ELECTROBIOLOGICAL PROCESS FOR TREATMENT OF WASTEWATER

R.K. Pandit and M.S. Mayadeo*

Department of Chemistry, Ramnarain Ruia College, Matunga, Bombay-400019

Comparative study of three processes - conventional activated sludge, alum aided activated sludge and electrobiological process has shown that the electrobiological process is superior to other two processes. This process is found to remove BOD and COD in comparatively shorter period. During the aerobic digestion of sludge, initial lag period was observed. This may be attributed to the depletion in bacterial population and to the "Sheathing" effect of aluminium hydroxide on the organic matter. The drainability of aerobically digested sludge was found to be better.

In the conventional waste water treatment by activated sludge process, the organic waste is first partially oxidized and partially converted in to microbial cells biologically. The micro-organisms growing are generally found to remain dispersed during their prolific growth. In the second phase occuring in the same aeration tank, the newly formed cells are bioflocculated and they are separated. Thus the overall efficiency of activated sludge process depends on bioflocculation.

The present authors have found that addition of Al(III) as alum, increase the efficiency of the activated sludge process by facilitating the removal of both dispersed and soluble organics within a short span of time. It also effects better removal of phosphates. The drainability of the sludges also is improved. It is found that the increase in the concentration of solids, alkalinity and phosphates increases the requirement of the chemical.

The percentage reduction in oxidizable volatile suspended solids during aerobic digestion in the chemical biological sludge is lower than in the plain biological activated sludge process. This can be attributed atleast partially to the 'sheathing' of the organic matter by the precipitated $Al(OH)_3$. It is also possible that aluminium ions can form complexes with the organic compounds present in the sludge and the biodegradability of these metal organic compounds is not known.

Some workers - notably Foyn [1], Mendia [2], and Poon and Brueekner [3] studied the electrolysis of sewage/sea water mixtures using graphite and Fe cathode and obtained substantial reduction in BOD, suspended solids, ammonia and phosphorous. Sea water could provide Mg^{2+} for facilitating flocculation and Cl_2 generation at the anode.

The sea water not being quite accessible in land locked areas and the high dissolved solids in sea water would impose severe restrictions on its use. The present authors have used electrolysis of sewage at aluminium electrodes to introduce Al(III) in controlled doses into the effluent and observed substantial removal of BOD, COD, PO_4^{3-}, nitrogen compounds, colour and suspended solids. Here studies of the electrochemical treatment in conjunction with activated sludge process —The Electro-biological process - has been undertaken.

EXPERIMENTAL

Experiments were carried out on degritted sewage from a local treatment works, which receives primarily domestic sewage with a small quantity of industrial waste. Experiments were carried out in a glass container placed on a magnetic stirrer. For determination of turbidity, samples were stirred in high speed laboratory blender to obtain as far as possible the same particle size and homogeneity. Turbidity determinations were made on HACH Turbiditimeter, using distilled water for dilution wherever necessary. Soluble state of a pollutant was determined on samples after filtering through glass fibre filter paper as recommended by Aziz and Tebutt [6].

RESULTS

From the data presented in Table 1, it is observed that for the same sewage sample and

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TABLE 1

EFFECT OF ELECTROLYSIS DURATION AND CURRENT DENSITY ON REMOVAL OF POLLUTANTS

		Cell Data	Duration of Electrolysis Minutes	Turbidity NTW	Floc formation	Soluble B.O.D mg/1	Soluble C.O.D. mg/1	Soluble Phosphate mg/1
CASE I	i)	10 volts	0	85	A	60	120	4.5
		220 m Amps.	10	100	B	35	80	0.5
			20	135	C	30	75	0.5
			30	175	D	30	75	0.45
	ii)	15 volts	0	85	A	60	120	4.5
		320 m Amps.	10	110	B+C	30	70	0.45
			20	144	D	28	68	0.45
			30	210	D	26	62	0.40
CASE II	i)	10 volts	0	110	A	80	130	5.5
		300 m Amps.	10	145	B+C	50	90	0.5
			20	180	D	45	80	0.45
			30	250	D	40	75	0.4
	ii)	15 volts	0	110	A	80	130	5.5
		480 m amps	10	160	B+C	45	80	0.4
			20	200	D	40	70	0.4
			30	230	D	35	60	0.36

