy and chemicals. According to Forgacs et al. (2004); Zhang et al. (2004); Ajaz et al. (2020) physical and chemical treatments are incompetent of fully eradicate dyes with their organic metabolites (5,12-13), undeviating to making of enormous amount of sludge based for the secondary pollution problems during the disposal into environment (14).

These contexts allowing many studies on biological treatment have been fascinated. This methodology found to be cheap, ecological harmless and pioneering advance that could clean the water system with a need to completely eradicate dyes. The current review would converse about ecofriendly biological treatment with elevated abilities to treat the textile dye wastewater.

2. GLOBAL SCENARIO OF TEXTILE DYES AND ITS IMPACT ON THE ENVIRONMENT:

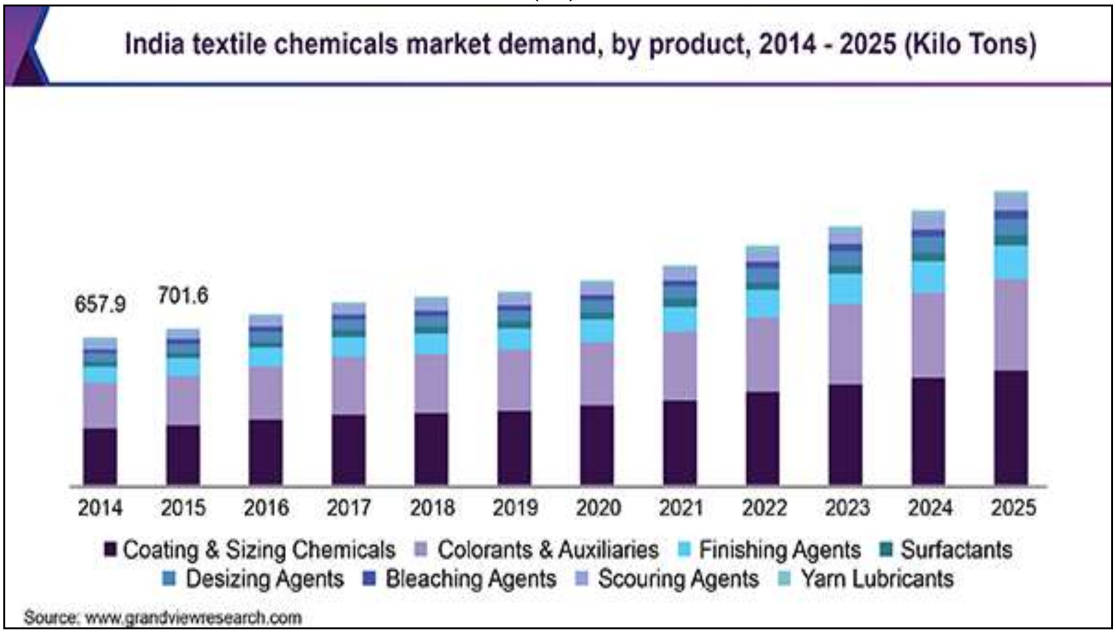
The textile dye chemicals mostly pollute all the part of our environment. Almost, majorly all the countries are using these textile chemicals as per year 2019 report of the world consumption of the textile chemicals (Figure 1) (15). These dyes are mostly utilized in textile industries. The following pie-chart explains major textile chemicals are consumed close to half of the world in the year 2018 by China compare to other countries. Currently, the China is the largest consumer of textile chemicals and now the country is following strict environmental regulation that forces the dye makers to shut their plants. This shut down of the industrial plants in the China has open more possibility for the India to cross the threshold in the international market (15).

Figure 1: World Consumption of textile chemicals (2018) from source: IHS MarKit.[15]



India is the second largest exporter of textiles globally as per the current report by grand view research industrial analysis (Figure 2) (16). The reports of year 2014-2025 include the Indian textile market demand is going to increase from the year 2020 to 2025 (16).

Figure 2: Indian textile market demand by product (2014-2025) adapted from www.grandviewresearch.com (16).



