RESEARCH ARTICLE

RETRACTED: Optimization of conditions for the biological treatment of textile dyes using isolated soil bacteria [version 1; peer review: retracted]

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Retraction

The article titled "Optimization of conditions for the biological treatment of textile dyes using isolated soil bacteria" ([version 1; referees: peer review discontinued]. F1000Research 2018, 7:351

<https://doi.org/10.12688/f1000research.13757.1>) by Shafkat Shamim Rahman and colleagues, has been retracted by F1000Research on grounds of misconduct by the first author. Following publication of the article, the editorial team at F1000Research were notified by Romana Siddique, from BRAC University, that the data presented in this paper significantly overlaps with the data in her recently published article : Siddique and Alif; ARRB, 22(5): 1-12, 2018; Article no.ARRB.38637;

<https://doi.org/10.9734/ARRB/2018/38637>.

In response to our queries to the authors, the second and last author listed on this article, Fahim Ahmed Alif and M. Mahboob Hossain, have stated that they were not aware of the submission of this article to F1000Research, and did not agree to be authors. We have evidence which confirms their statement.

After further investigation by the F1000Research team, and a separate investigation by BRAC University, it has become clear that Shafkat Shamim Rahman was not involved with the research presented in this paper, and that the decision to submit and publish the article was taken independently by him, and not his listed co-authors. BRAC University has confirmed that Shafkat Shamim Rahman is not currently based at their institution.

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Abstract

Background: In the 21st century, environmental pollution has been acknowledged as one of the major problems. The textile and dyeing industries contribute a major portion by discharging intensely complex effluent consisting of highly noxious azoic dyes.

Methods: In this study, biological treatment using acclimatized microorganisms were employed in search of a cheap and eco-friendly substitute for color removal from textile waste. The microbial inocula were isolated from effluent soil samples and then applied to flasks containing azo dyes as the only source of carbon for decolorization.

Results: Biochemical tests postulated predominance of *Enterococcus* and *Bacillus* bacterial strains. CO isolate or *Bacillus farraginis* emerged as the best decolorizer of Orange M2R dye, decolorizing 98% of the dye. BG isolate or *Paenibacillus macerans* showed maximum decolorization on Green GS dye that decolorized 97% of the dye. The optimum physiochemical condition for decolorization of OM2R and GGS dye was pH 7.0, 2% NaCl conc., 1% initial dye conc. and 37°C temperature by the selected isolates.

Conclusions: The findings were validated and have the potential for bioremediation in textile waste effluent treatment plants.

Keywords

Azo dye; decolorization; *Enterococcus*; *Bacillus*; optimization

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23rd May 2018 : Significant concerns have been raised about the overlap in the data presented in this paper, and that of another recently published article [Siddique and Alif; ARRB, 22(5): 1-12, 2018; Article no.ARRB.38637; <https://doi.org/10.9734/ARRB/2018/38637>]. In addition, the second and last author listed on this article, Fahim Ahmed Alif and M. Mahboob Hossain have stated that they were not aware of the submission of this article to F1000Research, and did not agree to be authors. We are currently investigating this and have suspended all peer review activity in the meantime.

RETRACTED

Abbreviations

OM2R - Orange M2R; GGS - Green GS; NaCl - sodium chloride; NaOCl - sodium hypochlorite; WAO - wet air oxidation; SM - salt media; NA - nutrient agar; O.D. - optical density; MR - methyl red; VP - Voges Proskauer; MIU - Motility Indole Urease Test; ml - milliliter; g/L - gram per liter.

Introduction

Industrialization has expanded in every corner of the globe in the 21st century and the textile industry has emerged as a leading sector. It uses thousands of tons of synthetic dyes (azo) annually¹. A large portion of those goes into water bodies untreated². Carcinogenic and recalcitrant molecules present in the dye penetrate into the ecosystem and harm every member of the system³. Humans use the polluted water directly for daily necessities which may result in diseases such as cancer, new genetic mutations or changes in the DNA etc. becoming an epidemic.

The textile industry in Bangladesh accounts for 45% of all industrial employment and contributes 5% to the total national income⁴. The industry employs nearly 4 million people, mostly women⁵. Despite the significant economic contribution, it has brought with it a range of environmental problems, mostly pollution of water resources. The textile industry consumes large quantities of water for various processes and discharges equally large volumes of wastewaters containing a variety of pollutants and coloring agents such as the azo dye^{6,7}.

