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Project Summary

Limestone - Lime Treatment of Acid Mine Drainage - Full Scale

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Utilizing a full scale neutralization plant, the effect of detention time, sludge recirculation, flow pattern, and treatment pH have been observed using limestone and lime separately and in combination. Data have been accumulated on highly acidic ferric iron acid mine drainage to determine the most economical method of treatment.

Plant operation indicates that combination limestone-lime treatment with sludge recirculation on both treatment lines is the most economical scheme of treatment.

Sludge studies indicate limestone treatment to high pH levels yielded sludges with the highest solids content. Sludges of slightly lower solids content were acquired during series flow treatment of similar AMD with lime and sludge recirculation.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The nationwide problems related to acidic discharges from coal mining operations are well documented in the popular and technical literature. Neutralization continues to be a necessary short-term measure in numerous instances, while long-range programs are being developed to abate acid production at the source.

Considerable effort has been expended in investigating the neutralization of acid mine drainage (AMD) with limestone, lime, and soda ash. A combination limestone-lime process has been shown to have cost advantages with improved effluent quality and sludge settling characteristics. Peabody Coal Company, in cooperation with the U.S. Environmental Protection Agency, designed, constructed, and operated a full scale treatment plant to study the process. Objectives of the study were:

1. To determine the most economical method of treatment of highly acidic mine drainage in large volumes.
2. To observe and report effectiveness of acid mine drainage treatment, with special emphasis on metal ion removal.
3. To characterize sludges from treatment processes as to settling behavior and solids content.

Background

The Will Scarlet Mine is an active coal-producing mine located approximately 3 miles southwest of Carrier Mills, Illinois, in Saline and Williamson Counties. Mining operations were started at Will Scarlet by the Stonefort Coal

Company in 1953. Peabody Coal Company purchased the mine in 1967.

Before construction and operation of the full scale treatment plant, acid mine runoff from old surface works was diverted into inactive surface mine pits. Even with construction of extensive dike systems and relocation of the South Fork of the Saline River, the major waterway, incidental pollution occurred during periods of river overflow, as well as seepage and surface runoff, and thus some acidic water entered the river.

Water quality of the plant influent varied with the amount of rainfall. With increasing amounts of precipitation, dilution of the plant influent was observed but was preceded by a flushing of more acidic influent water. The range of water quality observed in the plant influent is shown in Table 1. Small concentrations of ferrous iron were observed during the research period, usually associated with periods of heavy rainfall and seepage from the slurry lagoon next to the plant influent channel.

A neutralization process for coal mine drainage entails a series of individual units of operation. This design, however, is limited to one straight-line treatment system. Thus, to incorporate series treatment (with the potential for increased detention time) and combination treatment, the design of the Will Scarlet Water Treatment Plant consists of two identical systems of individual units with recirculation capabilities (Figure 1).

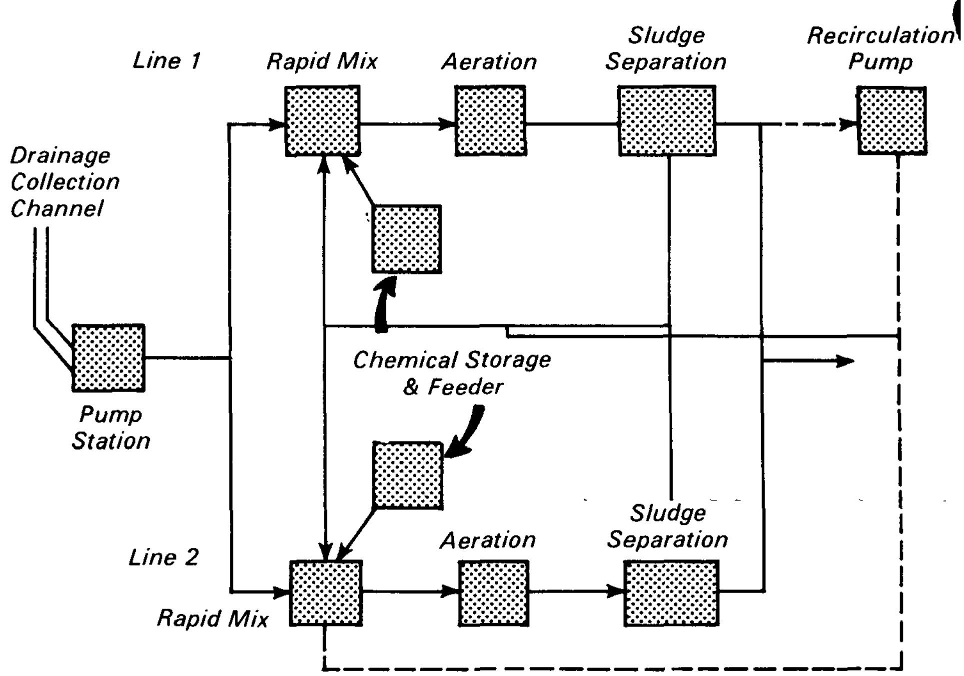

Figure 1. *Flow diagram of Will Scarlet treatment plant.*

Limestone vs. Lime

Two parallel continuous-flow studies were made using limestone on Line No. 1 and lime on Line No. 2 to treatment levels of pH 5.0 and 6.0, respectively. Parallel flow treatment with no sludge recirculation allowed for simultaneous treatment of the same plant influent in order to observe differences in operational data and effluent water quality.