There are up to 200,000 tons of these dyes lost to effluents. They are released into the environment every year making the water as liquid effluent which becomes highly colored and toxic. In the textile industry due to inadequacy of process like the dyeing and finishing operations toxic dyes vanished in the wastewater. Among all industrial sectors the wastewater from textile industry measured as the most polluting one. Textile wastewaters generate large volume with complex effluents composition with tremendous rise and fall in many parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, color and salinity.

Toxic dyes get away the conventional wastewater treatment and persist in the surroundings. Moreover, the manufacturing units of textile industry uses large amount of water which is serious concern as it lead to scarcity of water. Less than 1 mg/L some dyes is highly visible in the water which affects the visibility of surrounding water bodies. The effluents release into the water streams, lakes or rivers adversely affect the aquatic inhabitant as it contaminate the food sources of aquatic organisms and lowers the dissolved oxygen (17,18). Currently, environmental concerns linked with textile chemicals have change the focus toward green (bio-based) eco-friendly treatments.

3. TOXICITY OF TEXTILE DYES:

Many researchers have been examining dyestuff toxicity (genotoxicity, mutagenicity and carcinogenicity) studies diverge from tests with aquatic organisms (fish, algae, bacteria, etc.) to tests with mammals (19). The presence of many dyes in the discharges wastewater create visual problem as dyes are visible at very low concentrations.Dyes are highly persistent in ecosystem as they are intended to be chemically and photolytically steady leads to ecotoxic hazard when discharged into the surroundings. Mineralization of azo dyes directs to formation of an aromatic amine name an arylamin that supposed to be a carcinogenic. Inhaling or consuming the dye particle causes allergic reactions to skin, irritation to the eyes and pose serious risk of cancer as azo dyes are readily absorb via skin contact being water soluble in the nature. For instance, para-phenylene diamine (PPD) containing azo dyes are toxic and cause skin irritation, contact dermatitis, chemosis, lacrimation, exopthamlmose and permanent blindness.

Sudha et al. (2014) reported ingestion of PPD products leads to the rapid development of oedema on face, neck, pharynx, tongue and larynx along with respiratory distress (21). Puvaneswari et al. (2006) mentioned that azo dyes are linked to human cancer, splenic sarcomas, hepatocarcinomas, and nuclear anomalies in experimental animals and chromosomal aberrations in mammalian cells. Haley et al. (1975) recognized benzidine (BZ)-based azo dyes as a human urinary bladder carcinogen and tumorigenic in laboratory animals (23). Sudha et al. (2014) reported the effect of azo dye refer in the Table 1 (21). The toxic compounds of dyes readily mix with water bodies and enter into aquatic organisms (24,25) through food chain eventually reach humans. These cause physiological disorders such as hypertension, sporadic fever, renal damage and cramps in the human. Some azo dyes are carcinogenic, mutagenic reduce the efficiency of plant growth.

Table 1: Effect of dyes on the animal modified from Sudha et al. (2014) (21).

Effects on animal	Dye	Reference
Induce chromosomal aberration, lipid peroxidation, acetyl cholinesterase in mice	Acid Violet 7	Ben Mansour et al. (2010) (26)
Inhibits function of human serum albumin	Reactive Brilliant Red	Li et al. (2010) (27)
Mutagenic, cytotoxic, genotypic effects, formation of micronuclei, DNA fragmentation in human hepatoma cells	Disperse Blue 291	Tsuboy et al. (2007) (28)
Carcinogenic	Red 3	Kobylewski and Jacobson (2012) (29)
Hypersensitivity reactions	Blue 1, Red 40, Yellow 5, and Yellow 6	Kobylewski and Jacobson (2012) (29)
Genotoxic	Yellow 5	Kobylewski and Jacobson (2012) (29)

4. METHODS FOR DYE REMOVAL :

Textile dyestuff containing wastewater is recalcitrant and removed by physicochemical methods in many developed countries. Physical methods are mainly comprised of coagulation-flocculation, adsorption and filtration. Chemical methods mainly comprise of advanced oxidation, fenton oxidation, electrochemical oxidation, sonochemical oxidation and ozonation etc (30-32).