It is estimated that over 2,80,000 tons of textile dyes are discharged in industrial effluent every year worldwide. Therefore, pollution from these discharges contaminated with dyestuff is becoming alarming^{8,9}. This sector is placed as a major source of water pollution in Bangladesh¹⁰.

Textile wastewater is highly colored, resulting in the blocking of the majority of sunlight, thereby hindering the growth of aquatic animals and plants; it also contains the dissolved toxic substance and carcinogens^{11,12}. The serious damage of pollution is caused mainly due to the durability of the dyes in wastewater¹³. Azo dyes are widely known coloring agents used in industries and hence commonly released in the environment¹⁴. The dye wastewaters are extremely toxic to both aquatic fauna and flora, crop plants, and human beings¹⁵.

At present, there are several techniques that can be employed in dye removal from effluents. However, these methods are varied in efficiency due to the variety of existent dyes and to the effluents complexity, and the combination of various methods may be considered since each method showed its limitations. There are three categories of existing methods: physical, chemical and biological. Physical methods like Coagulation/Flocculation, Adsorption, Membrane filtration, and Ion exchange are expensive. Chemical methods like Fenton's reagent, Ozone, Photochemical, Sodium hypochlorite (NaOCl), Electrolysis and wet air oxidation are not cost effective and produce toxic byproduct.

Biological treatment, in the form of bacterial degradation, has been mainly applied in the removal of azo dyes^{16,17}, which generally is resistant to aerobic degradation^{18,19}. However, its degradation was observed in anaerobic conditions, but aromatic amines are formed as a final product, which can be toxic, mutagenic and carcinogenic²⁰. Under these anaerobic conditions, it is not possible to degrade the aromatic amines formed, which in turn are only degraded in an aerobic environment. Thus, to achieve a complete degradation of azo dyes, a method that combines anaerobic treatment of the dyes with the mineralization of aromatic amines under aerobic conditions should be applied^{21,22}. This research aimed to identify effective dye degrading bacteria from effluent soil samples and optimize the physiochemical condition for their optimum growth²³.

Methods

Soil sample and azo dye collection

Four soil samples (A: 23°55'2.6"N, 90°15'32.6"E; B: 23°47'41"N, 90°55'34.1"E; C: 23°46'54.0"N, 90°20'05.3"E; D: 23°56'52.8"N, 90°00'01.2"E) were aseptically collected from the effluent disposal area, in Savar, Hemayetpur and Arambazar in June 2015. Sterile plastic containers were used to carry the soil samples. The samples were stored at Microbiology and Biotechnology Research Laboratory under Dpt. of MNS, BUET University in sterile plastic bags at 4°C (to keep the microorganisms viable for later use²⁴). Commercially available azo dyes (Meera Dyestuff Industries, India) were collected from Mitford market in Dhaka.

Inoculation in dye-containing media, isolation and screening

One gram of each of the soil (effluent) samples (A, B, C, D) were taken to prepare a homogenous suspension. The suspension of each sample was individually applied to sixteen 1% dye containing (eight Orange M2R - OM2R and eight Green GS - GGS) SM broth media (glucose - 10 g/L; #G8270, dipotassium phosphate - 0.6 g/L; #1551128 USP, peptone - 10 g/L; #P7750, monopotassium phosphate - 1.9 g/L; #1551139 USP, magnesium sulfate - 1 g/L; #M2643, yeast extract - 1 g/L; #Y1625, pH: 6.0 - 6.4; Sigma Aldrich, St Louis, MO, USA) to detect the dye degrading capability. 1% solution of OM2R and GGS was made by adding 0.5g of dye into the 50ml distilled water. After 5 days, each conical flask was compared with the control and decolorization was observed. As each of the samples (A, B, C and D) contained a highly concentrated mixture of different types of microorganism, up to 10⁻⁴ and 10⁻⁵ dilutions were performed, and spread plate technique applied on NA plates followed by incubation for 24 hours at 37°C to obtain eight soil isolates (AO, BO, CO, DO, AG, BG, CG, DG). Selected isolates, based on morphology, were enriched in NA media and incubated for 24 hours at 37°C. The plates were sealed, refrigerated at 4°C and were frequently subcultured.

