ProMac â Systems for Reclamation and Control of Acid Production in Toxic Mine Waste

by

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ABSTRACT

The BFGoodrich Company's ProMac â System uses controlled release pellets to deliver the required concentration of an effective bactericide over an extended time period to control acid generation. The ProMac â System is site specific and includes a four step approach to *controlling acid* mine drainage: (1) Diagnosing the Problem, (2) Prescribing the Treatment, (3) Supervising the Application of Controlled Release Bactericides, and (4) Monitoring the Success of Applied Treatment. The success of the ProMac â System is evidenced by improved water quality, healthy vegetation, reduction in levels of acidophilic thiobacillus, and a corresponding increase in population of beneficial microorganisms.

INTRODUCTION

Acid mine drainage occurs as a result of the oxidation of iron sulfides. This oxidation process is catalyzed by the bacteria Thiobacillus ferrooxidans. Inhibiting or destroying these bacteria can significantly slow the rate of acid production. Anionic surfactants, organic acids and food preservatives act as bactericides and inhibit these bacteria. Bactericides can be sprayed on active coal and refuse piles in adequate concentration; however, the bactericide degrades with time and is lost due to runoff resulting in bacterial repopulation and renewed acidification. To overcome this inherent short duration effectiveness of spray applications, controlled release systems were developed.

Bacterial inhibition by controlled release of a bactericide is required for a period of several years to insure successful reclamation. If acid is generated in the early phases of reclamation it can percolate to the surface and destroy vegetation. However, maintaining a strong vegetative cover for three years or more, can break the acid production cycle due to three natural biological processes: (1) A healthy root system is established that competes for both oxygen and moisture with acid-producing bacteria; (2) Populations of beneficial heterotrophic soil bacteria and fungi are reestablished resulting in the formation of organic acids which are inhibitory to T. ferrooxidans; and (3) The action of plant root respiration and beneficial heterotrophic bacteria increases CO_2 levels in the spoil, resulting in an unfavorable microenvironment for growth of T. ferrooxidans.

Control of bacteria through the use of chemical agents requires the evaluation of their effectiveness on different toxic mine wastes. The geochemistry, hydrology, acid generation potential and neutralization potential of a specific site determine the bactericide that will function most effectively. Suitable laboratory tests were developed to provide good reliable information about site characteristics in a reasonable period of time. Column leaching studies, batch incubation tests and chemical analysis of the refuse are used to characterize an individual site.

CONTROLLED RELEASE TECHNOLOGY

Spray applications of bactericides effectively inhibit mine acid formation for three or four months and have to be repeated several times a year to get effective control on active refuse and coal piles. Controlled release systems offer a solution to this costly and time consuming practice. Figure 1 shows a hypothetical scenario for the combination spray and controlled release application.

Spray applications have the advantage of delivering an effective dose of the active agent quickly, but the level falls rapidly due to leaching, runoff, and biodegradation. To maximize the duration of effectiveness using a spray application, it is necessary to use large amounts of the agent, resulting in waste and in potential environmental problems. Decreasing the dosage increases the application frequency required. The controlled release system takes time to deliver the minimum effective concentration. The primary advantage, however, is that once an effective concentration is attained, it can be maintained for extended periods using less total active agent. Figure 1 shows how combined initial bactericide spray applications and controlled release systems can be utilized to get an immediate effective dose and long-term effectiveness without overapplication. The initial spray application is dependent not only on the concentration required to inhibit acid producing bacteria, but on the capacity of the overburden to adsorb the bactericide.

ACIDITY

Columns of coal refuse were constructed using glass columns 45 cm long, with an inside diameter of 6cm. The columns were sealed at the bottom with a rubber stopper which had a coiled drain tube to act as a trap and prevent back-flow. The base of each column was packed with a layer of silica glass beads sandwiched between stainless steel screens. Over this, each column had one kilogram of refuse of an identical particle size distribution. After an initial flush with water, the columns were leached weekly using a manostat pump. Columns were treated with 100 ppm (low), 500 ppm (medium), 1000 ppm (high) ProMac â concentrations relative to total weight of the refuse sample. Two columns were used as controls and received only water. Column leachates collected in graduated cylinders and were analyzed for acidity.

