CHAPTER 4

RESULTS

4.1 Wastewater Characteristic

Wastewater sampled from the primary holding pond, used for this study, was analysed and the results are shown in table 4.1. Standard B limits, obtained from third schedule of EQSIER 1979, are written for comparison and is noted that all the tested parameters are within limit. The limits for these parameters are same in the new Environmental Quality (Industrial Effluents) Regulations 2009 except for COD which is has been raised to 200 ppm.. Characteristic of untreated wastewater depends on its source.

Table 4.1 - Results of untreated water

Parameter	Units	Results	EQSIER 1979 Standard B limits
pH		8.57	5.5 – 9.0
COD	ppm	7	100 max
Suspended Solids	ppm	12	100 max
Chromium Hexavalent	ppm	< 0.01	0.05 max
Copper	ppm	0.07	1.0 max
Manganese	ppm	0.5	1.0 max
Zinc	ppm	0.01	2.0 max
Boron	ppm	1.01	4.0 max
Iron	ppm	0.15	5.0 max
Oil & Grease	ppm	< 0.1	10 max
Turbidity	NTU	20	NA

NA – Not available

The test methods used for the various parameters have minimum detectable limits. In the case of chromium hexavalent the result was found to be below the detectable limit

of 0.01 ppm. For oil and grease the result was found to be below the detectable limit of 0.1 ppm. Thus the results are written as < 0.01 and < 0.1 ppm respectively.

4.2 Tests Results Using Hydrated Lime for pH Adjustment

Table 4.2 shows the results obtained using hydrated lime for pH adjustment after chromium reduction stage. Figure 4.1 shows the graph of floc size versus pH when hydrated lime is used for pH adjustment. Figure 4.2 shows the graph of settling time versus pH when hydrated lime is used for pH adjustment.

It is observed that for hydrated lime, which is the design chemical, the best settling time of five minutes is obtained at pH 9.0. Floc size is biggest at pH 9.5 and the settling time is seven minutes. The supernatant solution after treatment with hydrated lime was tested and the results are shown in table 4.3. All the results were low and well within the EQSIER 1979 standard B limits.

Table 4.2 – Treatment Results Using Hydrated Lime for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage					
		7.5	8	8.5	9	9.5	10
Floc size with PAC alone		3	3	3	3	3	3
Floc size with PAC and PE		6	5	6	5	7	6
Settling time	min	7	10	8	5	7	6
Volume of 4% Hydrated Lime used to adjust pH	ml.	15.0	15.7	17.0	20.6	28.2	41.5

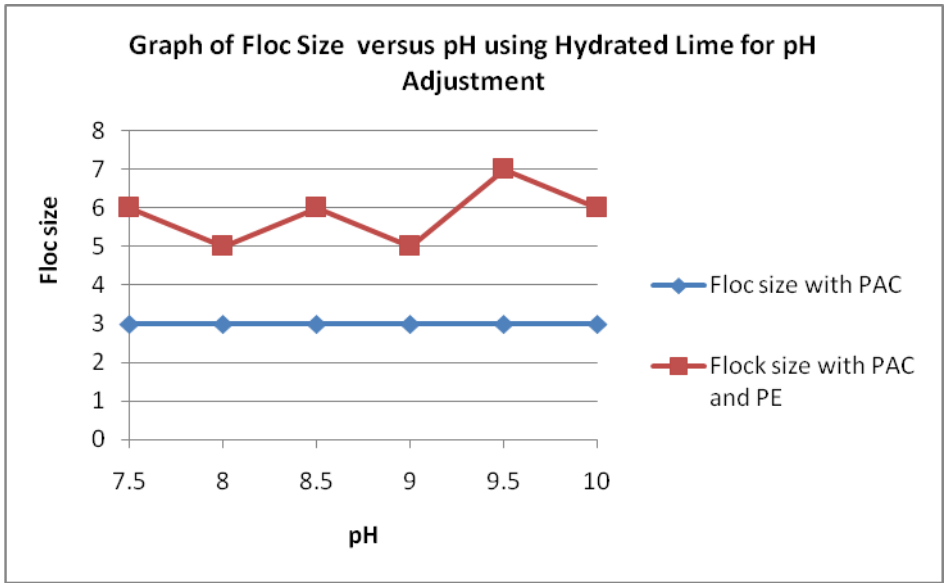

Figure 4.1 – Graph showing floc size when Hydrated Lime is used for pH adjustment.