Media optimization

Optimum growth conditions for the isolates were identified applying different physiochemical state (dye concentration, pH, NaCl concentration, temperature) to the time of growth. The

best four selected isolates were cultured in 50 ml SM broth with three different dye concentrations of 1%, 3% and 5%; for pH (5 to 8; adjusted by adding drops of basic NaOH or acidic diluted HCl in the solution) (Model: E-201-C, China), for NaCl tolerance (added 2%, 4%, 6% and 8% concentrated Sigma brand solution to the broth and incubated), and for temperature (30°C, 37°C, 45°C and 55°C) and incubated (Model: SAARC) at 37°C (except temperature parameter) for a period of 5 days with corresponding dye OM2R and GGS. Then, O.D. was measured by adjusting the wavelength at 590nm for OM2R and 510nm for GGS (Model: UV-VIS spectrophotometer UVmini-1240; Shimadzu, Kyoto, Japan). Each experiment was repeated to validate the results. The representative data is the average of all results.

Decolorization was measured by - Decolorization (%) = $\left\{ \frac{(\text{Initial O.D.} - \text{Final O.D.})}{\text{Initial O.D.}} \right\} \times 100$

Biochemical characterization

Gram staining and biochemical tests were performed on the bacterial isolates according to the Microbiology Laboratory Manual²⁵. Standard protocols were followed by gram staining and then the dried slides were observed under a microscope. **Motility tests**, enzyme tests (indole utilization, urease test, citrate utilization, oxidase test, catalase test, starch hydrolysis, nitrate reduction), fermentation tests (carbohydrate fermentation, methyl red test, Voges-Proskauer test, arabinose test, fructose test, galactose test, glucose test, lactose test, maltose test, mannitol test, sucrose test, trehalose test) and salt tolerance tests²⁶ were conducted according to individual standard protocols.

Results

Four isolates AO, BO, CO and DO were collected from effluent soil samples preliminarily inoculated for 5 days in SM broth containing 1% OM2R azo dye at room temperature. AO decolorized the dye. CO and AO isolates showed the highest decolorization rate (99% and 93%) and were selected for further optimization. The other two isolates performed moderately. For 1% GGS dye degradation BG (93%) and CG (94%) isolates were better than AG and DG. (Table 1).

Dye concentration optimization

After five days of reaction, CO isolate achieved 98% decolorization in SM broth containing 1% OM2R dye. The same rates

were also observed in 3% dye concentration. AO lagged in all three (1%, 3% and 5%) reactions. Degradation rate gradually decreased at higher concentration dye-containing media. Intriguingly, CG isolates resulted in 93% decolorization for both 1% and 3% dye concentration.

In GGS dye-containing media, 97%, 94% and 81% decolorization were achieved with the BG isolate in 1%, 3% and 5% dye concentration media respectively. CG isolates demonstrated a lesser rate in all three parameters (Table 2; Dataset 1²⁷). pH optimization showed, highest rate (90%) in pH 7 by AO isolate in OM2R dye and 92% by BG isolate in the same parameter. AO isolate also showed a slightly higher response in 2% NaCl media compared to CO. BG isolate resulted in gradually reduced rates of decolorization (90%, 6% and 8% NaCl containing media. For GGS dye, BG isolate was superior to all other isolates achieving 89% decolorization in 2% NaCl. The optimum temperature was 37°C in all four isolates. AO achieved 93% decolorization and BG 90% in two different dye-containing media. The decolorization rate gradually decreased with temperature elevation (Table 3; Dataset 2²⁸). In summary, 1% dye concentration, pH 7, 2% NaCl and 37°C appeared to be the optimum physiochemical condition for dye decolorization.

