Removal of Ammonia Nitrogen And Phosphorus Using Electrochemical Cell

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Abstract- *Biological treatment systems face many challenges in winter to reduce the level of nitrogen due to low temperatures. Ammonia Nitrogen contaminated wastewater has posed great threat on the safety of water resources. The present work aims to employ an electrochemical cell to investigate the effect of electrodes material in the reduction of Ammonia Nitrogen and Phosphorus in domestic wastewater. Effluent from Activated Sludge Process was used as sample and it was collected from Sewage Treatment Plant located at Avaniyapuram, Madurai. The ammonia nitrogen was found to be 89.6 mg/L in the waste water sample. An experimental study was carried out to investigate the removal efficiency of the electrochemical cell by using, pair of Aluminum and Copper as electrodes. The result indicates that the removal of ammonium nitrogen (NH4 + –N) and the lowering of phosphorus was influenced by the electrode material. Comparatively Aluminum electrodes showed effective results that the value is reduced to 8.96 mg/l which shows 90% removal of ammonia nitrogen.*

I. OBJECTIVES OF WASTEWATER TREATMENT

1. To improve quality of wastewater
2. Elimination of pollutants, toxicants and many such
3. Preservation of water quality of natural water resources
4. To make wastewater usable for other purposes
5. Prevention of harmful diseases

Methods of Wastewater Treatment:

Wastewater treatment technologies or advanced waste water treatment methods can be broadly classified into three sub divisions and are as follows:

1. **Physical treatment method:** It involves removal of pollutants/contaminants by physical forces.
2. **Chemical treatment method:** Removal of impurities or toxic wastes through chemical reactions.
3. **Biological treatment method:** Ejection of pollutants by biological activities.

Industrial Wastewater Treatment Process:

In order to produce a clean effluent that can be safely discharged to water bodies, industrial and municipal wastewater treatment process use four distinct steps of treatment to remove harmful contaminants.

a. Preliminary Treatment of Wastewater: This is the first step in wastewater treatment and its objective is to remove large debris, coarse solids and heavy inorganic material contained in the wastewater flow. It consists of physical operations such as:

1. Screening: Removes heavy solids in wastewater such as rags, paper, plastics, sticks and metals to prevent damage and clogging of downstream equipment.
2. Floatation: It is used for separation of floatable and suspended solid particles from waste water.
3. Grit removal: Here, grit chambers are used to slow down the flow so that solids such as sand, ash, cinder and eggshells will settle out of the water and it can be removed manually or mechanically.

b. Primary Treatment of Wastewater: Large debris and grit removed in the preliminary treatment is directed to primary treatment operations and it's objective is the removal of settleable organic and inorganic solids by sedimentation and the removal of materials that will float (scum) by skimming. It involves physical and /or chemical operations for treatment of wastewater.

1. It involves a more sophisticated tank called sedimentation tank or primary clarifier removes most of the suspended solids that will float or settle.
2. Sedimentation often uses chemicals like flocculants and coagulants.
3. Sludge that settles to the bottom of the clarifier is called as primary sludge and it is collected for further treatment called sludge treatment.
4. In this treatment about 50-70% of suspended solids, 35% of BOD will get reduced and it removes very few toxic chemicals

c. Secondary Treatment of Wastewater: This treatment involves a biological process and it's objective is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids.

1. Biological treatment process for secondary treatment are classified as aerobic (in the presence of oxygen) and anaerobic (in the absence of oxygen).
2. In most of the cases, secondary treatment involves biological treatment processes called Activated sludge Process. Aerated Lagoon, Trickling filters, Oxidation Pond, Rotating biological contactors.
3. During this process, primary effluent enters aeration tank where air is mixed with sludge and hence many microorganisms remove biodegradable organic matter.
4. A secondary sedimentation tank allows the microorganisms and solid wastes to form clumps and settle.
5. After this treatment, It generally removes 80-90% of all the pollutants have been removed and large proportion of toxic chemicals are removed.

d. Tertiary/Advanced Treatment of Wastewater: It is the final treatment stage of wastewater processing and its main objective is the removal of specific wastewater constituents which cannot be removed in previous stages and thereby increase the quality of the effluent to higher degree.

