

**AN INNOVATIVE APPROACH FOR REMOVAL OF IRON
FROM MISSISSIPPI GROUNDWATERS**

by

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INTRODUCTION

Comprising about five percent of the earth's crust, iron is present in almost all groundwater due to its abundance in a wide variety of crystalline rocks and soils. When groundwater is used as a water supply, the presence of iron in significant concentrations is objectionable because it supports the growth of microorganisms, produces unaesthetic conditions, and results in financial loss. In order to curtail these problems, the Environmental Protection Agency has set 0.3 mg/l as a maximum secondary standard for iron in potable water.¹

In the State of Mississippi, it is reported that 59 of the groundwater supplies exceed this recommended limit.² Necessarily, many Mississippi well supplies must be treated to remove the objectionable iron. Most current treatment methods consist of oxidizing the iron to the insoluble state and subsequent removal and disposal of the precipitates formed. This paper presents an innovation to the current technology-recirculation of the precipitates to achieve improved iron removal.³

METHODS AND PROCEDURES

Water supplies for the municipalities of Amory and Louisville were selected for study of the innovation. Prior to treatment the water supplies contain about 16 to 20 and 4 to 6 mg/l of iron, respectively. The Amory treatment facility employs coke tray aeration, chlorine oxidation, solids contact, and dual-media filtration. Alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 14.3 \text{H}_2\text{O}$) and lime ($\text{Ca}(\text{OH})_2$) are also used as treatment chemicals. The Louisville facility consists of surface aeration, chlorine oxidation, flocculation, clarification and dual media filtration along with addition of polyelectrolyte and lime. Block diagrams are shown in Figures 1 and 2.

Iron wastewater from the two plants was obtained and concentrated. At Amory the wastewater was taken from the blowoff of the solids contact unit, while at Louisville it came from the backwash of the filters and slant tube clarifiers. On-site jar tests were conducted with application of the iron sludge material at varying sludge recycle ratios. Aliquots of supernate were extracted at various time intervals during the sedimentation step and analyzed for total iron concentration by the phenanthroline method.

Again employing the conventional jar test method, a study of sludge oxidizing ability was conducted by varying the sludge contact time before chlorine

addition. First, an optimal sludge volume was added to the raw water. Then, after a specified time period a measured dosage of chlorine as sodium hypochlorite (NaOCl) was introduced. Finally, after a settling period of 10 or 60 minutes the supernate was analyzed for chlorine residual by the orthotolidine method. Iron concentration was also determined.

To simulate and study the conditions that would be encountered in a water treatment plant, a one-gallon per minute pilot plant utilizing iron sludge recirculation was operated at Louisville. The pilot facility is illustrated in block diagram form in Figure 3. Hydraulic detention times are noted by each unit. The loadings to the sedimentation and filtration units were 0.4 and 5.2 gpm/ft², respectively.

Chemical sequencing studies were conducted using alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$), recirculated iron sludge, and lime ($\text{Ca}(\text{OH})_2$) as treatment chemicals. Sludge recycle ratios were varied from 3 to 17 percent by volume.

RESULTS AND DISCUSSION

A summary of the jar test results of applying Amory iron sludge to the untreated water is illustrated in Figure 4. For each sludge recycle ratio, the percentage of the total iron removal was determined by comparing the final total iron concentration achieved to the total iron concentration present in the untreated water. Total iron removal markedly increased as sludge recycle increased. About 50 percent of the total iron was removed at a sludge recycle of 5 percent by volume. Results indicated that at 21 percent by volume sludge recycle, 96 percent total iron removal was achievable. This represented a reduction in total iron concentration from 16.5 to 0.5 mg/l. The equation describing iron removal as a function of sludge recycle is presented on the graph.

Illustration of the results from Louisville is presented in Figure 5. Total iron removal was computed as discussed previously. In contrast to the curve shown in Figure 4, sludge recycles of about 3 to 5 percent by volume achieved the greatest iron removal. Total iron removal tended to decrease to less than 50 percent at recycles above the 8 percent, leveling off to about 30 percent removal at the higher sludge recycle ratios.