Biochemical test results

AO, CO and CG isolates were gram -ve rod and AG and BG were +ve rod bacteria. BO and DO isolates were gram -ve cocci and DG was +ve coccoid. Other biochemical results (Table 4) also showed all the isolates were catalase, oxidase, nitrate and aerobic growth positive. All were capable of tolerating 6.5% NaCl in media and withstand 45°C. All recorded negative results for urease, citrate, VP, starch hydrolysis and 10%, 15% NaCl tolerance. Motility, Indole, MR, Casein hydrolysis, 7% NaCl soln. tolerance, carbohydrate tests produced mixed results (A mixture of positive and negative results, which indicated the disparity of a wide range of characteristics in these primarily unidentified organisms) (Table 4). Finally, software analysis using ABIS (Version: July 29, 2015) based on morphology characteristics and biochemical tests postulated AO as *Enterococcus termitis*, BO as *Enterococcus camelliae*, CO as *Bacillus farraginis*, AG as *Bacillus muralis*, BG as *Paenibacillus macerans*, CG as *Bacillus decolorationis* and DG as *Macroccoccus brunensis*. DO isolate remain unidentified.

Table 1. Results of O.D. at fifth day after de-colorization of 1% concentration dye in SM broth at room temperature.

	1 st O.D.	2 nd O.D.	Avg. O.D.	De-colorization (%)
Control	0	0	0	
AO	0.009	0.007	0.008	93
BO	0.025	0.037	0.031	74
CO	0.001	0.001	0.001	99
DO	0.025	0.021	0.023	81
AG	0.021	0.013	0.017	89
BG	0.009	0.013	0.011	93
CG	0.009	0.009	0.009	94
DG	0.043	0.033	0.038	76

Table 2. Results of O.D. & de-colorization (%) with different concentrations of dye.

	O.D. & De-colorization (%) in 1% conc.					O.D. & De-colorization (%) in 3% conc.					O.D. & De-colorization (%) in 5% conc.				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AO	0.031	74	0.025	79	0.019	84	0.013	89	0.009	93	0.041	74	0.036	74	0.024
CO	0.020	83	0.011	90	0.009	93	0.007	94	0.003	98	0.038	88	0.032	84	0.015
BG	0.025	85	0.018	89	0.013	92	0.009	95	0.005	97	0.031	83	0.025	83	0.019
CG	0.033	80	0.026	85	0.019	89	0.015	91	0.011	93	0.042	76	0.030	86	0.017

Table 3. Results of O.D. & de-colorization (%) with different parameters at pH 5.

	pH 5	pH 6	pH 7	pH 8	2% NaCl	4% NaCl	6% NaCl	8% NaCl	30°C	37°C	45°C	55°C												
Control	0	0	0	0	0	0	0	0	0	0	0	0												
AO	0.031	77	0.040	73	0.018	90	0.051	59	0.031	81	0.054	60	0.043	0.075	37	0.024	82	0.008	93	0.040	72	0.053	59	
CO	0.034	75	0.038	74	0.020	89	0.059	52	0.049	71	0.057	58	0.076	40	0.079	34	0.022	86	0.010	92	0.025	82	0.055	57
BG	0.042	80	0.055	85	0.051	92	0.089	73	0.019	89	0.045	72	0.070	62	0.099	40	0.031	86	0.025	90	0.035	84	0.075	58
CG	0.044	79	0.061	83	0.080	88	0.098	70	0.035	81	0.058	65	0.086	54	0.104	36	0.045	79	0.028	89	0.049	77	0.093	45

Table 4. Results of biochemical and sugar tests of the isolates collected from Nutrient agar.

Isolate no	Sample Isolate Name	Gram stain		MIU		Carbohydrate										Casein hydrolysis	Nitrate Reduction	Starch Hydrolysis	45° C	6.5% NaCl soln.	7% NaCl soln.	10% NaCl soln.	15% NaCl soln.	Aerobic Growth	Presumptive Organism
		Shape	+/	Motility	Indole	Urease	Glucose	Fructose	Sucrose	Galactose	Lactose	Mannitol	Maltose	Trehalose	Arabinose	Catalase	Oxidase	Sitons Citrate	MR	VP					
1.	AO	rod	-	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	+	+	+	-	+	+	<i>Enterococcus termitis</i>
2.	BO	cocci	-	-	-	-	+	-	+	-	-	-	+	+	+	+	-	-	-	-	-	-	+	+	<i>Enterococcus camelliae</i>
3.	CO	rod	-	-	-	-	-	-	-	+	-	-	-	+	-	+	+	-	-	+	+	-	+	+	<i>Bacillus farraginis</i>
4.	DO	cocci	-	-	-	-	-	+	-	+	+	-	-	-	+	+	+	+	+	+	+	-	+	+	<i>Unknown taxon</i>
5.	AG	rod	+	-	+	-	+	-	-	+	+	-	-	-	+	+	+	-	-	+	+	-	+	+	<i>Bacillus muralis</i>
6.	BG	rod	+	-	-	-	+	+	+	-	+	+	+	+	+	+	+	-	+	+	+	-	+	+	<i>Paenibacillus macerans</i>
7.	CG	rod	-	+	-	-	+	+	+	+	-	+	+	+	-	+	+	-	+	+	+	-	+	+	<i>Bacillus decolorationis</i>
8.	DG	cocci	+	-	-	-	+	+	-	+	-	+	+	+	-	+	+	-	-	-	+	-	+	+	<i>Macroccoccus brunensis</i>

