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V. Dean Adams

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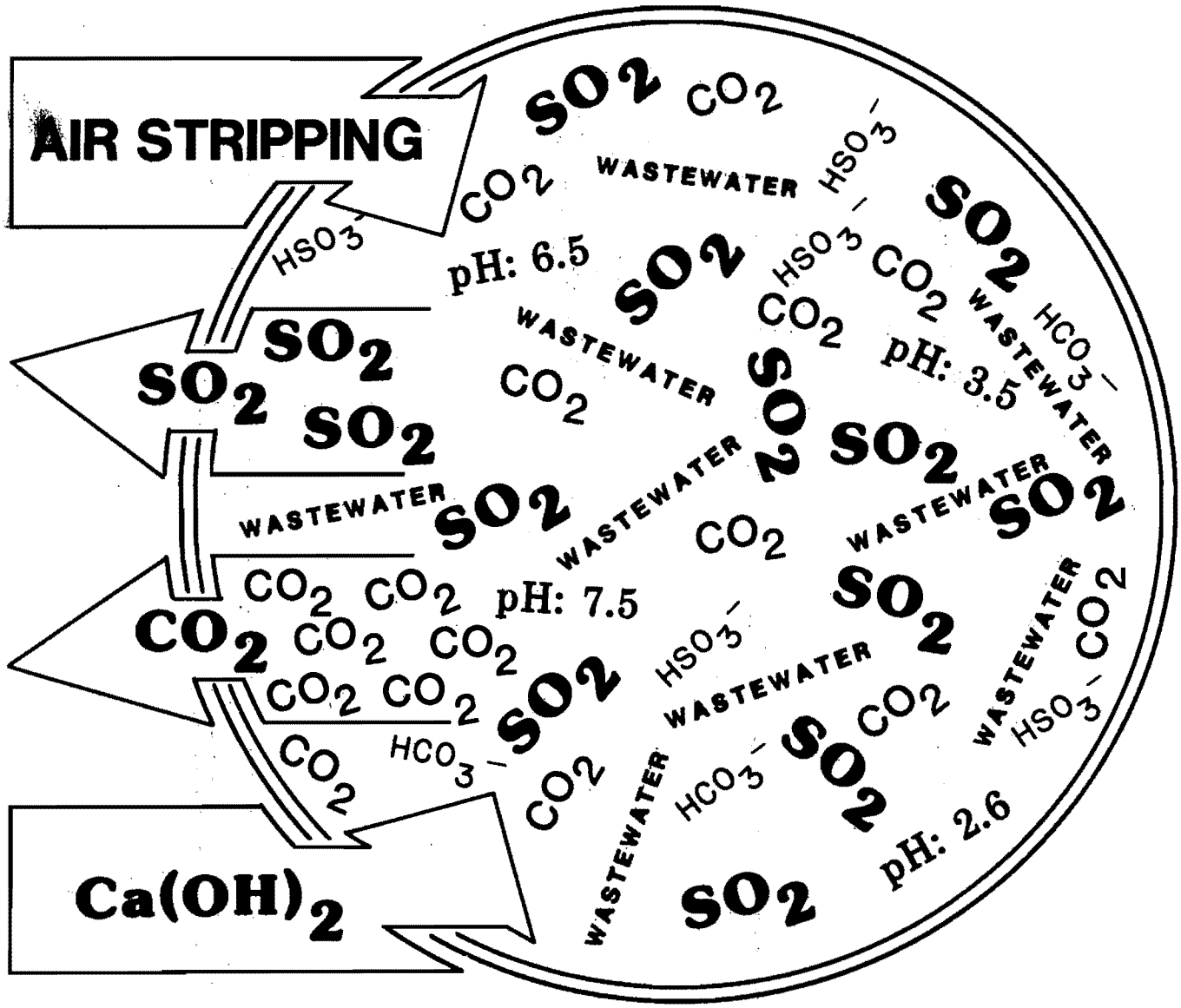

Report to

International Environmental, Inc.
Salt Lake City, Utah

LIME NEUTRALIZATION OF SO_2 TREATED WASTEWATER AFTER AIR STRIPPING

by

V. Dean Adams

Report to

International Environmental, Inc.
Salt Lake City, Utah

Submitted by

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CONTINUED LIME NEUTRALIZATION STUDIES

Part I

From the data presented by Adams and Watts (1981), additional lime neutralization studies were carried out to further look at the lime requirements for pH neutralization. As the lime requirements were less than the calculated amounts based on alkalinity (Nielson, Maxwell and Wangsgard-Montgomery (NMW-M) 1980) something was occurring which lowered the amount of lime needed. With the low pH during air stripping, it appeared that some of the alkalinity (at low pH, CO_2) was being stripped from the solution. Thus it seemed appropriate to look at some sewage with different initial alkalinity concentrations, and perform SO_2 treatment, air stripping and lime neutralization and compare the results. Secondary sewage samples were collected from the Hyrum Wastewater Treatment Plant, Hyrum, Utah. Samples as collected had an approximate alkalinity of 200 mg/l as $CaCO_3$. To compare this with higher alkaline secondary sewage samples, sodium bicarbonate was added to the sewage to raise the alkalinity to $\approx$ 300 mg/l as $CaCO_3$.