4.1 PHYSICO-CHEMICAL VERSES BIOLOGICAL METHOD

Physical methods had inadequacy of handling toxic dyes as dyes are absorbed in surfaces which direct to environmental harms (33-36). The chemical methods have limitation of production of secondary sludge-pollution (37). Moreover, the expenditure is high for the applying chemical methods. Currently, awareness on the use of harmful chemicals in the textile dying industries has encouraged the research on nature friendly substitutes.

The biological methods comparing to the physicochemical method, generally regarded as environmental friendly and cost effective. The biological methods enable complete degradation of textile dyes contrast to physicochemical method (38,39). Jirasripongpun et al. (2007) and Ajaz et al. (2020) mentioned biological methods can mineralize organic contaminants without producing secondary toxic sludge (5,40). Considering the cost effectiveness and eco-friendly nature of biological methods are promising in terms of performance without secondary pollution. The present review mainly concentrates on the alternative of sustainable environment friendly, economical feasible methods for the most demanding catastrophe of reduction of textile waste containing dyes.

4.2 BIOLOGICAL METHOD AND ITS SIGNIFICANCE COMPARE TO PHYSICO-CHEMICAL METHODS

Environmental pollution caused by textile dyes is global concerns. Currently, over the last two decades works on biological method has tremendously growing rapidly. This method applies inhabitant microorganism's degradation ability. As per the report shown in the Figure 2,(16) the second largest exporter of textiles dyes globally is the India leading to textile dyes used in the industries. Textile dyes are xenobiotic in the nature. They are difficult to degrade in the wastewater generated from the textile industries.

In biological treatment, the microbes are the front liner. Microorganisms are having promising importance for treating toxic pollutants in an eco-efficient way. Recent works on isolation of promising microbes could be done by adapting them to toxic wastes naturally with new resistant strains (48) or artificially adapted by budding new strains. The efficiency of microbial remediation can be increased in the near future by isolation of new stain or adapting to resident. These can removes the highly toxic wastes into harmless forms.

Saratale et al. (2009) reported one of the principles behind the remediation of textile dyes by microbes is the biotransformation enzymes (41). The application of microbial or enzymatic treatment for the complete degradation of textile dyes has significant advantages compare to physicochemical methods; environmental friendly (5), cost competitive, less sludge production or without producing secondary toxic sludge (40), the end products with complete mineralization or non toxic products and could help to reduce the enormous water consumption compared to physicochemical methods (20,41).

4.3 MICROBES - A POTENTIAL DYES REMOVAL

Environmental concern leads to critical attention to effluent discharge. Dyes concentration as low as 1 mg/L is visible creates aesthetic issues. Several research have been reported on microorganisms (Table 2) comprise of fungi (42-45), bacteria (41, 46-48), yeasts (49), actinomycetes (46) and algae (50) are capable of decolorize and even completely mineralize a wide range of dyes under certain environmental conditions.

Table 2: Potential microbes used for removal of textile industries dyes in biological treatment.

Strain	Organisms	Dye	Reference
Fungi	*Phanaerochate chrysosporium*	Orange II	Sharma et al. (2009) (43)
	Aspergillus sp.	Orange 3R	Singh et al. (2012) (59)
	Aspergillus ochraceus	Reactive blue 25	Parshetti et al. (2007) (45)
	Geotrichum sp.	Reactive black 5, Reactive red 158 and Reactive yellow 27	Khuad et al. (2004) (42)
Bacteria	*Bacillus thuringensis*	Acid dye	Dave and Dave (2009) (48) Dave and Dave (2012) (60)
	Enterococcus faecalis	Reactive orange II	Saharabodhe and patthade (2011) (51)
	Enterococccus agglomerans	Methyl red	Keharia et al. (2003) (52)
	Enterobacter sp.	Reactive Red 195	Jirasripongpun et al. (2007) (40)
	Bacillus sp.	Navy blue 2GL	Dawkar et al. (2009) (53)
	Aeromonas hydrophila	Acid amaranth , Crystal violet, Basic fuchsine, Brilliant green, Malachite green, Great red GR, Reactive red KE-3B, Reactive brilliant blue K-GR	Ren et al. (2006) (54)
	Aeromonas hydrophila	Reactive red 198	Chen et al. (2003) (55)
	Shewanella decolorationis	Crystal violet	Chen et al. (2008) (44)
	Kocuria rosea	Malachite green	Parshetti et al. (2006) (46)
Algae	*Spirogyra rhizopus*	Acid red 247	Ozer et al. (2006) (56)
	Cosmarium sp	Triphenylmethane dye and Malachite green	Daneshvar et al. (2007) (50)
Actinomycetes	*Streptomyces ipomoea*	Ornage II	Molian- Guijarro et al. (2009) (57)
Yeast	*Kluveromyces marxiamus*	Ramazol black B	Meehan et al. (2000) (58)
	Saccharomyces cerevisiae	Methyl Red	Jadhav et al. (2007) (49)