1. It utilizes some form of filtration to remove higher level of suspended solids which was not possible through primary and secondary screening and sedimentation.
2. Nutrients, heavy metals, specific toxic chemicals and other pollutants/contaminants are removed during this process.
3. It can remove more than 99% of all the impurities from sewage, producing an effluent of almost drinking-water quality.
4. It involves Disinfection which can be attained by means of physical disinfectants like UV light and chemical disinfectants like Chlorine.
5. During this process significant percentage of pathogenic organisms are killed or controlled.

ELECTROLYTES

Plate type Aluminium (Al) and copper were used as an electrode material. A rectangular shaped, Aluminium electrode with the dimensions of 11× 5 × 1 mm was used as the anode and cathode material, while a plate type of, copper of the same size was used as the anode and cathode material.

The anode and cathode material purchased from Balaji scientific, Karaikudi was made as electrode employable for study by punching, pulling, annealing, acid-washing. In order to attach the electric wires to both of the electrodes, a 2-mm hole was drilled at the top of both electrodes using a drill machine. A copper wire of diameter 0.5 mm was soldered onto each hole using Emerson and Cuming conductive epoxy, followed by an application of a thin layer of non-conducting epoxy to avoid any contact of wastewater where the copper wires and electrodes were connected.

The separation between the electrodes was maintained spacing of 1.5 cm thick scale to the two intermediates of the electrodes.

Analytical Methods

In order to view the progress of the treatment over time, the samples were collected on an hourly basis for seven hours, centrifuged, filtered, and preserved at 4°C until further analysis. The evaluation of the treatments included the analyses of ammonium nitrogen (NH_4 + $^{-}$N), phosphorus, chlorides, turbidity, pH, and electrical conductivity (EC). The NH_4 + $^{-}$N concentration was determined the Kjeldhal digestion apparatus (Guna instruments) as per Phosphorus were measured with by UV spectrophotometer (biotronics) as per pH and EC were measured using a pH meter and a conductivity meter, respectively.

COLLECTION OF SAMPLE

The electrochemical cell consists of beaker, anode and cathode of same type material and also DC power supply. A beaker with a capacity of 1500ml was taken as a batch reactor. The electrode materials used in this study were aluminum and copper electrode for comparative study. The electrochemical unit consists of two electrodes of the same dimension (11cm x 5cm x 1mm). These electrodes were used as both anode and cathode which are kept at certain specific distance in the electrochemical cell.

The whole setup was kept in fully dipped in electrolyte, homogenous which solution of sample waste water in the reactor during the process. For the analytical analyses, the samples were withdrawn on five minutes in intervals and filtered before further analysis was performed. The experiment was conducted until the system reaches equilibrium.

Initial Characterization

The STP effluent collected was characterized to determine pH, Turbidity, Conductivity, Total Suspended

Solids, Total Dissolved Solids, Sulphates, chlorides, Ammonia nitrogen and phosphorous as per the standard methods (American Public Health Association). Permissible values are taken for discharge of wastewater in surface water bodies as per Indian standards (IS 2490-1974).

Table 1: Initial Characterization

S. No	Characteristics	Unit	Value obtained
1	pH	-	8.16
2	Turbidity	NTU	3.05
3	Conductivity	µS/cm	1.34
4	Suspended solids	mg/L	800
5	Total Dissolved Solids	mg/L	635
6	Hardness	mg/L	550
7	sulphates	mg/L	806
8	Chlorides	mg/L	224.99
9	Ammonia nitrogen	mg/L	89.6

CHARACTERISTICS OF WASTE WATER

Some of the generalized parameters are to be tested to determine the performance and evaluation of sugar mill effluent treatment plant. Sampling is one of the most important procedure and important steps in the collection of wastewater sample from the effluent discharged to the treatment plant. The laboratory analysis and tests depends upon the sampling methods. The factor involved in the proper selection of sampling site is generally depends on the objective of the study. The volume of sample between 2 and 3 liters is normally sufficient for a complete analysis. The total number of samples will depends on the objectives of the monitoring process. During this study, the samples were collected in clean polyethylene containers.

