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# REMEDIATION OF REFINERY WASTEWATER USING ELECTROCOAGULATION PROCESS

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*ABSTRACT*
***This study was designed to assess the efficiency of the process of electrocoagulation in the remediation of wastewater from Kaduna Refinery and Petrochemical Company (KRPC). 50 liters of wastewater was collected from the effluent point of Kaduna Refinery and Petrochemical Company for the period of 13 months. The process of electrocoagulation (EC), sedimentation and filtration was performed according to various procedures to treat the wastewater. The results obtained showed high dissolved solids (DS), suspended solid (SS), turbidity, electrical conductivity, nitrate, sulphide, phosphate, cyanide, chlorides, oil and grease as well as heavy metals (Hg, Cr, Cd, Ni, and Pb) but the pH reduction was only 10%. The process of electrocoagulation can be effectively used to remove pollutant from refinery wastewater. It is recommended that Kaduna Refining and Petrochemical Company should add electrocoagulation as a supplement to enhance their treatment processes so as to help reduce the menace of water pollution faced by the inhabitants of Romi and Rido.***
***Keywords: Electrocoagulation, Wastewater, Refinery, Pollutants, Sedimentation, Filtration, Heavy metals***

## INTRODUCTION

In refining of refinery products, opportunities exist for the release of pollutant such as nitrate, sulphide, phosphate, Cyanide, chlorides, oil and grease and heavy (Hg, Cr, Cd, Ni and Pb) into the ecosystem. These pollutants are produced during refining process in an effort to improve human standard of living but ironically their unplanned intrusion into the environment can reverse the same standard of living by impacting negatively on the environment (Ugya *et al.,* 2015). Also, large quantities of water are being utilized for desalting, distillation, thermal cracking, catalytic and treatment processes to produce useful products such as liquefied petroleum gas, gasoline, jet fuel, diesel, asphalt and petrochemical feedstock during the refining of petroleum (Tobiszewski *et al.,* 2012; Ishak *et al.,* 2012; Dermentzis *et al.,* 2014; Metcalf and Eddy, 2014). This process of refining produces wastewater of 0.4 to 1.6 times the volume of the crude oil processed (Coelho *et al.,* 2006; Ishak *et al.,* 2012; Mizzouri and Shaaban, 2013).Disposal of untreated oil refinery wastewater (ORWW) into water bodies results in environmental and human health effect (Diya'uddeen *et al.,* 2011; Jo *et al.,* 2008). If not treated and disposed safely, fresh ORWW could be a main source of water pollution because it could percolate through soil and subsoil, resulting high contamination to receiving waters. Consequently, the treatment of raw oil refinery wastewater constituents before discharge has been made a legal requirement to prevent contamination of water resources and avoid both acute and chronic toxicities. The biological treatment of wastewater from industrial facilities has reportedly experienced the difficulties of poor biosolid separation, voluminous biological sludge, and low removal efficiencies. The existing wastewater treatment facilities have to improve their operating performance and provide an effluent of higher quality that conforms to more stringent regulations (Galil and Levinsky 2007).

Currently, electrochemical technologies offer the ideal tools for addressing environmental problems. The main reagents used are electrons, which are a clean reagent and eliminate the need for adding an extra reagent.The electrocoagulation (EC) technology induces coagulation and precipitation of contaminants by a direct current electrolytic process followed by separation of flocculent without the addition of coagulation-inducing chemicals (Shammas *et al.,* 2010). In its simplest form, an electrocoagulation reactor may be made up of an electrolytic cell with one anode and one cathode. The conductive metal plates are commonly known as ''sacrificial electrodes'' and may be made of the same or different materials (anode and cathode).

EC is the electrochemical production of destabilization agents (such as aluminum(III), iron(II) and iron(III)) that bring about the neutralization of the electric charge for removing pollutants. This process is characterized by reduced sludge production, no requirement for chemical use, and ease of operation (Emamjomeh and Sivakumar, 2009). EC has been applied successfully to tannery wastewater (Feng, 2007), petroleum refinery wastewater (El-Naas *et al.,* 2009), the removal of lignin and phenol from paper mill effluents (Ugurlu *et al.,* 2008), olive mill wastewater (khoufi *et al.,* 2007), the removal of heavy metals (Shafaei *et al.,* 2011), the removal of dairy effluents (Tchamango *et al.,* 2010), textile wastewater (Khandegar and Saroha, 2013).

