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Treatment of Textile and Electroplating Wastewater: Impact of UV Irradiation and Adsorption Techniques

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ABSTRACT

In the present study, wastewater collected from textile and electroplating industry situated in Ludhiana (Punjab), India was treated with novel techniques of adsorption using a natural and environmental friendly adsorbent dashmool (combination of 10 herbs) and UV irradiation. The initial levels of TDS, BOD and COD were found as 3000, 380 and 1200 mg/l in textile wastewater and 2100, 440 and 1440 in electroplating wastewater respectively. Adsorption process alone was able to reduce the levels of TDS, BOD and COD by 58.3 %, 28.9 % and 45.8 % respectively in the textile wastewater. These levels were reduced by 14.3%, 31.8% and 44.4% in electroplating waste water. The combined effect of adsorption and UV irradiation resulted in further decrease in the levels of TDS, BOD and COD, where final values of these parameters were found as 800, 30 and 150 mg/l in textile waste water. Similar trends were obtained in electroplating wastewater although variation was different. These techniques caused insignificant effect on pH values of the wastewater samples. Overall, the results clearly indicate that combined effect had a significant effect in reducing the levels of certain physico-chemical parameters causing pollution. Moreover the techniques are environmental friendly and have a greener approach. This combined technique can be helpful for the treatment of wastewater generated from other pollution causing industries.

Key words *Adsorbent, Dashmool, Irradiation, Electroplating Wastewater, Textile Wastewater*

Introduction

Rapid industrialization in India has been the main reason for the economic growth and development of the country. Central government and many state governments are giving many incentives such as free or concessional land, tax holidays and other benefits from time to time for setting up of industry. Some of such industries use natural resources for their subsistence. This has resulted in degradation of our natural resources especially water (Mittal and Sharma, 2011; Rani, 2019).

Some of the industries such as textile industry and electroplating industry use huge quantity of water to make their plant run. Ministry of Environment and Forests, Government of India has put textile industries in the category of most polluting industries. These industries are one of the largest water users and polluters resulting in high wastewater generation (Ghoreishi and Haghihi, 2003). This wastewater is considered as the most polluting among all effluents in the industrial sectors (Awomeso *et al.*, 2010), if the volume and composition of effluent is taken into account,. These effluents are the most difficult to treat due to their considerable amount of toxic substances (Hai *et al.*, 2007). Similar is the case with electroplating industry where contribution to water pollution is on the higher side when compared with other industries.

From textile industry, the effluents may be colourants, inhibitory compounds, surfactants, chlorinated products, high temperature and high pH etc. due to which there may be high levels of BOD, COD and TDS. The volume and pollution level may vary from one mill to another. For electroplating industry, the effluents may show greater acidity and ionic strength which make the solution harder and it becomes very difficult to treat it using conventional methods such as chemical (neutralization/precipitation) and physical (ion-exchange, membrane technology). Acids may be used to decrease pH of influent but it may end up in higher pH in the effluent owing to hydrogen ion reacting with chromate. Consequently, bases may be needed to comply with the requirements of discharge pH in wastewater (Hai *et al.,* 2007). Similarly, the use of direct ultraviolet rays along with deconvolution technique for effluent treatment of textile industry is also available. The advanced oxidation technique UV-H_2O_2FS-TiO_2 can be used to degrade textile dyes present in textile waste water (Vijayaragavan *et al.*, 2008). The wastewater can be effectively used if given combined treatment of membrane filtration and electrochemical process.

The treatment facilities for industrial effluents from major industries exist but the treatment facility is established in only very high cost industries and it is not found in small scale or medium industries. Similarly due to low profit margin, these industries are unable to bear extra financial burden for controlling pollution caused by the effluents (Singh and Kumar, 2016).

Bes-Pia *et al.* (2002) developed technology where textile water can be treated by physico-chemical process and membrane technologies. This helped in 100 % removal of COD. The textile waste water from a dyeing, printing and finishing industry can be treated by ozonation process, which helped in reducing COD and turbidity by 57% and 95% respectively. Ozonation combined with UV radiation was employed as an effective way for the removal of 2-naphthalenesulfonate (2-NS) in the electroplating solution13. But no single methodology may be suitable for such type of effluents. As conventional treatment plants may not prove successful in dealing with complete removal/ significantly reduce levels of pollutants, the combination of different approaches can be the answer. Moreover environmental friendly approaches are the need of the hour. The present paper deals with the adsorption process (Rani and Sud, 2014) combined with irradiation by ultra violet light. The system can be helpful in reducing the COD level in effluents significantly. The system is quite effective, economical, efficient and environmental friendly.

Effluents treatment plants are the most widely accepted approaches towards achieving environmental safety. But, unfortunately, no single treatment methodology is suitable or universally adoptable for any kind of effluent treatment. Since the conventional treatment methods are inadequate, there is the need for efficient tertiary treatment process. In this process, photoactive catalyst illuminates with UV light, generates highly reactive radical, which can decompose organic compounds. Our work includes adsorption process and irradiation by UV lamp for textile waste water which reduces COD up to 86%. We propose a simple system, which is effective, affordable and highly efficient for water treatment; thus protecting the natural environment.

