Removal of TDS from CETP effluent using Copper and Zinc electrodes for separation of cation and anion using Electrochemical Ion-Exchange Process

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Abstract : Industrial wastewater treatment by CETP effluent has been a viable solution for small and medium scale Industries due to shortage of capital cost for treating the wastewater effluent. CETP treats the heterogeneous wastewater coming out from different industries. Removal of TDS is the key issue which cannot be removed by physical or chemical processes. Electrochemical Ion-Exchange Process (EIX) is the viable solution for the removal of TDS from CETP effluent. EIX process was carried out at different operating parameters i.e Resins, Electrodes, Contact time, and Voltage for the TDS removal. Maximum removal of 44% and 31% was observed at 10V at 7 hours contact time when Anion Exchange Resin and Cation Exchange resins were used respectively.

Index Terms* - CETP *Effluent, wastewater, TDS removal, Electrochemical Ion-Exchange Process.

I. Introduction

Water, is the most vital element on our planet for survival[21], and has become an emerging environmental issues. Industrial water is the main contributor for water pollution.

Industrial water pollution effects environment and human health. Industries which discharge their effluent into river, oceans or any other water bodies contains many toxic pollutant which can harm the aquatic life.

In India, Small & Medium Scale Enterprises (SMEs) face stiff environmental regulations and also significantly contribute to the economy of India. SMEs discharge small amount of wastewater but its contains high amount of pollutant which leads to water pollution. Small and medium scale industries cannot effort their own effluent treatment plant, so CETP is the better option for them. They have to convey their effluents as per the standards prescribed by the CETP Plant. CETP has been accepted as a solution for collection, conveyance, treatment and disposal of the effluent from the industrial estates. There are 193 Common Effluent Treatment Plants (CETPs) installed in India, which serve 212 industrial areas/estates.

High TDS effluent is sent to the CETP by industry which is not treated by the CETP and disposed into the receiving water bodies which may cause toxicity, increase the salinity of water. There are many treatment for the removal of TDS from wastewater like Reverse Osmosis (RO), Multi Stage evaporator systems (MSES) which have high operating cost.

Electrochemical ion exchange (EIX) process can be the most effective TDS removal technique compared to other conventional treatment processes. It is the combination of electrochemical and Ion Exchange process which removes the TDS from the wastewater[7].

II. . Material and Method

Material

A lab-scale reactor of size (30×19×12.5 cm) was installed which was fabricated by glass material. Zinc and Copper electrodes were used having length 5cm, breadth 10 cm and Thickness 0.5 mm as anodes and cathodes. Ammeter and Voltmeter was used to measure the current and voltage. Amberlite IR 120 (CER), Amberlite IRA 400 (AER) resins were used for the Ion Exchange process.

Methods

The wastewater sample was collected from Common Effluent Treatment Plant. After the collection of effluent sample the analysis was carried out to check the initial characteristics of some major parameters like pH, TSS (Total Suspended Solids), TDS (Total Dissolved Solids) and COD (Chemical Oxygen Demand) and Chloride by standard method[34].

Table 1: Characteristics of CETP Effluent

Parameter	Inlet	Primary Outlet	Final Outlet	Discharged Limits
PH	6.86	7.92	6.74	5.5 to 9.5
TSS (mg/l)	65	676	281	100
TDS (mg/l)	6000	10795	9245	2100
COD (mg/l)	1200	1373	353	250

Laboratory scale two EIX cells i.e EIX cell-1, EIX cell-2 were installed and operated under varying operating parameters like different voltage (4,8,10), contact time (4,5,6,7), Electrodes(Copper and Zinc), Resins (Amberlite IR 120 (CER), Amberlite IRA 400 (AER)).

EIX Cell-1

EIX Cell-1 was operated by using Copper and Zinc electrodes and Amberlite IRA 400 (AER) at varying voltage and contact time. The purpose behind such cell configuration was to remove anion from wastewater.

Reaction with Anion Exchange Resins:

