

Remediation of pH values and removal of Fe from Agios Philippos Kirkis mine through a new experimental electric device using low cost mineral raw materials

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Abstract

This study focuses on both the remediation of the pH values and the removal of toxic load of Fe from pit lakes from Agios Philippos Kirkis mines (southern of Alexandroupoli, Evros Prefecture, Greece) by using a combination of economically and environmentally friendly mineral raw materials such as sterile aggregates (serpentinite, andesite), industrial rocks (magnesite), other natural and organic materials (peat and biochar) in a new experimental electric device. As raw materials for the consolidation of an important acid mine drainage, mainly sterile materials were used which resulted in the execution of laboratory tests to assess such as aggregates, based on sustainable disposal and reuse of sterile materials (serpentine, andesite, magnesite, peat and biochar). The treatment of polluted industrial waste water remains a topic of global concern since waste water discharged from municipalities, communities and industries must ultimately be returned to receiving waters or to the land (Weber *et al.*, 1991). Acid mine lakes have been formed worldwide and are responsible for numerous water quality problems, which severely limit their beneficial uses and may constitute an environmental risk both in the water body itself and downstream environments and water resources (Salmon *et al.*, 2008, Schindler, 1986, Geller, 1998, Geller *et al.*, 2009). Pit lakes or mining lakes, which are unique water bodies, such as this at Agios Philippos form in many places of the world as a consequence of opencast mining. When the activity ceases, the open pit is back filled with groundwater and surface water. The rate of filling is depended on climatic and geologic conditions, as well as the regional hydrologic characteristics. Assessment of the environmental risks of pit lake development is imperative for the mining industry and the public, especially in cases of high sulphidation deposits characterized by high concentrations of heavy metals (Plumlee, 1999).

Various mineral raw materials have been used as chemical reagents for the neutralization of pH, as well as for the removal of heavy metals. Several researchers have used experimental columns of batch type to examine the effect of various mineral raw materials. However, a research gap has been observed concerning the remediation of this phenomenon by using electrical driven flow forced device. The up to now proposed approaches for the remediation of this phenomenon include high cost techniques (Amarasinghe and Williams, 2007). For these reasons, in this study a new experimental electric forced device is proposed with the use of low cost mineral raw materials for achieving remediation of industrial waste water.

The basic concept for the construction of the experimental electrical device was the simulation of a standard continuous water recirculation system of the treated acidic runoff, in filters with a combination of mineral raw materials. The filters were filled with certain percentages of the selected mineral raw materials. Furthermore, 50 liters of waste water from the pit lake of Agios Philippos were placed into the experimental device. From the beginning of the experimental process periodic measurements of pH values of water were made. During the experimental process, sporadic samples of water were taken for geochemical analysis which it took place after the completion of the experimental process. In the experimental electrical device the combined use of mineral raw materials such as serpentinite, andesite, magnesite, peat and biochar as remediation agents of the acidic effluents of the selected lake with continuous water circulation, was evaluated. The variation of the pH values during the operation of the experiment is listed in Table 1. The pH values showed a continuously increasing trend from the first till the fourth day of the experiment, when pH reached the maximum value of 6.93. The infection of the pH curve after the fourth day indicates a general stability of pH at slightly reduced values of around 6.5–6.8 maintaining a steady trend with very small fluctuations.

Table 1. Results of geochemical analyses of the sediment sample deriving from the Agios Philippos mine.

Day	1 st	1 st	1 st	2 nd	3 rd	4 th	4 th	5 th	6 th	7 th
	Day(11:00)	Day(11:00)	Day(11:00)	Day	Day	Day(10:00)	Day(19:00)	Day	Day	Day
pH	2.99	3.79	4.70	6.04	6.45	7.13	6.65	6.57	6.54	6.82
T _{water} (°C)	25.2	26.0	29.0	28.0	29.0	37.6	37.8	39.8	38.0	37.6

Regarding the pH adjustment, the experimental device was particularly effective. This happened due to the participation of magnesite and serpentinite which were very effective in pH remediation (Teir *et al.*, 2006). In this study, the serpentinite may release magnesium ions while also engaging more H⁺. The increase in pH can be attributed mainly to the adsorption of H⁺ cations on the surface of serpentine crystals as the structure of serpentine consists of silicon tetrahedral which is combined with magnesium. Moreover, the studied serpentinite presents an important advantage in contrast to other lithotypes concerning the specific reaction surface. The Pliocene andesite had positively effected on the normalization of pH values due to its chemical composition, but is less effective than serpentinite and magnesite.

The results of the water geochemical analysis during the 7-day operation of the device suggest that the referred combination yielded satisfactory results with respect to the remediation of the removal of Fe.

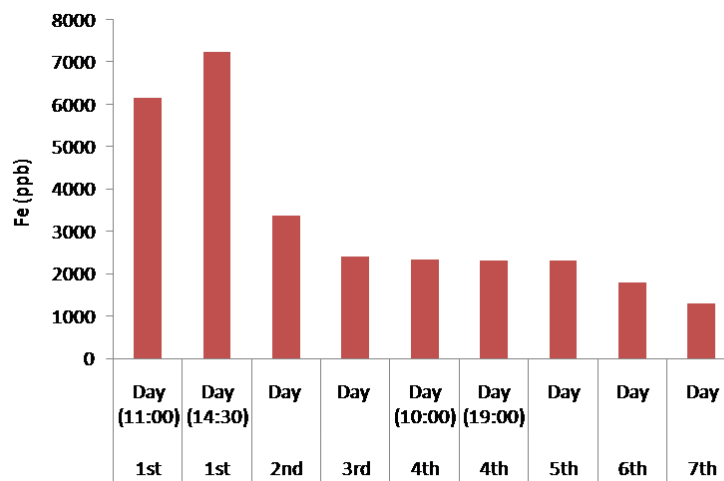


Figure 1. Histogram of Fe concentration in the treated water waste during the continuous water flow operation.

Fig. 1 illustrates the concentration of Fe in the water during the seven days of experiment. An increase in the concentration of Fe in the first day is observed explaining by the initial leaching of Fe from the serpentinite and the andesite, which contain small percentages of Fe, as well as to the contamination from the metallic parts of the pumps, as highly acidic solutions, like the initial treated water, promote solubility in the aerobic condition due to the oxidation of Fe^{2+} to Fe^{3+} through an increased oxidation potential and the temporarily increased its concentration until the pH increases. In the second day (pH > 4.5), there was a strong decrease in Fe concentration in the solution.

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