Electrocoagulation Treatment of Municipal Waste Water

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Abstract: ***This study is an attempt to treat municipal wastewater by electrocoagulation (EC) process where aluminium is used as sacrificial electrode. The effect of different operating parameter such as pH, current density, inter electrode gap, and reaction time on COD and color removal has been studied. The operating condition pH of 6, current density of 89 A/m^2, electrode of 20 mm and reaction time of 20 minutes was found optimum. At this condition maximum COD removal of 96% and color removal of 90% were achieved. Hence it is demonstrated that EC process is well applicable to treat municipal wastewater.***

Keywords: Municipal wastewater, COD reduction, color reduction, electrocoagulation, aluminium electrode

1. Introduction

Water is vital natural resource which is essential for a multiplicity of purposes. Its many uses include drinking and other domestic uses, industrial cooling, power generation, agriculture, transportation and waste disposal. In chemical process industry water is used as a reaction medium, a solvent, a scrubbing medium, and a heat transfer agent [1]. Unfortunately, it is being rapidly contaminated and urgent measures need to be taken for avoid its damage. In many countries, wastewater is released directly to lakes and rivers without treatment, which can damage the aquatic system. Therefore, the treatment of municipal waste water is required.

Municipal water use is directly related to the quantity of water withdrawn by populations in cities, towns, housing estates, domestic and public service enterprises. Sewage is a type of waste water that comprises domestic wastewater and is therefore contaminated with feces or urine from people's toilets, but the term sewage is also used to mean any type of waste water. Sewerage is the physical infrastructure, including pipes, pumps and screen, channels etc. used to convey sewage from its origin to the point of eventual treatment or disposal [2].

2. Experimental Methods

2.1 Material

Analytical reagent (A.R.) grade chemicals were used for the analysis of the various parameters of ECR. Wattman Filter paper was supplied by Kasliwal Brothers, Indore (M.P.). The Aluminium was used as electrode material. These sheets were procured from the local market. The effluent was obtained from a local municipal sewage tank, Indore (M.P), India.

2.2 Characterization

The municipal effluent contains several type of organic and inorganic material. Municipal effluent analysed for their basic parameter such as (BOD, COD, pH, TSS, TDS etc.) per standard method [3]. The water was light yellow in colour. The characteristic, of the municipal effluent before and after treatment under optimum conditions are shown in Table 1.

Table 1: Typical composition of textile effluent before and after treatment

Parameters	Municipal Effluent (mg/lit)	EC-treated municipal effluent under optimum condition
BOD	65	58.5
COD	426	12.7
DO	1.2	0.99
pH	8.5	7.1
TDS	4916.5	960
TSS	4308	717
Total hardness	8000	1000
Colour	Light yellowish	transparent

2.2 Experimental Setup

The treatment was carried out in a electrochemical reactor (ECR) in which electrodes of aluminium was inserted parallel for proper contact of wastewater. Current and voltage was supplied using a D.C. power supply. Reactor was placed on the digital magnetic stirrer plat form and stirrer was kept inside the reactor for proper mixing of waste water.

