Removal of Ammonical Nitrogen by Electrocoagulation Method

Raj N.Desai[1], Dr. D S. Vyas[2], Sejal M Patel[3], Helly Mehta[4]

[1] Research Scholar, Environmental Engineering, BVM Engineering College, Gujarat, India
[2] Professor, Civil(Environmental Engineering), BVM Engineering College, Gujarat, India
[3] Chemical Engineer, Unistar Environment and research Laboratory, Gujarat, India
[4] Assistant Professor, Civil Engineering Department, C.G.P.I.T, Gujarat, India

ABSTRACT

Nutrient compound such as ammonical nitrogen (NH_4-N), often present in different types of waters and wastewaters, can find their way to lakes, rivers and drinking water reservoirs.NH_4-N is becoming more important in the alleviation of environmental problems including eutrophication, corrosion and fouling. For this an experimental work was carried out focusing the general problem of effluent discharge for the industries containing high NH_4-N stream using electrocoagulation method. Different electrodes were used for carring out % reduction in ammonical nitrogen and based on it a comparative study was carried out which also shows reduction in COD as well. Combination of different pairs of electrodes such as aluminium, copper, and stainless steel were used as both anode and cathode, keeping their current and voltage constant and varying the treatment time for wastewater treatment.

Keyword: - *Pharmaceutical waste, Ammonical Nitrogen, electro coagulation, wastewater, electrodes.*

1. INTRODUCTION

The high content of ammoniacal nitrogen is the major factor that affects the toxicity of wastewater. Ammonical nitrogen (unionized ammonia, NH_3, and ammonium ion, NH_{4+}) has been found to exist in various types of agricultural, municipal (domestic) and many industrial wastewaters.[1] A large amount of ammonical nitrogen on the surface water is a source of pollution, due to Eutrophication of lakes and rivers and toxicity to aquatic life. Eutrophication of water bodies, a major global environmental problem whose main cause is disposal of nutrients (N and P) directly from water plants or indirectly from agriculture and leaching from sludge deposited in landfill and fields. The rapid development and industrialization along with an increased awareness about the need for a clean environment have forced industrialists, environmentalists and governments to look for cheap, efficient and long lasting solutions to waste water treatment and recycling of nitrogen and phosphorus. [7] Nitrate contamination in water resources is becoming a serious environmental problem worldwide.[6]

Ammonium nitrogen (NH_{4+}-N) is a very common chemical form in aquatic ecosystems and its toxic effect has been widely reported on life. Higher ammonium levels found in natural waters are indicative of deteriorated water quality, especially due to accelerated anthropogenic activity. The presence of nitrogen excess in the aquatic environment has caused serious destruction of the natural nutrient cycle between the living world, water and soil **(Violeta C,2010).** Total removal or at least a significant reduction of NH_4-N is obligatory prior to disposal into streams, lakes, seas and land surface.[9] High nitrate levels in water can cause methemoglobinemia, which is a condition found especially in infants of age under 6 months. Severe methemoglobinemia can result in brain damage and even death **(Seungmoon Lee,2006)**. Not only humans but animals are also affected by nitrates in the same way as human babies. NH_4-N is the toxicant that is causes the death of tilapia fish; concentrations as low as 0.2 to 0.5mg/l can be fatal for certain fishes.

Ammonia in wastewater can originate from many sources such as coke firing stations, fertilizer manufacturing, food processing, land fill lechate, slaughter houses and tanneries. Till now, the main NH_4-N removal processes involves i)air stripping, b)biological nitrification, c)denitrification, [3,2] d)chemical treatment and, e)selective ion exchange method.[4] Also, ammonical nitrogen has a contribution to corrosion of certain metals and to reduce the amount of dissolved oxygen in water due to nitrification process. High concentration of ammonium in surface water makes it unsuitable as drinking water; ammonium can reduce disinfection efficiency, conduct to nitrate formation, and cause taste and odor problems. The maximum level for drinking water set by the Council of the European Community is

of 0.5 mg NH_4^+/L.[8] Ammoniacal nitrogen also contributes to BOD in water. Nitrifying bacteria require a large amount of dissolved oxygen to convert NH_3 into NO_3-(4.3mg of O_2 for every 1.0mg of NH_3). Dissolved oxygen levels are commonly 8-10mg/l and fish require at least 5mg/l. In turbulent waters this is less of a problem. If NH_4^+ is released into waterways it will be degraded into nitrites and nitrates (NO_2-, NO_3-).

Advanced wastewater treatment processes for nitrogen removal are usually separated into biological denitrification and chemical denitrification.[5] The biological denitrification is separated into aerobic nitrification and anaerobic denitrification which removes TN or TKN (NH_3–N/NH_4+–N, NO_2–N, NO_3–N)**(Ruiz G,2013)**.This process is a two-step process. In the first step, ammonia is converted aerobically to nitrate (NO_3) and in the second step, nitrates are converted to nitrogen gas(N_2).

