The Impact of water chemistry in the vicinity of Imgi mine on the pollution potential in the Soo-young river, Korea

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Abstract To understand the effect of the branch (Ung-gol Stream) contaminated by mine water from the Imgi mine on the main stream (Soo-young River), water chemistry was investigated in the streams. Seventeen samples were withdrawn from three different regions. The ORP and conductivity increase after mine water joins, and then gradually down as the stream flow. After the Ung-gol stream joins the Soo-young River, the ORP and conductivity decrease gradually and sharply, respectively. The concentrations of metals and slufate show a similar behavior with the conductivity.

Key Words mine water, Imgi mine, pollution potential, Soo-young river

Introduction

The Imgi abandoned pyrophyllite mine is located in Imgi-ri, Cheolma-myeon, Kijang-gun, Busan Metropolitan City. Mining operation started in 1980, and continued through 1992 (KORES, 1987). The pyrophyllite ore deposit is a mixed pyrophyllite ore generated by hydrothermal alteration of andesitic rock. The main rock forming minerals are quartz, sericite, pyrophyllite, kaolinite and pyrite. The sulfide enrichment is developed as fine pyrite particles (maximum concentration 30%) near the mineralized zone or as a sulfur mineralized zone around the fissure. The extent of the mine site is 4 ha, and mining was operated as an open pit. About 65,850 tons of ore were produced from 1983 to 1985. The main product is the sericite-type prophyllite with muscovite. Even after 14 years of closure of Imgi pyrophyllite mine substantial acid mine drainage continues to be a severe problem as the stream water mixes with the river that culminates to the Hoeidong reservoir that serves as a drinking water source for Busan area. It has been abandoned for a long period without any proper pollution-prevention measures. Meteoric water interacts freely with waste rock dumps which contain acid-generating materials (Yim et al., 2005). The objective of the study was to understand the impact of the Imgi mine drainage to the streamwater and to investigate the downstream impact area to determine the extent of pollution.

Methods

The entire length of 1200 m of Ung-gol stream from the starting point of mixing of Imgi AMD to its point of discharge to Soo-young river as well nearly 600 m upstream of Soo-young river and more than 1000m of Ung-gol stream and Soo-young river mixed downstream were sampled. Also measured were the velocity, length and average width of the stream at each sampling point (fig.1). Sampling was performed in 8th August, 2006.

Samples were filtered hand pumped through 0.45µm nitro cellulose membrane filters using hand pump. Filtrate subsamples were allocated for, and then cation and anion were separated for analysis. Samples for cation analysis were acidified to pH<2.0 by adding nitric acid to prevent adsorption. The pH, Oxidation Reduction Potential (ORP), temperature, dissolved oxygen (DO), conductivity, and Total Dissolved Solid (TDS) values were measured to directly after sampling. Analysis for dissolved cations was performed using an inductively coupled plasma atomic emission spectrophotometer (ICP-AES; Jobin Yvon 38) at the Korea Institute of Geoscience and Mineral Resources (KIGAM). Anions were determined using ion chromatography (IC; Dionex series) at KIGAM.

Results and Discussion

The pH of the stream before coming in contact with the dump area remains neutral but pH drops rapidly to 4 before further declining to 3.5. Thereafter, for about 800m it remains below 4, but

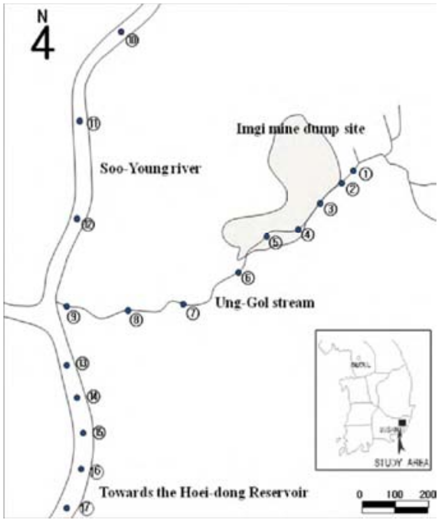

Figure 1 Dump site and the location of the study sites

gradually reaches neutrality after about 1200m. Fig. 2 enumerates the sample wise as well as downstream distance wise data of Imgi's pH. Even in the peak of the rainy season when the dilution is high, stream pH can be as low as 3.3. Considering the study was conducted in the August, when much of the precipitation had already taken place, episodal AMD from lean session can be neglected. At nearly 200 percent dilution to the Ung-gol stream, the load can be considered very high.

Redox potential (ORP) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced. ORP increases in the area of high AMD activity with the stream suggesting the increasing affinity for electrons (Fig. 3). This means the reduction environment is deeply settling over and above the atmospheric oxidative environment and remains so stabilized upto about 900m from the start of Imgi dump contact. Thereafter, without further AMD contribution, the reduction water environment begins to respond to the atmospheric oxidative environment and the oxidation environment begins to settle.

Electrical conductivity of water is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids in water create the ability for that water to conduct an electrical current, which can be measured using a conventional conductivity meter. Understandably, ORP and conductivity of water should be correlated as can be seen from the fig. 3.