Investigation into the oxidation potential of the iron sludge showed that given sufficient contact time the sludge would enhance oxidation of the iron. This is illustrated in Figures 6 and 7, representing the results from Amory and Louisville, respectively. As the time interval between sludge and chlorine addition in-

creased, up to a limiting value, chlorine residual increased. For the Amory water the chlorine residual remained constant after 14 minutes of sludge contact time, while a constant value was achieved after about 4 minutes at Louisville. This resulted in about 75 percent of the chlorine added originally remaining in solution.

Typical results achieved in operation of the pilot plant are presented in Table 1. These data were obtained by recirculating the iron sludge to the rapid mix unit, adding the lime at the flocculator inlet, and introducing alum at the sedimentation inlet. Excellent iron removal was noted, representing an average total iron concentration in the water to the filter of 0.5 mg/l for sludge recycle values of 3 to 6 percent by volume. Iron concentration tended to increase at sludge recycle ratios above about 7 percent by volume. Maintaining the recycle within the 3 to 6 percent range yielded a filtered water with 0.1 mg/l of iron or less, which is well below the 0.3 mg/l federal requirement. It is important to note that these results were achieved without the addition of chlorine as an oxidant.

SUMMARY AND CONCLUSIONS

Recirculation of iron sludge in two water treatment plants practicing iron removal was demonstrated to be a viable method for improving iron removal. Investigation of a range of recycle ratios suggested that the optimal recycle for 16 mg/l of iron was about 21 percent by volume and about 6 percent by volume for 5 mg/l of iron.

The sludge was demonstrated to improve oxidation. Upon application of sludge and then chlorine to the untreated water, results showed that, with provision of sufficient time, the sludge reacted with the water and reduced the requirements for an alternate chemical oxidant. The greater contact time required at Amory, 14 minutes as compared to 4 minutes at Louisville, was indicated to be a function of the much higher iron concentration in the raw water.

Although the study showed that a water with less than 0.3 mg/l of iron could be produced without adding chlorine, some chlorine or other oxidant will be necessary in treatment plants to maintain a residual, prevent biological growth in the plant, and polish the water prior to distribution. In addition, results suggested that provision should be made to allow for sufficient time between sludge and chlorine addition.

REFERENCES

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2. Robinson, Lloyd R., Jr., "The Effect of Organic Materials on Iron Removal in Groundwater," **Water and Sewage Works**, 114:10:377 (October 1967).
3. Mitchell, Gayle F., "An Innovative Approach to Iron Removal for Groundwater Using Iron Sludge Recirculation," Ph.D. Dissertation, Mississippi State University (August 1978).