N.B. : Electrode System - Aluminium/Aluminium, Electrode Area - 50 aq.cm. each

A : Turbid
B : Micro floc formation, Floc rises
C : Floc grows and rises, water mass becomes clear
D : Thick floc, rises, water mass becomes clear

with the same electrode system, floc formation proceeds fairly rapidly with increase in current density, as is evident from the increase in turbidity. The decrease in BOD and COD was sharp in the beginning, becoming slow with time. Increase in current density and electrolysis time was not found to improve the quality of the effluent commensurate with the increase of either of these two variables. As observed by Recht and Ghasemi [7], the reduction in phosphate was found to take place in first few minutes. It is possible that during electrolysis due to induced ionisation, removal of unstable soluble organics would take place as is reflected in the reduction of soluble BOD and COD. Electrolysis for prolonged periods or at high current densities led to the formation of thick floc which at best removes only dispersoids to the maximum extent. This sludge is rich in organics and hence needs further treatment to render it inoccuous before final disposal. Excessive floc will create an additional problem of its disposal.

Studies in Electro-Biological Treatment

To study the merits and demerits of the electrobiological method, this method was studied alongwith chemically aided activated sludge process. Conventional (i.e. without any chemical aid) activated sludge process, was carried out as a control.

For each experiment, the degritted sewage was mixed with activated sludge and aerated for few minutes for complete mixing and allowed to settle. The supernatent was removed, analysed and considered as base. Aeration was restarted and the mass was divided into three equal portions without shutting off the air, thus ensuring near equal distribution of sludge in each case. Further sampling at predetermined periods was carried out in the same manner. This procedure allows to maintain sludge solids concentration (MLSS level) nearly constant throughtout the study. MLSS concentration during the entire course of study varied in the range of 2000-2500 mg/1.