5. CONCLUSION :

Despite of the covid-19 pandemic shut down freshen up the part of countries environment, still textile dyes induced water pollution gains major attention. The textile dyes demand increasing in the majorities of the world. This eventually added into the environment which creates harmful effects on the animals. Moreover, it poses survival risks to the biota. The increasing loads of dyes with complex composition and release are dangerous to the biosphere. The awareness towards green (safe) environment demands for the efficient and environmental friendly methods for the remediation. This review present the importance of biological methods using microbes compares to extensively apply physico-chemical methods. The author is involved in the bioremediation of textile dyes from actual industrial effluents; suggest the promising and significant potential of microbes for the remediation actual textile dyes industrial wastewater. This impact significantly plays critical part in our environment.

REFERENCES:

1. Lavanya C., and Dhankar R., Chhikara S., Sheoran S, (2014): Degradation of Toxic Dyes: A Review. *International journal of current microbiology and applied sciences, 3*(6), 189-199.
2. Jin X.C., Liu G.Q., Xu Z.H., Tao W.Y, (2007): Decolorization of a dye industry effluent by Aspergillus fumigatus XC6. *Applied Microbiology and Biotechnology*, 74, 239-243.
3. Rajaguru P., Vidya L., Baskarasethupathi B., Kumar P.A., Palanivel M., Kalaiselvi K, (2002): Genotoxicity evaluation of polluted ground water in human peripheral blood lymphocytes using the comet assay. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis*, 517, 29–37.
4. de Aragao Umbuzeiro G., Freeman H.S., Warren S.H., De Oliveira D.P., Terao Y., Watanabe T., Claxton L.D, (2005): The contribution of azo dyes to the mutagenic activity of the Cristais River. *Chemosphere*, 60, 55–64.
5. Ajaz M., Shakeel S., Rehman A, (2020): Microbial use for azo dye degradation-a strategy for dye bioremediation. *International journal of microbiology*, 23(2), 149-159. doi: 10.1007/s10123-019-00103-2. Epub 2019 Nov 18. PMID: 31741129.
6. Kumar Praveen G.N., and Sumangala K.B, (2012): Fungal Degradation of Azo dye-Red 3BN and Optimization of Physico-Chemical Parameters. *International Research Journal of Biological Sciences*, 1(2), 17-24.
7. Swaminathan K., Sandhya S., Sophia A.C., Pachhade K., Subrahmanyam Y.V, (2003): Decolorization and degradation of H-acid and other dyes using ferrous-hydrogen peroxide system. *Chemosphere*, 50, 619–625.
8. Behnajady M.A., Modirshahla N., Shokri M, (2004): Photodestruction of acid orange 7 (AO7) in aqueous solutions by UV/H2O2: influence of operational parameters. *Chemosphere*, 55, 129–134.
9. Golab V., Vinder A., Simonic M, (2005): Efficiency of the coagulation/flocculation method for the treatment of dye bath effluent. *Dyes and Pigments*, 67, 93–97.
10. Chen T., Gao B., Yue Q, (2010): Effect of dosing method and pH on color removal performance and floc aggregation of polyferric chloride–polyamine dual-coagulant in synthetic dyeing wastewater treatment. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 355,121–129.
11. Malik S.N., Ghosh P.C., Vaidya A.N., Waindeskar V., Das S., Mudliar S.N, (2017): Comparison of coagulation, ozone and ferrate treatment processes for color, COD and toxicity removal from complex textile wastewater. *Water Science and Technology*, 76, 1001–1010.
12. Forgacs E., Cserhati T., Oros G, (2004): Removal of synthetic dyes from wastewaters: a review. *Environment International*, 30, 953–971.
13. Zhang F., Yediler A., Liang X., Kettrup A, (2004): Effects of dye additives on the ozonation process and oxidation by products: a comparative study using hydrolysed CI Reactive red 120. *Dyes and Pigments*, 60, 1-7.
14. Atteke C., Mounguengui S., Saha Tchinda J.B., Ndikontar M.K., Ibrahim B., Gelhaye E., Gerardin P, (2004): Biodegradation of Reactive Blue 4 and Orange G by Pycnoporus sanguineus Strain Isolated in Gabon. *Journal of bioremediation & biodegradation*, 4, 206. doi:10.4172/2155-6199.1000206.
15. World Consumption of textile chemicals-2018. Available from: IHS MarKit. https://ihsmarkit.com/products/chemical-textile-scup.html.
16. Indian textile chemicals market demand, by product 2014-2025 (Kilo Tons) Available from: www.grandviewresearch.com, https://www.grandviewresearch.com/industry-analysis/textile-chemical-market.
17. Ibrahim M.B., Poonam N., Datel S., Roger M, (1996): Microbial decolorization of textile dyecontaining effluents: a review. *Bioresource Technology*, 58(3), 217-227.
18. Wijetunga S., Li X.F., Jian C, (2010): Effect of organic load on decolourization of textile wastewater containing acid dyes in upflow anaerobic sludge blanket reactor. *Journal of Hazardous Materials*, 177(1-3), 792-798.
19. Dave R.H, (2006): 'Bacterial treatment of C.I. acid red 119 dye from dye containing waste'. Master of Philosophy thesis. Gujarat University, Ahmedabad, Gujarat, India.