Electrocoagulation has been investigated and applied for purifying the wastewater by many researchers previously and the results show demonstrates that electrocoagulation is a useful process in treating different wastes such as soluble oils, liquid generated by food, industrial materials, and fibers and effluents come from the paper industry (Fadali *et al.*, 2016; Mohammadizaroun and Yusoff, 2014; Martínez-Delgadillo, 2010; Ni'am *et al.*, 2007).It removes metals, colloidal solids and particles, petrochemical hydrocarbonsand soluble inorganic pollutants from aqueous media (Yilmaz *et al.*, 2007; Moussavi *et al.*, 2011). Mohammadizaroun and Yusoff, (2014) classified the factors that may affect the efficiency of electrocoagulation into: (i) factors related to the properties of the treated wastewater like nature of pollutants, pH of wastewater,temperature and amount of wastewater and (ii) Design of the treatment apparatus and treatmentparameters like voltage, current, type of sacrificial anode and alignment of electrodes. This study was designed to assess the efficiency of the process of electrocoagulationin the remediation of wastewater from Kaduna Refinery and Petrochemical Companysince the wastewater have become a menace to the inhabitants of Rido and Romi.

## MATERIALS AND METHODS

### Wastewater Sampling

Wastewater samples (50 liters) were collected from the effluent point of Kaduna Refinery and Petrochemical Company monthly for the period of 13 months according to standard method as described by APHA (1998). The electrochemical cell was constructed to have aluminium and iron electrodes according to the methods used by Hernández, *et al.* (2012), Mansour and Hasieb (2012) as well as Umran and Sadettin (2015). Wastewater samples were transferred into mechanical stirrer to promote flocculation. Coagulates found in the electrochemical cell after treatment were removed using the process of sedimentation and by filtering using Whatman filter paper. Temperature adjustment during the tests was undertaken at 295 K using heating plate, at 285 K using water flow and at 275 K with an ice bath. Maintenance of temperature within ±1 K range was done according to the method of Umran and Sadettin (2015). During the process of coagulation of sulphide, oxidation was prevented by the addition of nitrogen. The parameters such as dissolved solids (DS), suspended solids (SS), turbidity, electrical conductivity, pH, nitrate, sulphide, phosphate, cyanide, chlorides, oil and grease and heavy metals (Hg, Cr, Cd, Ni, and Pb) were determined before and after the process of electrocoagulation according to the procedure of APHA (1998). The initial concentration of the parameters was determined before the process of electrocoagulation while 10 ml of sample were taken from the reactor at an interval of 30min during the process of electrocoagulation for the re-determination of parameters. Both initial and final concentrations of parameters are used for the determination of reduction efficiency according to the method employed by Ugya and Imam (2015).

### Results and Discussion

The results obtained clearly show increment of nitrate (58% reduction), sulphide (65% reduction), phosphate (53% reduction), cyanide (93% reduction), chlorides (62% reduction), oil and grease (59% reduction) removal as treatment time increase (Fig 3). Similar results were reported by researchers such as Bayar *et al.* (2013) and Khosa *et al.* (2013) who showed that the high removal was due to change in pH resulting from the use of aluminum electrode. The high rate of heavy metal removal (Pb 99% reduction, Hg 100% reduction, Cr 98% reduction, Ni 100% reduction and Cd 99% reduction) (Fig 3) was due to low concentration of the metals in the wastewater. The high heavy metal removal efficiency was due to the types of electrode used. Researchers such as Vasudevan *et al.* (2011), Mansour and Hasieb (2012) and Rajemahadik *et al.* (2013) also reported high heavy metal removal efficiency using aluminium and iron electrode. The low pH recorded in the study (10%) (Fig 1) is attributed to the fact that the initial pH concentration of the wastewater is acidic, so the process of electrocoagulation increases the pH to neutrality rather than reducing the pH to a more concentrated acidic nature. Mouedhen *et al.* (2008) reported that at pH of 3, electrocoagulation process increase the pH of a solution to neutrality.

The high turbidity reduction recorded in the study is due to increase removal of DS (93% reduction) and SS (76% reduction), the high SS and DS reduction is attributed to the fact that coagulates present in the wastewater after the process of electrocoagulation were removed by the process of sedimentation and filtration (Scholtz, 2010; Matilainen *et al.,* 2010). The high electrical conductivity (72%) reduction can be link to the low reduction of pH since electrical conductivity tend to be higher when solution is acidic than when a solution is neutral. This result is due to the fact that at neutral pH more $OH^-$ is added (Kamaraj *et al.,* 2013; Kumarasinghe *et al.,* 2014).