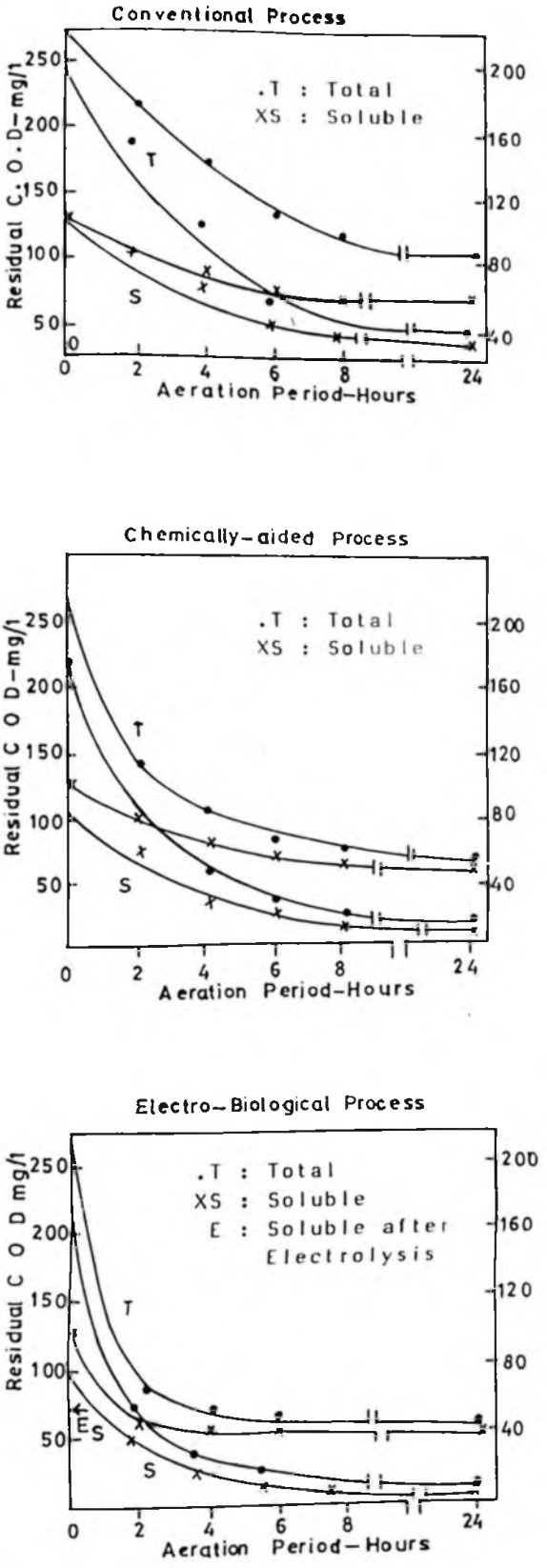


Fig. 1 Removal of BOD and COD in conventional and chemical process, and electro-biological process.

Of the three parts, one was used as control (i.e. for conventional process). The second portion was fed with 90 mg/l alum dose on the basis of previous experimentation. The third portion was electrolysed for ten minutes, as it was observed (vide Table 1) that electrolysis for ten minutes gives desirable reduction in soluble BOD, COD and phosphate. The aeration in three units was commenced simultaneously. The rate of aeration was maintained equal and constant in all the three units throughout the experimentation.

A series of twenty experiments were carried out. However for the purpose of interpretation the weighted average data is taken into consideration and is represented in Figure 1

It is worth noting that the reduction in both total and soluble BOD and COD is gradual in the convential activated sludge process. Optimum aeration time is found to be 8 hrs.

There is a sharp reduction in BOD and COD at the initial stages in processes with alum addition. However with the progress of aeration, the reduction became gradual. It is found that even soluble components decreased at the initial stages in this process.

The decrease in total BOD/COD is much more in the electrobiological process as compared to the other two processes. An interesting feature of this process is that there is a substancial reduction in soluble components, the extent being from 79 to 56 mg/l for soluble BOD and 127 to 88 mg/l for soluble COD.

Thus the electrobiological process is found to be superior to the other two methods. Aeration beyond 2 hrs does not seem to have any advantage.

Bacteriological examination of the three treated effluents reveal that the initial 9 logs MPN count per 100 ml in the raw waste reduces by 4 logs in convential process after 8 hrs of aeration, by 5 logs in alum aided activated sludge process and by 6 logs in electrobiological process even before aeration. The drop in MPN count in the latter two processes can be attributed to the removal of dispersoids. In addition, in electrobiological prccess, electrolysis itself can contribute to the removal of bacteria. This view is also in agreement with the findings of Zhuravela [8]. It is also possible that during electrolysis, liberation of chlorine also assist in the removal of bacteria.

Effect of Al(III) on the removal of VSS

Figure 2 represents this data where weighted average of percentage reduction in oxidizable VSS are plotted against the aeration period.

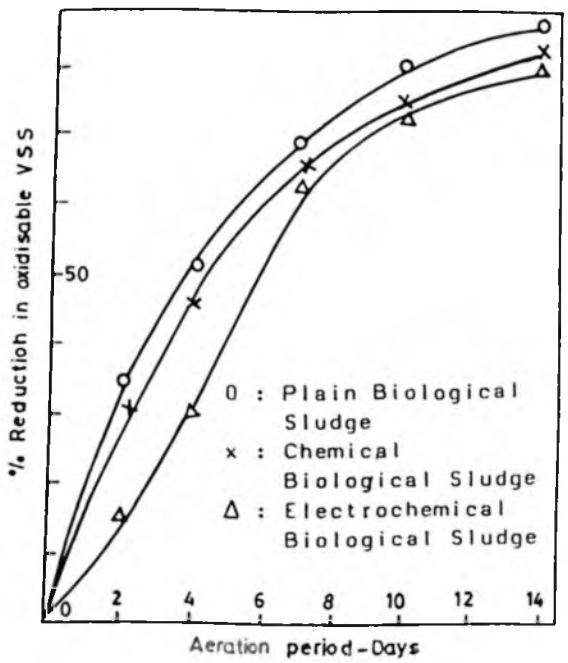


Fig. 2 Aerobic destruction of VSS in sludges

It is to be noted that the percentage reduction in oxidizable VSS in conventional biological sludge is better than that observed by the other two processes. The chemical biological sludge showed a higher percentage of reduction in oxidizable VSS than in the electrobiological sludge process in the inital stage of aeration. However the reduction is more or less the same at later stages of aeration.