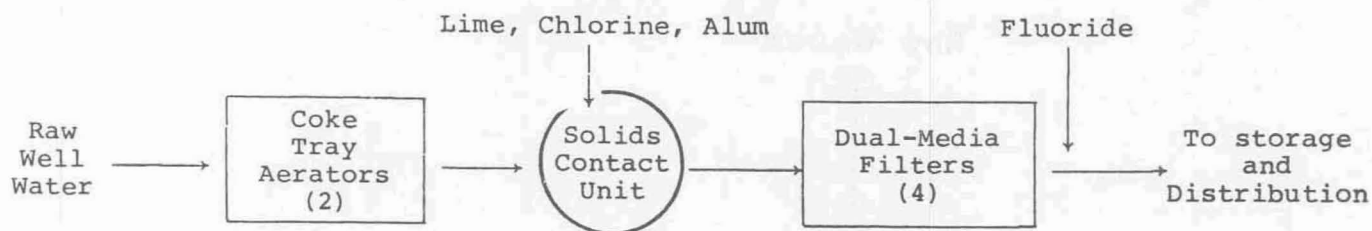


Figure 1. Block Diagram of the Amory, MS Water Treatment Plant

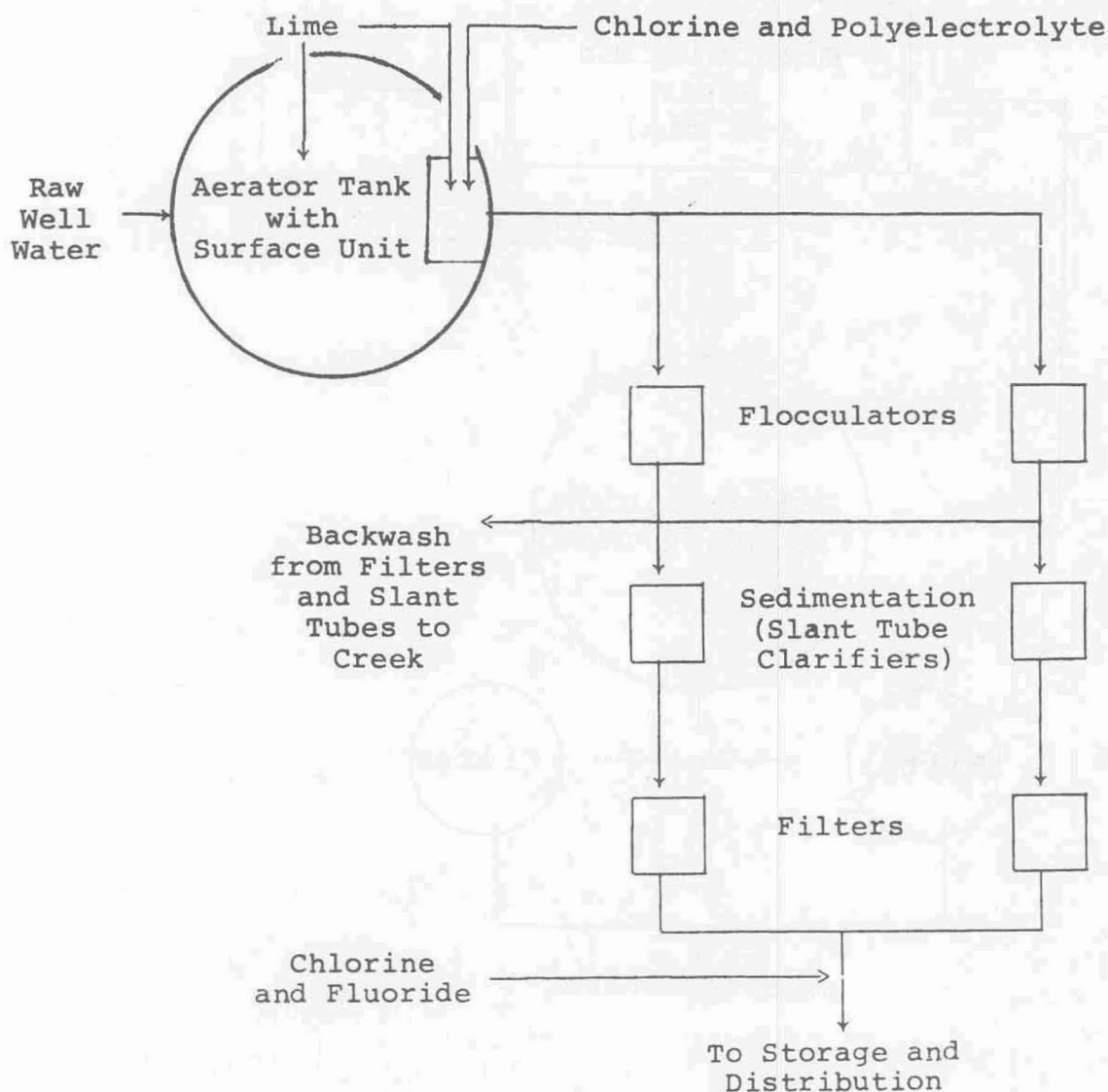


