Meadowbank Gold Mine Lake Water Treatability Study Using ChitoVan LC™

Prepared for Agnico Eagle Mines Ltd.

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ATTACHMENT 1: Residual Chitosan Field Test Instructions

ATTACHMENT 2: ChitoVan Lactate Aquatic Toxicity Data

1 Introduction

Agnico Eagle Mines Ltd. (AEM) contacted KI Environmental (KI) on September 4, 2008 to discuss performing a treatability study on the Portage Lake water at the Meadowbank Gold Mine. It was agreed that two field technicians would arrive with test equipment and a 100 lbs (45.4 kg) of ChitoVan LC™ which would be used to treat a small section of the lake that had become turbid.

Mike Yoshizawa and John Mandelin of KI arrived to the Meadowbank Gold Mine job site on September 9, 2008 with all the chemistry and equipment. Bench scale testing was performed on September 10, 2008 to determine treatability efficacy. This report summarizes the findings of the treatability test results. It also describes the field test water monitoring procedure and the protocol that will be implemented to dissolve the cartridges.

2 Chemistry of ChitoVan LC™

Chitosan is derived from chitin and is nature's second most abundant natural biopolymer next to cellulose. Chitin is the structural material found in crustacean shells such as shrimp, crabs, and lobsters. Chitin is also found in fungi cell walls and the exoskeletons of insects. Chitin and chitosan are natural components of biochemical degradation processes occurring naturally in the earth's soil and water. Like chitin, chitosan exists naturally in the environment (water and soil) because it is a biodegradation product of chitin.

Chitosan has been used in storm water treatment for several years. It has the unique ability to adsorb dissolved oil and grease from water, chelate (bond with) heavy metals, and flocculate (precipitate) suspended sediment. Chitosan-based water treatment has also been utilized for decades in various industrial, municipal, swimming pool, spa, and commercial aquarium clarification applications. The U.S. Environmental Protection Agency has approved chitosan for use in drinking water treatment and in the agriculture industry.

Water treatment with Chitosan, at proper dose rates, is highly effective in reducing turbidity levels by up to 99%. Chitosan's efficacy lies in its ability to make small suspended soil particles stick together to become larger and denser. The larger and denser floc particles are easily removed through settling. The cationic (positive charge) nature of chitosan molecules interact with the predominately, anionic (negative charge) sediment particles in water. As these opposite charges attract, the chitosan molecules can bind with numerous soil particles. One must avoid over dosing, which can cause the opposite of the intended effect. An excess of cationic material can cause the floc that initially formed at a lower dose to break apart.

3 Purpose

The goal of this study is to demonstrate the efficacy of ChitoVan LC™ water treatment at the Portage Lake. This will be accomplished through bench and field testing that explores:

- **Turbidity/pH**
- **Dose Rate**

- **Turbidity Reduction**
- **Residual Chitosan**

4 Materials and Methods

4.1 *Bench-Scale*

At 0900 on September 10, two samples were bottled at the shore of the lake. Sample no.1 was clean while sample no.2 was made turbid by swirling the settled solids within the sample area. The turbidity and pH of each sample was measured prior to treatment.

At 1600, one liter each of sample no.1 was poured into two beakers. One liter was left untreated and the other was treated with 0.5 mg/l. They were allowed to settle overnight and the turbidities and chitosan residuals (See Attachment 1 and 2) of each were measured the following day after settling for 20 hours (Figures 4.1-1, 4.1-2).

Figure 4.1-1. Comparing no Treatment vs. 0.5 ppm Chitosan After Settling 20 hrs

Figure 4.1-2. Residual Chitosan Test Kit

Sample no.2 was divided into 2L in two jars for treatability testing and comparisons. One jar was not treated and was used as a control. The water within the other jar was treated with an aqueous 1 % ChitoVan Lactate in 0.5 ppm increments. After each addition of polymer, the water was stirred somewhat vigorously for one minute and allowed to settle for five minutes. Visible sediment settling indicates that chitosan has coagulated the particles.

In general, the beaker may contain clear water on top, or be slightly cloudy, and there should be variation in coagulation amount between dose rates. The object of this test is not to produce completely clean, clear water in the beaker. Rather, it is to determine the most suitable dose rate.

For planning purposes, the smallest effective dosage is used as the initial dose rate.

