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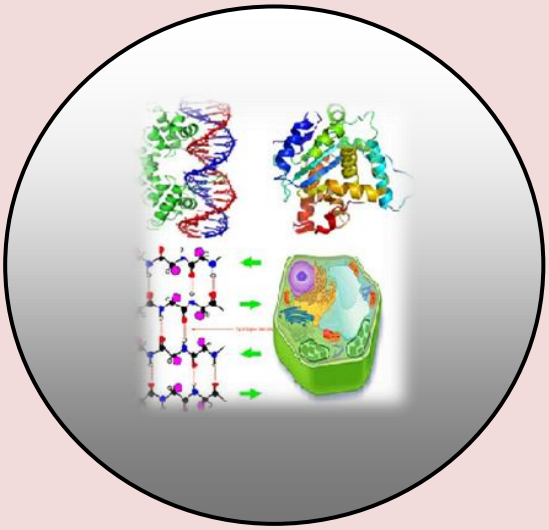

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RESEARCH PAPER

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Studies on Certain Factors Influencing Biosorption of Basic Fuchsin from its Aqueous Solution by *Aspergillus Fumigatus*

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ABSTRACT

Biosorption of basic fuchsin dye solution by living as well as dead biomass of A. fumigatus has been investigated. Three parameters namely dye concentration; contact time and dose of biosorbent were considered in the present study. Maximum biosorption (67.12 %) of basic fuchsin was recorded in living biomass with 250 ppm dye solution, where as minimum biosorption, 1.37 % was observed in dead biomass at 750 ppm dye solution. It was found that increase in biomass dose resulted in decreased adsorption of basic fuchsin.

Key words: Textile Effluents, Basic Fuchsin Dye, Fungal Biomass and Biosorption.

INTRODUCTION

The whole world is facing water crises because of unrestricted and excessive exploitation of water. The key reasons are: increased human population, rapid industrialization, urbanization, developmental processes leading to modernization and increased living standard (Gupta *et al*., 2015; Singh, 2017). Dyes are being widely used in various Indian industries such as textile, paper, plastic, leather, food, printing, cosmetic etc. to color their products (Mahmoodi *et al*., 2009; Gnanadoss *et al*., 2013). More than ten thousand types of such commercial dyes and pigments with over seven hundred tons of dye stuff are produced annually (McMullan et al., 2001; Revankar and Lele, 2007; Sulak and Yatmaz, 2012 and Murali and Uma, 2016). These dyes are commonly used in nylon, silk, acrylic and wool dyeing process are reported to be toxic, mutagenic and carcinogenic. However, the textile industry accounts for two-thirds of the total dyestuff and 10–15% of this annually produced dye is discharged as industrial effluents into the environment (Riu *et al*., 1998). This discharge of industrial water forms the major cause of its adverse impact on the environment (Robinson *et al*., 2001; Jebapriya and Gnanadoss, 2013). These pollutants can cause "oxygen sag" means rapid reduction of dissolved oxygen, leading to in the receiving water (Delclos *et al*., 1984; O'Neil *et al*., 1999 and Singh, 2017).

There are different structural varieties of dyes such as acidic dyes, basic dyes, disperse dyes, azo dyes, reactive dyes, mordant dyes and sulphur dyes. Most of these dyes are toxic and are often carcinogenic (Eren and Acar, 2006; Nidheesh *et al*., 2013). They make water bodies inhabitable aquatic systems. Because of their complex structure they can't be treated in conventional treatment plants for waste water. There are several harmful effects of these dyes on ecosystem. Even its minor amount (< 1 ppm) may cause abnormal coloration of water bodies, thus, inhibiting the passage of sun light here. This adversely affects the growth of microorganisms and their biological activities (Rajasekhar, 2014).

