

1 English summary

Herbert Pipperger, one person in charge of the mine, had the idea for our copper project in autumn 2008 based on a text from 1856 which suggests an improvement for the biohydro-metallurgic copper extraction. The copper water flows through a wooden channelling in which iron is put. Due to the simple reason that iron is more base than copper, it dissolves slowly while copper is precipitated. This copper mud contains about 70-80% copper. The *thiobazillus ferrooxidans* plays an important part. It dissolves the copper but also iron and aluminium from the ore. In the form of copper sulphate it reacts easily with the solid iron. This is how the mine in Prettau produces about a ton of copper a year.

The big disadvantage is the huge waste of iron, the high ionic concentration, and the permanent heavy metal pollution, because basically the same amount of iron is dissolved for the same amount of copper. All in all, it is just a replacement of chemical substances.

While developing the plant we decided to place emphasis on:

- ☒ The extraction of the copper in a form which can somehow be used afterwards.
- ☒ The purification of the water, which means a reduction of the heavy metal concentration.

The plant itself had to meet these criteria:

- ☒ High efficiency and functionality
- ☒ Affordable construction, instigation, and maintenance
- ☒ Simple and uncomplicated construction and instigation

Chronological procedure:

☒ Visit at the mine in Prettau: In order to become acquainted with the copper plant, to get some water samples, and to get some information about the mine, the students visited the mine in Prettau and the mining museum in Steinhaus in March 2009.

☒ Presentations on mining, copper, etc.: The students prepared some topics for the project and presented them to the class.

- Mining history in South Tyrol: This group gathered information concerning mining in Prettau and South Tyrol, like the metals which were obtained, but also concerning the current copper plant in the mine.
- Water: This group collected information concerning water in general, e.g. the different types of water, how it becomes polluted, and also the various methods to eliminate the heavy metals.
- Microbiology: This group gathered all the information concerning the bacteria and their importance in this process, but the influence of copper to organisms was also discussed.

- Copper: This group collected everything they could find concerning copper, e.g. chemical, physical, biological properties, the use of copper, copper ore, copper preparation, and the suggestion of 1856.

☒ Carrying out the experiments: Without a doubt this was one of the most important parts of the project. Some tests were needed for the understanding of some topics. Some experiments were carried out to get general information about the water. In a second step we gathered all the information and parameters we needed for the construction. In the end we tried out the methods which are used in the plant in our labs. All in all, we had 4 bigger topics to cover:

- Analytics: This group acquired all the physical-chemical data of the water in the mine and in our lab. First, pH-value, temperature, and oxygen content were metered in the mine. After that, water samples were taken and analyzed in the lab. The iron concentration and copper concentration were assessed. The provincial lab also took some samples and analyzed them, so we could compare their results with ours.
- Microbiology: This group figured out the ideal living conditions of the bacteria. They prepared some special culture mediums in which the bacteria grew. The bacteria were exposed to special conditions (temperature, pH-value) to calculate their optimums. Also the toxicity of copper was assayed.
- Electrochemistry: This group tested some electrochemical methods to extract the copper from the water. They tried the suggestion from 1856 to get the copper out of the water by using a carbon electrode. This group discovered that it could not use the electrochemical methods because of the low power.
- Precipitation: This group tried to get out the heavy metals and to improve the water quality. It tried some ion exchangers like wood chips. It also tried to clean the water just by shaking (to improve the bacterial activity) or by letting it flow through marble granule. In the end this group figured out the easiest and most economical method to get the water clean, i.e. by increasing the pH-value. It works so well that the group would even get the ions out of the water one by one.

☒ Planning of the plant: 4 different groups of students had to make suggestions for various plants and to present them to the class. In the end, everyone decided how to construct it. We decided not to do anything in the lake, because that would be useless. Heating the water would be a waste of energy and increasing the pH-value would decrease the solubility of the copper. So we will run two precipitations. The first one is to eliminate the heavy metals we do not need like iron and aluminium. We just need to increase the pH-value to 5 by adding lime water, which we prepare by ourselves before. Lake water and lime water are mixed in a mixing tube. The lime water is dosed with an outlet. It is regulated by a special measuring device for volume flow rate, which guarantees a constant volume rate and can be adjusted by hand. Then the water could possibly flow through the copper-plant which is already in operation. Due to the first precipitation there is almost no iron in the water which influences the iron-copper exchange negatively, so the plant might be more efficient. Therefore, the copper yield should be much higher than before. In a second step we will increase the pH-value to about 6.5, so the copper will precipitate. After each precipitation the salt is removed in an eliminator and afterwards pressed to extract most of the humidity. The water is fed into the Ahr River like before, just cleaner.

The extracted substances are an iron-aluminum-salt mixture, copper, and copperhydroxide. The first salt mixture must be disposed of. The copper can be sold to the same company as before. The copper hydroxide should be cleaned first, but after that it can be used as a pigment for ceramics, glass, etc. or also for batteries or as a catalyst.