CHAPTER V

RESULT & DISCUSSION

Refering to the experiments that were divided into three parts, it would be advantageous to discuss them seperately as follows :

Current effects

The electrochemical reaction is directly related to the quantity of electricity which passes through the wastewater conformed to Faraday's Law. From the result of the experiments it is found that percentage of BOD removal increases as the quantity of electricity increases, which is shown in Fig. 8. From the Figure, the graph is slightly curved, which shows that the current efficiency is not 100 percent. This is because there are some other reaction that will not affect the removal of BOD i.e.,current leakage, short circuiting, and losses in the form of heat.

From Fig. 9-10 and table 2, the results show that if the current is higher the efficiency is lower, regardless of the amount of electricity supplied. This is compatible with the theory that higher current results in higher power loss. Parts of the power loss is converted to that makes the temperature of the systems increased relatively with the current applied. The other parts of the power were lost throught the production of oxygen and hydrogen gas. It was found that at hight current density the gas was produced rapidly and had a large energy content, but the reaction time did not decrease correapondingly.

The results indicated that current should be small in order to minimize power consumption and prevent heating of the system. The power consumption was found to be 210.8 kwh/1000 gal. for 84 % BOD removal at 3.5 amp. and 75 minute detention time. This value could also be minimized by using an optimum cell design.