Methods and Procedures

Initially, an untreated portion of secondary sewage was tested for pH, alkalinity, dissolved oxygen, and sulfate. All analytical procedures were performed in accordance to Standard Methods (APHA 1975). Sulfur dioxide (SO_2) was then added to an approximate concentration of 500 mg/l and pH, dissolved oxygen, SO_2 and sulfate were determined. This solution was air stripped at 17.5 SCFH for 30 minutes; levels of pH, dissolved oxygen, SO_2 and sulfate were again determined. The sample

was then split into three portions. A 0.5 percent solution of calcium hydroxide was added to the split samples. Measurements on two of the portions recorded the amount of calcium hydroxide required to raise the pH to 6.5, and the additional amount required to raise the pH to 7.0. At this point, the dissolved oxygen, SO_2, and sulfate were again measured. Calcium hydroxide was also added to the third portion of the sample to determine the amount of $Ca(OH)_2$ required to raise the pH to 6.5, the amount required to raise the pH to 7.0, and the additional amount required to raise the pH to 9.0. SO_2 and sulfate tests were then run on this sample provided sufficient sample was available.

Some of the secondary sewage samples were spiked with a 1.5 percent solution of sodium bicarbonate in order to increase the alkalinity to approximately 300 mg/l. After the sodium bicarbonate spike was added, the test procedure was the same as outlined above.

Results and Discussion

The results are presented in Tables 1 - 6. Tables 7 and 8 are summary tables of data from Tables 1 - 6. From Table 7, the mean initial pH was 7.5 and the mean pH after 30 minute air stripping was 3.5 for the samples at a mean alkalinity of 216 mg/l as $CaCO_3$. Approximately 50 percent of the SO_2 was stripped from the SO_2 treated samples during the 30 minute stripping period. Lime neutralization to a pH of 6.5 required 96 mg/l $Ca(OH)_2$ and an additional 42 mg/l $Ca(OH)_2$ to reach a pH of 7. Table 8 shows that the mean initial pH of the sewage after sodium bicarbonate addition (to a total alkalinity of 297 mg/l $CaCO_3$) was 7.7. After SO_2 treatment and air stripping for 30 minutes the mean pH was at 3.1. Lime neutralization

Table 1. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on January 29, 1981.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.5	205	5.4		39.5									
2° Sewage	500	No	0	2.6		4.0	455										
2° Sewage	500	No	30	3.7		4.3	229		89	38	134	0.13	197				
2° Sewage	500	No	0	2.6		3.8	467										
2° Sewage	500	No	30	3.8		5.2	239		86	18	67	3.8	218		3.3	220	

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 2. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on January 30, 1981.

Sample	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.8	210	4.5		36.5									
2° Sewage	500	No	0	2.5		4.0	480										
2° Sewage	500	No	30	3.6		5.0	212		72	47	50	0.1	202				
2° Sewage	500	No	0						370	83		0.1	428				
2° Sewage	235	No	0	4.0		4.5	240		87	16							

[a] Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b] Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c] Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d] Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 3. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on February 2, 1981.

Sample	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.3	234	3.9		36									
2° Sewage	500	No	0	2.7		3.6	392										
2° Sewage	500	No	30	3.3		4.5	247		107	47	88		192				
2° Sewage	500	No	0	2.6		4.0	376										
2° Sewage	500	No	30	3.0		4.8	276		125	59	70	0.1	230		0.1	236	
2° Sewage	500	No	0						250	86	40		322				
2° Sewage	200	No	0	5.6		4.2	172		115	65			128				

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 4. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on February 13, 1981.

Sample	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.4	206	5.1		38									
2° Sewage	0	Yes	0	7.5	296												
2° Sewage	500	Yes	0	2.7		7.3	496										
2° Sewage	500	Yes	30	3.8		8.3	270		94	32		0.1	230	209			

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 5. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on February 19, 1981.

Sample	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.4	208	4.5		45									
2° Sewage	0	Yes	0	7.5	298	4.5		44									
2° Sewage	500	Yes	0	2.4		6.6	502	275									
2° Sewage	500	Yes	30	3.1		9.0	200	240	103	38	58	0.1	144	265			
2° Sewage	500	Yes	0	2.4		10.0	554	287									
2° Sewage	500	Yes	30	3.0		10.0	208	280	106	39	68	0.1	130	356		160	260
2° Sewage	500	Yes	0	2.4		9.5	502	254									
2° Sewage	500	Yes	30	3.0		9.4	218	249	111	40	63	0.0	161	328		145	273

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 6. SO_2 treatment of secondary wastewater, air stripping, and lime neutralization data for experiments performed on March 3, 1981.

