ABSTRACT

Ecological contamination is the prime threat to human on earth today. It means accumulation of dissolved or suspended solids which discharge most of the harmful, persistent toxic organic and inorganic pollutants such as pesticides, heavy metals, and non-degradable, bioaccumulative chemical compounds impurities into the environment. The removal of organic and inorganic contaminants from industrial waste water is an important issue to be addressed.

Hydroquinone occurs in the environment as a result of man-made processes as well as in natural products from plants and animals. Due to its physicochemical properties, hydroquinone is found to be concentrated in water when released into the environment. Hydroquinone is considered to be a major organic pollutant because of its toxicity even at low concentrations. Conventional methods are used for degradation of hydroquinone by anaerobic biodegradation and anodic oxidation. Another organic contaminant taken for the study was porcion blue 2 G dye. Many dyes are believed to be toxic and carcinogenic. They are prepared from known carcinogens such as benzidine or other aromatic compounds that might be formed as a result of microbial metabolism. Hence, removal of these dyes from effluents is important.

Inorganic contaminant used for the investigation was nickel. It is toxic to many aquatic organisms, even at very low concentration. In India, the acceptable limit of Ni in drinking water is 0.01 mg/L and the industrial discharge limit in wastewaters is 2 mg/L. Among the different biological
methods, biosorption have been demonstrated to possess good potential to replace conventional methods for the removal of dyes and metals.

Treatment of organic and inorganic effluents may be either aerobic, anaerobic, or a combination of both, depending on the type of microorganisms being employed. Hence, current research focuses on a combination of physical or chemical treatment processes with biological methods for treating effluents in a cost-effective manner. The main objective of this study is to investigate the biological and electrochemical processes for the removal of selected organic and inorganic compounds. This study involves biological and electrochemical parameters for the treatment of hydroquinone and the removal of dye and heavy metals in synthetic effluents. Keeping this in view, the following objectives have been considered.

In the first part of the work, degradation studies are carried out for the synthetically prepared effluent containing hydroquinone with various current densities. In 2 h of electrochemical oxidation with different charge inputs, the maximum COD of the effluent reduced from 3400 mg/L to 2587 mg/L (23.91%) for 3.2 A/dm². The effluent treated electrochemically was subjected to biochemical oxidation studies using bacterial strain were carried out in both aerobic and anoxic processes for 5 days. At the end of day 5, the maximum COD reductions obtained for aerobic process was 95.08% at 3.2 A/dm² and for the anoxic process was 91.23% at 3.2 A/dm². The kinetic model parameters were found to be better for the aerobic process at 3.2 A/dm² (kL = 0.0024 cm/s, R² = 0.9943) and anoxic process at 0.8 A/dm² (kL = 0.0022 cm/s, R² = 0.9985).
In the second part of the study, degradation studies are carried out for the synthetically prepared effluent containing hydroquinone with different bacterial cultures. In 2 h of pre electro oxidation, the COD of the effluent reduced from 3400 mg/L to 2975 mg/L, eventually BOD was increased and BI was estimated to be 0.4. Microbial oxidation studies using three bacterial strains are carried out for five days in sequence for the electrochemically pretreated synthetic effluent containing hydroquinone. The COD of the effluent reduced for the increasing degradation time for all the microorganisms. At the end of day 5, the maximum COD reductions obtained were 65.79%, 66.70% and 63.44% for the effluent containing the bacterial strain *Pseudomonas aeruginosa*, *Bacillus cereus* and *Pseudomonas putida* respectively. The biologically treated effluent streams are subjected to post electrochemical oxidation sequentially for 1 h.

In the third part of the study, degradation studies are carried out with immobilized bacterial and fungal cultures. Biochemical oxidation studies using bacterial and fungal strains immobilized were carried out for 5 days in sequence for the electrochemically pretreated synthetic effluent containing hydroquinone. At the end of day 5, the maximum COD reductions obtained for the bacterial strain was 66.78% and 54.4% for the fungal strain. The biologically treated effluent streams are subjected to electrochemical oxidation sequentially for 1 h. Then the same effluent was treated with immobilized microorganisms. The COD of the effluent for the bacterial strain was reduced from 429 mg/L to 261 mg/L. The minimum COD reduction was reduced for the fungal strain from 646 mg/L to 252 mg/L.
In the fourth part of the study, experiments were carried out in continuous flow electro and photo recirculation reactor for 6 hours under different operating conditions for the mineralization of the effluent. The effect of current density showed increase in electro and photochemical degradation efficiency. The electro and photochemical degradation efficiency of 92 % was achieved at optimum conditions such as current density 1 A/dm$^2$, 2 g/L of supporting electrolyte at the initial concentration of 250 mg/L.

In the fifth part of the study the biosorption of dye was carried out using immobilized microbes. The inactivated *Pseudomonas aeruginosa* and *Phanerochate chrysosporium* immobilized in a sol-gel matrix of sodium alginate and PVA shows its potential to adsorb the reactive dye Procion blue 2G at room temperature and constant pH. The maximum dye uptake is 1.648mg/g of bead for *Pseudomonas aeruginosa* and it is 1.242mg/g of bead for *Phanerochate chrysosporium*.

In the sixth part of the study, the biosorption of heavy metals were carried out using immobilized *E. coli*. Different operational parameters such as effect of contact time, initial metal concentration, and adsorbent dosage were studied. The results obtained from the adsorption of Ni ions onto the biofilm and biobeads showed that the biosorption increases with increase in contact time also. The adsorption of Ni ions was gradually increased for the first 5 h and equilibrium was nearly reached after 5 h for five different initial Ni ion concentrations. Batch kinetic and isotherm studies were carried out to determine biosorption and desorption efficiency of the biosorbent.