ABSTRACT

In textile industry, the effluents generated after a series of wet processing activities contain high concentration of non-biodegradable compounds, soaps, oil, grease, and alkaline rich wastes. Similarly, the effluents released by pharmaceutical manufacturing units are troublesome due to their complex nature and known to contain the ingredients that are designed to be highly active against microorganisms, which include bacteria, fungi, etc.

Numerous physicochemical treatment methods were proposed to treat these effluents but many of them failed to degrade the effluents into non-toxic materials due to their process nature. Currently, advanced oxidation processes (AOPs) are more lucrative on treating these industrial effluents. Many of these processes are more efficient and do not generate secondary pollutants.

This study presents the treatment of textile and pharmaceutical effluents by sonochemical based methods. Initially, sonolytic degradation was carried out in a bath type sonicator and the degradation was assessed based on the residual chemical oxygen demand (COD). The COD reduction obtained after 180 min of sonolysis was 39.13 and 20.13%, respectively, for textile and pharmaceutical effluents. It is well known that the sonolytic degradation consumes significant amount of electrical energy. In order to reduce the operating cost and to improve the degradation efficiency, two novel hybrid treatment methods, such as, sono-Fenton-sorption (SFS) and ultrasound coupled with dual oxidant system (US/DOX) were proposed.
In SFS, tea waste was employed as adsorbent. To improve the sorption capacity, the tea waste was activated by different methods and activation with HCHO followed by ultrasound produced better activation. Under optimal conditions, SFS showed 97.73 and 81.25% COD reduction, respectively, for textile and pharmaceutical effluent. During SFS, the increase in initial concentration of effluent increased the initial COD reduction for both the effluents. The increment in dosage of Fe(II) and H$_2$O$_2$ enhanced the COD reduction till optimum values are reached beyond which negative trend was found.

SFS enhanced the biodegradability index of the textile effluent significantly from 0.31 to 0.71. For pharmaceutical effluent, the enhancement was from 0.127 to 0.4. The reusability study of adsorbent indicated that the adsorbent was effective till the third cycle and further usage did not show any significant effect. SFS was found to improve the intra-particle diffusion coefficient and liquid film mass transfer coefficient significantly compared to sorption and sono-sorption. Similarly, the initial adsorption kinetic coefficient was found to be very high for SFS compared to sorption and sono-sorption.

The generation of iron sludge due to Fenton’s reaction and production of secondary pollutant during adsorption made SFS not attractive. Therefore, in the present study, another hybrid treatment method, US/DOX was employed to treat these effluents. In dual oxidant system (DOX), two effective strong oxidants, such as, hydrogen peroxide and ammonium persulfate, were employed. This method showed aggressive oxidation of organic pollutants present in effluents and made the process more attractive. In addition, DOX
does not produce any secondary pollutant at the end of the treatment process. In this study, iron-swarf, waste material resulting from metalworking operations such as milling and grinding, was employed as persulfate activator. Among the different activators, simultaneous use of iron-swarf and ultrasound was found to be most effective on the activation of persulfate oxidation.

The DOX system produced 56.82% COD reduction for textile effluent, while the individual processes, such as, hydrogen peroxide oxidation and persulfate oxidation produced 13 and 9%, respectively. For pharmaceutical effluent, the values were found to be 51.56, 20.31 and 10.49% respectively.

On the other hand, a significant enhancement in COD reduction was observed with US/DOX process and the COD reduction obtained for textile and pharmaceutical effluent was 97.73 and 100%, respectively. The optimum initial pH was found to be 3 for both DOX and US/DOX processes. The increase in temperature enhanced the COD reduction during DOX and US/DOX processes. Also the increase in mixing rate enhanced the COD reduction in DOX process whereas in US/DOX process, this trend was observed till the optimum value beyond which negative effect was observed. Step-wise addition of iron-swarf particles into the solution produced good results compared to single dose addition as the former made the iron-swarf available at all time, for its catalytic action.

A drastic reduction in electrical energy consumption on treating these effluents by US/DOX was observed. A moderate enhancement in biodegradability index of both the effluents was observed during US/DOX
process. The toxicity test showed that the effluent after US/DOX was less toxic compared to that of untreated one.

The present study revealed the potential of activated tea waste as sorbent on treating highly concentrated textile and pharmaceutical effluent. The sonolytic degradation was found to be more lucrative when it was coupled with other treatment methods on treating these effluents. The generation of sludge and secondary pollutants during SFS limits its application. To overcome this problem, US/DOX method was proposed. The potential of iron-swarf as activator for persulfate oxidation was explored and the results clearly showed that, US/DOX as most energy efficient and capable of treating these effluents effectively.