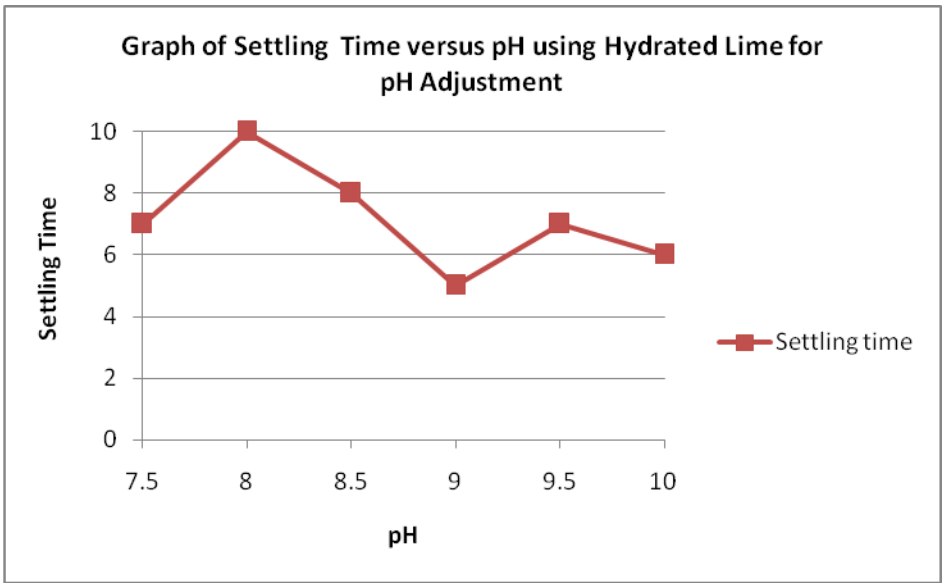

Figure 4.2 – Graph showing settling time when Hydrated Lime is used for pH adjustment.

Table 4.3 – Analysis of Supernatant Solution after Treatment Using Hydrated Lime for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage						EQSIER 1979 Standard B limits
		7.5	8	8.5	9	9.5	10	
COD	ppm	7	2	7	5	5	5	100 max
Suspended Solids	ppm	1	1	1	2	1	1	100 max
Chromium Hexavalent	ppm	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05 max
Copper	ppm	0.03	0.01	0.03	0.02	0.02	0.05	1.0 max
Manganese	ppm	0.5	0.4	0.1	0.3	0.5	0.3	1.0 max
Zinc	ppm	0.01	< 0.01	0.01	0.01	0.01	< 0.01	2.0 max
Boron	ppm	0.82	1.06	0.99	0.97	1.04	1.07	4.0 max
Iron	ppm	0.06	0.04	0.11	0.12	0.04	< 0.01	5.0 max
Oil & Grease	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	10 max
Turbidity	NTU	2	1	0	1	1	1	NA

NA – Not available

4.3 Tests Results Using Soda Ash for pH Adjustment

Table 4.4 shows the results obtained using soda ash for pH adjustment after chromium reduction stage. Figure 4.3 shows the floc size versus pH and figure 4.4 shows the settling time versus pH when soda ash is used for pH adjustment.

It is observed that for soda ash the settling time is below five minutes for pH below 9.0. The settling time increases to 12 minutes and 21 minutes for pH 9.5 and pH 10.0 respectively. Floc size was noted to be eight and seven at pH 7.5 and 8.5 respectively. Table 4.5 shows analysis of supernatant solution after treatment with soda ash. All the results were low and well within the EQSIER 1979 standard B limits.