Therefore, removal of these dyes from industrial effluents is extremely important before discharging them into the environment (O'Neill *et al*., 1999; Hameed and El-Khaiary 2008). Several physical and chemical treatment methods have been developed to remove dyes from waste waters. These include coagulation (Ellouze *et al*., 2011), photo-electro-catalytic methods (Khataee and Zarei, 2011) and electro-coagulation (Rajabi *et al*., 2011). The membrane filteration and ozonation have also been known to decolorize the textile effluents (Ramesh *et al*., 2013). These methods are very costly and create disposal problems due to accumulation of concentrated sludge. The use of excessive chemical reagents often created a secondary pollution problem that required additional cost for regeneration of treatment system (Crini, 2006; Lakshmi *et al*., 2009; Celekli *et al*., 2012). On the other hand, biosorption process has also been commonly used for the removal of dyes and organic pollution. Biosorption is a physico-chemical process which includes mechanisms such as adsorption, absorption, ion exchange, surface complexation and precipitation. Biosorption is a property of both living and dead organisms and has been continued as a promising technology for pollutant removal, an account of its efficiency, simplicity, analogus operation to conventional ion exchange technology and availability of biomass (Gadd, 2009; Patel, 2016). Different types of biomass such as that of fungi and yeast (Ozsoy *et al*., 2008), bacteria (Ozdemir *et al*., 2003; Pathak and Dikshit, 2011), algae (Padmesh *et al*., 2006) etc have been studied for their biosorption efficiency (Pathak and Dikshit, 2012). Biosorption process using fungal biomass has emerged as one of the most potent inexpensive, effective and simple mechanical properties (Fu and Viraraghavan, 2001; Gnanadoss *et al*., 2013). The fungi have important role in the wastewater treatment and have been proved suitable and effective for dye adsorption and the removal of pollutants from the textile effluents. Dyes and pigments are being removed by these fungi either in living or dead form through biosorption, bio-accumulation, bio-degradation and enzymatic mineralization (Singh, 2017). Fungal biomass has in fact been found as efficient adsorbents in the removal of dyes in waste waters as they secrete a variety of extracellular enzymes (Dorthy *et al*., 2012). Fungal cell walls are complex macromolecular structures consisting of chitins, glucans, mannans, proteins and also containing other polysaccharides, lipids and pigments. These different functional groups are able to bind dyes as well as metal ions to a varying degree (Gadd, 2009). As compared to the live biomass, dead fungal biomass is reported to offer variety of advantages e.g. continuous supply of nutrients not required, easy storage, reusability, more efficiency, easy operation, least affected by toxic wastes and no production of secondary compounds which could be toxic (Patel, 2016). The present study was carried out to evaluate the efficiency of living and dead biomass of *Aspergillus fumigates* to adsorb basic fuchsin dye from its aqueous solution and the effect of different parameters *i.e.* contact time, dye concentration and biosorbent dosages on biosorption.

MATERIALS AND METHODS

A strain of *Aspergillus fumigatus* obtained from the soil samples treated with aqueous solution of basic fuchsin for over 90 days, was used for the present study. The fungal culture was maintained on Potato Dextrose Agar plates. The spore suspension of *Aspergillus fumigatus* was inoculated in Malt Glucose Yeast Peptone (MGYP) broth medium and was allowed to incubate for 8-10 days at 28^0C. After adequate growth of the fungus, the fungal mass was separated from the broth medium and washed three to four times with tap water. One half of this washed mass was used as living mass and the other half of the fungalmass was autoclaved at 15 Pounds per square inch (psi) for 20 minutes to obtain dead fungalmass. 100 ml of 250 ppm basic fuchsin solution was taken in each of the set of six 250 ml Erlenmeyer flasks (set A). Out of six flasks taken, 5 mg of living *A. fumigatus* mass was added to three flasks and to the rest three flasks 5 mg of dead *A. fumigatus* mass was added. In the same manner, three flasks of set B were inoculated with 10 mg of living mass and the other three flasks with 10 mg of dead mass. Similarly, in set C, three flasks inoculated with 15 mg of living mass and the other three flasks with 15 mg of dead fungal mass. Three flasks were kept as control. All of these 21 flasks were shaken simultaneously on an orbital shaker at 150 rpm for 5 min, 10 min and 15 minutes. After completion of each time period, the solution of each flask was filtered through a plastic sieve to remove the fungal mass and unadsorbed dye in supernatant was estimated using UV-Vis Spectrophotometer (Model SL-159) at 550 nm wave length.

The adsorption capacity and Q-Value were calculated using the following formula:

$$Q = V (C_i - C_f) / m$$

Where Q- specific dye uptake (mg/g) of biomass, C_i and C_f are the initial and final dye concentrations (mg/l), m is adsorbent dosage (g) and V is the volume of dye solution (l).

The above mentioned procedures were repeated for 500 ppm and 750 ppm solution of basic fuchsin using both living and dead biomass of *A. fumigatus*.

