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Editorial

Editorial to Efficient Catalytic and Microbial Treatment of Water Pollutants

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1. Introduction

Several industries produce products and release waste compounds that can be very carcinogenic, and furthermore, can cause trouble for water organisms, such as algae and plants which rely on photosynthesis. Several physical, chemical, and electrochemical methods, such as oxidation, adsorption, photochemical, coagulation, and photocatalysis, have previously been used for the treatment and bleaching of wastewater originating from the textile industry. Traditional techniques are energy-consuming and costly and cannot entirely remove dye residues, such as those originating from azo dyes and related organic components consisting of metabolites, eventually causing a secondary pollution of dyes. However, there is a high need for dyes, used for making many different products, in society, which causes an enhanced production of waste. Industries relying on textiles utilize around 10,000 separate pigments and dyes, yielding a high production of 700,000 tons of dyes every year. Eliminating dye products that have been released into water is an essential topic in the production of textiles in industries. Around 15% of colorants were emitted by manufacturers into leachate and industrial waste streams while generating environmental issues and ecological catastrophes.

Dyes are typically synthetic chemicals used to impart colour to a material. They are mainly composed of carbon compounds, but inorganic pigments containing toxic heavy metals are also present (Balakrishnan, Antony et al., 2008) [1]. A dye containing a set of atoms called a chromosphere is primarily responsible for colour. In dye, there is an electron-withdrawing or donating group called an auxophore that enhances the colour of the chromosphere. Dyes are classified on the basis of chemical structure, application, and decomposition in aqueous solutions, such as basic dyes, dispersed dyes, acid dyes, and direct reactive dyes commonly used in the food, plastics, cosmetics, paper, and textile industries (Aksu 2005) [2].

In the textile industry, aqueous dye solutions are highly carcinogenic and significantly pollute sewage even at very low concentrations. These dyes absorb light and cause problems for aquatic photosynthetic plants and algae. Due to the constant demand for various colours in the market, the application of dyes has increased significantly (Singh and Singh 2006) [3], (Daneshvar, Ayazloo et al., 2007) [4], (Khaled, El Nemr et al., 2009) [5].

Various physico-chemical and electrolytic techniques, such as coagulation, adsorption, oxidation, photochemical, and photocatalytic, are often carried out for the bleaching of textile wastewater (Alinsafi, Evenou et al., 2007) [6], (Zhang, Yediler et al., 2004) [7]. Some microorganisms present in a polluted environment may have a complete decolorizing ability under certain conditions (Rai, Bhattacharyya et al., 2005) [8].

This study identified the optimal conditions for the biodegradation of selected dyes and the collection of metabolites after degradation. The toxic and non-toxic properties of the formed metabolites was investigated. This study also found possible perspective mechanisms of dye biodegradation being carried out by microorganisms. The toxic dye metabolites can be subjected to bacterial, physical and chemical treatments.

The moving bed biofilm reactor represents a different spectrum in advanced wastewater treatment, including dye removal. In the late 1900s, the moving bed biofilm reactor was introduced for the biological treatment of different types of wastewater (Delnavaz, Ayati et al., 2008) [9]. It has been suggested that the moving bed biofilm reactor is a suitable alternative for the common activated sludge reactors in treating domestic and industrial wastewater on a commercial scale. Moving bed biofilm reactors were used to treat synthetic wastewater with aromatic amine compounds. Borghei and Hosseini (2004) [10] used moving bed biofilm reactors in treating different domestic and industrial wastewaters. Currently, there are more than 400 full-scale wastewater treatment plants based on this process. Yang Qiqi, et al., (2012) proved that moving bed biofilm reactor technology was an alternative and successful method to treat different kinds of effluents under different conditions. Due to the need to investigate how the biosolid dynamics were influenced by process changes relevant to applied wastewater treatment systems and the suggested new routes of reactor design and optimization, the biofilm growth, detachment, and modelling of moving bed biofilm reactors were continuing to draw significant research attention. Erysipelothrix (2012) [11], Pajot, Delgado et al., (2011) [12], and Selvam and Priya (2012) [13] et al. have found that the biological decolourization of industrial dyes is a better technique than physicochemical methods because it is cheaper, environmentally friendly, and has high degradation potential in all textile dyes. Lin and Leu (2008) [14] have developed an environmentally friendly method in which a large number of anaerobic and aerobic bacterial strains, such as *Escherichia coli*, *Bacillus subtilis*, and *Rhabdobacter* sp., were tested for the biodegradation of azo dyes. Tripathi and Srivastava (2011) [15] et al. demonstrated the effect of *Pseudomonas putida* as a bleaching agent and observed a high level of discoloration of acidic orange dye under optimum conditions at different contact times and with different dye concentrations. Fulekar, Wadgaonkar et al. (2013) [16] applied *Comamonas testosterone* to methyl orange, maintaining contact for 7 days of incubation, and obtained satisfactory biodegradation decolourization results. Birmole, Patade et al. (2014) [17] studied the effect of *Shewanella haliotis* isolated from lake sediments, which resulted in a high degree of decolonization of azo dyes under static conditions. Elisangela, Andrea et al. (2009) [18] studied facultative *S. aureus* bacteria isolated from the activated sludge process in the textile industry and successfully decolorized four different azo dyes under micro aerobic conditions in a bioreactor. The sequential microaerophilic/aerobic phase can form an aromatic amine by reductively decomposing the azo bond and oxidizing it to a non-toxic metabolism. Ogugbue and Sawidis (2011) [19] et al. reported industrial bioremediation and detoxification effluents containing triarylmethane dyes through *Aeromonas hydrophila* isolated from industrial wastewater.