Table 4.4 – Treatment Results Using Soda Ash for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage					
		7.5	8	8.5	9	9.5	10
Floc size with PAC alone		3	3	3	3	3	3
Floc size with PAC and PE		8	4	7	5	3	4
Settling time	min.	5	5	5	4	12	21
Volume of 4% Soda Ash used to adjust pH	ml.	2.8	2.9	3.1	3.7	5.1	9.1

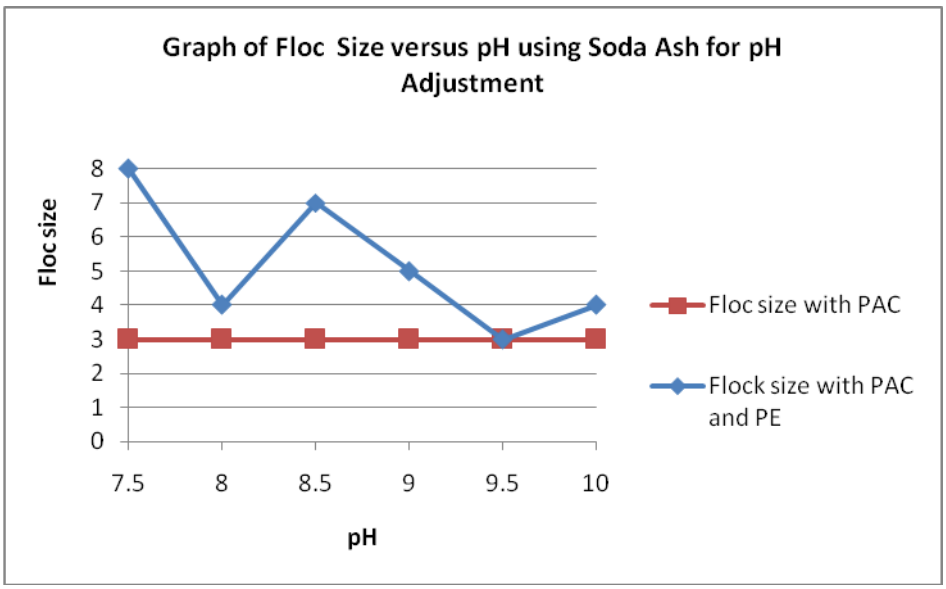

Figure 4.3 – Graph showing floc size when Soda Ash is used for pH adjustment.

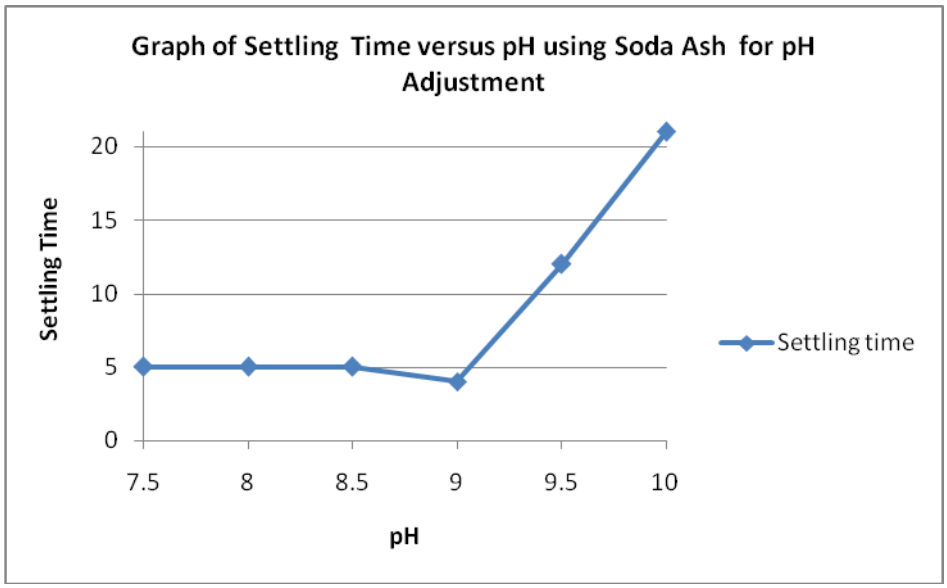

Figure 4.4 – Graph showing settling time when Soda Ash is used for pH adjustment.