Figure 2. Block Diagram of the Louisville, MS. Water Treatment Plant

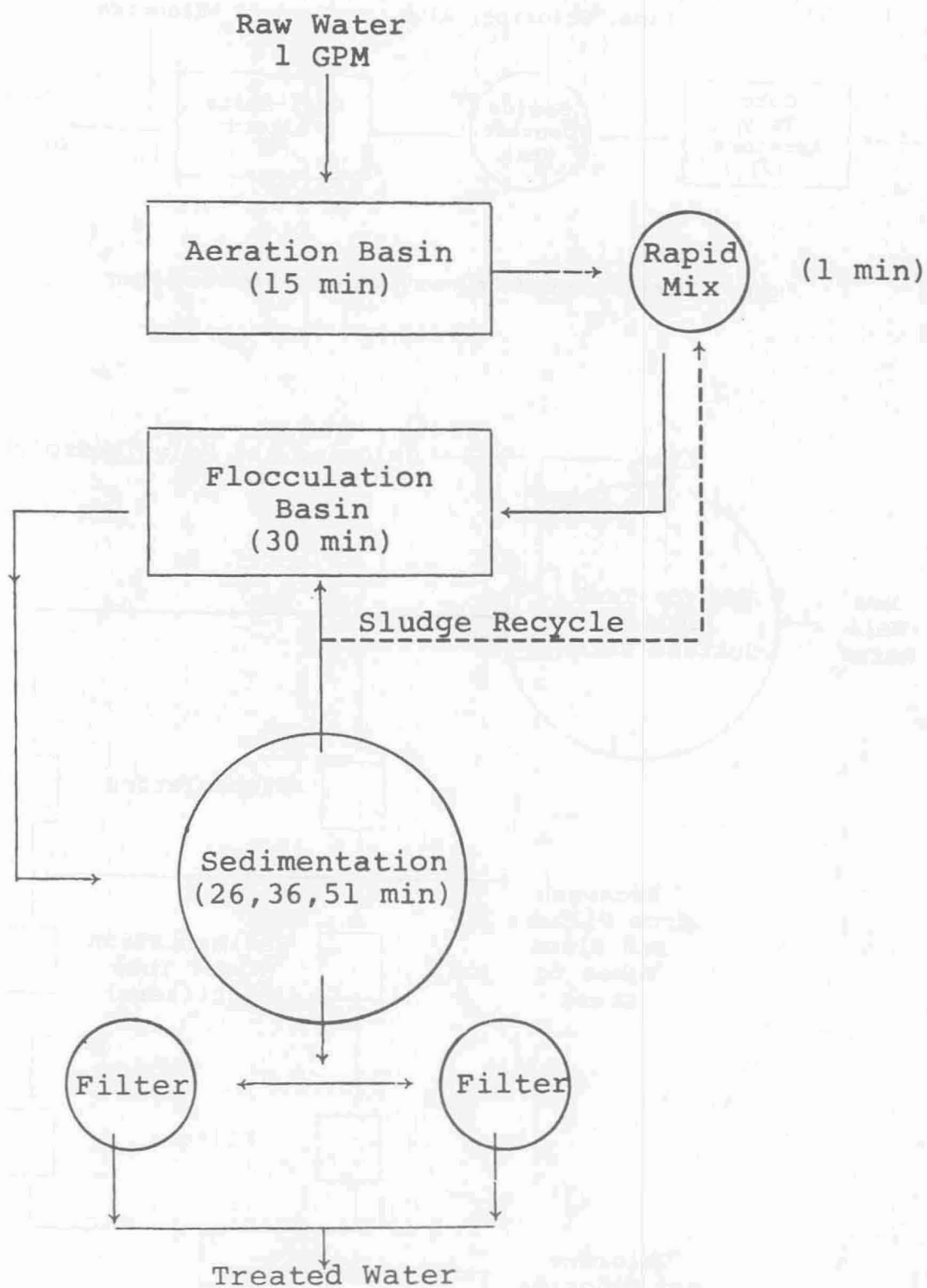


Figure 3. Block Diagram of 1 GPM Pilot Water Treatment Plant