+ = Positive reaction; - = Negative reaction

Dataset 1. Results of optical density (O.D) & de-colorization (%) with different concentrations of dye. Average O.D. calculated from 1st and 2nd O.D

<http://dx.doi.org/10.5256/f1000research.13757.d198164>

Dataset 2. Results of optical density (O.D) & de-colorization (%) with different parameters at day 5. Average O.D. calculated from 1st and 2nd O.D

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Discussion

Most of the isolates from the different soil samples were identified as *Bacillus* species. Dye decolorizing ability of isolates was investigated independently. CO (*B. farraginis*) showed the highest dye decolorization capacity (98%) in SM broth media containing 1% OM2R dye for 5 days at 37°C. However, as the concentration of dye increased up to 3% and 5% the decolorization rate decreased to 94% and 90% respectively, because of the intensity of azo dyes. On GGS dye degradation BG (*P. macerans*) showed 97% decolorization. This was similarly effective at 3% dye concentration (94%), however, the rate was found to slump at 5% dye concentration (81%).

pH is one of the important abiotic factors that affect the growth and metabolic homeostasis. The effect was studied at different pH values (5 – 8). At pH 7.0 AO (*E. termitis*) gave maximum decolorization (90%). A similar rate was observed at pH range of 5.0 and 6.0, with a swift reduction (80%) observed at pH 8 by AO (*E. termitis*). These results suggest that acidic pH values may influence the activity of the enzyme causing denaturation. Chang *et al.* (2001)¹⁴ found that azo reductase performance was affected by pH, with 5 times better dye reduction at pH 7.5 than below pH 6. These findings corresponded well to the best decolorization found between pH 7 - 9.5²⁹.

In the case of GGS, the maximum decolorization rate was attained at pH 7 by BG (*P. macerans*) at 92%. The majority of the azo dye reducing bacterial species reported so far were able to grow at pH near 7^{30–32}. The requirement of near neutral pH for optimum growth had been reported in several studies^{33–35}. Results indicate that a pH increase from 5.0 to 7.0 enhanced the decolorization of GGS dyes. At pH 5 the decolorization rate was 80% of dye by BG (*P. macerans*). A small increase was observed at pH 6 (85%) with an abrupt decrease at pH 8.0 (73%). It was observed that better decolorization rates were around pH 6 - 7 bands for both of OM2R and GGS dye by the selected isolates.

Decolorization percentage of OM2R by selected isolates was found to vary with different concentration (2 - 8 g/L) of NaCl when studied for 120 hours at 37°C. Maximum decolorization of OM2R by AO (*E. termitis*) was observed as 81% at 2% NaCl, but the percentage decolorization was found to decrease with increases of NaCl concentration (Table 3; Dataset 2²⁸). The decolorization attained by AO (*E. termitis*) at 37°C for 4%, 6% and 8% NaCl was 60%, 43% and 37%. Kargi and Dincer (1996)³⁶ mention that high salt concentrations (1% salt) are known to cause plasmolysis and/or loss of cell activity.

Similarly, at 2% NaCl concentration the decolorization percentage of GGS dye was 59% by BG (*P. macerans*). The decolorization attained by BG (*P. macerans*) at 37°C for 4%, 6% and 8% NaCl was 72%, 60%, and 40% (Table 3; Dataset 2²⁸).

