

A novel application of phosphogypsum: Treatment of a diamond mine's slimes tailings

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Abstract

Premier Mine's current slimes dam is nearing the end of its operational life. This is aggravated by a large volume of poor quality water in the dam which is not being recycled back into the process. The poor quality water is the result of a stable colloidal suspension formed from the dominant clay species present in the kimberlitic ore body.

The main objective of this test work was to clarify the water to improve the quality for reuse. Phosphogypsum has been identified as an alternative coagulant to clarify the slimes dam water at a relatively low cost. Laboratory- and plant-scale test work was done to investigate the optimum gypsum dosage, as well as to determine the most suitable application technique. The test work showed that gypsum can successfully destabilise the colloidal suspension. However, poor settling rates were achieved. This improved when the gypsum was added in a slurry form in two stages. The addition of flocculants to aid in settling did not have the desired effect, with resultant high consumption and operating costs.

Toxicity tests indicated no lethality to *Daphnia* organisms and showed a positive growth in the algae test. The establishment of a monitoring programme will assist in determining the long-term effects of gypsum on the environment.

Keywords: water treatment, slimes dam, colloidal effluent, phosphogypsum

Introduction

The use of coagulants and flocculants to enhance settling of colloidal clay suspensions is a well-known practice in water treatment. Clay characteristics and clay-water interactions are complex natural systems in which variables such as clay mineralogy and water quality determine the colloidal characteristics of the slurry system. Kimberlitic ore has some unique mineralogical characteristics, due to the abundance of the smectite clay group, talc, mica and chlorites. For the kimberlite to coagulate, it is necessary to reduce the net charge on the suspended particles by the adsorption of metal cations. Good quality water in contact with kimberlitic ore results in ion-exchange between the water and the ore, due to the characteristic of the smectite clay group that isomorphous substitution can take place in the tetrahedral and octahedral layers in its crystal structure.

This can result in a change in the concentration of the dissolved ionic species in solution and the pH of the solution. Increases in the silica, carbonate and sulphate levels lead to a reduction in the free divalent ion concentrations due to the formation of ion pairs, while at the same time increasing the sodium ion concentration dramatically. According to Vietti (1991), this can alter the sodium adsorption ratio (SAR) of the water to favour the formation of a stable, colloidal slurry in the presence of sodium-exchanged clays.

The Premier diamond mine at Cullinan extracts kimberlitic ore to recover diamonds. The end result of the metallurgical process is coarse tailings ($\geq +1$ mm) and fine tailings or slimes (> -1 mm). Currently the slimes and tailings are disposed of to

a slimes dam comprising an approximately 80 m high embankment with a length of about 1 100 m and a capacity of approximately 58×10^6 m³, (Cutting et al., 1996). Pipes with a diameter of 30 to 40 mm are used to pump slimes to the dam, where the coarse tailings settle rapidly and finer material remains in suspension. Further separation takes place until only the super-fine material (<10 μ m) remains permanently suspended in the water. The permanent super-fine suspension in the tailings dam results in a poor quality return water for re-utilisation in the process plant. The colloidal suspension also makes the water unsuitable for application in the diamond recovering section or for use as cooling water. This results in a large demand for raw and potable water, with associated cost implications. Table 1 shows a comparison of the quality of the raw water and process water.

TABLE 1
Comparison between raw water and process water

Analysis	Raw water (river water)	Process water (slimes dam water)
pH	7.8	10
TDS (mg/l)	143	765
Alkalinity (as CaCO ₃)	79	234
Ca ²⁺ (mg/l)	13	4
Mg ²⁺ (mg/l)	10	1
Na ⁺ (mg/l)	11	240
K ⁺ (mg/l)	3	28
Cl ⁻ (mg/l)	7	25
SO ₄ ²⁻ (mg/l)	16	284
Hardness	70	18
SAR (meq/l)	0.6	25.5
Turbidity	<5	2 000

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