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Photodegradation of Textile Effluent Using Solar Radiation

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Abstract: Recent study was carried out to examine the efficacy of solar radiation in improving the quality of textile effluent in term of physicochemical properties and to degrade the dissolved organic matter (DOM) in textile effluent. The experiment was performed in natural light with dark control and both the changes in physicochemical parameters and the DOM in textile effluent were examined. Physicochemical properties of textile effluent changed gradually after photodegradation in different time intervals and the effluent quality improved. Not all the parameters were in standard limit but the pollution load decreased substantially. After twenty days of photodegradation, fluorescent intensity of DOM in textile effluent decreased from 5.5 RU to 0.16 RU which indicated photo-oxidation of low molecular weight DOM, whereas dark control showed no significant change in DOM fluorescent intensity.

Keywords: Textile Effluent, Dissolved Organic Matter, Fluorescence, Photodegradation, Physicochemical Properties

1. Introduction

Textile industry is one of the major industries in the world that provide employment with no required special skills and play a major role in the economy of many countries [1] like Bangladesh. Wastewater from textile industries generally contains contaminants such as suspended solids (SS), dissolved organic matters (DOM), biochemical oxygen demand (BOD), chemical oxygen demand (COD), alkalinity etc at levels considered hazardous to the environment and could pose a risk to public health. The suspended solid concentrations in the effluents play an important role in affecting the environment as they combine with oily scum and interfere with oxygen transfer mechanism in the air-water interface [2]. The organic components are found to undergo chemical and biological changes that result in the removal of oxygen from water [3]. Textile industry uses large quantity of water in its production processes and highly polluted and toxic wastewaters are discharged into sewers and drains without any kind of treatment [4]. Textile industries generate 100-170 lit dye effluent per kg of cloth processed which could be characterized by strong odor, high COD & wide range of pH [5]. Textile effluents are also found to contain other organic and microbial impurities [2]. Textile industries produce large amounts of liquid wastes that contain organic and inorganic compounds [6]. There are different kinds of dyes which are used in dyeing process, where not all dyes that are applied to the fabrics are fixed on them and there is always a portion of these dyes that remains unfixed to the fabrics and gets washed out. These unfixed dyes are found to be in high concentrations in textile effluents. Dyes in water give out a bad color and can cause diseases like haemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis. They can block the penetration of sunlight from water surface preventing photosynthesis. Dyes also increase the biochemical oxygen demand of the receiving water and in turn reduce the reoxygenation process and hence hamper the growth of photoautotrophic organisms [7]. Human exposures to textile dyes have resulted in lung and skin irritations, headaches, congenital malformations and nausea [8]. It was found that dermatitis, asthma, nasal problems and rhinitis were acquired by workers after prolonged exposure to reactive dyes [9]. Discharge of effluent from textile industries to neighboring water bodies and wastewater treatment systems is currently causing significant health concerns [10]. Dissolved organic matter (DOM) can be contributed to the textile effluent from degradation of organic chemicals, azo dyes and even from from the biological treatment processes of wastewater [11]. On the other hand residual dyes and other synthetic and organic chemicals could be the prominent sources of dissolved organic matter (DOM) in textile effluent. Thus investigation of the component and properties of DOM as well as its effective removal is necessary for proper treatment of textile effluent. This study was focused on the characterization of textile effluent and identification of fluorescent DOM components as well as to find out the efficacy of solar radiation to degrade DOM and subsequent changes in physicochemical parameters in textile effluent.

2. Materials and Methods

2.1. Sample Collection and Photodegradation

Textile effluents for this research work were obtained from a textile industry which is located at Savar, Dhaka, Bangladesh. The sample contained wastewater from different production activities such as washing, dyeing, bleaching, printing etc. The samples were photodegraded by solar radiation for 20 days in natural radiation source. The approximate dose was six hours per day in the month of April.

2.2. Physicochemical Parameters Analyses

Physicochemical parameters of the samples were analyzed before and after irradiation. Measurements of irradiated samples were performed in four different time intervals which were five days, ten days, fifteen days and twenty days after photodegradation. Physicochemical properties such as pH and Total Dissolved Solid (TDS) were measured using pH meter (HM- 30P, pH Meter) and TDS meter (HANNA, HI 8734) respectively. Electrical Conductivity (EC), Dissolved Oxygen (DO) and turbidity were measured using EC Meter (CM- 31P), DO Meter (970 DO2 Meter, Jenway, UK) and Turbidity Meter (HANNA, HI 93703) respectively. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were measured using 5-Days BOD test and Closed Reflux Colorimetric method respectively.