ANALYTICAL PROCEDURE

pH

pH is measured by a pH meter using a glass electrode which generates a potential varying linearly with the pH of the solution in which its immersed. A pH value is a number from 1 to 14, with 7 as the middle (neutral) point. Values below 7 indicate acidic condition which increases as the number decreases, 1 being the most acidic. Values above 7 indicate base condition which increases as the number increases, 14 being the most alkaline. It is a logarithmic scale in which 2 adjacent values are increase or decrease values by the factor of 10 or we should use pH strips for measuring the pH.

Chemical Oxygen Demand

The organic matter present in the sample gets oxidized completely by K2Cr2O7 in the presence of H2SO4 produce carbon dioxide and water. The excess K2Cr2O7 remaining after the reaction is titrating within the ferrous ammonium sulphate solution. The dichromate solution consumed gives the oxygen required to oxidation of the organic matter. The Chemical Oxygen Demand (COD) method determining the quantity of oxygen required to oxidize the organic matter into the sample water, under specific conditions of oxidizing agent, temperature and time. The COD is calculated by titration method and formula is given by, COD = (A-B) × Normality of FAS × 8000/ ml of sample taken

Biological Oxygen Demand

The BOD test measures the strength of the wastewater by measuring the amount of oxygen used by the microorganisms as they stabilized the organic matter under controlled conditions of time and temperature. The BOD is measured by an empirical biological test. This test may be considered as wet oxidation procedure in which the living organisms serve as the medium for wet oxidation of the organic matter to convert carbon dioxide and water.

The BOD is calculated by following formula,

BOD, mg/L=[(Initial DO- Final DO) x300] /ml of sample water.

Dissolved Solids

The total dissolved solids are determined as the residue left after evaporation and drying of the filtered sample. A total dissolved solid (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid. Dissolved solids contained in the industry effluents are also critical parameter. Use of common and glauber salts etc. In processes directly increasing the total dissolved solids system. Disposal of high TDS bearing effluents can lead to increasing the total dissolved solids content of ground water and surface water.

harmful to vegetation and restrict its use for agricultural purpose. TDS are difficult to be treated with conventional treatment systems. The total solids are calculated by initial and final weight of crucible.

Where,

Total solids(mg/lit)=(A-B)x1000/v

A&B=Initial and Final weight of the dishing V =Volume of sample in mg

Dissolved Oxygen

Dissolved oxygen in the treatable wastewater is finding by this formula and the titration method also used in laboratory. Dissolved oxygen is refers to microscopic bubbles of gaseous oxygen that are mixed in water and available to aquatic organisms for a respiration process.

DO =Initial DO- Final DO5

Chloride

The chloride ion is determined by Mohr's method titration with standard silver nitrate solution in which the silver chloride is precipitated at first. The end of titration process is indicated by the formation of red silver chromate from excess amount of $AgNO_3$ and potassium chromate used as an indicator in neutral to slightly alkaline solution.

Colour

Presence of colour in the waste water is one of the main problems in sugarcane industry. Colours are easily visible to human eyes even at very low concentration. Most of the colours are generally in stable and has no effects of light or oxidizing agents. They are also easily degradable by the conventional treatment methods.

Sulphates

The turbidimetric method of measuring sulphates is based upon the fact that barium sulphate tends to precipitate in the colloidal form of uniform size and that this tendency is enhanced in the presence of hydrochloric acid, sodium chloride and glycerol. The absorbance of the barium sulphates formed is measured by using a spectrometer at 420nm and the sulphate ion concentration is determined by comparison of the reading with a standard curve.

$$SO4^{2-} + BaCl2 \longrightarrow BaSO4$$

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