The present research was undertaken to investigate the potential of electrocoagulation (EC) and electrochemical oxidation (EO) techniques for treating petroleum refinery wastewater. Different types of electrodes have been used in both electrocoagulation and electrochemical oxidation. In electrocoagulation, aluminium and mild steel were used as the anode. While in the electrochemical oxidation, ruthenium oxide coated titanium (RuO₂/Ti) was used as the anode.

In electrocoagulation, the experiments were conducted in a batch reactor. The effect of the operating parameters, such as the current density, pH, supporting electrolyte, treatment time, and anode material, was examined. The progress of the pollutant removal was measured through COD measurement. The electro-coagulation mechanism was modeled using adsorption isotherms. The sludge generated during electrocoagulation was analyzed by scanning electron microscopy (SEM) coupled with the energy dispersive analysis of X-rays (EDAX). The Fourier transform infrared (FTIR) spectroscopy analysis was used for the liquid effluent analysis. The results showed a maximum percentage COD removal of 87% can be achieved under optimum experimental conditions. The energy consumption and anode dissolution were 15 kWh/kg and 622 mg/dm³ respectively, within 40 min of
treatment time. The metal hydroxide, and the gases released during the electro-coagulation process, eliminated the pollutants in the wastewater. The adsorptability of the pollutants in the wastewater on the surface of flocs was modeled using the Langmuir, Tempkin, Freundlich, and Dubinin–Radushkevich models. The Freundlich isotherm model matches satisfactorily with the experimental observations for mild steel and aluminium anodes.

In electrochemical oxidation, the experiments were carried out in batch, and batch recirculation systems. The study focus on evaluating different operating parameters that affect the performance of the treatment process to produce high quality water. In a batch electro-oxidation treatment, the optimized conditions were the current density of 30 mA/cm$^2$, pH of 8, supporting electrolyte of 2 g/L, and treatment time of 120 minutes. Under the optimal condition, the energy consumption of 69 kWh/kg, mass transfer coefficient of 0.006164 cm/s, and a COD removal efficiency of 92%, were obtained. Batch recirculation experiments were carried out in a tubular electrochemical reactor. The performance of Tubular Electrochemical Reactor (TER) has been investigated using Residence Time Distribution (RTD) and Computational Fluid Dynamics (CFD) studies, which give the flow dynamic behaviour of the electrolyte inside the reactor. The results show that an increase in the flow rate has a considerable effect on the flow dynamics, and brings about more turbulence, which is very helpful in increasing the mass transfer coefficient between the electrode and the fluid flow. Also, the results obtained show positive influence of the mesh electrode on the flow dynamics.
behavior. The presence of dead volume and short circuiting in the reactor decreased with an increase in the flow rate. The performance of the TER was experimentally validated by studying the mass transfer and the color removal efficiency and the results show an improvement at higher flow rates. The treatment of petroleum refinery wastewater using batch recirculation experiments show about 84% of COD removal under optimum conditions. Further the result shows that an increase in the flow rate decreases the energy consumption, and enhances the mass transfer coefficient. The increase in the flow rate (30 to 120 L/hr) resulted in considerable improvement of the current efficiency, (CE), mass transfer coefficient, (km) and specific energy consumption, (SEC).

The thesis has been divided into five chapters:

Chapter 1 gives an introduction on the petroleum industry, the usage, recycle and reuse of water in the typical petroleum refinery, the current regulation of discharge limits for petroleum effluents and various treatments available to treat the petroleum effluent are discussed. Introduction electrocoagulation and electro-oxidation processes, advantages of electrochemical techniques in environmental protection and the purpose of this study are presented.

Chapter 2 presents a survey of the most important and prominent literature on the area of the research, the recent regulations for chemical constituents and processes, various aspects to improve petroleum industry to a
remarkable level and impact of petroleum refinery wastewater on the
environment are also discussed in this chapter.

Chapter 3 presents the wastewater characterization then materials,
electrochemical experimental setup, procedures, and conditions used to treat
the effluents by electrocoagulation and electrochemical oxidation.

Chapter 4 presents the results and discussion; this chapter is
focused on the electrocoagulation and electrochemical oxidation ability for
wastewater treatment. The effects of the operating conditions on the
performance of this process are presented. Adsorption isotherm models for
electrocoagulation process are proposed. The results of residence time
distribution (RTD) and computational fluid dynamics (CFD) simulation
studies are given to evaluate the performance of tubular electrochemical
reactor for effluent treatment.

Chapter 5 summarizes the experimental and theoretical
investigation and the assessment of the treatment processes were performed.
This chapter gives the conclusion made based on the analysis and further
future work.