A 24-hour total leachate volume was used to establish cumulative (volume dependent) acidity for each column as shown in Figure 2. Control columns displayed almost identical levels of cumulative acidity over the test period. Columns receiving surfactant treatments displayed much lower levels of acidity with increasing concentration of ProMac â Reductions in cumulative acidity compared to the controls at the end of the test period were 27% at the low concentration, 67% at the medium concentration, and 73% at the high concentration.

BACTERICIDE SCREENING

Continued efforts in testing various bactericides as well as inorganic approaches to the mitigation of acid generation were pursued. Several "treatments" have been evaluated to determine their potential for field application using column leaching tests, because indiscriminate use of bactericides on any reclamation project assumes that all compounds will positively affect all site materials. Figure 3 illustrates the variability in the effectiveness of different "bactericides." The concentrations at which bactericides are effective can be variable, thus demonstrating their material specific nature.

METAL ANALYSIS

Trace metals associated with exchangeable acidity have been monitored from column leaching experiments illustrated in Figure 2 to assess the potential reduction in metals due to the presence of bactericides (Figure (4). Results showed that significant reductions of all trace metals monitored were obtained and ranged from 25 to 50%.

BACTERIAL RESPONSE TO PROMAC â TREATMENT

In order to determine the secondary effect of ProMac â treatment of refuse piles on the top soil cover, enumeration of heterotrophic microorganisms was done. Representative core samples from both ProMac â treated and untreated areas were taken and counted for the amount of microorganisms present in each site. Each sample was subdivided in order to give estimates of the number of organisms in the cover soil, at the interface zone, and in the refuse.

The results showed that cover soil and interface zone of the treated area was much higher in beneficial heterotrophic organisms than the untreated. The exact opposite was true for the detrimental heterotrophic bacteria (T. ferrooxidans). The largest populations of of T. ferrooxidans in the untreated refuse material. Microbial counts of beneficial-bacteria were correlated to the depth of the sample, where the highest counts were found in the top layer, followed by the middle layer and the least numbers at the bottom; therefore, treatment with ProMac 0 increased the number of the beneficial heterotrophic microbial population. (Figure 5)