2.3. Characterization of DOM in Textile Effluent

All the samples were filtered through glass-fiber membrane (0.45µm) to remove suspended materials that may react with DOM. The fluorescence intensity of DOM was determined on a Fluorescence Spectrophotometer (F- 4600, Hitachi, Japan). Excitation-Emission Matrices (EEMs) were created using FL Solutions software. Before analysis, DOM samples were diluted 100 times to keep the spectra within the upper limit of analysis. To generate an EEM, excitation wavelengths were scanned from 225 to 500 nm in 5 nm steps, and the emitted fluorescence detected between 240 and 600 nm in 2 nm steps. Excitation and emission slit widths were 5 nm. Scan speed was 1200 nm/min, permitting collection of a complete EEM in 18 min.

3. Results and Discussion

3.1. Characterization of Textile Effluent

General characteristics of textile effluent and their changes after photodegradation are presented in the Table 1. Dissolved Oxygen (DO) in raw textile effluent (Tx-R) was 2.6 mg/L which increased rapidly after the irradiation of effluent for different time intervals (Figure 1).

DO value of textile effluent after five days of photodegradation (Tx-A5DP) increased 2.6 mg/L to 5.1 mg/L. After ten days of photodegradation (Tx-A10DP) and after fifteen days or twenty days of photodegradation (Tx-A15DP or Tx-A20DP) the DO value became 5.8 mg/L and 5.7 mg/L respectively which were within the standard limit for inland surface water [12]. Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) of the Tx-R were very high, 126 mg/L and 658 mg/L respectively and they decreased up to 54 mg/L and 353 mg/L for Tx-A20DP (Figure 2).

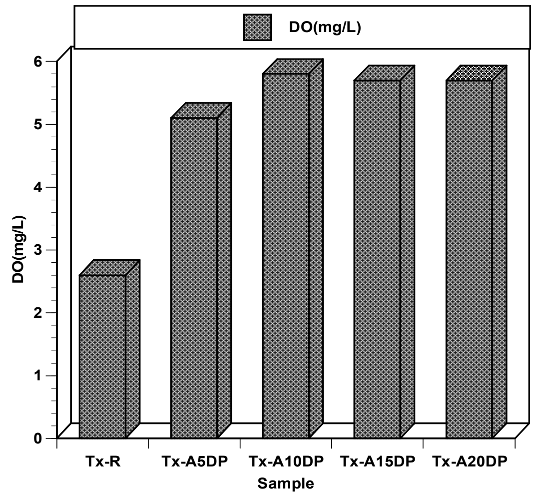

Figure 1. *Changes in Dissolved Oxygen (DO) in textile effluent after photodegradation.*

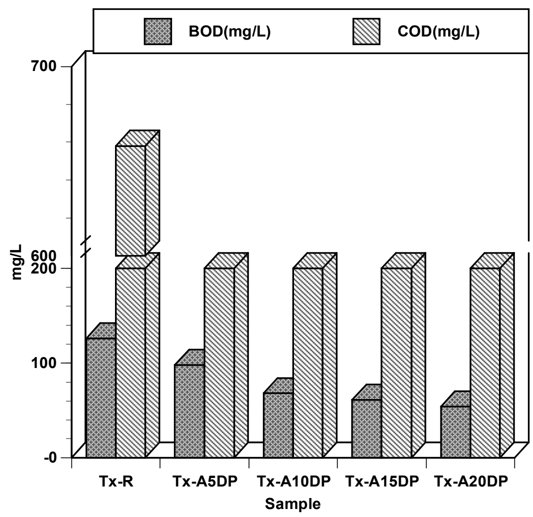

Figure 2. *Changes in BOD and COD in textile effluent after photodegradation.*

Reduction of BOD_5 and COD indicated the decomposition of oxidizable organic matter by solar radiation. Degree of biodegradability (BOD/COD) value decreased very slowly with increasing duration of solar radiation. Most of the BOD/COD ratios are found in the range of 1:5 to 1:6, indicating the presence of non-biodegradable substances.

Electrical Conductivity (EC) in Tx-R was also high but decreased gradually with increasing radiation (Figure 3). The turbidity of the raw effluent was 136 FTU and it decreased up to 119 FTU for Tx-A20DP. This may be due to the gradual settle down of suspended particulate matter and break down products of different organic and inorganic matter in wastewater.