To determine the optimum temperature for dye decolorization a temperature range of 30°C – 55°C was examined. As seen in Table 3 the optimum temperature for OM2R dye decolorization was 37°C as the AO (*E. termitis*) attained a maximum decolorization of 85%. Angelova *et al.* (2008)³⁷ found that the azo dye reduction rate rose with an increased temperature, with a maximum rate of around 40°C, 3–5 times faster than at 30°C. At 30°C and 45°C the degradation rate for OM2R by AO *E. termitis* was 82% and 72% of dye. A low decolorization of 59% of the dye was detected at 55°C by AO (*E. termitis*) isolate. Temperatures above 55°C were not studied since results shown that the increase from 37°C to 45°C promoted a marginal decrease in dye decolorization (Table 3; Dataset 2²⁸).

The optimum temperature for GGS dye decolorization was 37°C for the BG isolate (*P. macerans*), attaining a maximum decolorization of 90% of dye. In the case of BG, at 30°C and 45°C the decolorization percentage was 86% and 84% of dye respectively. No improvement in dye decolorization was observed at temperatures above 45°C, with low decolorization of 58% and 45% of dye detected at 55°C by BG (*P. macerans*) isolate as evident from Table 3. BG (*P. macerans*) has a broad range of compatibility from 30°C to 45°C. Within the optimal values of temperature, the lowest temperature was selected as the optimum temperature since this leads to lower energy costs.

Conclusion

Traditional wastewater treatment is inefficient and remains a threat to environment³⁸. Biotreatment offers an easy, cheap and effective alternative for color removal of textile dyes³⁹. Hence, economic and eco-friendly techniques using bacteria can be an alternative method. The present study strongly concluded that

the bacterial isolates *E. termitis*, *E. camelliae*, *B. decolorationis*, *P. macerans* species were a good microbial source for textile effluent treatment, in biological degradation of textile dye. However, decolorization potential of the isolates needs to be validated by demonstration in appropriate bioreactors before its application.

Data availability

Dataset 1: Results of optical density (O.D) & de-colorization (%) with different concentrations of dye. Average O.D. calculated from 1st and 2nd O.D. [10.5256/f1000research.13757.d198164](https://doi.org/10.5256/f1000research.13757.d198164)²⁷

Dataset 2: Results of optical density (O.D) & de-colorization (%) with different parameters at day 5. Average O.D. calculated from 1st and 2nd O.D. [10.5256/f1000research.13757.d198165](https://doi.org/10.5256/f1000research.13757.d198165)²⁸

Competing interests

No competing interests were disclosed.