Materials and Methods

Study Area

The selected study area is the Industrial city of Ludhiana. The sites for collection of effluent samples were selected from electroplating and textile units of Focal Point Ludhiana city, Punjab, India. Ludhiana is the major Industrial city of Punjab with respect to textile industry. The city can be found approximately in the middle of the state and it has the total area close to 120 square miles. The city is located about 800 feet high over the mean sea level. It lies with the coordinates 30° 54' 3.4740'' N (latitude) and 75° 51' 26.1972'' E (longitude).

Method of Sample Collection

These water samples were collected in 1 litre PET (poly ethylene terephthalate) bottles after thoroughly washing/ rinsing them with the same. The sampling bottles were labelled with sample number, date of sampling and sampling site. Prior to analysis, the samples were filtered through Whatman filter paper No. 1, stored and preserved as per the standard procedure (APHA, 2005). The equipments and instruments used in this study were all calibrated to check their status before and in the middle of the experiments.

Analysis of Wastewater Samples

The samples were analyzed for BOD, COD, pH and TDS before and after each of the experiments. The available standard procedures were followed for the measurement of these parameters. The techniques and methods followed for collection, preservation and analysis are given by (APHA, 2005; Trivedy and Goel, 1998). Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of effluent were analyzed by the five day BOD bottle method and titration methods, respectively. The TDS was determined as explained by Baird *et al.* (2017).

Materials

A noble and environmental friendly adsorbent dashmool was used for the adsorption study. As the name suggests, dashmool is a combination of 10 (dash) herbs (mool). These 10 ayurvedic herbs are Bilva root (*Aeglemarmelos*), Agnimantha root (*Premna integrifolia*), Shyonaka root (*Oroxylum indicum*), Patala root (*Stereospermym suaveolens*), Kashmari root (*Gmelina arborea*), Bruhati root (*Solanum indicum*), Kantakari root (*Solanum xanthocarpum*), Shalaparni root (*Desmodium gangeticum*), Prushniparni root (*Uraria picta*), Gokshura root (*Tribulus terrestris*). The main idea of using it as adsorbent was that it contains many roots of different and through the root system; absorption or adsorption mainly takes place. Secondly, this compound is naturally occurring and may not have its own residual effect on water to be treated. Other materials used were 0.1M HCl for activation, distilled water and cotton etc. The adsorbent was filtered with distilled water. Thereafter, it was washed with 0.1M HCl and vacuum filtered three times with distilled water. The washing ensured that alkaline residues have been completely removed. The sample (dashmool) was then dried in an oven at 100°C for 1 hour.

Adsorption Procedure

The continuous flow adsorption experiments were carried out using glass column. Exactly 10.0 g of dashmool was loaded in a glass column of 2 cm internal diameter and 35 cm height. The total bed height of dashmool in the column was 30.0 cm and raw effluent/ waste water was pumped upward through the column while maintaining the flow rate of 5 ml/min. Experiment was continued for about 5 hours. Sampling was done at regular interval of one hour. The various parameters such as COD, BOD, pH and total dissolved solids (TDS) were measured from these samples to assess the extent of adsorption. After elution, the dashmool bed was washed with distilled water. This washing continued till pH of the wash effluent was stabilized to 7.0. Thereafter the dashmool was dried and again used for further experiments. All the experiments were done in duplicate and the data was converted to average value of replicate experiments. Care was taken that constant flow rate was maintained throughout the experiment.

Irradiation with UV light

The UV system is the most common advanced oxidation process for removel/ reduction of various types of pollutants from wastewater (Rani and Sud, 2022). Therefore it as decided that combined effect of adsorption and UV irradiation should assessed. After the adsorption process, the treated waste water samples were irradiated with UV (254 nm wavelength) light for 5 hours using UV lamps. After irradiation, the samples were again analyzed for BOD, COD, pH and TDS.

Results and Discussion

Effect of adsorption on pH of wastewater

As explained in the Materials and Methods, The wastewater samples were passed through the column of adsorbent, dashmool for the adsorption study. The pH of the sample was measured before the experiment and 5 hours after the experiment. The intermediate readings were taken at an interval of one hour.

The Fig. 1 shows that the pH was reduced from 8.0 to 7.4 in the textile wastewater. Therefore 7.5 % reduction in pH was noted. Similarly, in the electroplating wastewater, the initial pH of 7.5 wass reduced to 7.3, i.e 2.7 % reduction.