$R_z\,NR_3OH + HCl \longleftrightarrow R_z\,NR_3Cl + H_2O$

$R_z\,NR_3OH + NaCl \longleftrightarrow R_z\,NR_3Cl + NaOH$

$2\,R_z\,NR_3Cl + H_2SO_4 \longleftrightarrow (R_z\,NR_3)_2SO_4 + 2HCl$

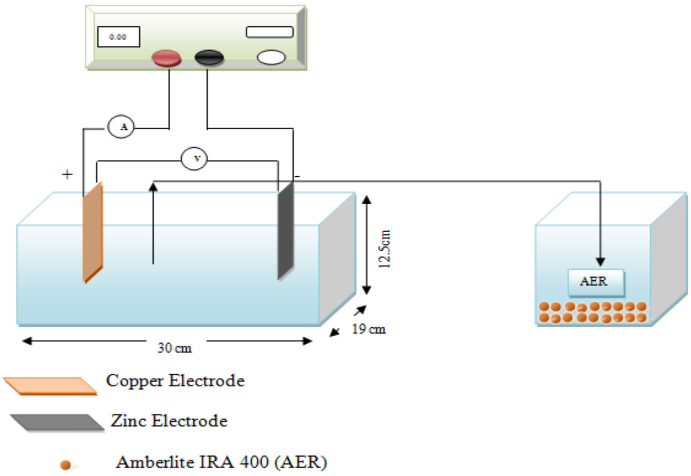

Figure.1 : Lab Scale Set-up of EIX - Cell 1

EIX Cell-2

EIX Cell-2 was operated using Copper and Zinc electrodes and Amberlite IR 120 (CER) at varying voltage and contact time. The purpose behind such cell configuration was to remove cation from wastewater.

Reaction with Cation Exchange Resins

$R_z\,SO_3H + NaOH \longleftrightarrow R_Z\,SO_3Na + H_2O$

$R_z\,SO_3H + NaCl \longleftrightarrow R_Z\,SO_3Na + HCl$

$2R_z\,SO_3Na + CaCl_2 \longleftrightarrow (R_ZSO_3)_2Ca + 2NaCl$

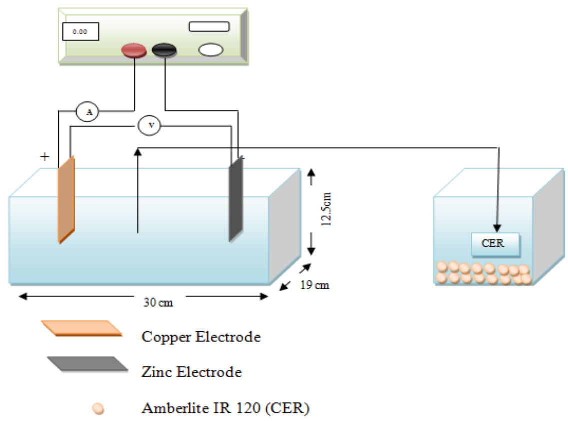

Figure.2 : Lab Scale Set-up of EIX - Cell 2

Wastewater was inserted into the reactor and operated with various operating parameters like contact time (4,5,6,7 hrs), voltage (4,8,10 V) and then % removal of TDS was calculated.

The percentage removal of TDS was determined by using the following formula:

$$\%\, removal\ of\ TDS = \frac{C\ initial - C\ final}{C\ initial} \times 100$$

Where, C initial and C final are the initial and final TDS concentrations respectively.

III. Result and Discussion

Results for Batch Experiments of EIX cell 1

Electrodes : Zinc and Copper
Resins: Amberlite IRA 400 (AER)

Table 2 Removal of TDS from Wastewater (EIX Cell 1)

Initial TDS Concentration (mg/L)	**pH**	**Voltage (V)**	**Con-tact Time (hrs)**	**TDS concentration after treatment (mg/L)**	**% Removal of TDS**
10,795	7.92	4	4	10,725	0.6
			5	10,680	1.06
			6	10,660	1.2
			7	**10,002**	**7.3**
		8	4	10,700	0.8
			5	10,605	1.7
			6	10,430	3.3
			7	**9,555**	**11**
		10	4	7945	26
			5	7180	35
			6	6910	36
			7	**6020**	**44**