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References

- Saroj S, Kumar K, Pareek N, et al.: **Biodegradation of azo dyes acid red 183, direct blue 15 and direct red 75 by the isolate *Penicillium oxalicum* SAR-3**. *Chemosphere*. 2014; **107**: 240–248. [PubMed Abstract](#) | [Publisher Full Text](#)
- Sultana MS, Islam MS, Saha R, et al.: **Impact of the effluents of textile dyeing industries on the surface water quality inside D.N.D embankment, Narayanganj**. *Bangladesh Journal of Scientific and Industrial Research*. 2009; **44**(1): 65–80. [Publisher Full Text](#)
- Maiti S, Sinha SS, Singh M: **Microbial decolorization and detoxification of emerging environmental pollutant: cosmetic hair dyes**. *J Hazard Mater*. 2017; **338**: 356–363. [PubMed Abstract](#) | [Publisher Full Text](#)
- Keane J, de Velde DW: **The role of textile and clothing industries in growth and development strategies (PDF)** (Report). Investment and Growth Programme Overseas Development Institute (ODI). Accessed 9 October 2017. [Reference Source](#)
- Uddin MN: **Role of Ready-Made Garment Sector in Economic Development of Bangladesh**. *Journal of Accounting, Business & Management*. 2014; **21**(2): 54–70. [Reference Source](#)
- Kabir ES, Kabir M, Islam MM, et al.: **Assessment of effluent quality of Dhaka export processing zone with special emphasis to the textile and dyeing industries**. *Jahangirnagar Uni J Sci*. 2002; **25**: 137–8. [Reference Source](#)
- Parvin F, Rahman MM, Islam MM, et al.: **Isolation of Mixed Bacterial Culture from Rajshahi Industrial Zone and Their Efficiency in Azo Dye Decolorization**. *Indian Journal of Science and Technology*. 2015; **8**(10): 950–957. [Publisher Full Text](#)
- Reddy A, Singh S, Tyengar L: **Bacterial decolorization and degradation of azo dyes**. *Int Biodeterior*. 2007; **59**(2): 73–84. [Publisher Full Text](#)
- Jin X, Li SQ, Xu ZH, et al.: **Decolorization of a dye industry effluent by *Aspergillus fumigatus* XC6**. *Appl Microbiol Biotechnol*. 2007; **74**(1): 239–243. [PubMed Abstract](#) | [Publisher Full Text](#)
- Belal AR, Cooper JM, Khan NA: **Corporate environmental responsibility and accountability: What chance in vulnerable Bangladesh?** *Crit Perspect Account*. 2015; **33**: 44–58. [Publisher Full Text](#)
- Walsh GE, Bahner LH, Horning WB: **Toxicity of textile mill effluent to freshwater and estuarine algae, crustaceans and fishes**. *Environ Pollut*. 1980; **21**(3): 169–179. [Publisher Full Text](#)
- Chung KT, Stevens SE Jr, Cerniglia CE: **The reduction of azo dyes by the intestinal microflora**. *Crit Rev Microbiol*. 1992; **18**(3): 175–90. [PubMed Abstract](#) | [Publisher Full Text](#)
- Jadhav JP, Parshetti GK, Kalme SD, et al.: **Decolorization of azo dye methyl red by *Saccharomyces cerevisiae* MTCC 463**. *Chemosphere*. 2007; **68**(2): 394–400. [PubMed Abstract](#) | [Publisher Full Text](#)
- Chang JS, Chou CH, Yen YC, et al.: **Kinetic characteristics of bacterial azo-dye decolorization by *Pseudomonas luteola***. *Water Res*. 2001; **35**(12): 2841–2847. [PubMed Abstract](#) | [Publisher Full Text](#)
- Sharma KP, Sharma K, Bhardwaj SM, et al.: **Environmental Impact Assessment of the printing industries in Sanganer, Jaipur: A case study**. *J Indian Bot Soc*. 1999; **78**: 71–85. [Reference Source](#)
- Singh PK, Singh RL: **Bio-removal of Azo Dyes: A Review**. *International Journal of Applied Sciences and Biotechnology*. 2017; **5**(2): 108–126. [Publisher Full Text](#)
- Wang H, Zheng XW, Su JQ, et al.: **Biological decolorization of the reactive dyes Reactive Black 5 by a novel isolated bacterial strain *Enterobacter* sp. EC3**. *J Hazard Mater*. 2009; **171**(1–3): 654–659. [PubMed Abstract](#) | [Publisher Full Text](#)
- Prasad SS, Aikat K: **Study of bio-degradation and bio-decolourization of azo dye by *Enterobacter* sp. SXCR**. *Environ Technol*. 2014; **35**(5–8): 956–965. [PubMed Abstract](#) | [Publisher Full Text](#)
- Coughlin MF, Kinkle BK, Tepper A, et al.: **Characterization of aerobic azo dye-degrading bacteria and their activity in biofilms**. *Water Sci Technol*. 1997; **36**(1): 215–20. [Publisher Full Text](#)
- Isik M, Sponza DT: **Fate and toxicity of azo dye metabolites under batch long-term anaerobic incubations**. *Enzyme Microb Technol*. 2007; **40**(4): 934–939. [Publisher Full Text](#)
- Carvalho MC, Pereira C, Gonçalves IC, et al.: **Assessment of the biodegradability of a monosulfonated azo dye and aromatic amines**. *Int Biodeterior Biodegradation*. 2008; **62**(2): 96–103. [Publisher Full Text](#)
- Lin J, Zhang X, Li Z, et al.: **Biodegradation of Reactive blue 13 in a two-stage anaerobic/aerobic fluidized beds system with a *Pseudomonas* sp. isolate**. *Bioresour Technol*. 2010; **101**(1): 34–40. [PubMed Abstract](#) | [Publisher Full Text](#)
- Solis M, Solis A, Pérez HI, et al.: **Microbial decolouration of azo dyes: a review**. *Process Biochemistry*. 2012; **47**(12): 1723–1748. [Publisher Full Text](#)
- Islam ST, Lam JS: **Wzx flippase-mediated membrane translocation of sugar polymer precursors in bacteria**. *Environ Microbiol*. 2013; **15**(4): 1001–1015. [PubMed Abstract](#) | [Publisher Full Text](#)
- Cappuccino JG, Sherman N: **Microbiology: A Laboratory Manual**. Benjamin Cummings New York, Science. 2005. [Reference Source](#)
- Nasir A, Rahman SS, Hossain MM, et al.: **Isolation of *Saccharomyces Cerevisiae* from Pineapple and Orange and Study of Metal's Effectiveness on Ethanol Production**. *Eur J Microbiol Immunol (Bp)*. 2017; **7**(1): 76–91. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Rahman SS, Alif FA, Hossain M: **Dataset 1 in: Optimization of conditions**