Table 4.5 – Analysis of Supernatant Solution after Treatment Using Soda Ash for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage						EQSIER 1979 Standard B limits
		7.5	8	8.5	9	9.5	10	
COD	ppm	4	1	6	7	14	7	100 max
Suspended Solids	ppm	1	1	1	1	1	1	100 max
Chromium Hexavalent	ppm	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05 max
Copper	ppm	0.01	0.01	0.01	0.01	0.07	< 0.01	1.0 max
Manganese	ppm	0.4	0.2	0.4	0.2	0.3	0.4	1.0 max
Zinc	ppm	0.01	0.01	0.01	< 0.01	0.01	0.02	2.0 max
Boron	ppm	0.98	1.05	1.18	0.77	1.00	0.88	4.0 max
Iron	ppm	0.03	0.03	0.02	0.01	0.10	< 0.01	5.0 max
Oil & Grease	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	10 max
Turbidity	NTU	2	1	0	1	0	1	NA

NA – Not available

4.4 Tests Results Using Caustic Soda for pH Adjustment

Table 4.6 shows the results obtained using caustic soda for pH adjustment after chromium reduction stage. Figure 4.5 shows the floc size versus pH and figure 4.6 shows the settling time versus pH when caustic soda is used for pH adjustment.

It is observed that for caustic soda the settling time is below five minutes for pH between 9.0 and 9.5. For pH below 8.5 the settling time was found to be above seven minutes. The floc size was noted to be between five and seven for pH above 9.0. Table 4.7 shows analysis of supernatant solution after treatment with soda ash. All the results were low and well within the EQSIER 1979 standard B limits.

Table 4.6 – Treatment Results Using Caustic Soda for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage					
		7.5	8	8.5	9	9.5	10
Floc size with PAC alone		3	3	3	3	3	3
Floc size with PAC and PE		5	5	6	5	7	6
Settling time	min.	8	15	7	5	4	8
Volume of 1% Caustic Soda used to adjust pH	ml.	10.3	10.5	10.7	11.3	12.6	14.3