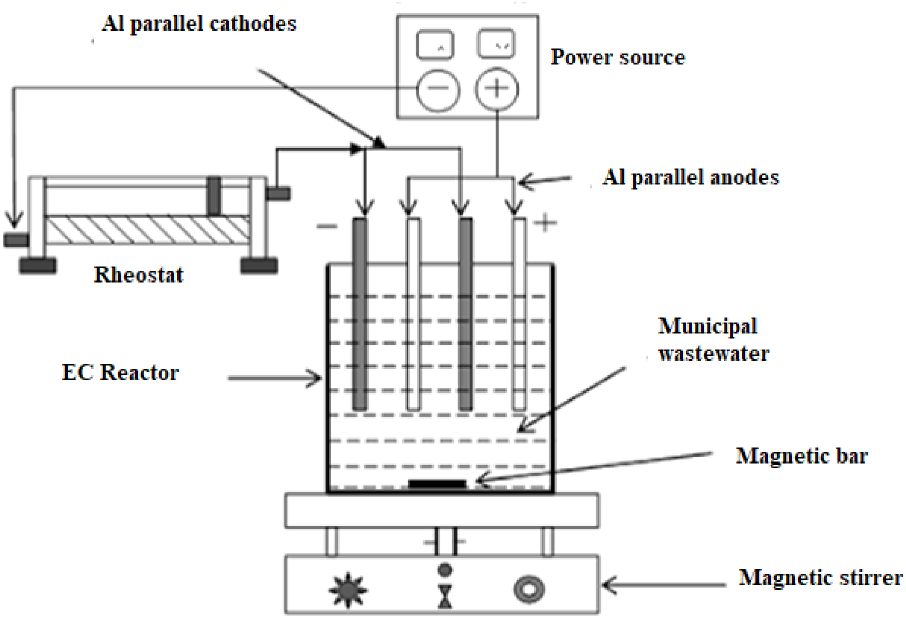

Figure 1: Experimental set up used for the electro-coagulation treatment

3. Result and Discussion

3.1 Effect of Applied Current Density

The current density (CD) being a surrogate parameter is found to influence the treatment efficiency of the electrochemical degradation processes. Therefore, the applied CD was varied to examine its effect on the COD and colour removal for a plate configuration of aluminium electrodes in parallel arrangement [4].

This optimal value can cut down the investment and operational cost. Operating CD is critical in a batch ECR as it is the only parameter which can be directly controlled. The optimal value of CD is an important input to operate continuous ECRs. A low-medium current produces a low bubble density, leading to a reasonable upward momentum flux- conditions that favour bubble residence in the active zone initiating floc formation [5].

At higher CDs the hydroxide ion concentration on the surface of the cathode increases and apart of the OH^- are carried away by diffusion or electric migration into the bulk of the solution. In practical applications, it is necessary to limit the operating CD to reduce excessive evolution of oxygen and other negative aspects such as a heat generation [6]. The selection of an appropriate CD depends on other operating parameters such as pH_0, waste water character, conductivity, temperature, and the flow rate as well. Too large a CD would result in a significant decrease in the current efficiency (CE). At higher CDs the hydroxide ion concentration on the surface of the cathode increases and a part of the $OH^-$are carried away by diffusion or electric migration into the bulk of the solution [7].

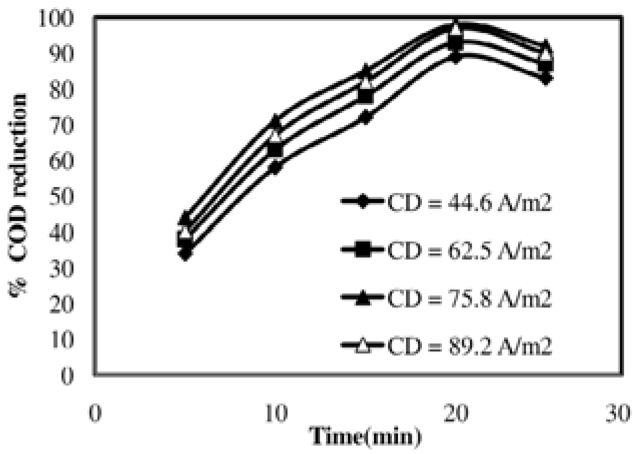

Figure 2: Effect of current density on COD reduction of Municipal Effluent

Figure 2 Presents the COD removal efficiency as a function of applied CD for 4 plate configuration. At 44.6 Am^{-2}, 70% COD removal is observed; at 62.5Am^{-2}, 83% COD removal is observed; at 75.8 Am^{-2}, 97% COD removal is observed in 43 min; at 89.2 Am^{-2}, 87% COD removal is observed. Above these values of CD, the Cod removal efficiency tends to increase limit and further it decreases.

Figure 3 presents the Colour removal efficiency as a function of applied CD for 4 plate configuration. At 44.6 Am^{-2}, 77% colour removal is observed; at 62.5 Am^{-2}, 84% colour removal is observed; at 75.8Am^{-2}, 94% colour removal is observed; at 89.2Am^{-2}, 90% colour removal is observed in 25 mins.