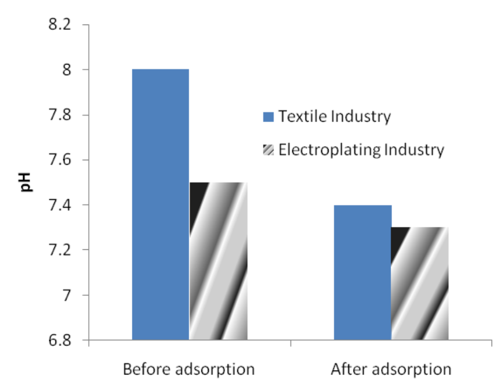

Fig. 1. Effect of adsorption of pH of wastewater from textile and electroplating industry

Effect of adsorption on BOD, COD and TDS of wastewater samples

As explained in the Materials and Methods, The wastewater samples were passed through the column of adsorbent, dashmool for the adsorption study. The measured parameters included BOD, COD, pH and TDS. The BOD and COD are the most widely used parameters of organic pollution applied to both wastewater and surface water (Singh *et al.*, 2022). The widely recommended limits of BOD are 30 mg/l. The prescribed standard of COD is 250 mg/l in case of industries. Here also, these quality parameters were measured at an interval of one hour during the period of experimentation, i.e 5 hours. The data is presented graphically in Fig. 2. The adsorption process had a significant effect on these quality characteristics (TDS, BOD and COD).

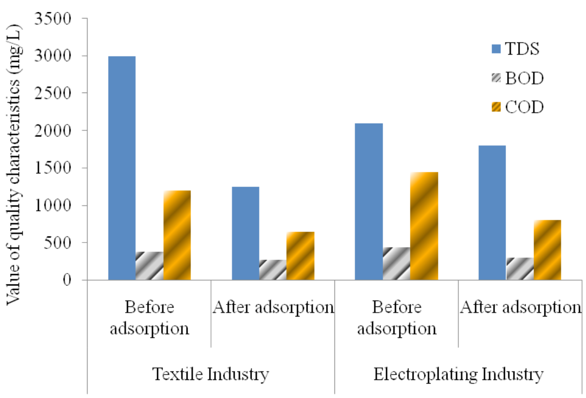

Fig. 2. Effect of adsorption on pH of wastewater from textile and electroplating industry

The TDS value reduced from 3000 mg/l to 1250 mg/l in the textile waste water and from 2100 mg/L to 1800 mg/l in electroplating wastewater. Therefore, Reduction in TDS was 58.3 % and 14.3 % in textile wastewater and textile wastewater respectively.

Similarly, the BOD value was decreased from 380 mg/l to 270 mg/l in the textile waste water and from 440 mg/l to 300 mg/l in electroplating wastewater. Therefore, the significant decrease in TDS was 28.9 % and 31.8 % in textile wastewater and textile wastewater respectively.

The trend in COD values was in line with TDS and BOD values although the extent of variation was different. The COD value reduced from 1200 mg/l to 650 mg/l in the textile waste water and from 1440 mg/l to 800 mg/l in electroplating wastewater. Therefore, Reduction in TDS was 45.8 % and 44.4 % in textile wastewater and textile wastewater respectively.

From the above date, it can be easily inferred that dashmool when used as adsorbent can be helpful in reducing the pollution level in different types of wastewaters with respect to TDS, BOD and COD.

Effect of UV radiation on quality characteristics of wastewater

After the adsorption experiment, the samples were subjected to UV radiation as explained in Materials and Methods. The pH value was further lowered to 7.2 from 7.4 in textile wastewater with the UV treatment but there was no effect of UV irradiation on pH in electroplating wastewater. The levels of other three parameters TDS, BOD and COD are shown in Fig. 3.

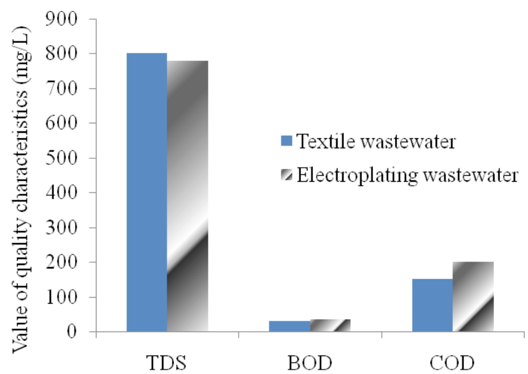

Fig. 3. Levels of TDS, BOD and COD in wastewater after combined treatment of adsorption and UV radiation

In textile wastewater, the TDS value was furthered lowered to 800 mg/l from the TDS level of 1250 mg/l which was obtained after adsorption experiment. Therefore, it resulted in 36 % reduction. In electroplating wastewater, the impact of UV irradiation was much higher as the TDS value was reduced to 780 mg/l from the TDS level of 1800 mg/l which was obtained after adsorption experiment. It caused a reduction in TDS 56.7 % reduction.

The effect of UV radiation was much higher in case of BOD value where it reduced to 30 and 35 mg/l from the adsorbed treated wastewater values of 270 and 300 mg/l for textile and electroplating wastewater respectively. The COD values were also reduced significantly as values were 150 and 200 mg/l as compared to the adsorbed treated wastewater values of 650 and 800 mg/l for textile and electroplating wastewater respectively.

Conclusion

The main focus of research work is on the treatment of wastewater arising out from textile and electroplating industries of Punjab by using the environmental friendly and cost effective techniques of adsorption and UV irradiation. It was found that dashmool, a combination of 10 ayurvedic herbs can be used as useful adsorbent in reducing the levels of TDS, BOD and COD levels in industrial wastewater. When this technique was combined with UV irradiation, it reduced the levels of these parameters further. The combined technique can be tested on wastewater of sources other than textile and electroplating industries.

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