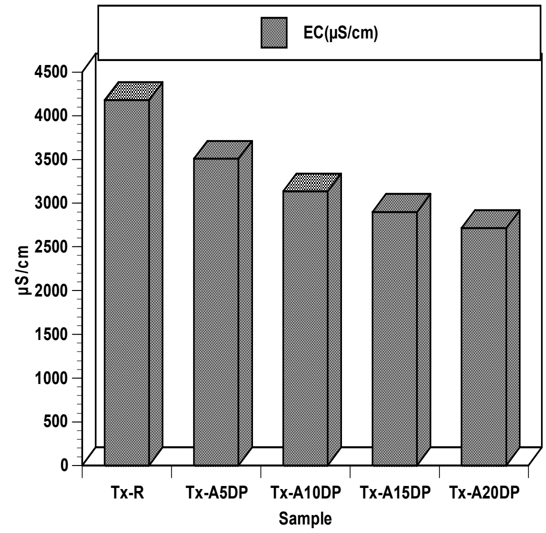

Figure 3. *Changes in Electrical Conductivity (EC) of Textile Effluent after photodegradation.*

Reduction of Total Dissolved Solid (TDS) might be due to the degradation of dye molecules induced by the reaction with oxidative species from water hydrolysis [13] and decomposition of other dissolved organic and inorganic molecules (Figure 4).

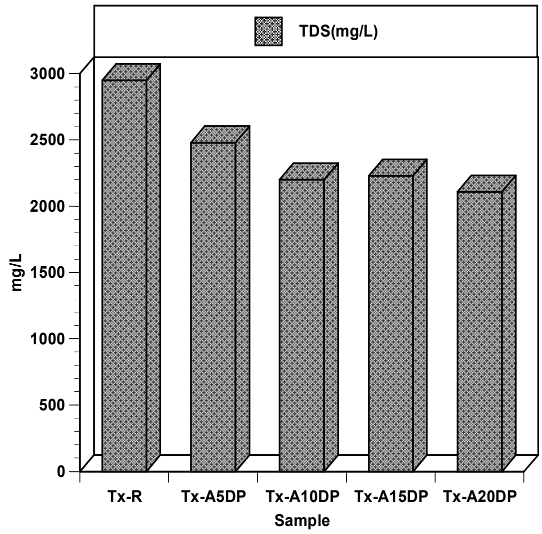

Figure 4. *Changes in Total Dissolved Solid (TDS) of Textile Effluent after photodegradation.*

pH value of the Tx-R was 9.8 and after 20 days of photodegradation it was reduced to 8.9 which is also within the standard limit for inland surface water [12]. It may be deduced that the oxidation of aromatic compounds induced by ionizing radiation gives some lower molecular weight aliphatic compounds such as aldehyde and organic acids and that further oxidation of the organic acid formed leads to the formation of carbon dioxide [14, 15].

Table 1. *Physicochemical Properties of Photodegraded and Raw Textile Effluent Samples*

Sample	DO (mg/L)	BOD (mg/L)	COD (mg/L)	BOD/COD	pH	EC (µS/cm)	TDS (mg/L)	Turbidity (FTU)
Tx-R	2.6	126	658	0.19	9.8	4179	2950	136
Tx-A5DP	5.1	98	472	0.20	9.4	3507	2480	130
Tx-A10DP	5.8	68	392	0.17	9.1	3134	2200	128
Tx-A15DP	5.7	61	378	0.16	9.1	2900	2230	122
Tx-A20DP	5.7	54	353	0.15	8.9	2716	2110	119

3.2. Changes in Fluorescent Intensity of DOM After Photodegradation

Dissolved Organic Matter (DOM) content was identified by the relative fluorescent intensity of the DOM which is expressed in RU (Raman Unit, nm^{-1}).

To identify the substances that are responsible for fluorescence properties of DOM, 3D Excitation-Emission Matrices (EEMs) were created and data were analyzed. For all EEMs, three fluorescence peaks were identified that were always detectable. These were the peaks from protein like substances (e.g., tryptophan, tyrosine etc) detected at Ex/Em 250-300/290-370 nm, humic like substances detected at Ex/Em 375-450/380-580 nm and fulvic acids detected at Ex/Em 300-400/380-480 nm. On the other hand fluorescent intensity of raw textile effluent (Tx-R) decreased dramatically after photodegradation in different time intervals which indicated the degradation or reduction of DOM content in textile effluent (Figure 5). Fluorescent intensity of Tx-R was close to 5.5 RU which decreased to 3.5 RU after five days of photodegradation (Tx-A5DP). Fluorescent intensity decreased gradually and it became 0.16 RU after twenty days of photodegradation which indicated substantial degradation of low molecular weight humic substances, organic dyes and others dissolved organic substances in wastewater. Fluorescent intensity of Control textile effluent (Tx-C) was measured which was kept in dark to compare the degradation rate with photodegraded textile effluent. Tx-C showed no significant change in its fluorescent intensity which suggested that, solar radiation can play potential role in the degradation of DOM in textile effluent.