Limestone treatment exhibits several advantages over lime treatment: (1) lower sludge volumes; (2) higher solids content in the sludges; (3) lower chemical treatment costs; and (4) greater ease of materials handling. However, limestone's inefficient reactivity at higher pH waives results in inability to attain pH levels greater than 6.5 and in the deposition of large quantities of limestone "fines" in aeration tanks and effluent structures and channels. The lower efficiency of limestone treatment can only indicate that much of this chemical is unreacted at the plant outfall and, in essence, wasted into the sludge settling basin.

Table 1. *Range of Water Quality of Plant Influent*

Parameter	*Range*
pH	*2.4 - 3.1*
Acidity[a], b.p. to pH 8.3	*1700 - 9200*
Acidity[a], cold with H_2O_2 to pH 7.3	*1500 - 8500*
Alkalinity[a], to pH 4.5	*0 - 93*
Specific conductivity[b]	*2800 - 7900*
Iron, total, ppm	*145 - 1130*
Iron, ferrous, ppm	*0 - 65*
Iron, ferric, ppm	*145 - 1070*
Sulfate, ppm	*2200 - 6600*

[a]*ppm as $CaCO_3$.*
[b]*µmhos/cm at 25C.*

Combination Limestone-Lime Treatment

In an effort to combine the advantages of limestone and lime treatment, a series of combination (two-stage) limestone-lime treatment processes were performed. Limestone's high reactivity and efficiency with low treatment costs at lower pH ranges (pH 3.4 to 4.1) were utilized in the first stage of treatment with recirculation of resultant sludges. Lime, though more expensive, proved to be highly reactive, efficient, and capable of effecting desirable results in the pH range 6.0 to 7.0. Second stage lime treatment was utilized to achieve neutralization of the final treated effluent at pH 7.0, "polishing" the intermediate limestone effluent.

Investigations of combination limestone-lime treatment involved operation of the treatment plant in series (two-stage) flow with the effluent from Line No. 1 being recirculated as influent to Line No. 2.

Conclusions

Acid mine drainage from the Will Scarlet Mine area can be neutralized to pH 7.0 with a combination of limestone and hydrated lime, or with hydrated lime alone.

Variations in treatment schemes indicated that the most economical mode of treatment in terms of operating cost (¢/1000 gals/1000 ppm acidity as $CaCO_3$), was achieved through combination treatment by utilizing limestone on Line No. 1 with effluent pH 3.7 and lime on Line No. 2 with final effluent pH 7.0. Sludge was recirculated on both treatment lines at an approximate rate of 200 GPM (757 l/min.) to each respective rapid mix vessel, representing 12-18% of the volume of plant influent.

Sludge recirculation had the overall effect of reducing cost of treatment when limestone was used as the neutralizing agent. In combination treatment, sludge recirculation was effective due to the recirculation of limestone, rather than lime sludge.

Detention time of treatment processes in excess of the theoretical minimum required contributed little in reducing the cost of treatment regardless of the treatment agent used.

Sludge Characteristics

Favorable settling behavior was exhibited by limestone-lime and lime treatment processes with the majority of resultant sludges settling in one hour. Higher solids content and more dense sludges resulted from limestone treatment of acid mine drainage at pH levels in excess of pH 4.5, than with lime treatment.

Recommendations

1. Further studies should be conducted to determine adequate mixing of limestone in high volume delivery treatment of acid mine drainage. A tremendous solids buildup occurred in the aeration tanks at the Will Scarlet Water Treatment Plant when limestone was used as the neutralizing agent.
2. Highly alkaline industrial wastes should be considered as potential treatment agents in a search for more economical treatment costs.
3. Detailed study should be conducted to determine the effects of settling basin (Pit #10) effluent on the South Fork of the Saline River.
4. The settling basin (Pit #10) should be studied for possible industrial and recreational uses.
5. A detailed study should be conducted to determine the feasibility and economics of removal of purported trace toxic pollutants (i.e., Cd and Hg) in acid mine drainage.
6. A separate report should be prepared on operational aspects of treatment of high volume delivery of acid mine drainage.

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***John F. Martin** is the EPA Project Officer (see below).*

The complete report, entitled "Limestone - Lime Treatment of Acid Mine Drainage - Full Scale," (Order No. PB 81-172 645; Cost: $17.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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