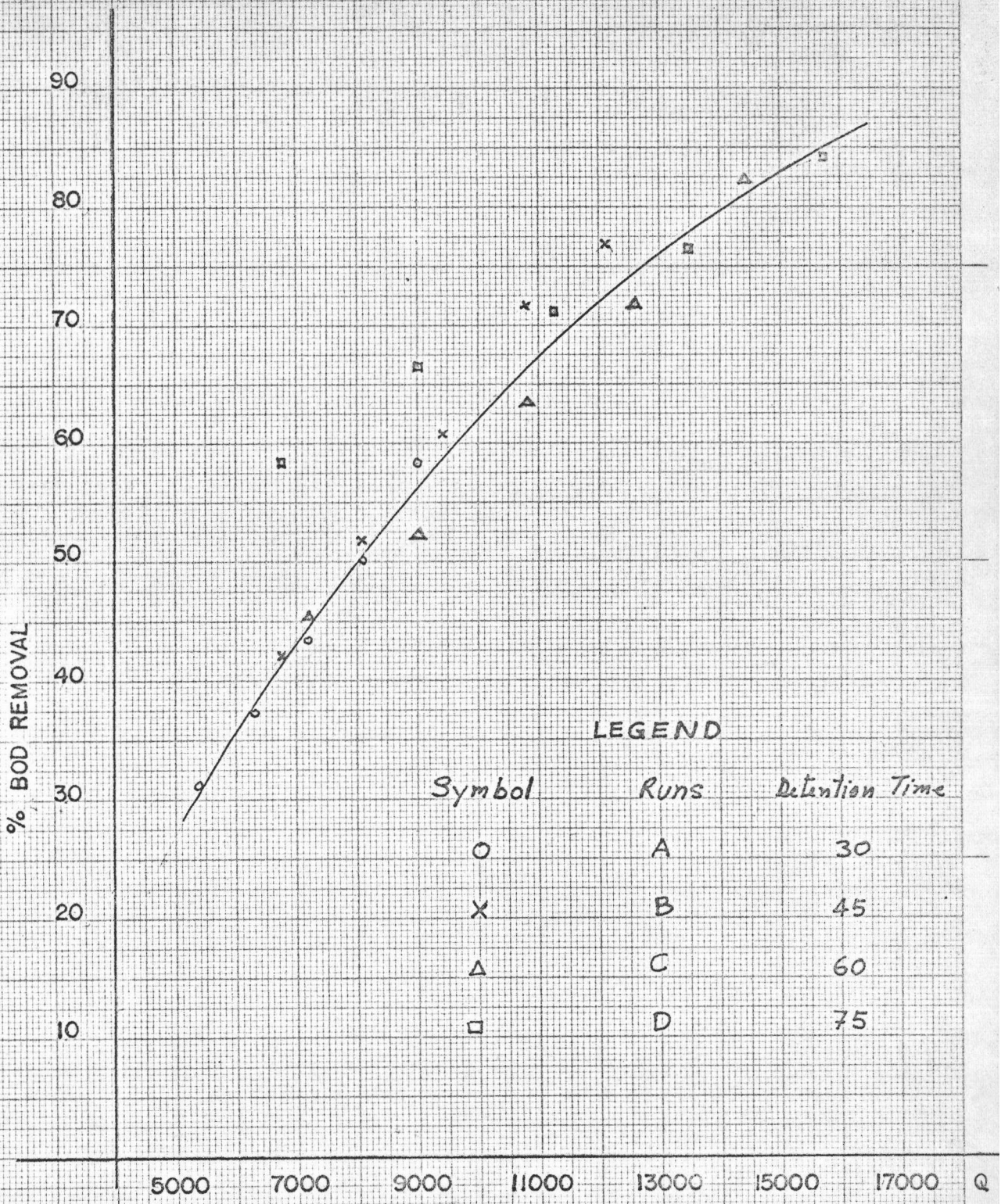


FIG. 8 PERCENT BOD REMOVAL VERSUS COULOMBS

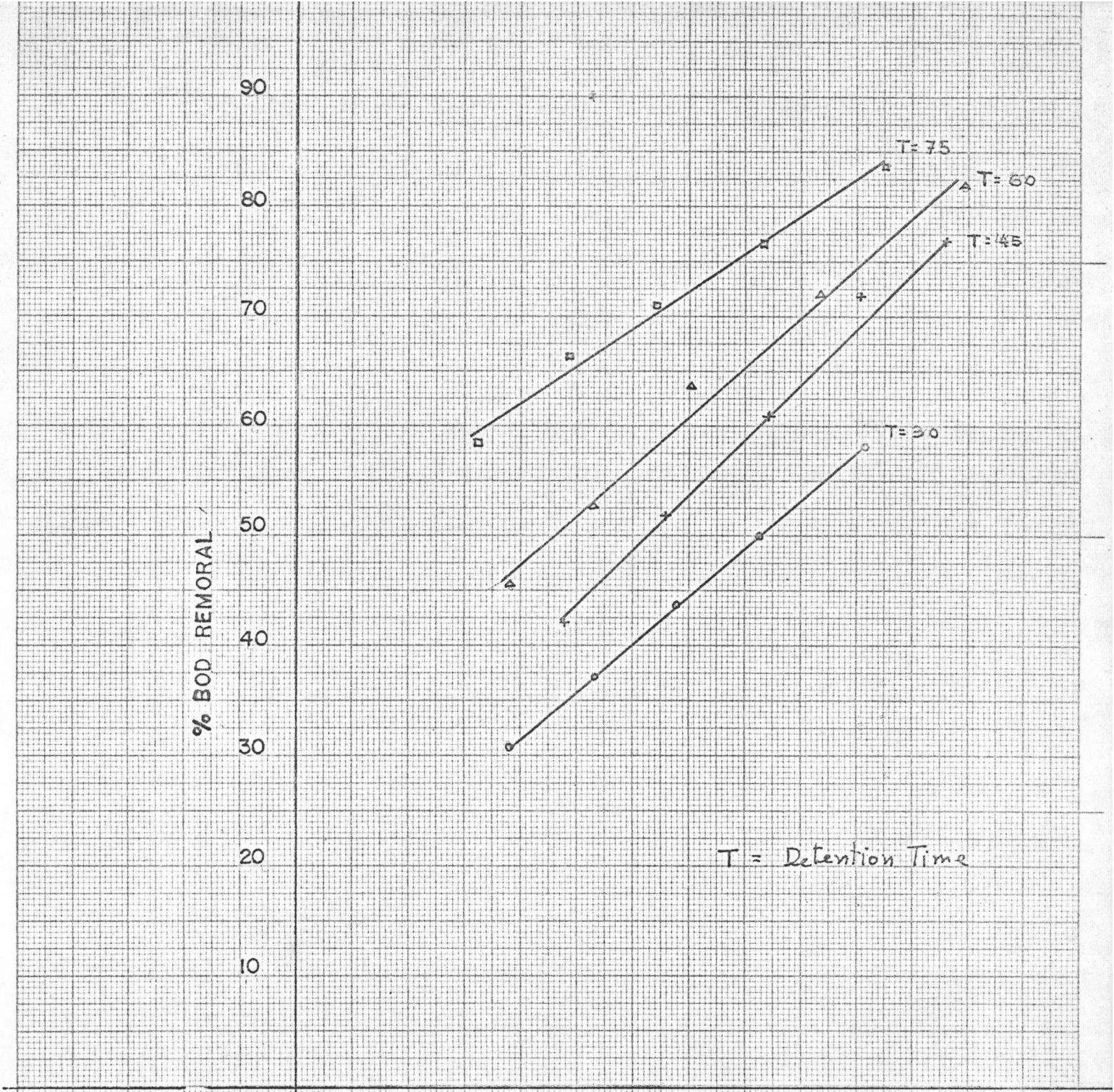


FIG. 9 PERCENT BOD REMOVAL VERSUS KWH / 1000 GAL FOR VARIOUS TIME

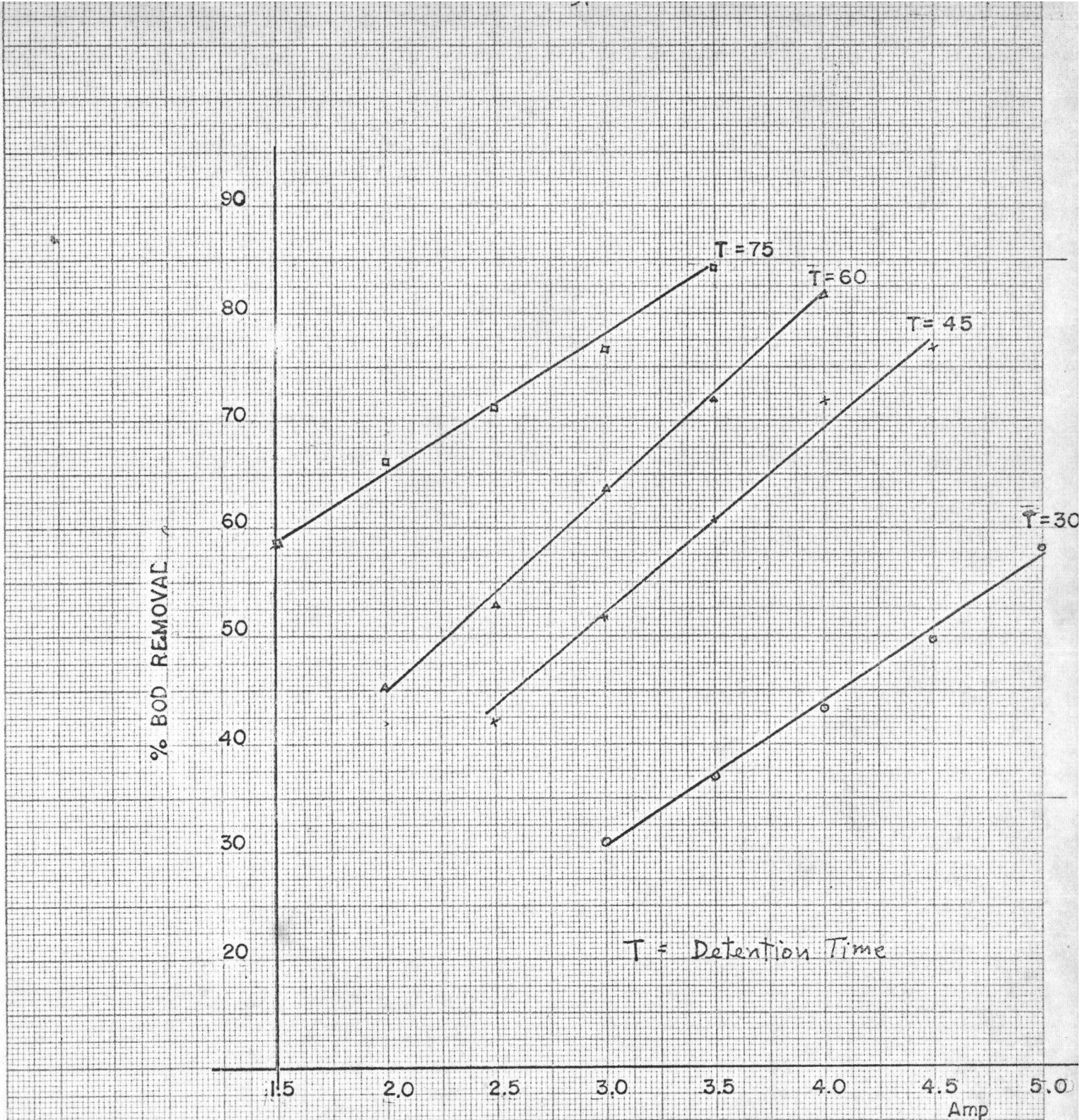


FIG. 10. PERCENT BOD REMOVAL VERSUS CURENT FOR VARIOUS TIME

Table 2 Percent BOD removal versus treatment time and current dosage

Amp.	Detention Time, Minute			
	75	60	45	30
5.0				58.18
4.5			76.81	49.9
4.0		81.81	71.81	43.63
3.5	84.27	71.8	60.9	37.27
3.0	76.56	63.63	51.81	30.9
2.5	71.35	52.72	42.27	
2.0	66.6	45.45		
1.5	58.64			