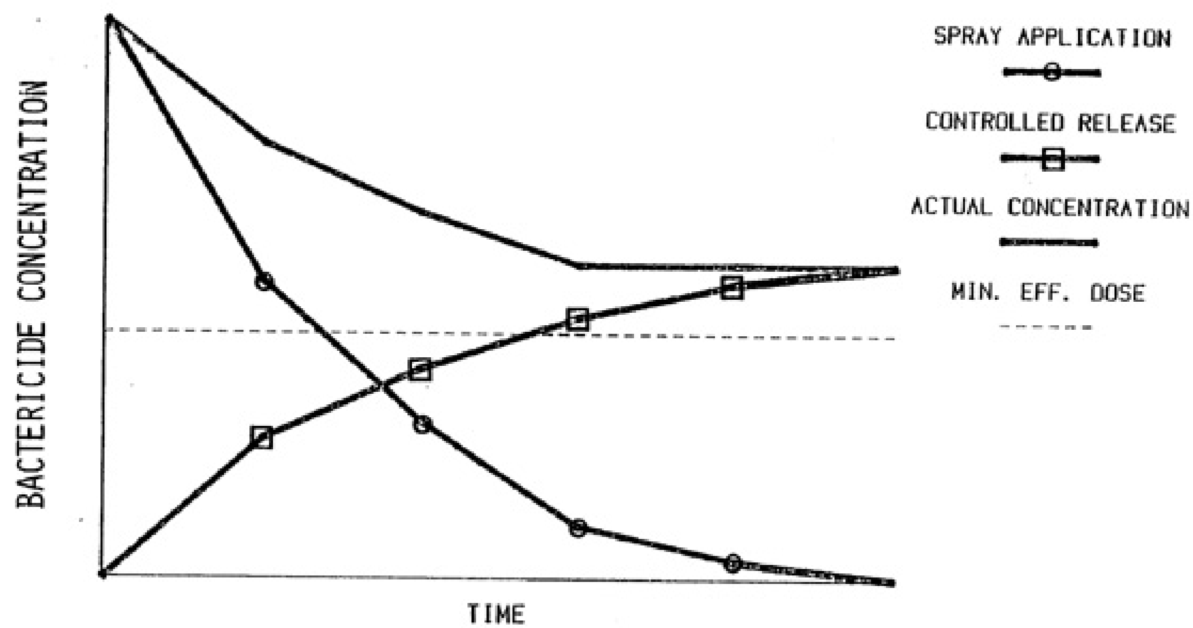

FIGURE 1. COMBINATION SPRAY AND CONTROLLED RELEASE

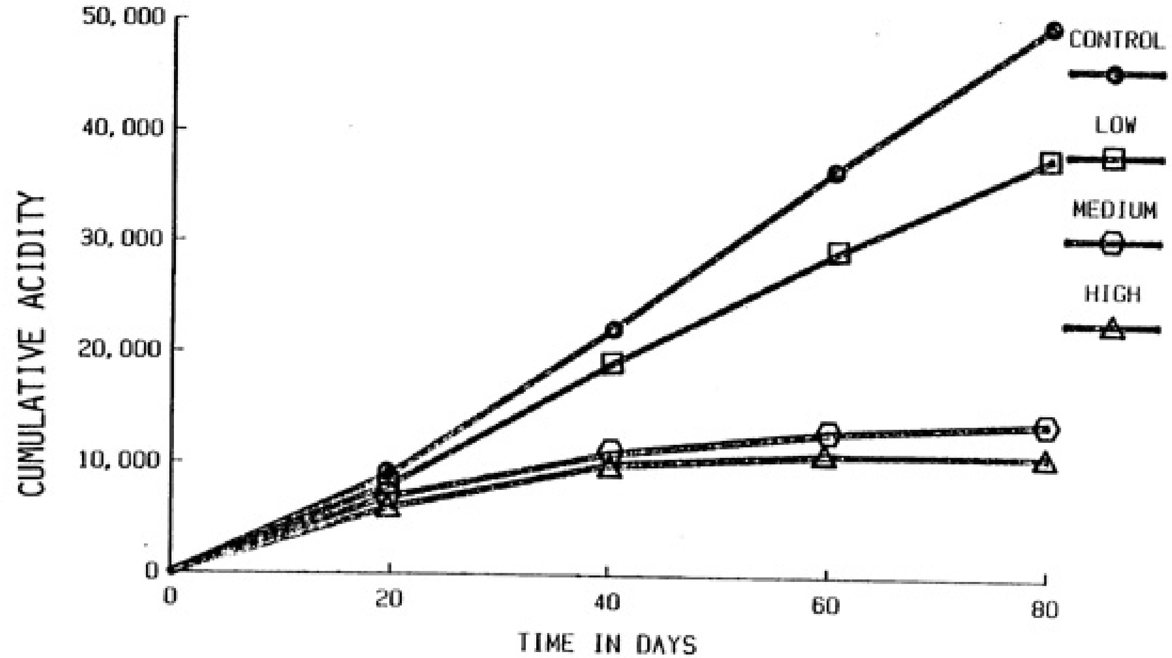

FIGURE 2. ACID REDUCTION WITH INCREASING BACTERICIDE CONCENTRATION