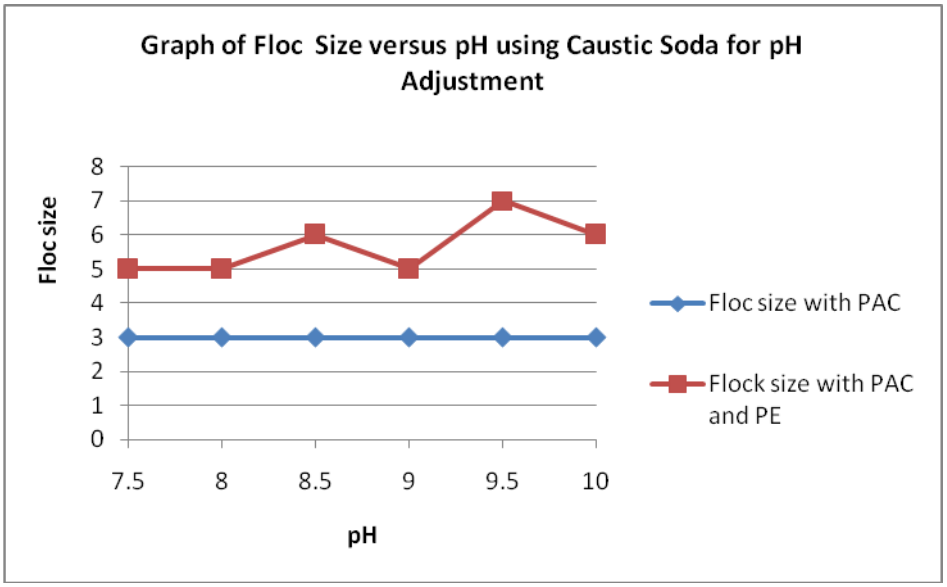

Figure 4.5 – Graph showing floc size when Caustic Soda is used for pH adjustment.

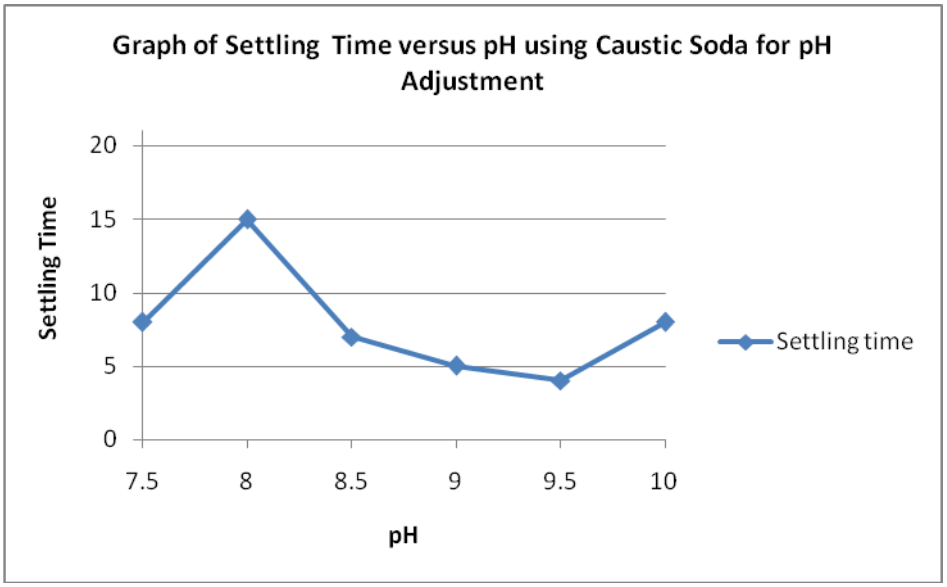

Figure 4.6 – Graph showing settling time when Caustic Soda is used for pH adjustment.

Table 4.7 – Analysis of Supernatant Solution after Treatment Using Caustic Soda for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage						EQSIER 1979 Standard B limits
		7.5	8	8.5	9	9.5	10	
COD	ppm	11	2	11	3	7	5	100 max
Suspended Solids	ppm	1	3	1	0	1	1	100 max
Chromium Hexavalent	ppm	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05 max
Copper	ppm	0.01	0.03	0.01	0.02	0.01	0.04	1.0 max
Manganese	ppm	0.2	0.2	0.2	0.3	0.3	0.3	1.0 max
Zinc	ppm	0.01	< 0.01	0.01	< 0.01	0.01	< 0.01	2.0 max
Boron	ppm	1.02	1.06	1.02	1.01	0.82	0.9	4.0 max
Iron	ppm	0.15	0.12	0.15	0.15	0.02	< 0.01	5.0 max
Oil & Grease	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	10 max
Turbidity	NTU	0	5	0	0	0	1	NA

4.5 Tests Results Using Potassium Hydroxide for pH Adjustment

Table 4.8 shows the results obtained using potassium hydroxide for pH adjustment after chromium reduction stage. Figure 4.7 shows the floc size versus pH and figure 4.8 shows the settling time versus pH when potassium hydroxide is used for pH adjustment.