Objectives of the Current Special Issue were:

1. To use microorganisms for dyes bioremediation.
2. To investigate the degradation potential of the microorganisms.
3. To use microorganisms for environment cleanup.
4. To investigate the removal of dyes through physical and chemical processes and the biological process.
5. To find out the toxic nontoxic nature of the dye-degraded products.

2. Selection of the Specific Bacterial Strains

The cultures of the bacterial strains, such as denitrifying and anaerobic ammonium oxidizing bacteria, eg., *Candidatus Brocadia anammoxidans,* have been used for the degradation (decolourization) of the methylene blue, rhodamine B, and Congo red dyes, which are significant polluting agents in wastewater effluents from textile industries.

According to Kamboh, Solangi et al. (2009) [20], adsorption was found to be efficient in the removal of pollutants from gases and wastewater. It was considered a simple, fast, cost effective, reusable, and highly efficient process if a low-cost adsorbent was used.

Shah, Ali et al. [21] and Tanaka, Fujimoto et al. (2008) [22] proposed that a hybrid methodology comprised of coagulation and adsorption was a more cost effective, environmentally friendly, and optimized treatment. Earlier, several studies have shown biological nutrient removal possibilities [23–30] studied the removal of nutrients from wastewater by using polyethylene biofilm carriers as well as studies on adsorption of hazardous dyes [31–33].

3. Optimization of Degradation

The effect of various conditions such as dye concentration, pH, temperature, carbon and nitrogen supplementation, time, and aeration regimes on the decolourization efficiency were also analysed in this Special Issue. The percentage of decolourization was measured at 1-day intervals, as discussed earlier in this Special Issue.

4. Degradation of Dye in Optimal Conditions

After determining the optimum conditions, further decolourization experiments were performed at optimum conditions. The percentage decolourization was measured at 1-day intervals. The degraded products formed by bacteria present in the solution were separated, and the Spectroscopic Analysis of the degraded products were performed by FTIR, GCMS, and HPLC.

5. Isolation and Purification of Metabolites by Using Silica Gel and Pencil Column

The metabolites formed by the selected bacterial strain present in the solution were isolated via a large silica gel column. The different fractions obtained were subjected to further purification through a pencil column.

6. Spectroscopic Analysis of the Metabolites or Fractions

The different fractions present in the dyes were recombined and subjected to different spectroscopic analysis, such as NMR, FTIR, and MS. After the structural elucidation, a possible mechanism of biodegradation was proposed.

7. Further Treatment of the Dye-Degraded Products by Physical and Chemical Processes

The supplemental degradation of products or metabolites formed need to be identified. After identification the metabolites can be efficiently removed by physical and chemical processes.

The ash of coal fired power plants can be used in the form of a bed. The dye solution can be passed from the ash bed for treatment. Due to porosity, adsorption capacity, and high surface area, fly ashes work like activated carbon as adsorbents.

Wastewater treatment uses peat to bind soluble water content that could not be efficiently removed with biological wastewater treatment. Peat is a complex material containing lignin, cellulose, and fulvic and humic acids as its major constituents. Peat has been studied for its potential to be a sorbent for dyes. Peat contains polar functional groups such as aldehydes, ketones, acids, and phenols, which indicate that peat could be involved in chemical bonding and these groups may be responsible for cation exchange capacity. It is thus expected that dyes and metabolites will be adsorbed by peat.

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