OBSERVATIONS

Tables. Percentage adsorption and Q value at different time intervals in response to different dose of fungal mass of Aspergillus fumigates in differing concentration of basic fuchsin:

(a) Basic fuchsin concentration: 250 ppm aqueous solution

(b) Basic fuchsin concentration: 500 ppm concentration

(c) Basic fuchsin concentration: 750 ppm concentration

Dose	Type	Contact Period					
		5 min		10 min		15 min	
		% Adsorption	Q-Value	% Adsorption	Q-Value	% Adsorption	Q-Value
5 mg	Living	20	1500	17.04	1278	31.25	2344
	Dead	5.97	448	11.38	854	6.96	522
10 mg	Living	28.8	2160	13.30	1000	28.48	2136
	Dead	5.93	445	8.01	601	1.37	118
15 mg	Living	5.08	381	15.49	1162	30.50	2280
	Dead	18.73	1405	14	105	7.8	586

Dose	Type	Contact Period					
		5 min		10 min		15 min	
		% Adsorption	Q-Value	% Adsorption	Q-Value	% Adsorption	Q-Value
5 mg	Living	6.9	345	41.4	2077	30.3	1515
	Dead	41.62	2081	36.48	1960	32.02	1601
10 mg	Living	46.44	2325	47.44	2372	31.44	1572
	Dead	50.74	2537	39.2	1824	37.56	1878
15 mg	Living	27.96	1388	40.66	2033	32.52	1801
	Dead	33	1650	39.9	1995	36.02	1626

Dose	Type	Contact Period					
		5 min		10 min		15 min	
		% Adsorption	Q-Value	% Adsorption	Q-Value	% Adsorption	Q-Value
5 mg	Living	16.4	401	34.52	863	48.48	1212
	Dead	15.88	397	8.11	811	50.56	1264
10 mg	Living	21.76	544	30.8	770	44.2	1105
	Dead	16.56	414	33.24	831	49.2	1230
15 mg	Living	18.4	184	32.44	324.4	67.12	6712
	Dead	19.96	460	33.8	811	54.88	1678

RESULTS AND DISCUSSION

The living mass of *A. fumigatus* was found to be more effective (up to 67.1% adsorption) for the biosorption of basic fuchsin dye than the dead fungalmass that showed a maximum of 54.88% only. Using 250 ppm dye concentration. The minimum dye removal (1.37%) was recorded for dead fungalmass in 750 ppm dye solution. A high Q value of 6712 was recorded for living mass at 250 ppm concentration of basic fuchsin dye.

The strain of *Aspergillus fumigatus* used in the present study was isolated from soil treated with basic fuchsin solution over 90 days so it is expected that the strain has greater tolerance to basic fuchsin. A comparison of the biosorptive capacity of living as well as dead mass of *A. fumigatus* showed that, at 250 ppm dye concentration, the living mass was more effective than the dead mass. At 500 ppm dye concentration, the dead mass was comparatively more effective. But at 750 ppm the efficiencies of both living and dead fungal mass were reduced compared to that at 250 ppm and 500 ppm dye concentrations.

It has been reported that increase in dye concentration after a certain limit is accompanied by decrease in the removal of dye. Omar, (2015) attributed the decreasing decolorization of dye at higher dye concentration to the higher concentration of dye being toxic to metabolic activities. Ogugube and Sawadis, (2011) and Kumar, (2013) also confirmed the result that, the decreasing decolorization of dye at higher dye concentration to increase in dye toxicity due to inhibition of cellular metabolic activities. In case of still higher concentration, a slight recovery by living biomass may be due to induction of stress tolerant mechanism.

Balut *et al*., (2006) and Kalaiarasi *et al*., (2012) concluded that, in case of dead biomass, at low concentration there will be unoccupied active sites on the adsorbent surface and the number of available binding sites increase with an increase in biosorbent concentration. This was due to the fact that almost all the ions were bound to the biomass at the establishment of equilibrium between the dye molecules bound to the biomass and those remaining un-adsorbed in the solution (Vasanthkumar *et al*., 2006).

At 750 ppm concentration, dye decolorization decreased sharply with both type of biomass. It may be due to the fact that increase in dye concentration beyond a certain limit leads to greater competition between the dye molecules for the limited binding sites, so this leads to reduction in extent of biosorption. Namdhari *et al*., (2012) suggested that reduction in decolorization by living biomass may be due to toxic effect. In case of non viable biomass of *A. fumigatus* it may be due to desorption Kumar (2013) and Kalaiarasi et al., (2012).

