INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	**Pranjal Pratim Das**
Roll Number	:	**176107027**
Programme of Study	:	**Ph.D.**

Thesis Title: **Treatment of Steel Industry Wastewater by an Integrated Ozonation and Electrocoagulation Process**

Name of Thesis Supervisor(s)	:	**Prof. Mihir Kumar Purkait**
Thesis Submitted to the Department/ Center	:	**Chemical Engineering**
Date of completion of Thesis Viva-Voce Exam	:	**10/06/2024**
Key words for description of Thesis Work	:	**Steel industry effluents; Cyanide; Phenol; Electrocoagulation; Ozonation; Kinetic model study; Cost-estimation**

SHORT ABSTRACT

The steel industry plays a crucial role in global economic growth, yet its expansion has led to increased wastewater discharge, which varies based on the unit operations used, such as blast furnaces, coke ovens, and rolling mills among others. Such wastewater often contains toxic pollutants like cyanide, phenol, oil & grease, ammonia-N, and colored compounds. Conventional treatment methods, including chemical coagulation and biological processes, sometimes fail to fully remove these contaminants, thus prompting the need for more effective solutions.

The thesis investigates the use of both standalone and integrated ozonation and electrocoagulation techniques for the treatment of different steel industrial effluents. The work explores the combined ozone-assisted electrocoagulation treatment of biological oxidation treated (BOT) wastewater consisting of colour, iron and ammonia-N from Tata Steel Industry, India. The experimental conditions such as 1.33 mg s^{-1} (ozone generation rate), 40 min (ozonation time), 100 A m^{-2} (current density), and 30 min (electrolysis time) were found to be optimum for reducing all the target pollutants below their respective permissible limits of surface water quality. The removal capacity of the hybrid process was observed to be 98.2%, 90.6%, and 62.8% for colour, iron, and ammonia-N, respectively. The removal of pollutants followed the pseudo first-order kinetic model with R^2 value of about 0.99 for iron, ammonia-N, and colour,

respectively. The sauter mean diameter of the ozone microbubble was found to be 425 μm, and the range of the microbubble size varied between 20 μm and 650 μm. Finally, the cost analysis study showed that the proposed hybrid process was found to be economical compared to other reported literature.

The work also focuses on the treatment of cyanide and phenol rich steel plant wastewater from Tata Steel Industry, India via hybrid ozonation assisted electrocoagulation method. The experimental operating condition was optimized which showed that the ozone generation rate of 1.33 mg s^{-1}, ozonation time of 40 min, current density of 100 A m^{-2}, and electrolysis time of 30 min were sufficient for reducing all the pollutant concentrations below their permissible limits. The removal efficiencies of the combined process at the optimum conditions were observed to be 99.8%, 99.5%, 94.7%, 95%, and 46.5% for cyanide, phenol, COD, BOD, and chloride, respectively. The kinetic study conducted showed that pseudo first-order reaction fitted best with the highest R^2 of 0.99 for cyanide, COD, BOD, and chloride, respectively. Further, the mass transfer study illustrates an increase in the dissolved ozone concentration in the solution for an increase in the volumetric mass transfer coefficient, K_l a. Finally, the cost estimation study of the hybrid process was carried out and compared with that of the other reported literature.

In addition, the work establishes the performance of standalone ozonation and electrocoagulation processes for the treatment of cold rolling mill (CRM) wastewater consisting of phenol, COD, BOD, iron, and oil content from Tata Steel Industry, India. The optimum experimental conditions of 200 Am^{-2} (current density), 1.12 mg s^{-1} (ozone generation rate), and 30 min (treatment time) were adequate in lowering the amount of all the pollutant content below their respective discharge limits. Comparative analysis showed that the electrocoagulation process was more efficient than ozonation for treating the cold rolling mill (CRM) wastewater, thus achieving higher removal rates for phenol (98%), iron (97.5%), COD (90.5%), BOD (85.7%), and oil & grease (88%). The pseudo first-order kinetic model was found to be best suited with the highest R^2 value of 0.99 for phenol, COD, BOD, iron, and 0.98 for oil & grease. Moreover, mass transfer analysis for ozonation indicates an increase in the volumetric mass transfer coefficient (K_l a) with an increase in the ozone generation rate. The cost of ozonation process was found to be about six times than that of electrocoagulation. Nevertheless, the efficiencies and operating costs for both the processes were found to be satisfactory compared to other methods reported in the literature.