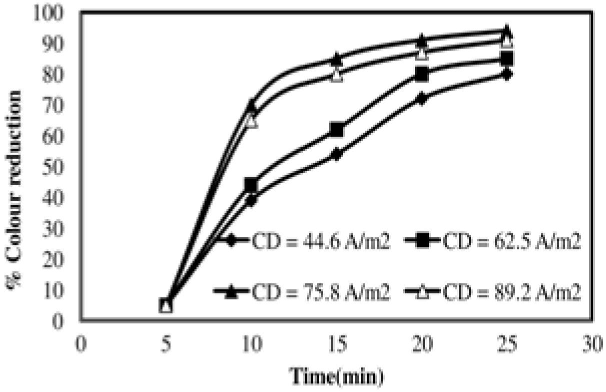

Figure 3: Effect of current density on colour reduction of Municipal Effluent

Colour and COD reduction percentage was increased with the increase in current density due to production of metallic ions in solution. With the increasing generation of metallic ions is directly proportional to current density. The increase in metallic ions approaches to its maximum limit and after that the presence of metallic ions is in excess as a result of which there is a fall in COD reduction efficiency [8].

3.2 Effect of pH

The initial pH (pH_0) of the waste water will have a significant impact on the efficiency of the ECR. The pH of the solution plays a very important role in influencing the electrochemical processes. The effect of pH_0 in the range of 2-10 at the optimal has been investigated. Fig. shows the effect of pH_0 on COD removal for a 4 plate configuration at 89.2Am^{-2} CD. It is observed that the initial pH (pH_0) adjustment of the waste water to pH_0 2for the EC process shows nearly 33% COD removal; at pH_0 4, as the ECT progresses, 69% of COD is removed in 20 minutes; at 6 pH the maximum COD reduction of 96% is achieved; at8 pH COD is removal efficiency decreases to 47%; at pH 10 the COD removal efficiency again increases to 83%. The EC process with aluminium electrodes shows high treatment efficiency, especially for$2<pH_0<10$.

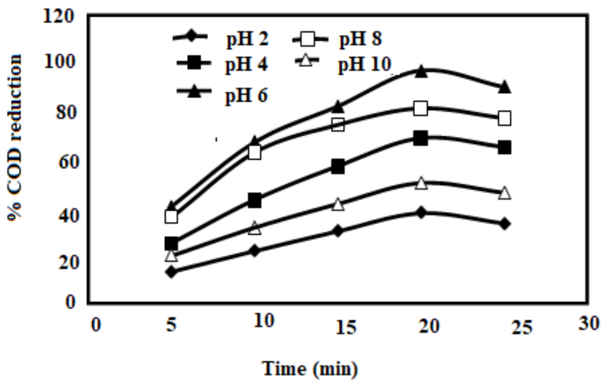

Figure 4: Effect of pH on COD reduction of Municipal Effluent

Figure 4 presents the COD removal efficiency as a function of applied pH for 4 plate configurations. At pH 2, 33% COD removal is observed; At 4 pH 69% removal is observed; At pH 6, 96% COD removal is observed; At pH 8, 47% COD removal is observed, At pH 10,83% removal is observed. Above these values of CD, the COD removal efficiency tends to increase till certain limit and further it decreases. The different results of COD and Colour reductions are achieved at varying pH are due to the quality and quantity of hydroxide ions generated at particular pH [9]. At pH greater than 6 and pH less than 6, protons in the solution get reduced to H_2, consequently the proportion of the hydroxide ions produced is less, leading to a lower removal efficiency.