(Bharathi and Ramesh, 2013; Mohammad Razi *et al*., 2017) reported that dye removal rate increase with an increase in contact time to a certain extent, it may be due to deposition of dyes on the available adsorption material, any further increase in contact time will not increase the uptake. Many studies as far as the effect of contact time have recorded that, initial uptake of dye was rapid but gradually slows down (Kabut and Taha, 2014). The situation is expected because a large number of vacant sites on the adsorbent surface are available at the initial stage (Uddin *et al*., 2002; Kalaiarasi *et al*., 2012). In case of living biomass, the increase in time of exposure to the toxic dye there may be decrease in metabolic activities. So that beyond a certain limit the efficiency of living biomass to adsorb the dye is expected to decrease.

Analysis of the result of the present study suggested that an increase in biosorbent dosage at a certain limit results in increased removal of dye. Salleh et al., (2011) supported the result of the present study. Most of the workers reported that the number of available biosorption sites increase with an increase in biosorbent concentration but further increase in dosage did not improve biosorption (Vasanthkumar *et al*., 2006; Kumar *et al*., 2006; Pipiska *et al*., 2017). Lin *et al*., (2013) believed that at high biosorbent concentration cause aggregation, overlapping and overcrowding on adsorbent particles so that the adsorption capacity is decreased. Kumar (2013) observed decreasing adsorption of basic fuchsin with increasing biomass dosage.

In the present study the maximum adsorption was found at initial dye concentration *i.e.* 250 ppm with 15 mg living biomass and 15 minutes of contact time (table-1). It may be due to at lower concentration, dye was less toxic to the living biomass. As biosorbent dosages (5 mg/100ml to 15 mg/100ml) increase, the dye removal rate increased because the amount of sorption sites at the surface of adsorbent will increase by increasing the dosage of adsorbent. Hassani *et al*., (2015) and Seow and Lim,(2016) reported that a relatively strong increase in adsorbent dosage resulted in the increase of the removal efficiencies of basic green 4 (BG4) and basic yellow 28 (BG28) dyes at initial dye concentration. They suggested that increasing dosage of adsorbent will provides more surface area, thereby leading to more binding sites for the adsorption of pollutants. In the present finding the percentage of decolorization increased with time of incubation.

The result are accordance with Pratiwi *et al*., (2017) they obtained that percentage of decolorization gradually increased with incubation time, up to a point till it reaches the equilibrium. Gopi *et al*., (2012) observed that, in case of living biomass further increase in time of incubation did not show any significant effect on degradation activity. This may be due to the accumulation of some toxic secondary metabolite which inhibits fungal growth and show negative effect on overall dye degradation Phatake *et al*., (2015).

At 500 ppm concentration, dead *A. fumigatus* biomass showed maximum adsorption (50.74%) at 10 mg biomass and 5 minutes of contact time (table-2). At 750 ppm concentration of basic fuchsin living biomass was more effective than the dead biomass with 5 mg biosorbent dosage and 15 minutes of time interval (table-3). In the present findings at both the increasing concentrations (*i.e.* 500 ppm and 750 ppm) decrease in dye biosorption was observed with both (living and dead) type of biomass in comparison to initial dye concentration (table-1). Rajasekhar (2014) also observed that at lower concentration the ratio of the initial number of dye molecules to the available surface area is low subsequently the functional adsorption becomes independent of initial concentration of initial concentration. At higher dye concentration the available sites of adsorption becomes fewer and the percentage removal of dye is dependent upon initial concentration. Amin, (2008) observed the effect of initial dye concentration on removing reactive orange dye where the percentage of removal was noticed to be decreased Mohammad Razi *et al*., (2017). In general, the increase in dye removal along with adsorbent dose increases because the amount of sorption site at the adsorbent surface will increase by increase of adsorbent dosage. But in the present study as the biosorbent dosage increase, the decolorization efficiency decreased which may be due to the overlapping, overcrowding and saturation of the biosorbent surface with the dye molecules (Das and Das, 2016). Dye removal rate increase with an increase in contact time to a certain extent but any further increase in contact time will not increase the uptake due to deposition of dyes on the available adsorption sites on adsorbent material (Bharathi *et al*., 2013; Mohammad Razi *et al*., 2017). In case of living biomass, increase in time of exposure to dye solution, the decrease in metabolic activities because dye toxicity causes reduction in biosorption (Gopi *et al*., 2012). Similar kinds of results were obtained by Al-Prol *et al*., 2017.