Figure 4 shows the concentration variation of total iron, aluminum and manganese along the stream. Total Iron, concentration of all species of iron in the stream provide the concentration fluctuations in the Imgi downstream (Fig. 4). The iron concentration as expected increases when the stream comes in contact with the Imgi mineralized zone but declines sharply as it crosses the

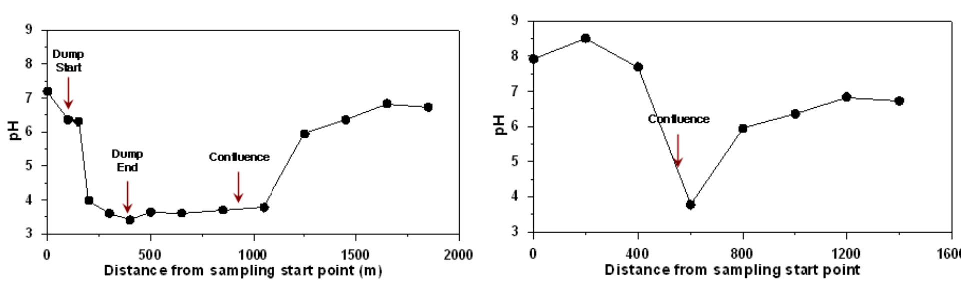

Figure 2 Downstream pH variations at the Imgi area, (left: Ung-gol stream, right: Soo-young River)

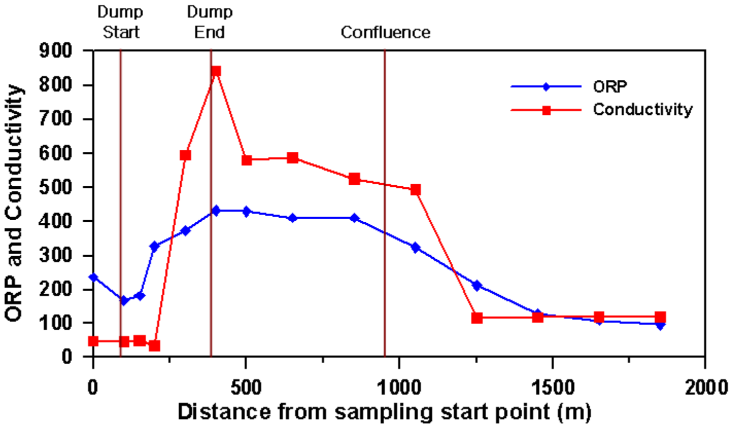

Figure 3 *ORP(mV) and Conductivity (µs/cm) along the sampling length*

active AMD zone before being negligible just with in 150 meters from the place where Ung-gol stream meets Soo-young river. Aluminum concentration shows the same trend as Iron as because they co-precipitate at the pH range 4—7. While the starting and ending concentrations were nearly same, Al concentration was much higher than that of Iron in the stream run; the rates of increase and decrease show similarity. Soluble manganese concentration, though showing similar trend to Fe and Al, show higher comparative environmental persistence. Over the last 1000m of the sampling, its concentration remains stable between 4mg/L to 0.2mg/L. It is important to observe further downstream to see whether Mn conc. remains in similar steady state values. One of the major anions in any AMD, sulfate conc. shows similar trend. But what is of importance is that it started as negligible (2mg/L) but at the end of the sampling length the concentration was elevated to about 28 mg/L. However, it is quite possible that it might not have been contributed by the AMD only as other water channels that joined the Soo-young river could have as well contributed to it.

Conclusions

The following conclusions can be made from the study:

- pH of the stream before coming in contact with the dump area remains neutral but pH drops rapidly to 4 before further declining to 3.5. Thereafter, for about 800m it remains below 4, but gradually reaches neutrality after about 1200m.
- Redox potential resuts show that at the contacts of AMD with the Ung-gol stream the reduction environment is deeply settling over and above the atmospheric oxidative environment and remains so stabilized upto about 900m from the start of Imgi dump contact. Thereafter, without further AMD contribution, the reduction water environment begins

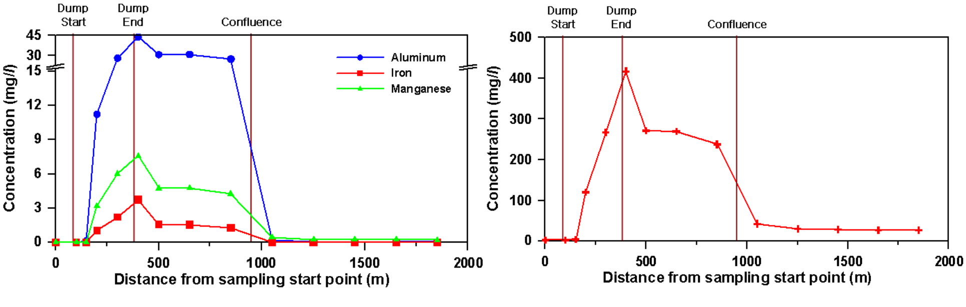

Figure 4 *Metals and Sulfate concentration along the sampling length, (left: metals, right: sulfate)*

to respond to the atmospheric oxidative environment and the oxidation environment begins to settle in the water.

- The concentrations of metals and slufate show a similar behavior with the conductivity. Initial sulfate concentration of the Ung-gol stream is found to be low (2mg/L) but after the mine water joins the stream, the concentration increases to 418 mg/L and then remains over 200 mg/L.

Acknowledgements

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