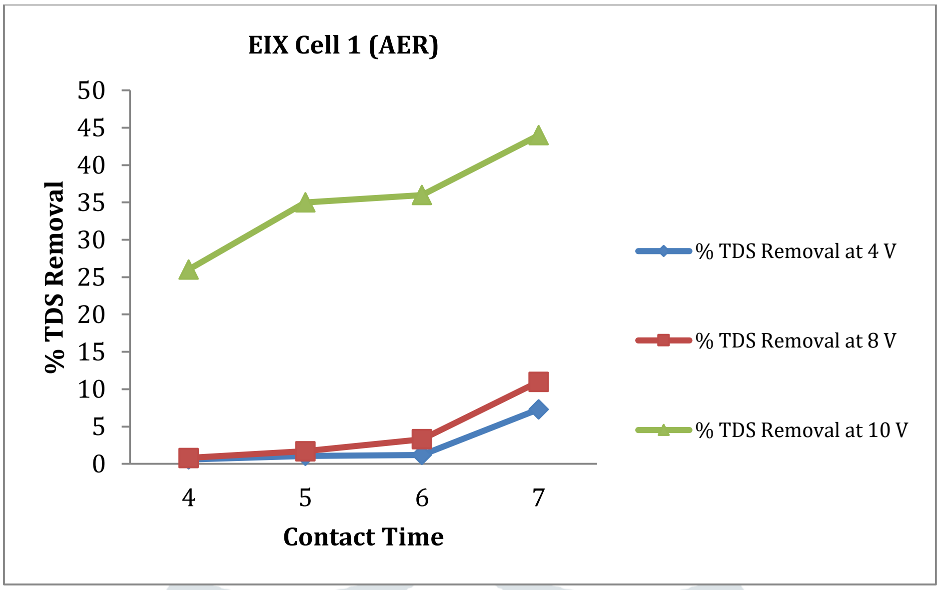

Figure 3: % TDS Removal from wastewater at varying Voltage and Contact Time using Anion Exchange Resins

The graph above shows removal of TDS using AER at different voltage and contact time. The results showed removal efficiency at 7 hrs upto 7.3%, 11%, 44% at 4 V, 8 V, 10 V respectively. The removal was due to the anion removal by Ion Exchange Resins.

Results for Batch Experiments of EIX cell 2

Electrodes : Zinc and Copper
Resins: Amberlite IR 120 (CER)

Table 3 Removal of TDS from Wastewater (EIX Cell 2)

Initial TDS Concentration (mg/L)	pH	Voltage (V)	Contact Time (hrs)	TDS concentration after treatment (mg/L)	% Removal of TDS
10,795	7.92	4	4	10,005	7.3
			5	9725	9.9
			6	9815	9
			7	**9160**	**15**
		8	4	9645	10
			5	9235	14
			6	9205	14.7
			7	**8465**	**21**
		10	4	8845	18
			5	8695	19
			6	7460	30
			7	**7435**	**31**

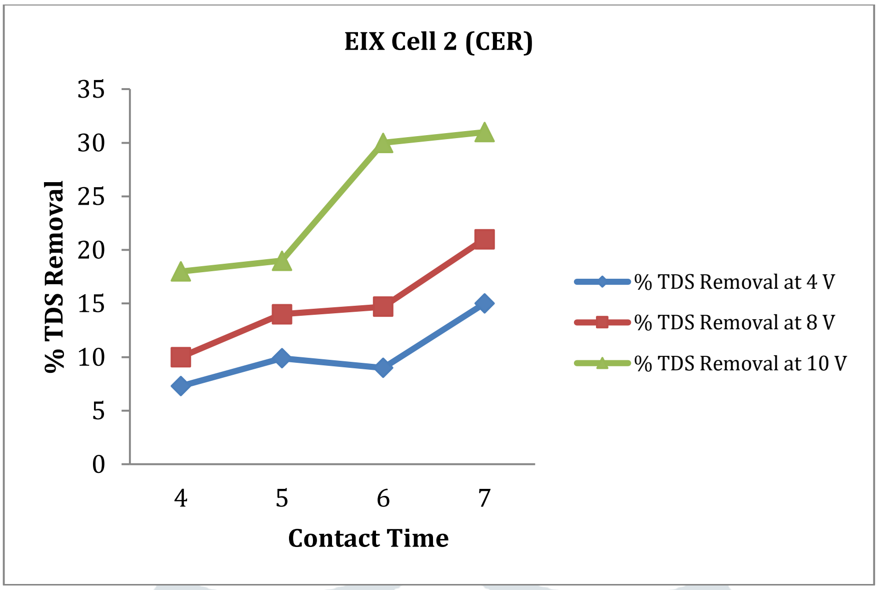

Figure 4: % Removal of TDS from wastewater at varying Voltage and Contact Time using Cation Exchange Resins (CER)

The graph above shows removal of TDS using CER at different voltage and contact time. The results showed removal efficiency at 7 hrs upto 15%, 21%, 31% at 4 V 7 hrs, 8 V 7 hrs, 10 V 7 hrs respectively. The removal was due to the cation removal by Ion Exchange Resins.

IV. CONCLUSION

1) Due to liberation of H^+ or OH^- ions during ion exchange operation pH change was observed under various condition.
2) Higher efficiency of TDS removal was 44%, 31% for EIX Cell 1, EIX Cell 2 respectively due to separation of charged ions towards positively charged electrodes resulted in removal of salts and also due to the anion and cation removal by Resins.
3) Maximum efficiency of 44% TDS removal was observed at 10 V with Anion Exchange Resins (AER) at 7 Hours Contact time.
4) TDS removal efficiency increase with increase in contact time, highest removal efficiency of TDS was achieved at 7 Hours contact time as compared to 4, 5, 6 hours.

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