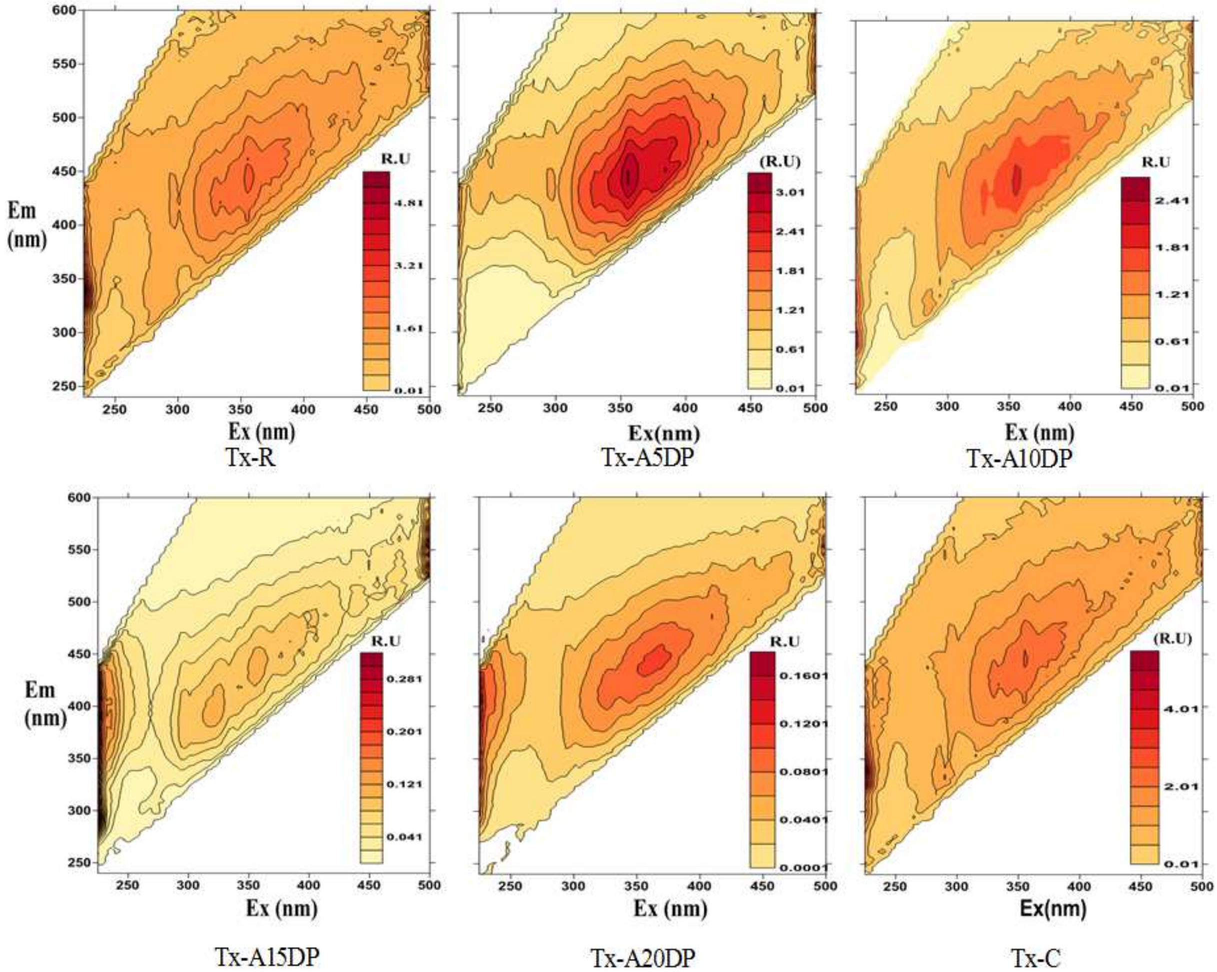

Figure 5. *Changes in fluorescent intensity (in RU) of DOM in Textile effluent.*

4. Conclusion

Wastewater like textile effluent contain large amount of color (dyes), total dissolved solid, turbidity, pH, chemical and biochemical oxygen demand, dissolved organic matter etc which make it unsuitable for easy discharge and other uses. Study reveals that, photodegradation by solar radiation could be an effective mean to reduce such parameter after some preliminary treatments. Photodegradation is also effective to remove dissolved organic matter (DOM) which might be an inherent pollutant in textile effluent. Although photodegradation of textile effluent is beneficial, more effective removal might be achieved through the modification of this process (e.g., catalyst addition) which would increase the efficiency of the removal techniques.

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