ABSTRACT

Effective management of water resources and control of water pollution are becoming increasingly important for a healthy environment. Due to industrialization, water sources are polluted to a considerable extent. Although various industries are responsible for discharging hazardous organic wastes into our water resources, the textile industry is of major concern. Since these textile industry wastewaters pose a high threat to the aquatic systems, intensive research for novel technologies that pursue easy degradation of such substances with higher efficiency has been stimulated.

A promising way to perform the degradation of these types of recalcitrant pollutants is by the application of Advanced Oxidation Processes (AOPs), which are well known strong technologies for waste treatment purposes. Though, from an application point of view, they still require further advancement and refinement. A new promising application field is their integration with biological treatments, which allows taking advantage of the individual potentialities of each other.

In this research, a new catalyst, steel scrap, has been employed as part of the Fenton process, replacing the conventional Fenton catalyst. Degradation study of textile dyeing effluent has been conducted using three light sources viz., room, UV light and solar light sources. In order to meet the regulatory requirements in terms of colour and COD removal, a biological
treatment under the Sequencing Batch Reactor (SBR) was coupled to the solar photo-Fenton, with steel as the catalyst.

Initially, studies on degradation of textile dyes using Fenton/UV photo-Fenton /Solar photo-Fenton oxidation process were conducted. Three different textile dyes, namely, reactive blue, reactive yellow and reactive black solutions of concentration 100 mg/L were analyzed for colour, pH, and COD. The effect of operational variables such as dose of FeSO₄, dose of H₂O₂, and pH on degradation of textile dyes were studied. In the decolourization of textile dyes solution, Fenton molar ratio in the range of 25:1, 50:1, and 100:1 and pH in the range of 2 to 7 were maintained in this study. Maximum decolourization was observed by Fenton/UV photo-Fenton /Solar photo-Fenton oxidation with optimum Fenton molar ratio of 50:1 and pH 3 in all three dyes.

The textile dyeing effluents were characterized for various physico-chemical parameters viz., pH, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solids, Total Suspended Solids, Chlorides, and Sulphates as per standard methods (APHA, 2005). The particle size of steel scrap, used as Fenton catalyst in the study, was in the range of 0.5-2 mm. To characterize the steel scrap, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), Thermo gravimetric analysis (TGA), Scanning Electron Microscopy (SEM) and EDAX Analysis were used.

Laboratory-scale Feasibility studies on Fenton process under room light with steel scrap as catalyst had been carried out in order to study the
effects of operating parameters such as pH, Catalyst dose, H₂O₂ dose by varying one variable at a time; this was also validated by using Response Surface Methodology (RSM). The decolourization at wavelengths of 436 nm, 525 nm, and 620 nm and COD removal were studied.

With the input from the optimization studies, detailed studies were carried out by Fenton process under solar light with steel scrap as catalyst. The effect of solar light intensity, the reusability of catalyst, volume of effluent, kinetic study and contact time were studied.

In order to scale up the solar photo-Fenton reactor to industrial application, a bench scale reactor was fabricated. The performance of the reactor was studied by varying the liquid volume and recycle flow rate of textile dyeing effluent. It was observed that maximum COD removal of 71 % was achieved with recycle flow rate of 500 mL/min.

Performance of sequencing batch reactor treating textile dyeing effluent at influent COD concentration of 1790 mg/L was evaluated. The COD removal efficiency was found to be 65 %. The maximum COD removal of 66 % and the best sludge settling properties at SRT 10 days and SBR cycle time of 8 hours was obtained.

The coupled reactor was operated in semi-continuous mode. The solar photo-Fenton with steel scrap catalyst reactor treated the textile dyeing effluents in batch cycles, providing photo treated effluent to the biological sequential batch reactor. It was observed that the solar photo-Fenton with steel scrap catalyst treatment was able to remove 73 % COD in 2 hours and
the pre-treated effluent was transferred to biological treatment, where 92 % of COD removal in 2 hours was achieved. The use of steel scrap catalyst in the solar photo-Fenton reaction greatly improves COD removal without formation of sludge. In general, the overall COD removal efficiency in the coupled process was found to be 93 %. Results obtained from this research indicated that the solar photo-Fenton with steel scrap catalyst treatment could be suitable pre-treatment method for enhancing biodegradability of textile dyeing effluents treated in the coupled solar photo-Fenton and biological treatment system. Also, it was observed that the coupled treatment processes would be able to improve the degradation efficiency and reduce the treatment time when compared to individual process, which would imply a lower total volume of biological reactor and lower energy consumption (requirements for mixing and aeration) to achieve an overall performance to meet the limits of the environmental legislations.