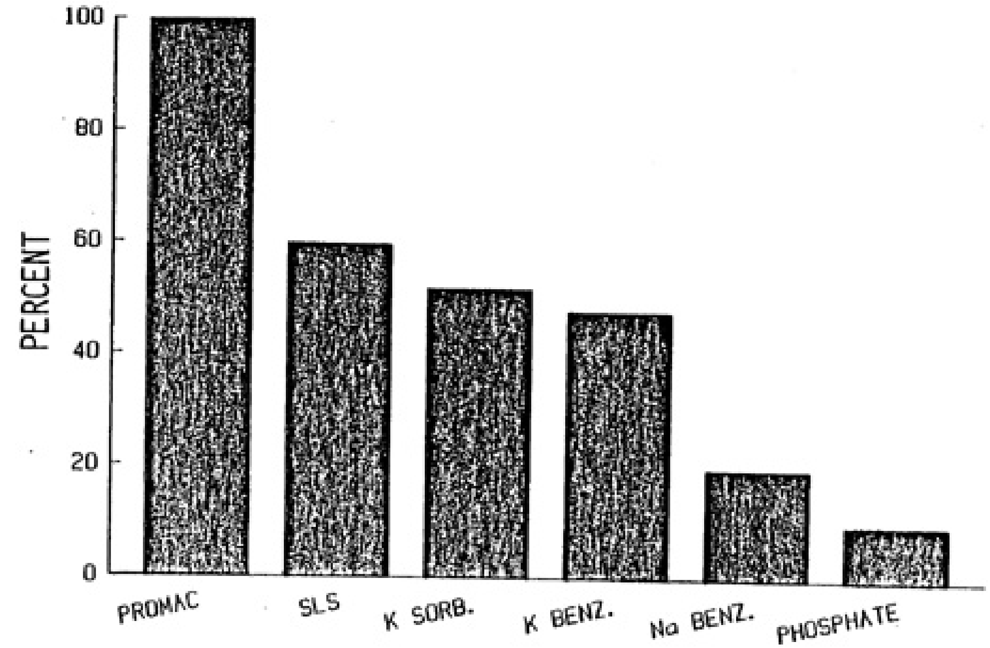

FIGURE 3. RELATIVE EFFECTIVENESS OF BACTERICIDES AS A PERCENT OF PROMAC®

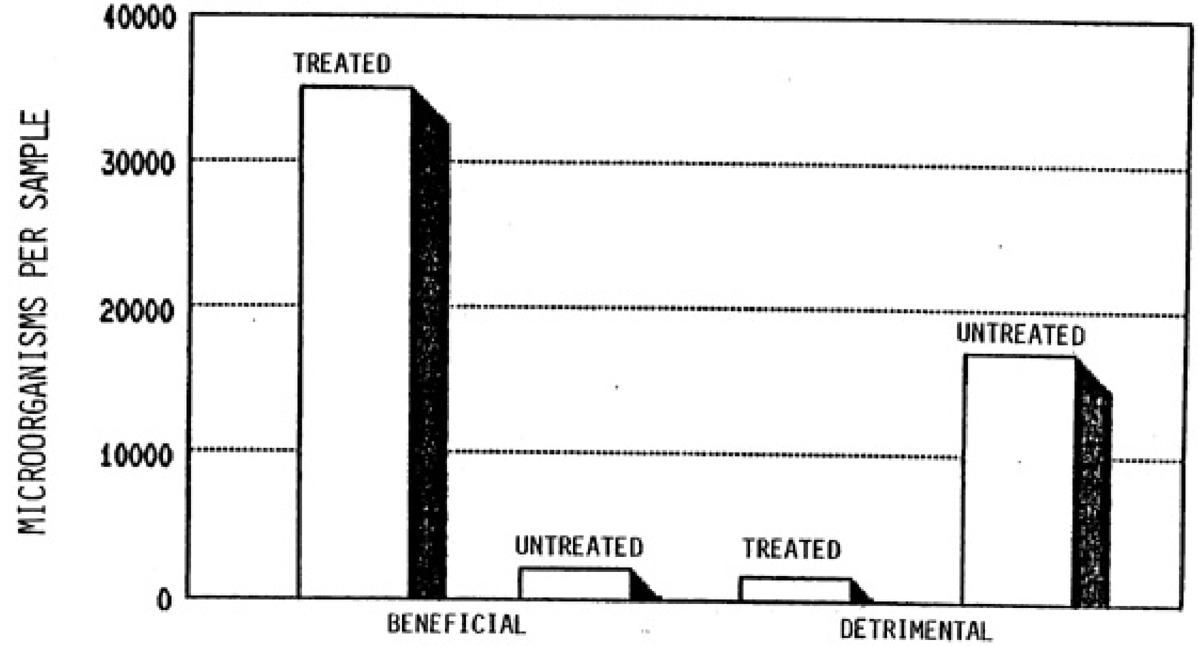