Results for dosage of biomass and contact period at 250, 500 and 750 ppm were analysed statistically (Anova). There is no significance in variance were observed at 500 and 750 ppm for both dosage of biomass and contact period. But at 250 ppm concentration there is a significance of difference in Q-Value were observed ($F = 37.057$) when contact period were taken into consideration.

CONCLUSION

Aspergillus fumigates effectively tolerate basic fuchsin dye at 250ppm concentration. Increase in dye concentration within the range of 500 to 750ppm resulted in gradual reduction in degradation process because at low dye concentration all the dye molecules present in the solution are able to interact with the binding sites. Biosorption is very helpful and cost effective process then other technologies. In future it might be helpful to remove pollution from water bodies without creating secondary pollution problem.

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REFERENCES

Al-Prol, A.E., El-Moselhy, K.M., Azzem Kamel, M.A., Amer, A. and Abdel-Moneim, M. (2017). Bioremediation of reactive blue 19 and reactive black 5 from aqueous solution by using fungi *Aspergillus niger*. *Int. J. Curr. Microbiol. App. Sci*. 3, 1676-1686.

Amin (2008). Removal of reactive dye from aqueous solutions by adsorption onto activated carbon prepared from sugarcane bagasse pith. *Desalination*. 223, 152-161.

Bharathi, K.S. and Ramesh, S.T. (2013). Removal of dyes using agricultural waste as low-cost adsorbents: a review. *Appl. Water Sci*. 3, 773-790.

Celekli A., Yavuzatmaca M. and Bozkurt, H. (2012). Binary adsorption of reactive red 120 and yellow 81 on *Spirogyra majuscule*. *Textile and Light Industrial Science and Technology*. 1, 29-36.

Crini (2006). Non-conventional low cost adsorbent for dye removal: a review. *Bioresource Technology*. 97, 1061-1085.

Das, S. and Das, N. (2016). Application of dried macrofungi for the removal of synthetic dyes from aqueous environment. *International Journal of Chem Tech Research*. 9, 312-318.

Delclos, K.B., Tarpley, W.G., Miller, E.C. and Miller, J.A. (1984). 4-Aminoazobenzene and N, N-dimethyl-4-aminoazobenzene as equipotent hepatic carcinogens in male C57BL/6XC3H/He F_1 mice and characterization of N-(deoxyguanosine-8-yl)-4-aminoazobenzene as the major persistent hepatic DNA-bound dye in these mice. *Cancer Ress* 44. 6, 2540-2550.

Dorthy, A.M., Sivaraj, R. and Venckatesh, R. (2012). Decolorization efficiencies of dyes and effluent by free and immobilized fungal isolates. *International Journal of Environment Science and Research*. 1, 109-113.

Ellouze, E., Ellouze, D., Jrad, A. and Ben Amar, B. (2011). Treatment of synthetic textile wastewater by combined chemical coagulation/ membrane process. *Desalination and Water Treatment*. 33, 118-124.

Eren, Z. and Acar, F.N. (2006). Adsorption of Reactive black 5 from an aqueous solution: equilibrium and kinetic studies. *Desalination*. 194, 1-10.

Fu, Y. and Viraraghavan, T. (2001). Fungal decolorization of dye waste water: a review. *Bioresour. Technol*. 79, 251-262.

Gadd (2009). Biosorption critical review of scientific rationale, environmental importance and significance for pollution treatment. *J Chem Technol Biotechnol*. 84, 13-28.

Gnanadoss, J.J., Peeris, S.M. and Jebapriya, G.R. (2013). Biological enhanced absorption of synthetic dyes using oyster mushroom fungus *Pleurotus ostreatus. Asian J. Exp. Biol. Sci.* 4, 637-640.

Gnanadoss, J.J., Peeris, S.M. and Jebapriya, G.R. (2013). Biologically enhanced absorption of synthetic dyes using Oyster Mushroom *Pleurotus ostreatus. Asian J. Exp. Biol. Sci.* 4, 637-640.

Gopi, V., Upgade, A. and Soundararajan, N. (2012). Bioremediation potential of individual and consortium non-adapted fungal strains on azo dye containing textile effluent. *Advances in Applied Science Research*. 3, 303-311.