20. Shah K, (2014): Biodegradation of Azo Dye compounds. *International Research Journal of Biochemistry and Biotechnology*, 1(2), 005-013.
21. Sudha M., Saranya A., Selvakumar G., Sivakumar N, (2014): Microbial degradation of Azo Dyes: A review. *International Journal of Current Microbiology and Applied Sciences,* 3(2), 670-690.
22. Puvaneswari N., Muthukrishnan J., and Gunasekaran P, (2006): Toxicity assessment and microbial degradation of azo dyes. *Indian Journal of Experimental Biology,* 44, 618-626.
23. Haley T.J, (1975): Benzidine revisited: a review of the literature and problems associated with the use of benzidine and its congeners. *Clinical Toxicology,* 8(1), 13-42. doi: 10.3109/15563657508988044. PMID: 805682.
24. Fang H., Wenrong H., Yuezhong L, (2004): Biodegradation mechanisms and kinetics of azo dye 4BS by a microbial consortium. *Chemosphere,* 57(4), 293- 301.
25. Asad S., Amoozegar M.A., Pourbabaee A.A., Sarbolouki M.N., Dastgheib S.M, (2007): Decolorization of textile dyes by newly isolated halophilic and halotolerant bacteria. *Bioresource Technology*, 98, 2082-2088.
26. Ben Mansour H., Ayed-Ajmi Y., Mosrati R., Corroler D., Ghedira K., Barillier D., Chekir-Ghedira L, (2010): Acid Violet 7 and its biodegradation products induce chromosome aberrations, lipid peroxidation, and cholinesterase inhibition in mouse bone marrow. *Environmental science and pollution research international,* 177, 1371-1378.
27. Li W.Y., Chen F.F., Wang S.L, (2010): Binding of reactive brilliant red to human serum albumin: insights into the molecular toxicity of sulfonic azo dyes. *Protein & Peptide Letters,* 175, 621-629.
28. Tsuboy M.S., Angeli J.P.F., Mantovani M.S., Knasmuller S., Umbuzeiro G.A., Ribeiro L.R, (2007): Genotoxic, Mutagenic and cytotoxic effects of the commercial dye CI Disperse Blue 291 in the human hepatic cell line HepG2. *Toxicology in vitro,*. 21(8), 1650-1655.
29. Kobylewski S., and Jacobson M.F, (2012): Toxicology of food dyes. *International journal of occupational medicine and environmental health,* 18(3), 220-46. doi: 10.1179/1077352512Z.00000000034. PMID: 23026007.
30. Kumar A., Kumar A., Sharma G., Naushad M., Stadler F.J., Ghfar A.A., Dhiman P., Saini R.V, (2017): Sustainable nano-hybrids of magnetic biochar supported g-C3N4/FeVO4 for solar powered degradation of noxious pollutants. Synergism of adsorption, photocatalysis & photo-ozonation. *Journal of Cleaner Production,* 165, 431–451.
31. Kumar A., Kumar A., Sharma G., Al-Muhtaseb A.a.H., Naushad M., Ghfar A.A., Stadler F.J, (2018): Quaternary magnetic BiOCl/g-C3N4/Cu2O/Fe3O4 nano-junction for visible light and solar powered degradation of sulfamethoxazole from aqueous environment. *Chemical Engineering Journal,* 334, 462–478.