It was reported recently that nitrous oxide (N_2O), which is one of the most important greenhouse gases, could be produced during both nitrification and denitrification in activated sludge and released to the atmosphere. Also, in the biological treatment of high strength industrial wastewater, high concentrations of ammonium or nitrite inhibit the nitrification. The purpose of these treatment processes is to remove nitrogen from the sewage. Thus, these methods are not good enough to treat high strength industrial wastewaters.

2. Materials and Method

Raw Wastewater: The raw wastewater used in this experiments was collected from the outlet of the Effluent Treatment Plant (ETP) of a pharmaceutical company located near Vapi, Gujarat. The sample was stored at 4˚ C immediately after collection. Its initial Characterization are as shown below in Table 1.

2.1.Materials

Chemicals used: Alum**,** NaOH, Potassium dichromate ($K_2Cr_2O_7$), Sulfuric acid (H_2SO_4) about 98%, Mercuric sulfate ($HgSO_4$), Silver Sulphate ($AgSO_4$), Ferroin indicator, Boric Acid Indicator, Borate Buffer Solution, Anhydrous Magnesium chloride ($MgCl_2$), Di-Sodium Hydrogen Ortho-Phosphate(Na_2HPO_4)

Electrodes: 1. Aluminum 2. Copper 3. Stainless steel

Experimental Setup:

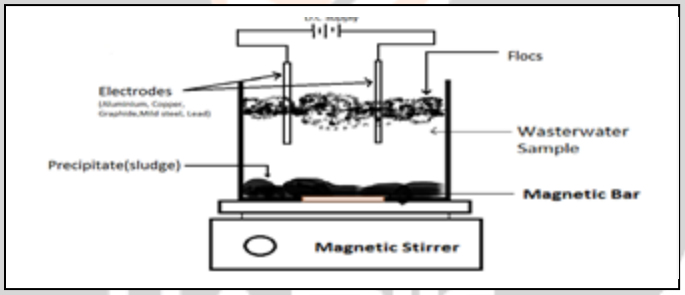

Fig-1: Electrochemical Coagulation

Table-1: Characteristic of Raw Wastewater

Sr.No	Parameter	Method Used	Values	Permissible Limit
1.	pH	Glass Electrode	7.09-7.97	5.5-9
2.	TDS	Gravimetric Method	20,052 mg/L	2100 mg/L
3.	TSS	Gravimetric Method	22 mg/L	100 mg/L
4.	NH_4-N	Kjeldal method	962.47 mg/L	50 mg/L
5.	COD	Open Reflux	5364.2 mg/L	250mg/L
6.	BOD(at 3 Days, 27^0)	-	1170 mg/L	30 mg/L

All the above mentioned Permissible limits are as per the norms described by Gujarat Pollution Control board.

2.2 Experimental Procedure:

Experiment is to be carried out in a 2 L of glass reactor. Connect the electrodes to the D.C. supply through wires and immerse the electrodes in sample. Pass regulated current with the help of D.C supply and take samples at regular intervals. Take the sample from 5 cm above the bottom of the reactor. Estimate the results of NH_4-N in mg/L.

3. RESULTS AND DISCUSSION

From the table 1, it is clear that waste from pharmaceutical industry contains high amount of TKN, COD, BOD and TDS. Thus, by providing electrocoagulation process treatment for wastewater by different electrodes and varying parameters, results were obtained to have reduced level in NH_4-N removal from waste water.

3.1 Electrocoagulation by Aluminum electrodes:

While treating the wastewater by using Al electrodes following were the results obtained keeping the current and voltage condition as mentioned below. The table shows the reduction in Ammonical Nitrogen along with COD as we go on increasing time.

Table-3: Reduction of NH_4-N by using Al Electrode

- Current-1.48-1.50 A.
- Voltage- 15 V

Sr.No	Time	NH_4-N (mg/L)	% Reduction in NH_4-N	COD (mg/L)	% Reduction in COD
1	0	962.473	0	5147	0
2	30	775.46	19.43	5017.6	2.51
3	60	641.76	33.32	4704	8.61
4	90	508.06	47.21	4218	18.05

From table 3 experimental results showed that using Aluminum electrodes, NH_4-N removal reached nearly by 508.06 mg/L from initial value 962.47 mg/l after treating waste for 90 minutes. About 42.7 % removal of Ammonical nitrogen can be removed by electrocoagulation Process.COD removal at that time was observed to be reduced by 18 %. Below figure shows the graphical representation of reduction of NH_4-N by using Al Electrode at the condition of Current: 1.48-1.50 A and Voltage- 15 V.