Gupta, V.K., Khamparia, S., Tyagi, A., Jaspal, D. and Malviya, A. (2015). Decolorization of mixture of dyes: A critical review. *Global J. Environ. Sci. Manage*. 1, 71-94.

Hameed, B.H. and Al-Khaiary, M.I. (2008). Removal of basic dye from aqueous medium using noval agricultural waste material: Pumpkin seed hull. *Journal of Hazardous Materials*. 155, 601-609.

Hassani, A., Khataee, A., Karaca, S., Karaca, M. and Kiransan, M. (2015). Adsorption of two cationic textile dyes from water with modified nanoclay: A comparative study by using central composite design. *J. Environ. Chem. Eng*. 3, 2738-2749.

Jebapriya, G.R. and Gnanadoss, J.J. (2013). Bioremediation of textile dye using white rot fungi: A review. *Int J Cur Res Rev*. 5, 1-13.

Kalaiarasi, K., Lavanya, A., Amsamani, S. and Bagyalakshmi, G. (2012). Decolourization of textile dye effluent by non-viable biomass of *Aspergillus fumigates*. *Braz. Arch. Boil. Technol*. 55, 471-476.

Khataee, A.R. and Zarei, M. (2011). Photoelectrocatalytic decolorization of diazo dye by zinc oxide nanophotocatalyst and carbon nanotube based cathode: Determination of the degradation products. *Desalination*. 278, 117-125.

Kumar, P. and Charaya, M.U. (2013). A comparative assessment of the efficiencies of living vs dead biomass of *Aspergillus niger* link to adsorbe basic fuchsin from its aqueous solutions. *Plant Archives*. 13, 485-488.

Lakshmi, U.R., Srivastava, V.C., Mall, I.D. and Lataye, D.H. (2009). Rice husk ash as an effective adsorbent: Evaluation of adsorptive characteristics for Indigo Carmine dye. *Journal of Environmental Management*. 90, 710-720.

Mahmoodi, N.M., Arami, M. and Gharanjig, K. (2009). Laboratory studies and CFD modeling of photocatalytic degradation of colored textile waste water by titania nanoparticles. *Desalination and Water Treatment*. 1, 312-317.

McMullan, G., Meehan, C., Conneely, A., Kirby, N., Robinson, T., Nigam, P., Banta, I.M., Marchant, R. and Smyth, W.F. (2001). Microbial decolorization and degradation of textile dyes. *Appl. Microbial Biotechnol.* 56, 81-87.

Mohammad Razi, M.A., Mohd Hishammudin, M.N.A. and Hamdan, R. (2017). Factor affecting textile dye removal using adsorbent from activated carbon: A review. *ISCEE*. 103, 1-17.

Murali, K. and Uma, R.N. (2016). Removal of basic dye (methylene blue) using low cost biosorbent: water hyacinth. *International Journal of Advanced Engineering Technology*. 7, 386-391.

Namdhari, B.S., Rohilla, S.K., Salar, R.K., Gahlawat, S.K., Bansal, P. and Saran, A.K. (2012). Decolonization of reactive blue MR, using *Aspergillus* species isolated from textile waste water. *J. Boil. Sci.* 1, 24-29.

Nidheesh, P.V., Gandhimathi, R. and Ramesh, S.T. (2013). Degradation of dyes from aqueous solution by Fenton processes: A review. *Environmental Science and Pollution Research*. 20, 2099-2132.

O'Neil, C., Hawkes, F.R., Hawkes, D.L., Lourenco, N.D. and Pinheiro, H.M. (1999). Colour in textile effluents-sources measurement, discharge consents and simulation: a review. *J. Chem. Technol. Biotechnol* 74. 11, 1009-1018.

O'Neill, C., Hawkes, F.R., Lourenco, N.D., Pinheiro, H.M. and Delee, W. (1999). Color in textile effluents-source measurement discharge contents and simulation: a review. *J Chem Technol Biotechnol*. 74, 1009-1018.

Ogugube, C.J. and Sawidis, T. (2011). Bioremediation of detoxification of synthetic waste water containing triarylmethane dyes by *Aeromonas hydrophila* isolated from industrial effluent. *Biotechnol. Res. Inter.* 42, 17-27.

Omar (2016). Decolorization of different textile dyes by isolated *Aspergillus niger. Journal of Environmental Science and Technology*. 9, 149-156.

