ABSTRACT

The textile dyeing industry has long been one of the largest water users and polluters. The textile dyeing wastewaters are coloured by the release of unfixed dye and hence they are aesthetically objectionable. Due to stringent environmental regulations, process modifications such as the use of low salt dyes and improved operating practice of separation of wastewaters into two streams namely dye bath wastewater (high salt content) and rinse wastewater (less salt content) are introduced in the industries. The removal of colour from the textile wastewaters is achieved either by separation or oxidation techniques, which have several limitations. Hence there is a need for a more suitable technology for decolourisation of textile dyeing wastewaters.

Photocatalytic oxidation (PCO) involving the interaction between the ultraviolet light (UV) radiation and a semiconductor has proved to be a potential wastewater treatment technique. The solar light, the most direct and bountiful source of energy can be used as the light source for activating Titanium dioxide (the most commonly used semiconductor). A number of solar photocatalytic reactors have been investigated so as to facilitate the possible transfer of this technique to the industry. But, still solar PCO has not been sufficiently efficient for large-scale application. Hence, the scope of this study was to develop a simple, efficient and economical solar photoreactor and to demonstrate its applicability for the decolourisation of textile dyeing
wastewaters, so as to facilitate the possible transfer of solar PCO technique to the industry.

The development of solar photoreactor is a complex exercise since it has to deal with the photocatalyst in the solid phase and the organic pollutant in the liquid phase. The configuration of the solar photoreactor must be able to address the two important parameters namely efficient exposure of the photocatalyst to the solar radiation and good contact between the organic pollutant and photocatalyst. Based on the above concepts two ‘Water-Bell Fountain Solar Photoreactors’ were developed. The fabrication of the reactors involved construction of water fountains in shallow ponds. The water fountain was used for keeping the wastewater containing the photocatalyst in the form of thin films so as to achieve efficient exposure of photocatalyst to the solar radiation.

A very detailed laboratory scale feasibility study was carried out on decolourisation of simulated rinse wastewaters (SRWWs), rinse wastewaters (RWWs) and dye bath wastewaters. The photoactivity of two titanium oxides (viz., Degussa P25 and Indigenous, IS grade) was studied under UV and solar light sources. The photocatalytic decolourisation of textile dyeing wastewaters was found to be first order. A catalyst concentration of 1.0 g/L was necessary for solar photocatalysis, whereas only one tenth of 1.0 g/L was needed for UV photocatalysis. The solar photocatalytic decolourisation of dye bath wastewater was found to be not feasible. The rate of decolourisation increased with
increase of solar UV light intensity. The photoactivity of both the catalysts was not affected by the reuse of the catalysts.

The performance studies conducted on ‘Water-bell Fountain’ solar photoreactors proved the practical applicability of the reactors for decolourisation of RWWs. A pilot-scale solar photoreactor was designed for ninety percent decolourisation of RWWs for treating a flow of 11,760 L/day. The cost of the solar photocatalytic treatment system with indigenous titanium dioxide as photocatalyst proved to be marginally economical when compared with the cost of an existing treatment plant that uses chemical precipitation and adsorption.

Hence, it is concluded that for tropical countries, the solar PCO using titanium dioxide as photocatalyst has proved to be a more suitable wastewater treatment technique for decolourisation of textile dyeing wastewaters. In this technique, renewable solar radiation is used as the light source for photoactivation and the non-toxic and non-soluble titanium dioxide is used as the photocatalyst. With the development of ‘Water-Bell Fountain Solar Photoreactors’ efficient transfer of this solar PCO technique for large-scale application is facilitated.