- for the biological treatment of textile dyes using isolated soil bacteria. *F1000Research*. 2018.
[Data Source](#)
28. Rahman SS, Alif FA, Hossain M: **Dataset 2 in: Optimization of conditions for the biological treatment of textile dyes using isolated soil bacteria.** *F1000Research*. 2018.
[Data Source](#)
 29. Saratale RG, Saratale GD, Chang JS, *et al.*: **Bacterial decolorization and degradation of azo dyes: A review.** *J Taiwan Inst Chem Eng*. 2011; **42**(1): 138–157.
[Publisher Full Text](#)
 30. Chang JS, Lin CY: **Decolorization kinetics of a Recombinant *Escherichia coli* strain harboring azo dye decolorizing determinants from *Rhodococcus* sp.** *Biotechnol Lett*. 2001; **23**(8): 631–636.
[Publisher Full Text](#)
 31. Kalme S, Ghodake G, Gowindwar S: **Red HE7B degradation using desulfonation by *Pseudomonas desmolyticum* NCIM 2112.** *Int Biodeter Biodegr*. 2007; **60**(4): 327–333.
[Publisher Full Text](#)
 32. Suzuki T, Timofei S, Kurunczi L, *et al.*: **Correlation of aerobic biodegradability of sulfonated azo dyes with the chemical structure.** *Chemosphere*. 2001; **45**(1): 1–9.
[PubMed Abstract](#) | [Publisher Full Text](#)
 33. Espeche ME, MacCormack WP, Fraile ER: **Factors affecting growth of an *n*-hexadecane degrader *Acinetobacter* species isolated from a highly polluted urban river.** *Int Biodeterior Biodegradation*. 1994; **33**(2): 187–196.
[Publisher Full Text](#)
 34. Kwapisz E, Wszelaka J, Marchut O, *et al.*: **The effect of nitrate and ammonium ions on kinetics of diesel oil degradation by *Gordonia alkanivorans* S7.** *Int Biodeterior Biodegradation*. 2008; **61**(3): 214–222.
[Publisher Full Text](#)
 35. Shukor MY, Dahalan FA, Jusoh AZ, *et al.*: **Characterization of a diesel-degrading strain isolated from a hydrocarbon-contaminated site.** *J Environ Biol*. 2009; **30**(1): 145–150.
[PubMed Abstract](#)
 36. Kargi F, Dincer AR: **Effect of salt concentration on bioreactor treatment of saline wastewater by fed-batch operation.** *Enzym Microb Technol*. 1996; **19**(7): 529–537.
[Publisher Full Text](#)
 37. Angelova B, Avramova T, Stefanova L, *et al.*: **Temperature effect on bacterial azo bond reduction kinetics: an Arrhenius plot analysis.** *Biodegradation*. 2008; **19**(3): 387–393.
[PubMed Abstract](#) | [Publisher Full Text](#)
 38. Momtareen T, Fahim AA, Rahmani SS, *et al.*: **Isolation, characterization, molecular identification and phylogenetic analysis of dye-degrading bacteria from textile sludge.** Under review. 2018.
 39. Roy CK, Jahan MAA, Rahman M: **Characterization and treatment of textile wastewater by aquatic plants (macrophytes) and algae.** *European Journal of Sustainable Development Research*. Under Review. 2018.

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