If there is no coagulation after a significant dosage – greater than 5 ppm – there may be treatability issues. This is rare, and may occur for different reasons which need to be investigated.

The jars were settled overnight and the following day the turbidity was measured after 20 hours of settling. Since the sample turbidity was greater than 10 NTU the chitosan residual was not measured because it clogs the filter paper.

4.2 *Field Application*

The field portion of testing is scheduled to begin on the afternoon of September 12, 2008. Thirty-three ChitoVan LC™ will be tied to a drag line in parallel which will be pulled through the channel of the lake (Between the East Dike and turbidity curtain) behind a boat until all of the chitosan lactate is dissolved[1].

Figure 4.2-1. ChitoVan Cartridges Prepared for Use

While applying the chitosan and 24 hours after treatment, samples will be bottled for turbidity, pH, temperature and residual chitosan testing on location (See Attachment 1). At regular intervals throughout the application process, sampling will occur at both the surface and less than a foot off the bottom at four identifiable locations spaced evenly within the channel. After 24 hours, samples will also be retrieved from these locations.

Weather could affect the test parameters; so the wind, air temperature, and precipitation will also be recorded at the time of each sampling event.

[1] The volume of water to be treated is approximately 120,000 m^3 (34 million gallons). Thus, 100 lbs of ChitoVan added to 120,000 m^3 is approximately 0.40 ppm.

5 Results and Discussion

5.1 Bench Scale

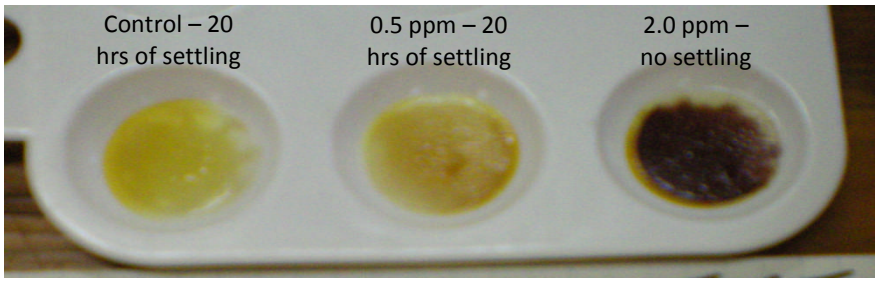
The turbidity and pH of samples no.1 and 2 were recorded prior to the addition of chitosan (Table 5.1-1).

Table 5.1-1. Initial Parameters

Parameter	Sample no.1 Lake Water	Sample no.2 Turbid Lake Water
Turbidity (NTU)	13.70	431
pH	7.3	7.4

In the sample no.1 control beaker the turbidity was reduced from 13.70 to 11.4 NTU through 20 hours of settling (Figure 5.1-1). The 0.50 ppm treated beaker turbidity was reduced by over 60 percent to 4.78 NTU. The residual chitosan test showed that the residual was ~ 0.1 ppm after overnight settling (See Attachment 1). In figure 5.1-1, the 2.0 ppm filter paper was prepared as a "spiked" from tap water for comparison purposes.

Figure 5.1-1. Chitosan Residual Results and Comparison



The final turbidity of the untreated sample no.2 that had settled 20 hrs was reduced from 431 to 131 NTU via gravity settling. The treatability test revealed that 0.5 ppm was required to produce coagulation. To obtain more significant results sample no.2 was dosed with 2.0 ppm. In 20 hours the turbidity was reduced to 12.1 NTU for a total turbidity reduction of 97 percent. The turbidity was reduced by 90 percent in comparison to the untreated and settled sample.

6 Conclusions

6.1 *Bench-Scale*

ChitoVan LC™ as a treatment agent was capable reducing the turbidity of the relatively clean sample no.1 (Lake Water) by more than 60 percent in comparison to the untreated sample (Blank = 11.4 NTU, Treated = 4.78 NTU). Therefore, it is expected that the field test would reduce the turbidity by a similar amount after settling for one day.

The bench results indicate that if the water did become cloudy again, that passive chitosan treatment would reduce turbidity by over 90 percent.

When used in a more permanent configuration it is recommended that the cartridge be placed either within a conveyance channel or a Camlock hose on the pressure side of the transfer pump. This would allow for more controlled conditions and easy replacement. Also, when chitosan treatment is coupled with passive filtration, further turbidity reduction would occur.