It is observed that for potassium hydroxide the settling time is below five minutes for pH above 9.0. Floc size was noted to be between five and seven for pH 9.0 and above. Table 4.9 shows analysis of supernatant solution after treatment with potassium hydroxide. All the results were low and well within the EQSIER 1979 standard B limits.

Table 4.8 – Treatment Results Using Potassium Hydroxide for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage					
		7.5	8	8.5	9	9.5	10
Floc size with PAC alone		3	3	3	3	3	3
Floc size with PAC and PE		7	6	6	5	7	7
Settling time	min	6	8	6	5	4	2
Volume of 1% Potassium Hydroxide used to adjust pH	ml	2.6	2.7	2.8	3.0	3.5	4.1

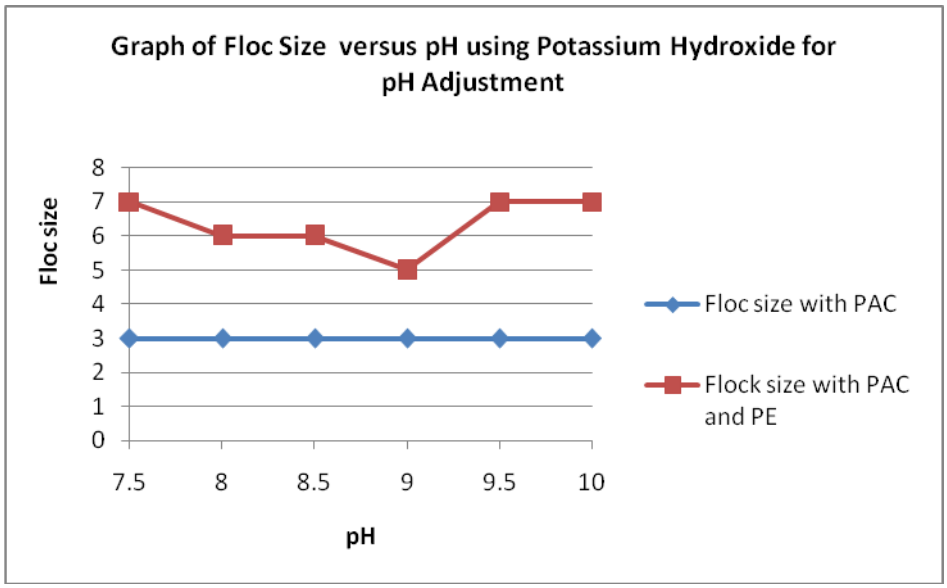

Figure 4.7 – Graph showing floc size when Potassium Hydroxide is used for pH adjustment.

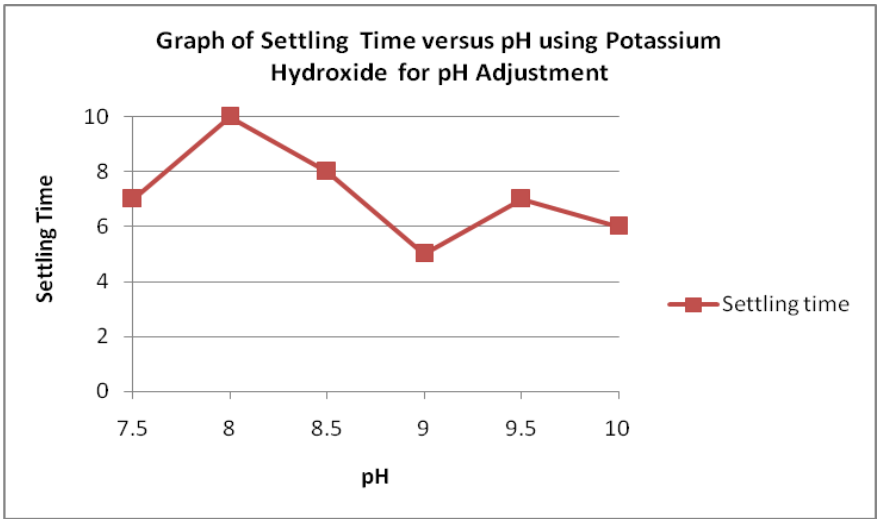

Figure 4.8 – Graph showing settling time when Potassium Hydroxide is used for pH adjustment.