Run code A,B,C, and D

Effect of initial pH

Table 3 and Fig. 11 show the results of the experiments. The initial pH had affected BOD removal efficiency. It was possible that the electrolysis of aqueous solution at high pH resulted in higher efficiency, because the decomposition voltage was higher that at low pH.. This conforms to the theory (see electrochemistry in Ref. 16)

Table 3 Summary the result of adjusted initial pH of wastewater

Initial pH	% BOD removal	cost/1000 gal. Baht	% power loss
11.7	82.29	81.6	14.46
8.4	71.14	128.9	46.00
7.0	67.21	122.2	50.08
5	56.72	108.3	49.12

** Electricity dosage, 4 Amp. 60 minute

Run code E

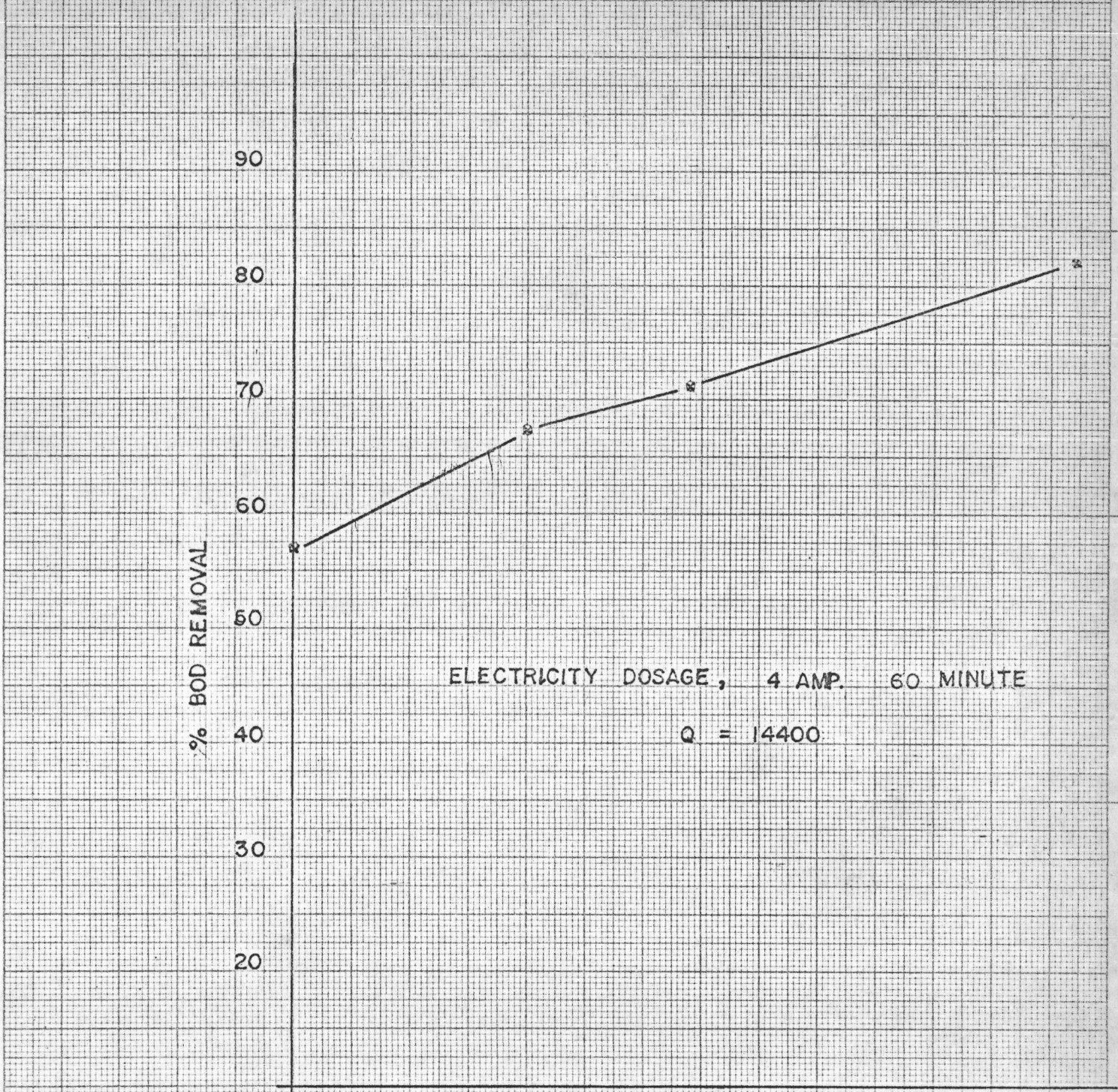


FIG. 11. PERCENT BOD REMOVAL VERSUS PH

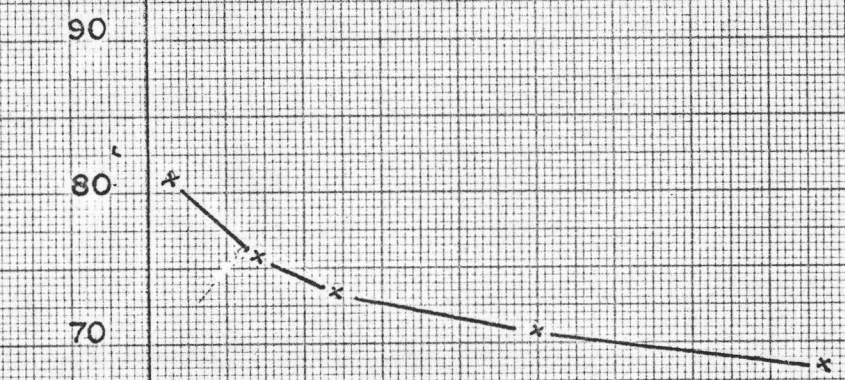
Effect of NaCl addition

Sodium chloride, an inexpensive chemical, was used as the electrolyte. Table 4 and Fig. 12 show the general trends of power reduction with increase in concentration of electrolyte. It could be seen that added NaCl had not much on the BOD removal. Added NaCl in wastewater would increase conductivity of wastewater, which was necessary to obtain optimum condition in the electrolytic treatment. Another property of chloride ions was found to have the power to oxidze organic-N as shows in the experment run code F. (see p. 103)

Table 4 Summary the result of adjusted initial chloride ions of wastewater

Chloride ions	conductivity micro-mho	% BOD removal	cost/1000 gal.	% power loss
29.2	0.9×10^3	80.71	121.8	52.54
142	1.2×10^3	75.71	112.9	45.34
244	1.5×10^3	73.57	107.8	37.75
502	2.3×10^3	70.71	91.4	31.50