32. Kumar A., Sharma S.K., Sharma G., Al-Muhtaseb A.a.H, Naushad M., Ghfar A.A., Stadler F.J, (2019): Wide spectral degradation of Norfloxacin by Ag@BiPO4/BiOBr/BiFeO3 nano-assembly: elucidating the photocatalytic mechanism under different light sources. *Journal of Hazardous Materials,* 364, 429–440.
33. Naushad M. (2015): Surfactant assisted nano-composite cation exchanger: development, characterization and applications for the removal of toxic Pb2þ from aqueous medium. *Chemical Engineering Journal,* 235, 100–108.
34. Naushad M., Mittal A., Rathore M., Gupta V, (2016): Ionexchange kinetic studies for Cd(II), Co(II), Cu(II), and Pb(II) metal ions over a composite cation exchanger. *Desalination and Water Treatment, 54*(10), 2883–2890.
35. Sharma G., Naushad M., Pathania D., Mittal A., El-Desoky G.E, (2015): Modification of Hibiscus cannabinus fiber by graftcopolymerization: application for dye removal. *Desalination and Water Treatment,* 54(11), 3114–3121.
36. Albadarin A.B., Collins M.N., Naushad M., Shirazian S., Walker G., Mangwandi C, (2017): Activated ligninchitosan extruded blends for efficient adsorption of methylene blue. *Chemical Engineering Journal,* 307, 264–272.
37. Vikrant K., Giri B.S., Raza N., Roy K., Kim K.H., Rai B.N., Singh R.S, (2018): Recent advancements in bioremediation of dye: current status and challenges. *Bioresource Technology,* 253, 355–367.
38. He X.L., Song C., Li Y.Y., Wang N., Xu L., Han X., Wei D.S, (2018): Efficient degradation of azo dyes by a newly isolated fungus *Trichoderma tomentosum* under non-sterile conditions. *Ecotoxicology and Environmental Safety,* 150, 232–239.
39. Guo G., Tian F., Zhang C., Liu T., Yang F., Hu Z., Liu C., Wang S., Ding K, (2019): Performance of a newly enriched bacterial consortium for degrading and detoxifying azo dyes. *Water Science and Technology,* 79, 2036–2045.
40. Jirasripongpun K., Nasanit R., Niruntasook J., Chotikasatian B, (2007): Decolorization and degradation of CI Reactive Red 195 by Enterobacter sp. *Thammasat international journal of science and technology*, 12,6–11.
41. Saratale R.G., Saratale G.D., Parshetti G.K., Chang J.S., Govindwar S.P, (2009): Outlook of bacterial decolorization and degradation of azo dyes: a review. *International Journal of Environmental Research and Public Health,* 11-59.
42. Kuhad R.C., Sood N., Tripathi K.K., Singh A., Ward O.P, (2004): Developments in microbial methods for the treatment of dye effluents. *Advances in Applied Microbiology,* 56, 185-213. doi: 10.1016/S0065-2164(04)56006-9. PMID: 15566980.
43. Sharma P., Lakhvinder S., Dilboghi N, (2009): Biodegradation of Orange. J Sci Ind Res. 68, 157-161.