Ozdemir, G., Ozturk, T., Ceyhan, N., Isler, R. and Cosar, T. (2003). Heavy metal biosorption by biomass of *Ochrobactrum anthropi* producing exopolys accharide in activated sludge. *Bioresource Technology*. 90, 71-74.

Ozsoy, D., Halil Kumbur, H., Saha, B. and Hans Van Leeuwen, J. (2008). Use of *Rhizopus oligosporus* produced from food processing wastewater as a biosorbent for Cu (II) ions removal from the aqueous solutions. *Bioresource Technology*. 99, 4943-4948.

Padmesh, T.V.N., Vijayaraghavan, K., Sekaran, G. and Vela, M. (2006). Biosorption of acid blue 15 using fresh water macroalga *Azolla filiculoides:* batch and column studies. *Dye and Pigments*. 71, 77-82.

Patel (2016). Review on biosorption of dyes by fungi. *International Journal of Innovative Research in Science, Engineering and Technology*. 5, 1115-1118.

Pathak, R.K. and Dikshit, A.K. (2011). Isolation and characterization of bacterial strains to be used as biosorbent for removal of atrazine from waste water. *Asian Journal of Microbiology, Biotechnology and Environmental Science*. 13, 137-142.

Pathak, R.K. and Dikshit, A.K. (2012). Effect of Various Environmental Parameters on Biosorptive Removal of Atrazine from Water Environment. *International Journal of Environment Science and Development*. 3, 289-293.

Phatake, Y.B., Marathe, R.J. and Shejul, M.S. (2015). Use of fungal isolated from textile effluent for degradation of synthetic dyes and optimization of degradation process. *Global Journan of Bio-Science and Biotechnology*. 3, 314-319.

Pipiska, M., Valica, M., Partilava, D., Hornic, M., Lesny, J. and Hostin, S. (2017). Removal of synthetic dyes by dried biomass of fresh water moss *Vesicularia dubyana*: A batch biosorption study. *Environments*.

Pratiwi, D., Indrianingsin, A.W. and Darsih C. Hernawan (2017). Decolorization and degradation of basic dye effluent using *Ganoderma lucidum. Earth and Environmental Science*. 101, 1-8.

Rajasekhar (2014). Removal of malachite green from aqueous solution using corn cob as adsorbent. *International Journal of Engineering and Computer Science*. 3, 5083-5087.

Ramesh, S.T., Gandhimathi, R., Elavarasi, T.E., Isaithamizh, R., Sowmya, K. and Ndheesh, P.V. (2013). Comparision of methylene blue adsorption from aqueous solution using spent tea dust and raw coir pith. *Global Nest Journal*. 16, 146-159.

Revankar, M.S. and Lele, S.S. (2007). Synthetic dye decolorization by white rot fungus, *Ganoderma* sp. WR-1. *Bioresource Technology*. 98, 775-780.

Rjabi, M., Bagheri Roochi, M. and Asghari, A. (2011). Effect of electrolyte nature on kinetics of remazol yellow G removal by electrocoagulation. *Russian Journal of Physical Chemistry A*. 85, 1820-1824.

Robinson, T., McMullan, G., Marchant, R. and Nigam, P. (2001). Remediation of dyes in textile effluent: A critical review on current treatment technologies with a proposed alternative. *Biores Technol*. 77, 247-255.

Salleh, M.A.M., Mahmoud, D.K., Karim, W.A. and Idris, A. (2011). Cationic and anionic dye adsorption by agricultural solid wastes: A comprehensive review. *Desalination*. 280, 1-13.

Seow, T.W. and Lim, C.K. (2016). Removal of dye by adsorption: A review. *International Journal of Applied Engineering Research*. 2675-2679.

Sing (2017). Biodegradation of synthetic dyes: A mycoremediation approach for degradation/ decolourization of textile dyes and effluents. *Journal of Applied Biotechnology and Bioengineering*. 5, 1-7.

Vasanthkumar, K., Ramamurthy, V. and Sivanesan, S. (2006). Biosorption of malachite green, a cationic dye on to *Pithophor* sp. a fresh water algae. *Dyes Pigments*. 69, 102-7.

Yagub, M.T., Sen, T.K. and Ang, H. (2012). Equilibrium, kinetics and thermodynamics of methylene blue adsorption by pine tree leaves. *Water Air Soil Pollut*. 223, 5267-5282.

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