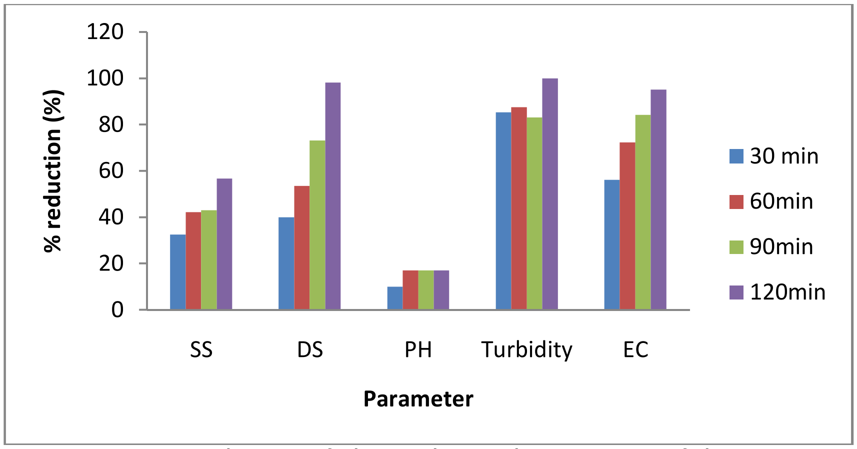


Figure 1: Percentage reduction of phsico-chemical parameters of the wastewater

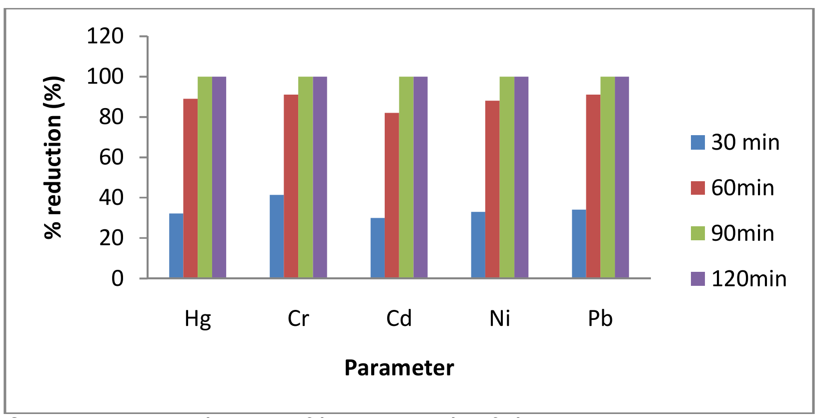


Figure 2: Percentage reduction of heavy metals of the wastewater

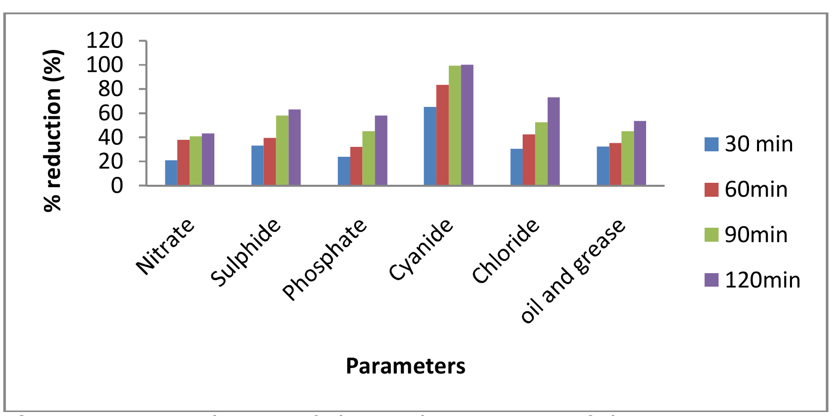


Figure 3: Percentage reduction of chemical parameters of the wastewater

**Conclusion**

Electrocoagulation is a treatment process that is able of being an efficient treatment process as conventional methods such as chemical coagulation. From this research, it has been observed that electrocoagulation is capable of having high removal efficiencies of suspended solids, dissolved solids, heavy metals (Hg, Cr, Cd, Ni and Pb) , and achieving a more efficient treatment processes quicker than traditional coagulation and economical than other methods of treatment such as ultraviolet (UV) and ozonation.The results obtained shows that refinery wastewater can be remediated using the processes of electrocoagulation since all the pollutants were significantly reduced. It is thereby recommended that Kaduna Refining and Petrochemical Company should include electrocoagulation as part of their treatment processesso as to aid the drastic reduction of the menace of water pollution experienced by the inhabitants of Romi and Rido.

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