Sample	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.8	222	7.7		33									
2° Sewage	0	Yes	0	8.2	297												
2° Sewage	500	Yes	0	2.4		11.2	408	229									
2° Sewage	500	Yes	30	3.1		8.3	198	251	85	34	33	0.3	148	308		142	271
2° Sewage	500	Yes	0	2.3		13.2	476	232									
2° Sewage	500	Yes	30	2.9		9.2	188	263	102	31	55	0.3	144	308		136	266
2° Sewage	500	Yes	0	2.3		10.6	488	274									
2° Sewage	500	Yes	30	2.9		10.3	198	264	119	39		0.3	150	295		132	282

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

Table 7. Summary of SO_2 treatment of secondary wastewater, air stripping, and lime neutralization of samples with an approximate alkalinity of 200 mg/l as $CaCO_3$.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.5(3)	216(3)	4.6(3)		37.3(3)									
2° Sewage	500	No	30	3.5(5)		4.8(5)	241(5)		95(5)	42(5)	82(5)						

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

[e]Numbers in ( ) are the number of data points used to calculate the mean values.

Table 8. Summary of SO_2 treatment of secondary wastewater, air stripping, and lime neutralization of samples with an approximate alkalinity of 300 mg/l as $CaCO_3$.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition								
									$Ca(OH)_2$ mg/l			pH 7.0			pH 9.0		
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	D.O. mg/l	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.5(3)[e]	212(3)	5.8(3)		39(3)									
2° Sewage	0	Yes	0	7.7(3)	297(3)												
2° Sewage	500	Yes	30	3.1(7)		9.2(7)	211(7)		103(7)	36(7)	55(5)						

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide in mg/l required to raise pH from 7.0 to 9.0.

[e]Numbers in ( ) are the number of data points used to calculate the mean values.

to a pH of 6.5 required 103 mg/l $Ca(OH)_2$ and an additional 36 mg/l $Ca(OH)_2$ to obtain a pH of 7. As can be observed, the lime requirements for neutralization of the sewage samples with a mean initial alkalinity of 216 mg/l as $CaCO_3$ and the lime requirements for neutralization of the sewage samples with a mean initial alkalinity of 297 mg/l $CaCO_3$ are nearly the same (138 and 139 mg/l $Ca(OH)_2$ respectively).

When these lime requirements are compared to those stated in the NMW-M report (1980), they are <u>much</u> less than NMW-M's. For instance NWM-M indicated that for a sewage sample containing 300 mg/l as $CaCO_3$ alkalinity, 336 mg/l CaO would be required to bring the pH of the SO_2 treated solution back to a pH of 6.5. This would then be compared to the present experimental data of 103 mg/l of $Ca(OH)_2$ or 78 mg/l CaO to obtain a pH of 6.5. The actual amount needed for neutralization to pH 6.5 is 77 percent less than what NMW-M has indicated. This would represent a substantial saving of chemical costs and thus operation and maintenance costs.

CONTINUED LIME NEUTRALIZATION STUDIES

Part II

To further verify the loss of alkalinity (at low pH, CO_2) during the SO_2 treatment-air stripping process, additional experiments were designed and performed. The process was similar to Part I but inorganic carbon was also measured to show that the inorganic carbon was being stripped from the solution.

Methods and Procedures

Secondary sewage samples from the Hyrum Sewage Treatment Plant, Hyrum, Utah, were used in these experimental procedures. Initial tests were run on the sewage to determine the pH, alkalinity, inorganic carbon, and sulfate concentrations (APHA 1975). Inorganic carbon was also determined using an Oceanography Carbon Analyzer and a method which uses phosphoric acid and infrared analysis of carbon dioxide (Oceanography International 1975). Sulfurous acid was added to an aliquot of sewage to give a concentration of 500 mg/l as SO_2. Inorganic carbon, sulfate and SO_2 were determined. The sewage-plus-SO_2 mixture was then aerated at 17.5 SCFH for 30 minutes. After the air stripping, inorganic carbon, sulfate, and sulfite were again determined. The sewage-plus-SO_2 was divided into two portions. One portion was titrated with a 1.5 percent calcium hydroxide solution to pH endpoints of 6.5 and 7.0. The other portion was titrated with the 1.5 percent calcium hydroxide solution to pH endpoints of 6.5, 7.0, and 9.0. The amount of calcium hydroxide required to raise the pH to the above mentioned values was thus determined. Inorganic carbon, sulfate, and SO_2 were run again on the sewage-SO_2-calcium hydroxide solutions.

