CHAPTER 5

DISCUSSION

5.1 Untreated Wastewater

The untreated wastewater used for the study was collected from the primary holding pond. The intention is to carry out the preliminary study using the actual wastewater sample. As can be seen in table 4.1, analysis of the wastewater used for this study showed that most of the parameters tested were within the EQSIER 1979 standard B limits. Untreated wastewater characteristics from the power station for year 2007 are shown in Table 5.1. It can be seen that maximum values for pH, chromium hexavalent and iron does go above the limit and the treatment process need to bring them within limit.

Table 5.1 ; Characteristics of untreated wastewater at Sultan Azlan Shah Power Station for year 2007

Parameters	Units	Minimum	Maximum	Average	EQSIER 1979 Standard B limits
Temperature	Deg. C	28.3	33.30	30.23	40 max
pH		6.72	11.20	8.78	5.5 – 9.0
COD	ppm	2	69.00	18.10	100 max
SS	ppm	3	97.00	25.30	100 max
Chromium Hexavalent	ppm	0.01	0.06	0.02	0.05 max
Copper	ppm	0.01	0.85	0.20	1.0 max
Manganese	ppm	0.06	0.90	0.48	1.0 max
Zinc	ppm	0.01	0.28	0.06	2.0 max
Boron	ppm	0.13	1.73	0.59	4.0 max
Iron	ppm	0.11	5.30	0.42	5.0 max
Oil & Grease	ppm	3.2	3.20	3.20	10 max
Turbidity	NTU	3	76.00	31.51	NA

NA – not available

5.2 Findings on Use of Alternative Chemicals for pH adjustment

The main wastewater treatment plant is designed to use hydrated lime for pH adjustment after the chromium reduction stage. This chemical works well in the treatment process. As can be seen in the study the best settling time is five minutes at pH 9.0. Even though the floc size was bigger at pH 9.5 the settling time increased to seven minutes. This increase in settling time can be attributed to a few reasons. Zhao (2003) states that there are many unresolved difficulties and problems in trying to integrate the phenomena which control the settlement behaviour. It is believed that the settling behaviour of flocculated suspension is complex, depending on factors such as floc size, density, velocity, viscosity, flocculation and wall effect as well as the formation of aggregate structures.

The results in chapter four show that the alternative chemicals used, that is soda ash, sodium hydroxide and potassium hydroxide produce flocs but their characteristics with respect to floc size and settling time varies at various pH. The best pH seems to be at 9.0 where most of their settling times are in the region of four to five minutes. At pH 9.0 the floc sizes were also found to be of number five.

EPA(2007) mentions that sodium hydroxide or lime is used frequently to raise pH. It can be seen that these chemicals and the other two chosen for this study does work although their performance at various pH varies. Basically what contributes to hydroxide precipitation is the alkalinity of the chemical used which raises the pH of process water. At the required pH the waste metal hydroxide precipitates out.

In the case of soda ash, the floc size decreases to number three and it's settling time increases to 12 minutes at pH 9.5. This does not look like a good chemical as in real process the pH does fluctuate based on the response of the dosing pumps. Soda ash seems to work well between pH of 7.5 to 8.5 but this is not the optimum pH for metal hydroxide precipitation.

With caustic soda the settling time improves to four minutes at pH 9.5 and the floc size too increases to number seven. This can be seen in Table 4.5. As the pH increases to 10.0 the settling time increases to eight minutes while the floc size roughly maintains at number six.

As for potassium hydroxide the floc size increased to number seven at pH 9.5 while the settling time improved to four minutes. At pH 10.0 the floc size maintained at number seven whereas the settling time improved to two minutes.

5.3 Floc Size and Settling Time

The floc sizes determined in the study were conducted visually. A chart, attached in appendix 2, with the approximate size of the floc was used to aid the determination. Since some judgment was used, there can be some error in the determination of the floc sizes.

The settling time determination also involved visual observation. The time taken for the bulk of the flocs to settle to the bottom is timed from when the stirrer is stopped. Some amount of judgment need to be used as there can be some flocs sticking to the stirrer paddle and some floating.

There are some possible interferences that may make determination of optimum jar test conditions difficult. Floatation of coagulated floc may occur due to gas bubble formation caused by mechanical agitator, temperature increase or chemical reaction (ASTM, 2003).

As mentioned by Hanson and Cleasby,(1990a) and Hanson and Cleasby,(1990b) the coagulation process may form small flocs or fragile flocs which break up when subjected to physical forces. In wastewater treatment process, proper use of coagulant like polyaluminium chloride is important. Zhao (2003) mentioned that Al species adsorb negatively charged particles resulting in charge neutralization.

Use of polyelectrolyte improves floc size and settling time (Hanson and Cleasby,1990a and Hanson and Cleasby,1990b). However optimum dosage of polyelectrolyte is important as Bache and Zhao (2001) demonstrated that the viscosity of supernatant of a polymer-dosed sludge changed with polymer dosage.

In this study only the chemicals used for pH adjustment after chromium reduction stage varied while keeping other conditions the same. Another study to determine the optimum dosage of polymer with the selected chemical for pH adjustment can be conducted.

Zhao (2003) has mentioned that aluminium coagulants are more effective at lower temperatures and broader pH range. Similarly the optimum dosage of polyaluminium chloride with the selected chemical for pH adjustment can be conducted.

5.4 Analysis of Supernatant Solution

Analysis of the supernatant solution for hydrated lime, soda ash, caustic soda and potassium hydroxide are shown in tables 4.3, 4.5, 4.7 and 4.9 respectively. All the tested results are within EQSIER 1979 standard B limits. It can be seen that there is almost no reduction in boron. This is because the treatment process does not remove boron. Marked improvement can be seen with respect to suspended solids and turbidity.