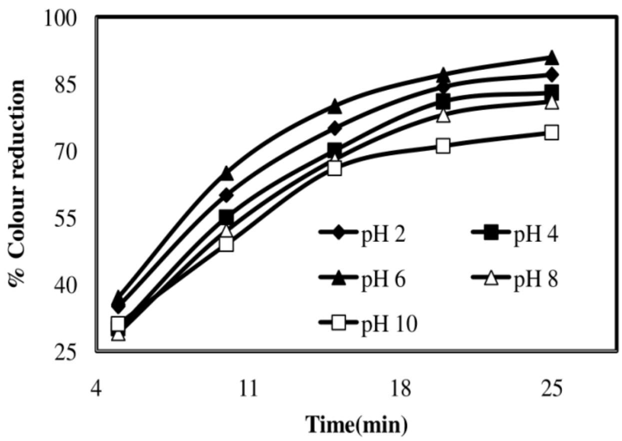

Figure 5: Effect of pH on colour reduction of Municipal waste water

Figure 5 presents the colour removal efficiency as a function of applied pH for 4 plate configurations. At pH 2, 86% colour removal is observed; At pH4 80% colour removal is observed; AtpH 6, 90% colour removal is observed; AtpH 8, 77% colour removal is observed, At pH 10,72% colour removal is observed in 25 mins.

The rate of most chemical and electrochemical reactions increase with an increase in temperature. In the present study, the electrochemical degradation process was found to be exothermic showing the heat generation as a function of the initial pH (pH_0) of the cell solution. The higher the pH_0, the higher is the end temperature of the solution after EC treatment. The increase in temperature is rationalized as the neutralization of opposite charges along with the chemical reaction taking place in the ECR [10].

4. Conclusion

On the basis of the present studies on the electrochemical treatment of municipal waste water electro-coagulation the following conclusion can be drawn:

1) The municipal effluent contains organic and inorganic substances, which contribute to the high COD and colour of the effluent.
2) Electrochemical treatment using Aluminium electrodes for municipal waste water showed a good potential in reducing its COD, total solids concentration and colour. The optimized operating conditions of the batch ECR using parallel type Aluminium plate electrodes.
3) A maximum COD removal of 96%was achieved with a corresponding colour removal of 90% on optimal pH 6 of the municipal at the municipal effluent at the current density 89.28Am^{-2}.

References

[1] Khairul, M.; Mahmad, N.; Electro-coagulation process by using aluminium and stainless steel electrodes to treat total chromium colour and turbidity, Procedia chemistry 2016,19,681-686.

[2] Hutnan, M.; Drtil, M.; Kalina, A.; Anaerobic stabilisation of sludge produced during municipal waste water treatment by electro-coagulation, Journal of Hazardous Materials 2006, 131, 163-169.

[3] APHA, AWWA, WEF, 1998. Standard Methods for the Examination of Water and Wastewater, nineteenth ed. APHA, Washington.

[4] Tran, N.; Drogur, P.; Mercier, G.; Phosphorus removal from spiked municipal waste water using either electrochemical-coagulation or chemical-coagulation as tertiary treatment, Separation and purification technology 2012, 95, 16-25.

[5] Pouet, M.; Grasmick, A.; Urban waste water treatment by electro-coagulation and floatation, Water Science and Technology, 1995, 31, 275- 283.

[6] Vasudevan, S.; Lakshmi, J.; Remediation of phosphate – contaminated water by electro-coagulation with aluminium, Aluminium alloy, and mild steel anodes, Journal of Hazardous Materials, 2009, 164, 1480-1486.

[7] Bukhari, A.; Alaadin.; Investigation of electro-coagulation treatment process for removal of the total suspended solids and turbidity from municipal waste water, Bio-resource Technology, 2008, 99, 914-921.

[8] Moreno, H.; Parga, J.R.; Gomes, A.J.; Rodriguez, M.; Electro-coagulation treatment of municipal waste water in Terreon Mexico, 2013, 51, Issue 13-15.

[9] Yadav, K.A.; Singh, L.; Mohanty, A.; Saatya, S.; Shrikrishnan, T.R.; Removal of various pollutants from waste water by electro-coagulation using Fe-Al electrode, 2012, 46, 1-3.

[10] Zaleschi, L.; Saez, C.; Canizares, P.; Cretescu, I.; Electrochemical-coagulation of treated waste water for reuse, 2013, 51, 16-18.