868	3.4×10^3	68.42	79.9	22.02

Run code F



90
80
70
60
50
40
30
20
% BOD REMOVAL
ELECTRICITY DOSAGE, 4 AMP. 60 MINUTE
Q = 14400
100
300
500
700
900
CHLORIDE MG/L

FIG. 12 PERCENT BOD REMOVAL VERSUS CHLORIDE IONS

Nitrogen Compounds Removal

In the electrolytic cell of this experiment, both oxidation and reduction took place in a single compartment. Every particle in the cell would be oxidzed or reduced spontaneously, but for all of the organic compounds the process was normally irreversible.

The reduction of organic nitrogen compound could be considered in its simplest form as reacting with atomic hydrogen. The products were still the organic nitrogen compound dissolved or suspended in wastewater. In the case of oxidation, nitrogen compound could be converted to ammonia. For compound in higher oxidation state would be converted to nitrate.

For inorganics compounds, oxidation reaction were generally reversible processes. The stages in the oxidation reduction of nitrogen compounds were as follows:

$$N\bar{O}_3 \rightleftharpoons N\bar{O}_2 \rightleftharpoons N_2O_2^{=} \rightleftharpoons NH_2OH \rightleftharpoons NH_3$$

As the oxidation reduction goes on, the intermediate products in the reaction might be in gas state and escaped from the treatment system, according to Muller, E., and Weber, (1903). In wastewater containing adequate chloride ions, chlorine would be produced and reacted with NH_3-N and some organic nitrogen. At break point chlorination, most of the NH_3-N was converted to nitrogen gas and some organic nitrogen that could react with residual chlorine that was left in the effluent.