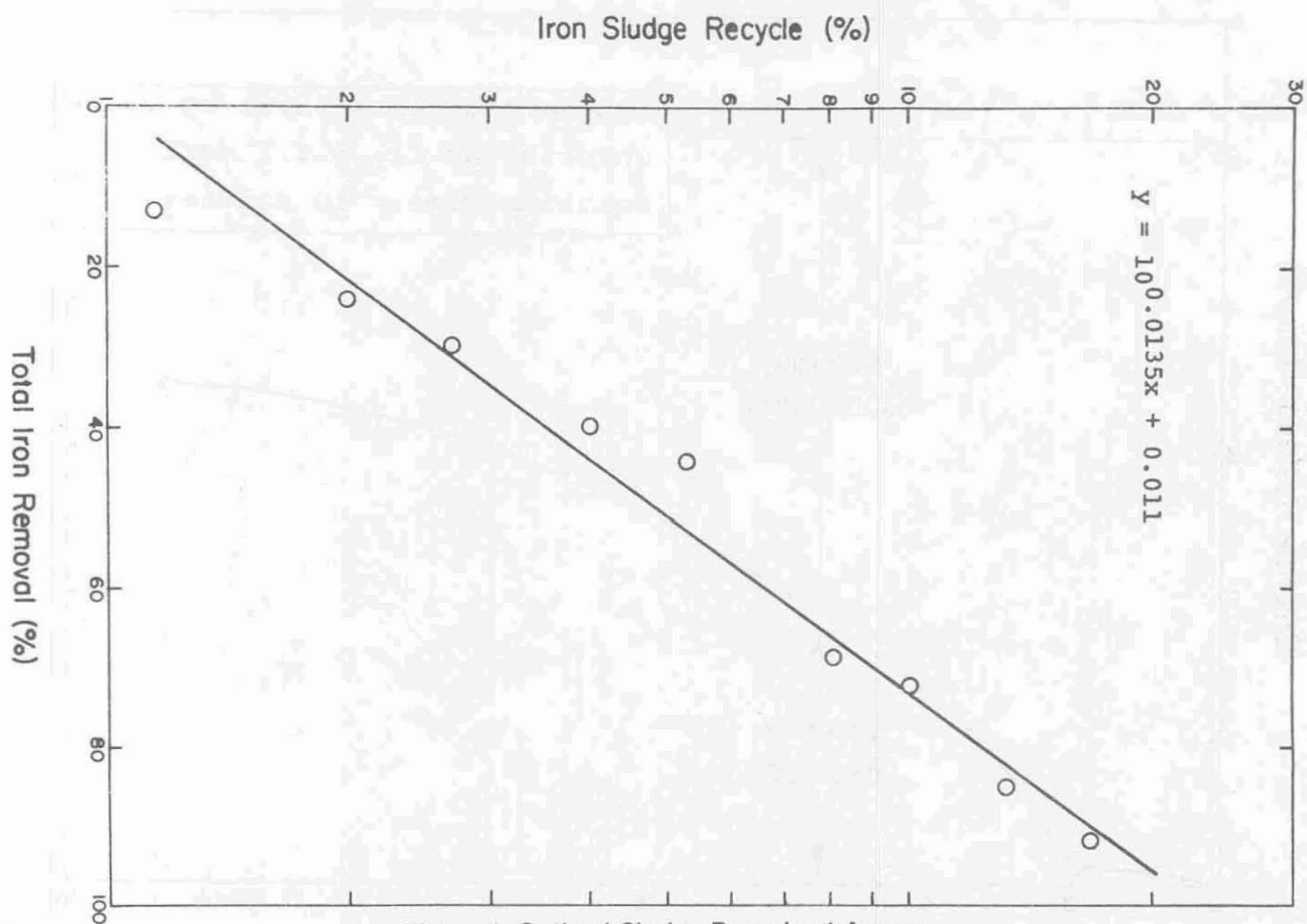


Figure 4. Optimal Sludge Recycle at Amory

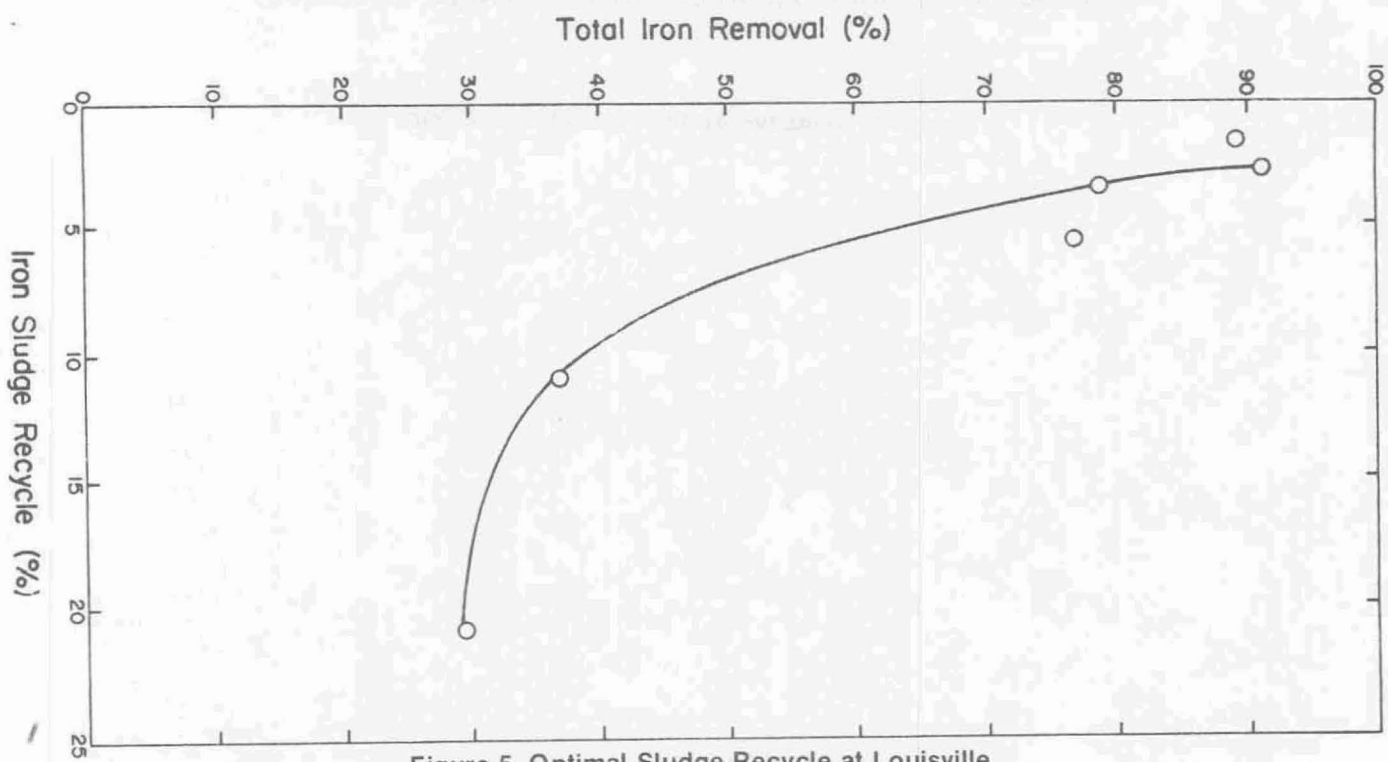


Figure 5. Optimal Sludge Recycle at Louisville