All the results of the supernatant solutions were within the EQSIER 1979 standard B limits. It can be seen that the flocculation process worked for the untreated wastewater sample used as the supernatant solutions were much clearer as indicated by the turbidity and suspended solids results. A true test of the performance of treatment process can be to test using wastewater with the worst condition seen in table 5.1. In this way it can be ascertained if the alternative chemicals work for the worst wastewater condition.

Based on findings of this study, preliminary studies were conducted using caustic soda for pH adjustment at the main wastewater treatment plant. The process worked well. The treated water was tested for all 23 parameters and the results are shown in Table 5.2 . It was found that all the 23 parameter for the treated water were within limits.

Table 5.2 : Analysis of Treated Water Using Caustic Soda for pH Adjustment at Main Wastewater Treatment Plant

No	Parameter	Units	Test 1	Test 2	EQSIER 1979 Standard B limits
1	pH		7.2	7.5	5.5 – 9.0
2	Temperature (on site)	^{o}C	29.9	30.5	40
3	COD	mg/l	26	6	100
4	BOD_5	mg/l	5	1	50
5	Total Suspended Solids	mg/l	7	7	100
6	Mercury as Hg	mg/l	ND(<0.001)	ND(<0.001)	0.05
7	Cadmium as Cd	mg/l	ND(<0.005)	ND(<0.005)	0.02
8	Chromium Hexavalent as Cr^{6+}	mg/l	ND(<0.02)	ND(<0.02)	0.05
9	Arsenic as As	mg/l	ND(<0.01)	ND(<0.01)	0.1
10	Cyanide as CN	mg/l	ND(<0.02)	ND(<0.02)	0.1
11	Lead as Pb	mg/l	ND(<0.02)	0.02	0.5
12	Chromium Trivalent as Cr^{3+}	mg/l	ND(<0.02)	ND(<0.02)	1.0
13	Copper as Cu	mg/l	ND(<0.02)	ND(<0.02)	1.0
14	Manganese as Mn	mg/l	0.23	0.009	1.0
15	Nickel as Ni	mg/l	0.05	0.01	1.0
16	Tin as Sn	mg/l	ND(<0.01)	ND(<0.01)	1.0
17	Zinc as Zn	mg/l	0.07	0.01	2.0

18	Boron as B	mg/l	0.1	1.27	4.0
19	Iron as Fe	mg/l	0.09	0.09	5.0
20	Phenol	mg/l	0.002	ND(<0.001)	1.0
21	Free Chlorine as Cl_2	mg/l	ND	ND	2.0
22	Sulphide as S^{2-}	mg/l	ND(<0.01)	0.1	0.50
23	Oil & Grease	mg/l	ND(<0.2)	ND(<0.2)	10.0

ND - Not Detectable

5.5 Weight of Sludge Generated

Weight of sludge generated at various pH using different treatment chemicals is as shown in Table 4.10. All the chemicals were noted to generate highest amount of sludge at pH 8.5 and lowest amount at pH 9.0. At pH 9.0, amount of sludge generated was 1.2mg, 1.7mg and 2.7mg for potassium hydroxide, hydrated lime and sodium hydroxide respectively. For pH 9.0 soda ash generated the highest amount of sludge that is 9.0 mg.

From the data sodium hydroxide seems to generate about 58 % more sludge than hydrated lime at pH 9.0. Test has been carried out by using sodium hydroxide in the main wastewater treatment plant and it is noticed that the amount of sludge generated is much less as compared to hydrated lime. This matter can be revisited and further study carried out as the literature mentions that sodium hydroxide should generate less sludge compared to hydrated lime.

There can be some errors in the determination of weight of sludge generated as not all the sludge settled to the bottom of the beaker. Some of the sludge sticks to the stirrer paddles of the jar test equipment while some floats. Care was taken to get all the sludge into the filter paper.

5.6 Quantity and Cost of Chemical Used for Treatment Process

As mentioned in item 5.2, the best pH for treatment is at 9.0. Amount of chemical used to raise pH from 3.0 to 9.0 is taken from Tables 4.2, 4.4, 4.6 and 4.8 and is listed in Table 5.3. These are the required amount of chemical to treat 800 ml of sample.

Using the amount of chemical required and current price of the chemicals, the estimate treatment cost for 1000 m^3 of wastewater was calculated. This is shown in Table 5.4.

The cost of chemicals can vary according to market condition but this data is good for comparison. It can be seen that potassium hydroxide is the cheapest. Sodium hydroxide is second cheapest. Chemicals like hydrated lime, soda ash and potassium hydroxide are in powder or crystalline form and manual labour is required to load into the bag unloader. Cost of labour is estimated at about RM 500.00 for each loading. Sodium hydroxide (48 %) is in liquid form and installed pumps can be used for preparing each charge. Use of sodium hydroxide can work out to be cheaper in the long run and will be a lot easier to handle.

Table 5.3 – Quantity of chemical used to raise pH from 3.0 to 9.0

Chemical	Quantity of chemical used to achieve pH 9.0 (ml)
4 % Hydrated Lime	20.6
4 % Soda Ash	3.7
1 % Caustic Soda	11.3
1 % Potassium Hydroxide	3.0

Table 5.4 – Estimate cost of chemicals to treat 1000 m^3 of wastewater

Chemical	Cost of chemical as at July 08 (RM /kg)	Estimate Cost to treat 1000m^3 of wastewater (RM)
Hydrated Lime	0.40	421
Soda Ash	1.70	315
Caustic Soda	0.80 (48% liquid)	235
Potassium Hydroxide	3.90	146