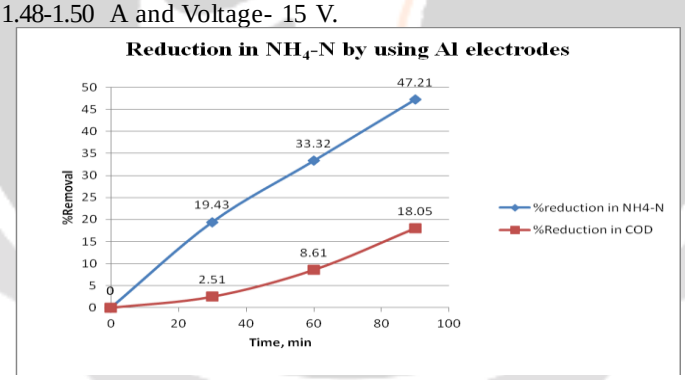

Fig-2 : Reduction of NH_4-N by using Al Electrode

3.2 Electrocoagulation by Copper electrodes:

The following were the results obtained during wastewater treatment using copper electrodes and, the current and voltage condition are as mentioned below.

Table-4: Reduction of NH_4-N by using Cu Electrodes.

- Current-1.48-1.50 A.
- Voltage- 15 V

Sr.No	Time	NH_4-N (mg/L)	% Reduction in NH_4-N	COD (mg/L)	% Reduction in COD
1	0	962.47	0	5147	0
2	30	748.72	22.21	4860.8	5.56
3	60	695.24	27.77	3449.6	32.98
4	90	615.02	36.10	1568	69.54

From table 4 experimental results showed that using Copper electrodes, NH_4-N removal reached nearly by 615.02 mg/L from initial value 926.47 mg/l after treating waste for 90 minutes. About 36 % removal of Ammonical nitrogen can be removed by electrocoagulation Process. COD removal at that time was observed to be reduced by 69 %.

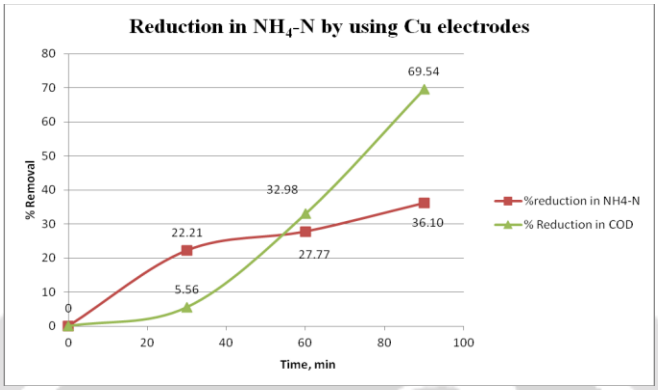

Fig-3 : Reduction of NH_4-N by using Cu Electrode

3.3 Electrocoagulation by Stainless Steel electrodes

Table-5: Reduction of NH_4-N by using SS Electrode

- Current-1.48-1.50 A.
- Voltage- 15 V

Sr.No	Time	NH_4-N (mg/L)	% Reduction in NH_4-N	COD (mg/L)	% Reduction in COD
1	0	962.47	0	5147	0
2	30	802.2	16.65	4860.8	5.56
3	60	762.09	20.82	3606.4	29.93
4	90	681.87	29.15	1881.6	63.44

From table 5 experimental results showed that using SS electrodes, NH_4-N removal reached nearly by 681.87 mg/L from initial value 926.47 mg/l after treating waste for 90 minutes. About 29.15 % removal of Ammonical nitrogen can be removed by electrocoagulation Process. COD removal at that time was observed to be reduced by 63.44 %.

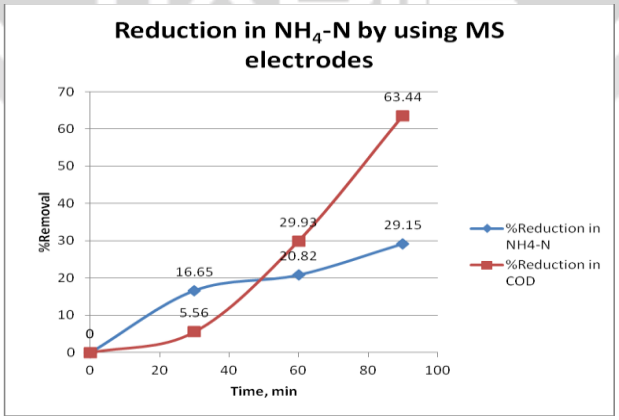

Fig-4 : Reduction of NH_4-N by using SS Electrode

It is observed till now that maximum NH_4-N removal was obtained by using Aluminium electrodes which was 47 % along with reduction in COD upto 18%. Also by using Copper electrodes it was noticed to have reduction in NH_4-N upto 36% and COD by 69% which is remarkable. Results obtained were carried out keeping voltage and current constant, including spacing between the electrodes so as to carry out comparative study for NH_4-N reduction.

4. CONCLUSIONS

From the series of experiments carried out to reduce ammonical nitrogen, it was observed that the amount of NH_4-N reduces upto 47% along with COD by using Aluminum electrodes keeping Current condition from 1.48-1.50 A and constant Voltage at 15 V. Also it was noticable that by using copper electrodes and for same current and voltage condition, COD reduces upto 69% and NH_4-N upto 36%. So for wastewater that have high amount of COD can be treated by using Cu electrodes. Further work can be carried out using combination of different electrodes.

5. ACKNOWLEDGEMENT

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