Electrochemical Treatment of Wastewater

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The study has demonstrated the success of a simple and reliable physico-chemical process in treating wastewater. The electrolytic cell, operated as a batch unit, will be capable of producing an effluent of good quality. Used in tertiary treatment, electrochemical process will be able to produce effluent of quality equal to or at times even better than that produced by conventional methods.

During the first quarter of this century electrolytic treatment of wastewater enjoyed popularity in Europe and United States but was later pushed into background due to development of biological treatment methods. Foyn(1) set up a cell to electrolyse sea-water/sewage/mixture for the removal of phosphate from sewage, through reaction between magnesium hydroxide produced at the cathode with ammonium compounds in the sewage and with phosphate under alkaline conditions. He used graphite anodes and iron grid as cathode in his pilot plant. Mendia(2) studied the process on the pilot plant scale using graphite bars as anodes and expanded iron plates as cathodes, and could obtain maximum of 71% reduction in B.O.D. with initial value of 808 mg/l and complete removal of suspended solids. Poon and Brueckner[3] electrolysed wastewater - seawater mixture using graphite anode and iron cathodes system. They observed that chlorine produced by the reaction removed NH_3 by chlorination, phosphorus by $Mg(OH)_2$ flocculation at high pH. Batch treatment was found to be more effective than continuous flow treatment.

The literature on the subject indicates that electrochemical method can be used to treat not only sewage but also various types of industrial wastes.

In India this method has not been tried at all, so far, for treatment of domestic wastewater. Taking into consideration various aspects it can be said that this can be a reliable physico-chemical process for treating a wastewater and with this view the present study was undertaken.

The work reported here pertains to treatment of raw sewage and secondary effluent of a biological treatment unit. This helped in evaluating the process as a secondary as well as tertiary method of treatment for sewage in particular. It is hoped that the observations can be generalised for treatment of other wastes also.

MATERIALS AND METHODS

i) Electrode Material Screening:

It is a well known fact that the electrode material can influence the course of electrolytic reaction. In a manufacturing process an electrode of specific material has to be used to achieve the desired reaction and yield. However, in waste treatment this assumes an entirely different dimension because no reaction can be specific due to the fact that constituents of waste will never be in fixed proportion all the time. Only the aim can be specific and that is to achieve maximum treatment i.e. removal of pollutants at minimum cost and in minimum time.

Anode materials were considered before cathode materials because of the greater possibility of decomposing of the organic waste by an oxidation reaction and because of the greater dependence of anodic reaction on the electrode material.

Noble anodes, not attacked during electrolysis are of greatest interest, but were not considered because their use in waste treatment is ruled out due to extreme high cost. The second type, eroding anodes can be used in waste treatment because in many cases the eroded material will form floc which will help to remove suspended material and part of the soluble material. In neutral or acid anolyte, graphite is likely to be inert. The experimental evidence showed that graphite electrode softens and later disintegrates imparting colour and fine suspension to the treated sample. In alkaline solution iron and stainless steel should also be inert. Copper, lead, magnesium and aluminium are of possible interest as eroding anodes. Use of copper and lead was not considered due to high cost and also due to possibility of secondary pollution. Thus only magnesium and aluminium were thought to be proper for use.

The idea of using magnesium was later dropped because magnesium is normally present in all

wastes and it was thought advisable to use the properties of magnesium hydroxide, which is likely to be produced during electrolysis, to bring about the treatment. The final choice therefore rested with aluminium.

Earlier workers in the field have mostly used graphite anode and iron or stainless steel as cathode materials. After giving due weightage to all the factors, the final choice rested with Al-Al anode-cathode system. Aluminium has many advantages, the foremost being low cost and easy availability in the Country. The system using both anode and cathode made of aluminium was, therefore, used in this study. Such a system has a distinct advantage in that material being the same, the polarity can be alternated to avoid passivity.

ii) For all the experiments carried out in this study direct current was obtained from a line operated power supply. Voltage and current to the cell were measured with precision instruments. Experiments were carried out in glass container and the samples, 1 litre, were stirred with a teflon covered stirring bar on a magnetic stirrer throughout the experiment.

RESULTS AND DISCUSSION

Earlier workers in the field have mostly used seawater as the source of magnesium and they state that in electrolysis magnesium is precipitated as magnesium hydroxide which is the chief agent in bringing about the purification. However, in this study it was decided to electrolyse sewage as it is and take advantage of magnesium already present as also the precipitation of aluminium hydroxide due to errosion of aluminium anode. Table 1 gives the data of the study.

Table 2 gives the data of work carried out with sewage mixed with sea-water, the sea-water to sewage ratio being 1:19.