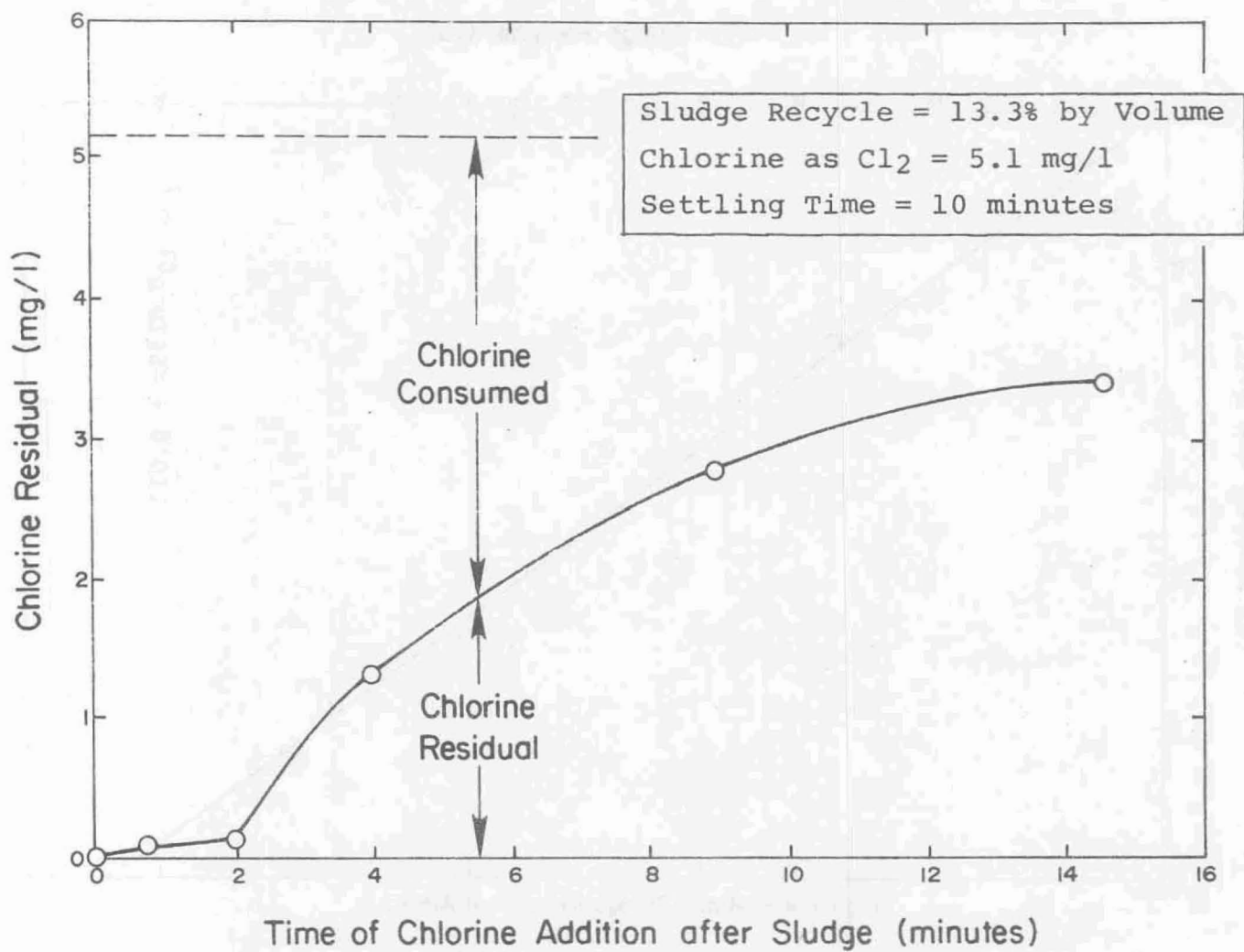


Figure 6. Oxidative Ability of Sludge at Amory

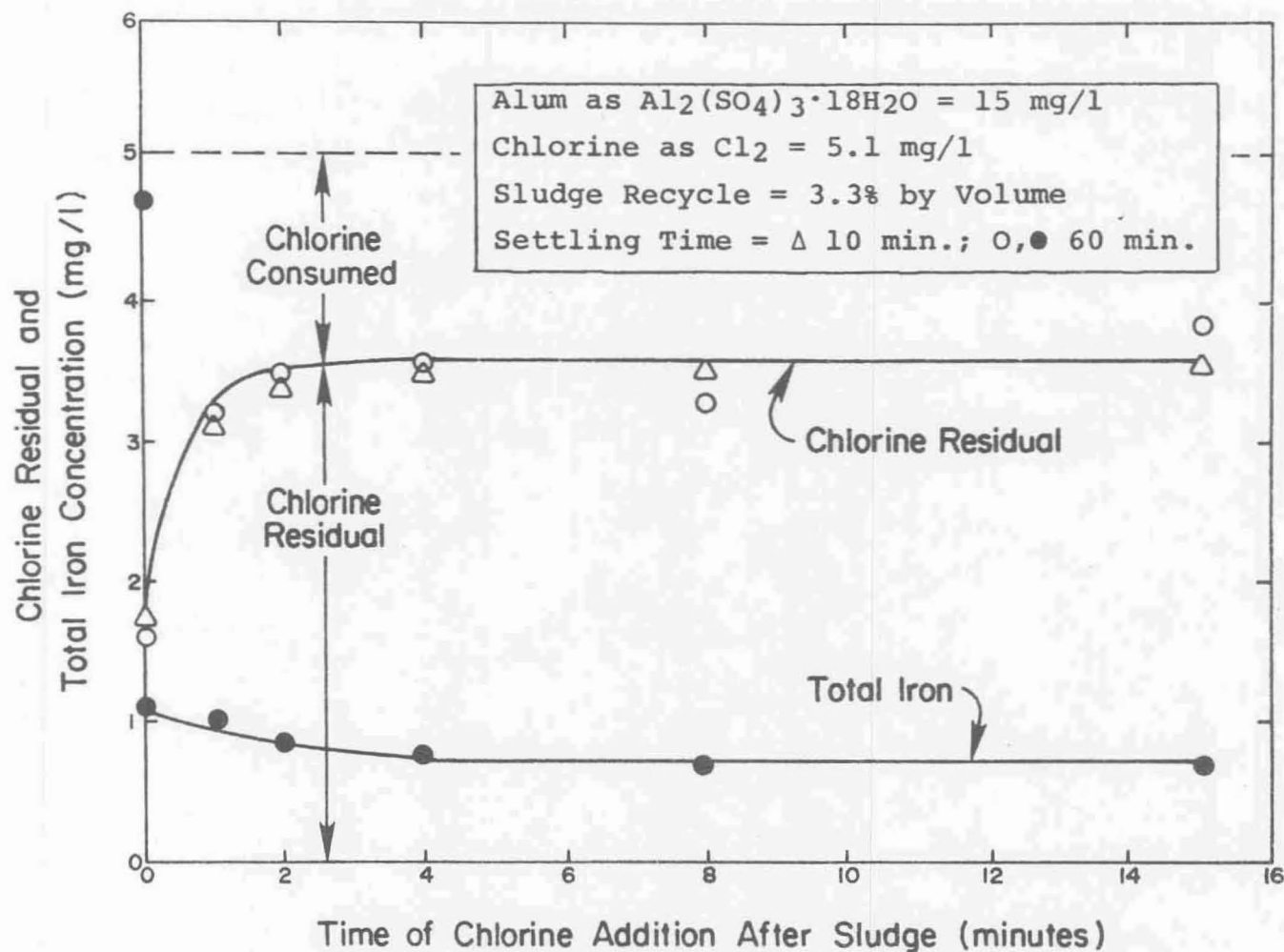


Figure 7. Oxidative Ability of Sludge at Louisville

Table 1. Iron Removal Achieved with a 1 GPM Pilot Plant Utilizing Iron Sludge Recycle

Chemical Treatment			Iron Removal Achieved (%)	
Sludge (%)	Lime (mg/l)	Alum (mg/l)	Water To Filtration	Water After Filtration
2.9	40	26	88	96
4.9	40	26	84	96
5.8	38	28	91	96
9.9	37	23	89	98
15.6	37	23	85	98