Table 4.9 – Analysis of Supernatant Solution after Treatment Using Potassium Hydroxide for pH Adjustment

Parameter	Units	Set pH after chromium reduction stage						EQSIER 1979 Standard B limits
		7.5	8	8.5	9	9.5	10	
COD	ppm	9	4	13	24	7	4	100 max
Suspended Solids	ppm	4	3	1	1	1	1	100 max
Chromium Hezavalent	ppm	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05 max
Copper	ppm	0.02	0.02	0.04	0.02	0.01	0.00	1.0 max
Manganese	ppm	0.4	0.4	0.2	0.3	0.3	0.2	1.0 max
Zinc	ppm	0.02	0.01	0.02	0	0.01	0.01	2.0 max
Boron	ppm	0.93	1.12	0.90	0.78	1.27	0.82	4.0 max
Iron	ppm	0.10	0.11	0.15	0.07	0.02	0.01	5.0 max
Oil & Grease	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	10 max
Turbidity	NTU	9	7	0	0	0	1	NA

4.6 Weight of sludge generated

Weight of sludge generated at the various treatment with the different chemicals were taken. Graph of the sludge weight generated at various pH with the different

chemicals is shown in Figure 4.9. To minimise waste generation lesser generation of sludge is preferred. As a general pattern it can be seen that the sludge generation is low at pH 7.5 and 9.0 for all the four chemicals used for pH adjustment. At pH 9.0 the amount of sludge generated can be seen as low for Hydrated Lime, Caustic Soda and Potassium Hydroxide. But for Soda Ash sludge generation was highest when compared with the other chemicals at pH 9.0.

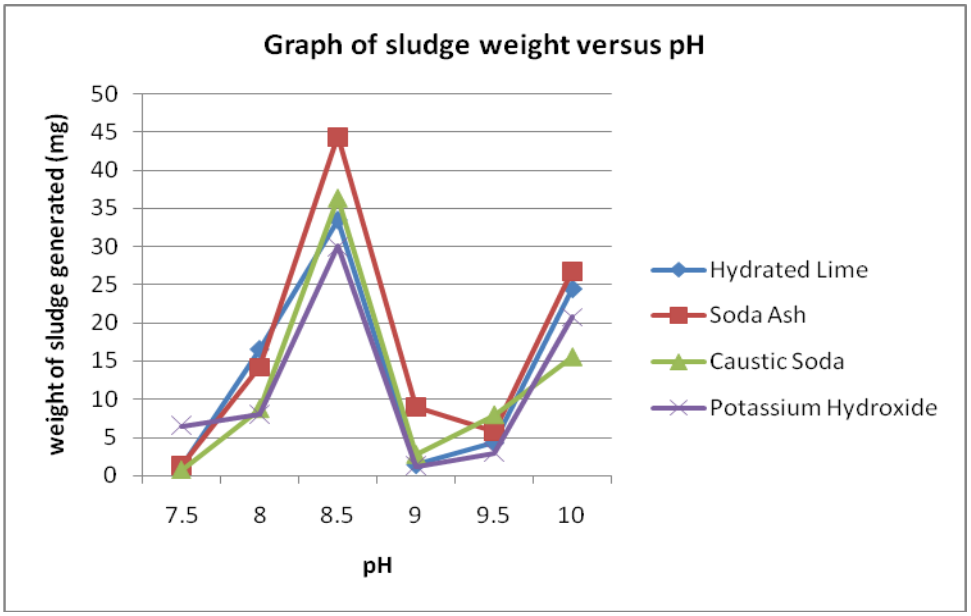

Figure 4.9 – Graph showing weight of sludge generated using different chemicals at various pH