Secondary sewage samples were also spiked with a 1.5 percent sodium bicarbonate solution to raise the alkalinity and inorganic carbon of the sewage sample prior to the SO_2 addition. After the sodium bicarbonate was added, the test procedure was the same as outlined above.

Results and Discussion

The results are presented in Tables 9, 10, and 11. The total inorganic carbon after SO_2 treatment and air stripping is reported as <1 mg/l C in all cases. It appears that essentially all of the CO_2 is being stripped from solution during the air stripping process. It is also interesting to note that some of the CO_2 is leaving the solution after the SO_2 addition but prior to the air stripping process.

Using data from Tables 9, 10, and 11, the mean lime requirement for pH neutralization to 6.5 is 71 mg/l $Ca(OH)_2$ (n=7) and 57 mg/l $Ca(OH)_2$ (n=7) to reach pH 7 from pH 6.5. These values are similar to the lime values in Part I, again showing a much lower lime requirement than the NMW-M (1980) report suggested. Based upon their numbers (336 mg/l CaO required), these data indicate that 84 percent less lime is required for neutralization to pH 6.5.

Conclusions

1. Lime requirements for neutralization of SO_2 and air stripped secondary wastewater to pH 6.5 is much less (77 and 84 percent) than calculated (NMW-M 1980) lime requirements based on initial alkalinities.
2. Alkalinity (CO_2) is being stripped to <1 mg/l C from the SO_2 treated wastewater at low pH during the air stripping process.

Table 10. SO_2 treatment of secondary wastewater, air stripping, lime neutralization, and total inorganic data for experiments performed on July 17, 1981.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition					
									$Ca(OH)_2$ mg/l			pH 7.0		
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.6	237	55		25						
2° Sewage	500	No	0			37 → 9[e]	540	40						
2° Sewage	500	No	30	4.9		<1	272	35	60	30	60			
2° Sewage	0	Yes	0		334	69								
2° Sewage	500	Yes	0			1	564	40						
2° Sewage	500	Yes	30	4.6		<1		39	69	60	30	<1	316	79

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

[e]Total inorganic carbon decreasing with time during the analytical process.

Table 11. SO_2 treatment of secondary wastewater, air stripping, lime neutralization, and total inorganic data for experiments performed on July 29, 1981.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition						
									$Ca(OH)_2$ mg/l			pH 7.0			
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	8.1	268	65		38						
2° Sewage	500	No	0			42	512	67						
2° Sewage	500	No	30	4.6		<1	258	79	75	45		<1	190	166
2° Sewage	0	Yes	0	8.2	301	54		40						
2° Sewage	500	Yes	0			21→12[e]	496	62						
2° Sewage	500	Yes	30	4.1		<1	220	47	70	68				
2° Sewage	500	Yes	0			22→17[e]	546	31						
2° Sewage	500	Yes	30	4.8		<1	272	35	60	82		<1	214	132

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

[e]Total inorganic carbon decreasing with time during the analytical process.

Table 9. SO_2 treatment of secondary wastewater, air stripping, lime neutralization, and total inorganic data for experiments performed on March 25, 1981.

	Treatment			Chemical Parameters					Chemical Parameters After Lime Addition					
									$Ca(OH)_2$ mg/l			pH 7.0		
Sample	SO_2 Added mg/l	$NaHCO_3$[a] Added Yes/No	Air Strip at 17.5 SCFH min	pH	Alkalinity mg/l as $CaCO_3$	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$	pH 6.5[b]	pH 7.0[c]	pH 9.0[d]	Total Inorganic Carbon mg/l as C	SO_2 mg/l as SO_2	$SO_4^=$ mg/l as $SO_4^=$
2° Sewage	0	No	0	7.5	226	58		37						
2° Sewage	500	No	0	2.8		51→33[e]	522	37						
2° Sewage	500	No	30	3.9		<1	216	36	75	58		<1	227	118
2° Sewage	0	Yes	0	7.8	305	81								
2° Sewage	500	Yes	0	2.7		69→53[e]	588	38						
2° Sewage	500	Yes	30	4.5		<1	376	38	87	58		<1	294	166

[a]Samples spiked with sodium bicarbonate ($NaHCO_3$) to increase alkalinity to approximately 300 mg/l (as $CaCO_3$).

[b]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH to 6.5.

[c]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 6.5 to 7.0.

[d]Calcium hydroxide ($Ca(OH)_2$) in mg/l required to raise pH from 7.0 to 9.0.

[e]Total inorganic carbon decreasing with time during the analytical process.

3. Lime costs (chemical and operation and maintenance) for neutralization (pH 6.5) of air-stripped-SO_2 treated sewage should be much less than those costs predicted by NMW-M (1980).

Future Studies Required

1. Further data analysis and experimental processes need to be evaluated to determine how and what parameters are needed to predict lime neutralization costs.

References

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