The Study of the Effect of Long Term Water Cover on the Mill Tailings of the Silver Lake Mill # 1, near Silverton, Colorado.

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Abstract. Mining and milling of metals were the primary industries in the study area for most of the late 1800's into the early 1900's. Wastes from the mining and milling processes are abundant in the area and present significant threats to the environment. Abandoned in 1900, the Silver Lake Mill is located on Silver Lake, southeast of Silverton, CO. Tailings (mill wastes) are located above and below the lake level providing an excellent location to study long term water cover of mill tailings. The project included water samples from the lake, its outlet and inlets plus tailings samples above and below water level. These samples were used to determine if the lake was contaminated and if so, it's source. Field parameters of pH, conductivity, temperature, and dissolved oxygen were observed. Samples were analyzed for Al, Fe, Cu, Ni, Zn, Cd, and Pb. All parameters except Ni were found in the lake but neither the inlets nor the outlets had high enough metals concentrations to be the sole contributor. Examination of these results show that the lake holds contaminated water with increasing metal concentration at depth. It also reveals that the source of contamination is primarily transfer from the submerged tailings. Lastly, it shows that the contamination is generally contained within the lake.

Introduction

The Silver Lake mill #1 is located over 12,000 ft above sea level, on Silver Lake, which is approximately 3 miles southeast of Silverton, Colorado. It is found in a classic hanging valley that is accessible only by pack trail a few months of the year. The mill was active from 1890 to 1900 extracting precious metals out of the ore produced from the mines in the Silver Lake Basin. The mill produced over 500,000 tons of tailings (mill wastes) over the ten years in production [1]. All of these tailings were piped into neighboring Silver Lake creating an artificial beach cutting the lake in half. Portions of the tailings are found above and below the water level. The milling technology used at the time was very inefficient and 40 to 60% of the metals in the original ore ended up in the tailings [2]. Approximately 400,000 tons of the tailings were removed to be reprocessed in 1913 but the rest are still present in the lake today [2]. This creates an interesting situation where metal rich mill tailings have been relatively undisturbed, above and below the water level, for over a century.

Methodology

The project included water samples from the inlets and outlets, the lake itself, as well as the tailings above and below the water level. All water sampling locations were analyzed for the dissolved oxygen, conductivity, ph, and temperature as well as tested for the metals Al, Fe, Cu, Ni, Zn, Cd, and Pb. The tailings samples were tested for the metals above as well as Hg.

Results

The stream samples consisted of all running inlets and outlets. Most of the inlets showed metals concentrations below the analysis reporting limits. Zinc generally had the highest concentration, but it also has the highest toxicity threshold [2]. Data for the stream samples is recorded in Table 1.

Table: 1

Total Metals Analysis for Stream Samples in μg/l

Site	Al	Cd	Cu	Pb	Zn
Inlet # 1	<200	<4.0	<25	<3.0	44.9
Inlet # 2	<200	<4.0	<25	<3.0	<20
Inlet # 3	<200	<4.0	<25	<3.0	<20
Inlet # 4	291	10	190	119	1670
Iowa Inlet	<200	<4.0	28.1	40.3	319
Outlet	<200	<4.0	<25	8	276

*Ni and Fe were not found above the respective reporting limits of 100 and 40 μg/l and therefore not included in this table.

The lake has also been sampled at several different depths. Figure 1 shows the metal concentrations and their linear trends for a location in the center of the lake. The overall trend shown is increasing metals concentration with depth.

Figure 1

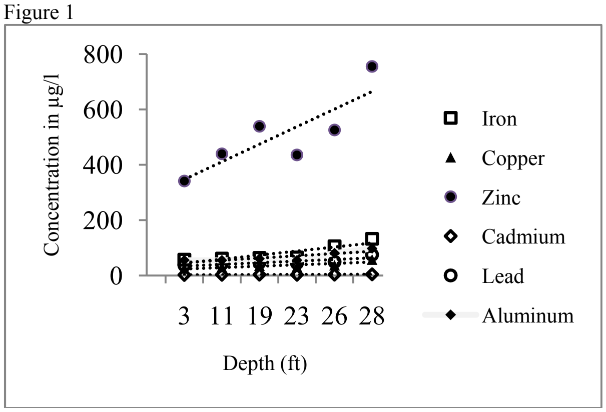

Figure 1 - A plot of the concentration of selected metals in Silver Lake with respect to depth [3].

The tailings were sampled above and below the water level to determine the effect of water cover on the tailings. The above water sample has a lower concentration for all analysis taken except for Cadmium where the results were within 0.8 mg/kg.

Figure 2

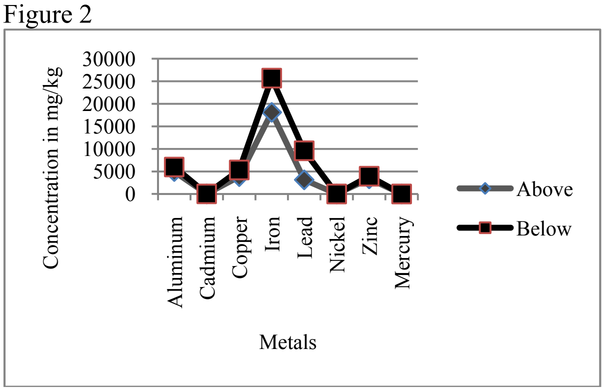

Figure 2 - A plot of the concentration of Metals in the Tailings above and below the water surface.

Discussion

It appears that Inlet #4 and the Iowa Inlet are the largest stream contributors to the metals in the lake. They are also the only two found inlets that flowed from a mine opening. According to data from Church et. al. the stream below the outlet of this lake measures no toxicity for Al, Cd, Cu, and Zn [2]. It can also be assumed that, at the outlet, Pb is non-toxic because its concentration is found below the drinking water standard, which is much more strict the than stream water standard [4].

The lake samples show an upward trend in the metals concentration with depth. This is unusual because lakes with a prevailing wind direction, as Silver Lake has, normally engage in annual overturning of the water column. Overturning does not appear to be happening in Silver Lake as even historical data suggests increasing concentrations with depth.

The tailings samples were analyzed to find that most of the parameters had a higher concentration in the below water sample. This could be due to the fact that the above water sample was exposed to rainwater and snowmelt. These water types generally are under-saturated with respect to metals which causes them to readily absorb metals from the tailings that are above the water level. The water in the lake, for the most part, will not absorb metals as readily as the rainwater because it is closer to its saturation point with respect to metals. Also, any rainwater in the area is washed into the lake carrying with it dissolved materials.

Significance

The significance of this research lies with the correlation of this situation with other underground mines, currently filled with tailings and water as well as prospective milling sites.

Conclusion

The findings of this project show that the water of Silver Lake does contain metals and they appear to be primarily from the submerged tailings. However, the outlet has low metal concentrations and is diluted with other stream water before it reaches the Animas River. Therefore, the quality of the water downstream does not appear to be negatively impacted by the metals found in Silver Lake.

Acknowledgments

First I would like to thank the WSU Summer Research Grant Donors and the American Association of Petroleum Geologists Grants-in-Aid Program for their financial support. I would also like to thank my WSU Advisor, Dr. John Gries, Bill Simon of the Animas River Stakeholders Group, and Lane Boyer, my field assistant.

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