The observed initial lag in the electrobiological sludge process is probably due to some retarding effect resulting in the lowering of the oxidation of VSS.

The lowering of the rate of oxidation in both the sludges can be attributed partly to the "sheathing" or "coating" effect of aluminium hydroxide. Same was the observation in our earlier work on the aerobic digestion of chemical biological sludge.

The decreased bacteriological population in the initial stages can also contribute to the initial lag periods in the electrochemical biological sludge.

Drainability of aerobically digested sludges

Sample volumes of 200 ml of each of the three types of sludge, aerated for 14 days, were dewatered using Buchner funnel covered with a piece of muslin cloth and whatman No.1 filter-paper, both cut to size and the funnel fitted with a rubber stopper on a graduated cylinder with a side tube.

Figure 3 represents the weighted average of the experimental data. It can be observed that the chemical-biological and electrochemical biological sludges are superior to plain biological sludge, marginally. The probable reason for the same is that the sludge gets mineralised to a great extent during 14 days of aeration. The initial rapid filtration may be due to the initial thinness of the sludge layer which in due course settles to form a compact layer.

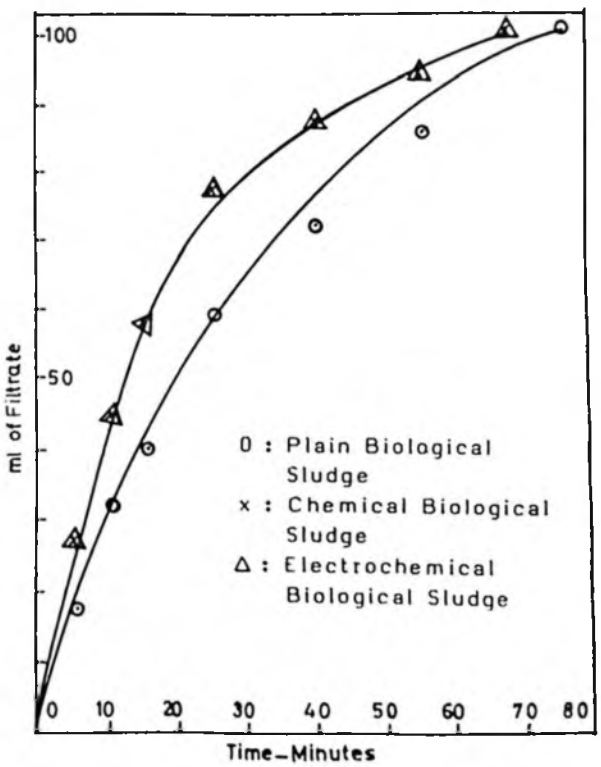


Fig. 3 Drainability of aerobically digested sludges

Concluding remarks

The study indicates that the judicious incorporation of aluminium ions through electrolysis followed by activated sludge process yields a high quality effluent in shorter duration. This is expected to bring down the cost of treatment substantially.

It is necessary to point out here that during electrochemical process catalytic effect of trace metals, already present can also contribute to the effectiveness of the process. Trace metal ion concentrations as low as 0.1 to 10 nM are known to influence reactions such as hydrolysis, decarboxylation and redox reactions such as oxidation through chlorination. The oxidation due to chlorine, liberated during electrolysis, is known to be enhanced by the metal with multiple oxidation state, (eg. Mn and Fe in the oxidation of oxalate) which are likely to be present in the sewage.

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