44. Chen C.H., Chang C.F., Ho C.H., Tsai T.L., Liu S.M, (2008): Biodegradation of Crystal Violet by a *Shewanella* sp. NTOU1. *Chemosphere,* 72(11), 1712-20.
45. Parshetti G.K., Kalme S.D., Gomare S.S., Govindwar S.P, (2007): Biodegradation of Reactive blue-25 by *Aspergillus ochraceus* NCIM-1146. *Bioresource Technology,*, 98(18), 3638-42. doi: 10.1016/j.biortech.2006.11.017. Epub 2007 Jan 3. PMID: 17204422.
46. Parshetti G., Kalme S., Saratale G., Govindwar S, (2006): Biodegradation of malachite green by *Kocuria rosea* MTCC 1532. *Acta Chimica Slovenica*, 53, 492-498.
47. Kalyani D.C., Patil P.S., Jadhav J.P., Govindwar S.P, (2008): Biodegradation of reactive textile dye Red BLI by an isolated bacterium Pseudomonas sp. SUK1. *Bioresource Technology, 99*, 4635– 4841.
48. Dave S.R., and Dave R.H, (2009): Isolation and characterization of *Bacillus thuringiensis* for Acid red 119 dye decolourization. *Bioresource Technology,* 100,249-253.
49. Jadhav J.P., Govindwar S.P, (2007): Biotransformation of Treatment of simulated reactive yellow 22 (azo) dye malachite green by *S. cerevisiae*. *Yeast*, 23,316-323.
50. Dhaneshvar N., Ayazloo M., Khatae A.R., Pourhassan M, (2007): Biological Decolorization of Dye Solution Containing malachite green by microalgae *Cosmarium* sp. *Bioresource Technology,* 29, 1-7.
51. Sahasrabudhe M.M., and Pathade G.R, (2011): Biodegradation of sulphonated azo dye C.I. reactive orange 16 by *Enterococcus faecalis* strain YZ 66. *European Journal of Experimental Biology*, 11,163-173.
52. Keharia H., and Madamwar D, (2003): Bioremediation concepts for treatment of dye containing water: A review. *Indian Journal of Experimental Biology,* 41, 1068.
53. Dawkar V.V., Jadhav U.U., Ghodake G.S., Govindwar S.P, (2009): Effect of inducers on the decolorization and biodegradation of textile azo dye Navy blue 2GL by *Bacillus sp.* VUS. *Biodegradation*, 20, 777-787.
54. Ren S., Guo J., Zeng G., Sun G, (2006): Decolorization of triphenylmethane, azo and anthraquinone dyes by a newly isolated *Aeromonas hydrophila* strain. *Applied Microbiology and Biotechnology,* 72, 1316-1321.
55. Chen K.C., Wu J.Y., Liou D.J., Hwang S.C.J, (2003): Decolorization of the textile dyes by newly isolated bacterial strains. *Journal of Biotechnology*, 101(1), 57-68.
56. Ozer A., Akkaya G., Turabik M, (2006): The removal of Acid Red 274 from wastewater: Combined biosorptionand biocoagulation with 'Spirogyra rhizopus'. *Dyes and Pigments*, 71, 83–89.
57. Molina-Guijarro J.M., Perez J., Manoz-Dorado J., Guillen F., Moya R., Hernandez M., Arias M.E, (2009): Detoxification of azo dyes by a novel pH-versatile, salt-resistant laccase from *Streptomyces ipomoea*. *International journal of microbiology,* 12, 13-21.
58. Meehan C., Banat I.M., McMullan G., Nigam P., Smyth F., Marchant R, (2000): Decolorization of Remazol Black-B using a thermotolerant yeast, *Kluyveromyces marxianus* IMB3. *Environment international*, 26(1-2), 75-9. doi: 10.1016/s0160-4120(00)00084-2. PMID: 11345742.
59. Singh A.K., Singh R., Soam A., Shahi S.K, (2012): Degradation of textile dye orange 3R by *Aspergillus* strain (MMF3) and their culture optimization. *Current Discovery*. 1(1), 7-12.
60. Dave S.R., and Dave R.H, (2012): "Optimization of process parameters for enhanced biodegradation of acid red 119 by *Bacillus thuringiensis SRDD*", *Songklanakarin journal of science and technology,* 34(1), 23-30.