FIGURE 4. DENSITY OF MICROORGANISMS IN PROMAC® TREATED AND UNTREATED MINE REFUSE RECLAMATION SITE

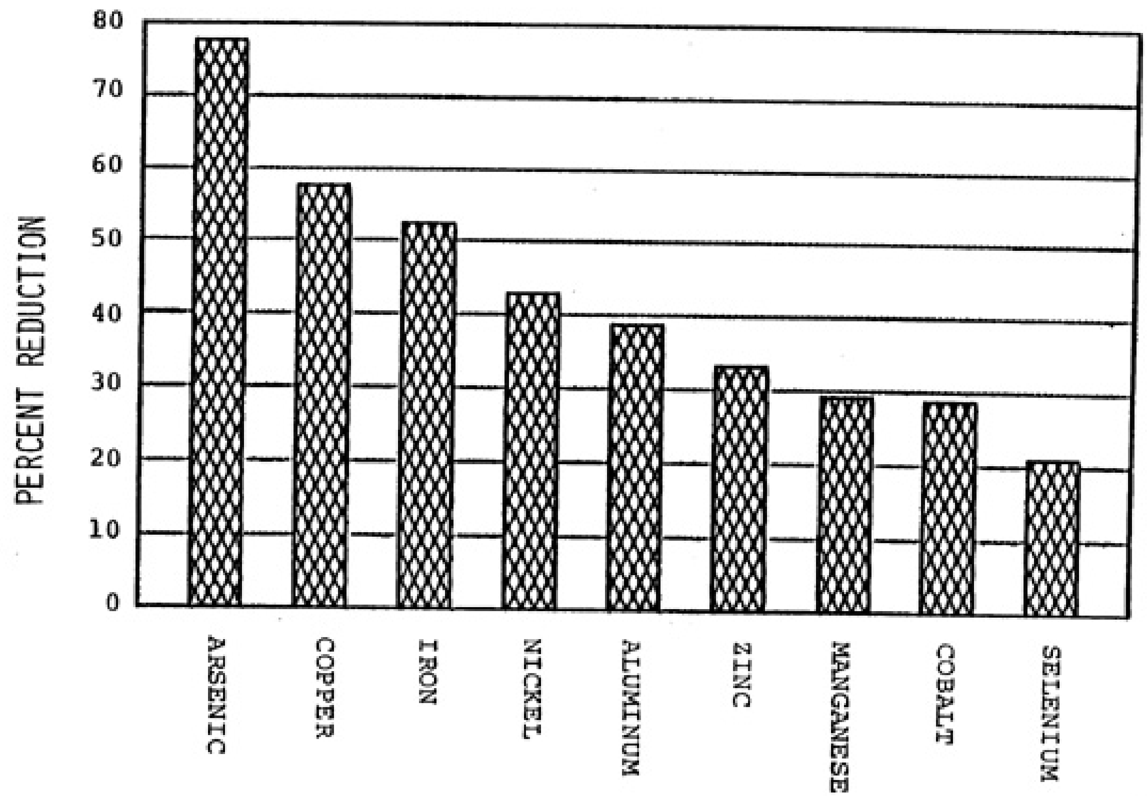

FIGURE 5. REDUCTION IN TRACE METALS