From the data presented in Tables 1 and 2 it will be observed that addition of sea water has no particular advantage. This may be due to the fact that magnesium already present in the sewage is sufficient to bring about the desired effect. As a matter of fact sea water will increase salt concentration in the treated waste thereby rendering it unsuitable for some purposes.

STUDIES OF ELECTROMECHANICAL TREATMENT ON SECONDARY EFFLUENT:

To see the suitability of electrochemical process as a tertiary treatment method, the secondary effluent of activated sludge process unit was electrolysed. The analysis of untreated and treated (electrolysed secondary effluent) is given in Table 3, from which it will be observed that on electrolysis the secondary efluent improves in quality thus indicating that electrochemical treatment can be adapted for tertiary treatment. Reduction in COD indicates that durin

TABLE 1

ELECTROLYSIS OF RAW SEWAGE

Parameter	Raw Sewage	Treated i.e. Electrolysed sewage	percent reduction
1. pH	6.9	7.2	-
2. Chemical Oxygen Demand - mg/l	504	120	76.19
3. Biochemical Oxygen Demand - mg/l	300	60	80.00
4. Phosphate as PO_4 mg/l	11.3	1.3	88.49
5. Ammonia Nitrogen as N-mg/l	30	18	40.00
6. Total Nitrogen as N - mg/l	48	23	52.08
7. Suspended Solids mg/l	300	Negligible	100
8. Colour	Highly turbid	Colourless, bright	

Cell Data:

Sample Volume	:	1 litre
Voltage	:	10 Volts
Current	:	200 mAmp
Electrode material	:	Aluminium
Electrode Area	:	50 Sq. cm each
Reaction time	:	30 minutes

TABLE 2

ELECTROLYSIS OF RAW SEWAGE MIXED WITH SEAWATER

Parameter	Raw seawage	Treated i.e.Electrolysed sewage	Percent reduction
1. pH	6.9	7.3	--
2. Chemical Oxygen Demand - mg/l	480	80	83.33
3. Biochemical Oxygen Demand - mg/l	280	50	82.14

Table 2 (Contd.,)

Parameter	Raw sewage	Treated i.e.Electrolysed sewage	Percent reduction
4. Phosphate as PO_4 mg/1	10.5	0.9	91.42
5. Ammonia Nitrogen as N - mg/1	28	17	39.28
6. Total Nitrogen as N - mg/1	43	21	51.16
7. Suspended Solids mg/1	250	Negligible	100
8. Colour	Highly turbid	Colourless bright	--

Cell Data

Voltage	:	10 Volts
Current	:	900 mAmp
Electrode material	:	Aluminium
Electrode area	:	50 Sq.Cm.each
Reaction	:	30 minutes

electrolysis the refractory organics are getting destroyed. Further reduction in both COD and BOD increase in electrolysis time also indicates that electrochemical treatment can attack refractory organics.

SOME IMPORTANT FEATURES OF ELECTROCHEMICAL PROCESS

The most important and notable feature of this process is the near deodorisation and complete removal of turbidity and colour. Suspended solids will have to be removed by floatation because during electrolyis due to gas formation the floc floats as froth and hence continuous removal of scum will be essential. The buoyant floc can be made to settle after stirring, which helps in releasing the gases. However, if flocculation and settling tanks are to be avoided, the removal of suspended matter by floation is essential. This will make the plant compact.

Continuous stirring or movement during the process is essential. This helps not only in avoiding dead zones in the cell but actually helps in the removal of suspended and colloidal matter by adsorption on the floc.

CONCLUSIONS

i) Electrochemical treatment can be adapted as a simple and reliable physico-chemical process for treating waste waters particularly in case of small units.

TABLE 3

ELECTROLYSIS OF SECONDARY SEWAGE EFFLUENT

Parameter	Untreated	Electrolysed for 30 minutes	Electrolysed for 60 minutes
1. pH	7.5	7.8	7.8
2. Chemical Oxygen Demand - mg/1	62	34 (45.16)	28 (54.83)
3. Biochemical Oxygen Demand- mg/1	6	4 (33.33)	3 (50.00)
4. Phosphates as PO_4 mg/1	6	4.5 (25.00)	4 (33.33)
5. Amonia Nitrogen as N mg/1	5.5	4 (27.27)	4 (27.27)
6. Total Nitrogen as N mg/1	9	6 (33.33)	5.5 (38.88
7. Suspended Solids mg/1	12	0 (100)	0 (100)
8. Colour	Slightly turbid	Clear & bright	Clear bright

Note: Figures in parenthesis indicate percent reduction.

Cell Data:

Voltage	:	10 Volts
Current	:	200 mAmp
Electrode material	:	Aluminium
Electrode area	:	50 Sq.cm.each

ii) It can effectively reduce chemical biochemical oxygen demand

iii) It can reduce phosphate and nitrogen

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