Total solids and BOD removal

Wastewater usually contain organic and inorganic pollutants, suspended or dissolved. The mechanism of removal might be as follows:

1. The dissolved solids mainly removed by the active oxygen species, the reaction were known to be as follows:

$$9H_2O \rightarrow O_3 + 6H_3\dot{O} + 6e$$

$$C_6H_{12}O_6 + 4O_3 \longrightarrow 6CO_2 + 6H_2O$$

2. The suspended solids would be flotated by the fine bubbles of oxygen and hydrogen that generated at the anode and cathode respectively. This floated scum would impart part of the BOD removal. At the same time, some suspended solids would be oxidized by active oxygen and converted to non putrescible substances.

From the experiment total solid removal was found to be paralled to the electricity dosage and BOD. removal, as according to Table 5 and Poon, Calvin P.C., and Bruechner, T.G., (1975)

Table 5 Percent total solid removal versus treatment time and current dosage

Amp.	Detention time, minute			
	75	60	45	30
5.0				40.8
4.5			48.8	38.7
4.0		54.3	43.5	37.1
3.5	24.9	49.3	40.1	33.8
3.0	27.3	46.3	44.3	27.9
2.5	27.1	43.4	38.0	
2.0	26.9	26.2		
1.5	24.7			

Run code A,B,C, and D

Alkalinity, Acidity and pH relationship

The majority of alkalinity in soft-drink waste is inorganic chemical compounds. When subjected to electrolytic oxidation reduction the process was reversible. The experiments showed no significant effect of changes in alkalinity, while the pH was normally decreased from about 9 to 6.5. It was possible that the decrease in pH was due to the CO_2 produced in the systems reacted with alkalinity and changed parts of the strong alkali to salt of weak acid. All experiments showe decrease of pH, but in no case the pH was reduced to below 6. (Table 6) It was possible that pH would decrease while alkalinity was no changed significantly. The phenomenon was due to the deposition of some ions that caused high pH in wastewater.

Table 6 Alk, Acd, and pH relationship of experimental Run code C

Electricity dosage coulombs	pH	Alk. as $CaCO_3$	Acd. as $CaCO_3$
0 (Raw)	9.0	1480	0
7,200	6.1	1160	408
9,000	6.1	1080	304
10,800	6.1	1080	380
12,600	6.3	1240	156
14,400	6.6	1520	120

Power Requirements

Power consumption in the experiments for 80% BOD remeval was about 220 kwh/1000 gal. The most critical factor of power consumption was the loss through cell resistance, which was found to be about 50%. From the experiments the power loss increases with the increase in current applied. (Table 8). Laboratory test had shown that the best can be expected for this treatment of soft-drink waste was a reduction of about 84% in BOD. (Fig8) This reduction would be achieved by a dose of about 15,500 coulombs per 675 cc. or 210 kwh/1000 gal. If the cost of electricity was 0.5 baht/kwh, the treatment cost would be 105 baht/1000 gal. (Table 7).

Organic - N

It was observed during this study that the organic-N was not effectively reduced with respect to the current applied. But organic-N was remarkably reduced in the present of adequate choride ions. A more complete investigation might find the conditions, where this organic-N was converted. It might be removed with the scum formed form foam, or converted to other forms of nitrogen in the treated waste.

During the study, it was inconvenient to determine nitrates because of the lack of suitable apparatus. Analysis of treated waste for nitrates were subjected to many interference. The Brucine and Chromotropic Acid in standard method were used semultaneously, but the nitrate content still could not be determined.

Table 7 Cost of treatment baht / 1000 gal. versus treatment time and current dosage

Amp.	Dentention time, minute			
	75	60	45	30
5.0				101.5
4.5			115.8	82.6
4.0		119.5	100.9	68.1
3.5	105.4	93.8	84.6	53.1
3.0	83.7	70.6	66.0	38.2
2.5	64.3	53.2	48.0	
2.0	49.0	38.9		
1.5	32.5			

** Electricity cost / kwh = 0.5 baht

Run code A,B,C, and D

Table 8 Percent power loss versus treatment time and current dosage

Amp.	Dentention time, minute			
	75	60	45	30
5.0				52.9
4.5			60.44	55.32
4.0		60.50	53.71	53.01
3.5	36.05	58.95	49.05	51.97
3.0	35.48	57.64	46.21	53.14
2.5	32.03	52.06	47.70	
2.0	26.93	44.98		
1.5	22.76			

Run code A,B,C, and D