

Removal of lead and zinc from mining effluents by applying air micro-nanobubbles

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Resumen

La investigación realizada tiene como objetivo principal remover la concentración de plomo y zinc presentes en los efluentes mineros de una unidad minera en Peru aplicando micronanoburbujas de aire. Para dicho estudio se tomó una muestra de 54 litros de efluentes mineros el cual fue dividido en tres grupos de 18 litros cada uno con tres repeticiones, en un periodo de 10, 15 y 20 minutos cada uno. En los resultados se pudo observar la remoción de plomo (de 51,3 mg/L a 1,29 mg/L) y zinc (de 17,601 mg/L a 0,26 mg/L) aplicando micronanoburbujas de aire en 15 minutos

Palabras clave: Micronanoburbujas, plomo, zinc, efluente minero

Abstract

The main objective of the research is to remove the concentration of lead and zinc present in the mining effluents in Peru by applying air micronanobubbles. For this study a sample of 54 liters of mining effluents was taken, which was divided into three groups of 18 liters each with three repetitions, in a period of 10, 15 and 20 minutes each. In the results it was possible to observe the removal of lead (from 51.3 mg / L to 1.29 mg / L) and zinc (from 17.601 mg / L to 0.26 mg / L) applying micronanobubbles in 15 minutes

Keywords: Micro-nano bubbles, air, lead, zinc, mining effluent

1. Introduction

Currently, mining is one of the most important sectors in the country's economy. However, because it is a purely extractive activity, it has many negative impacts on man and the environment, mainly affecting natural resources such as water, soil, air, flora and fauna.

Water is a vital resource for the existence not only of humanity but of the entire ecosystem, that is why its care and preservation of it takes on increasing importance; However, paradoxically, it is evident that water bodies are contaminated more often either naturally or anthropogenic, the latter being the one that generates the most negative effects, mainly due to effluents generated by urbanizations and different industries, including mining

The waters coming from mining effluents have acidic pH. To neutralize the acidic waters, techniques such as lime milk (Calderón and León, 2005), or dolomite (Flores, 2009, Romero, Flores and Arévalo, 2010) are used.

Nanotechnology is a new approach focused on understanding and mastering the properties of matter at the nanometer scale: a nanometer (one billionth of a meter) is the length of a small molecule. At this scale, matter offers different and often surprising properties, in such a way that the boundaries between established scientific and technical disciplines are often blurred. Hence the strong interdisciplinary nature inherent in nanotechnology. (European Commission, 2004)

The environmental nanotechnology is a technological discipline which study properties of natural and manmade nanomaterials, applications, techniques for their characterization, integration processes and transformation into ecosystems. The Microbubbles (MBs) have diameter more than 100 μm , the micro-nanobubbles (MNBs) have diameter between 1 to 100 μm and the nanobubbles (NBs) have diameter less than 1 μm within the fluid field (Valverde, 2016).

The micro-nanobubbles generation technology in water is applied in: sea water, water bodies, groundwater, domestic wastewater and industrial wastewater (Valverde, 2017).

2. Materials and Methods

The research design was Pre-experimental.

The place of study is located at approximately 4250 m.a.m.s.l., in Department of Lima



Figure 1. Location of the study area

Preparation of laboratory samples

The sample was 54 liters of effluent with three repetitions 18 Liters each one.

Initial Analysis from parameters of the prepared samples

The parameters for initial analysis of the prepared samples were: Temperature ($^{\circ}\text{C}$), pH, Turbidity (NTU), Electrical conductivity (mS/cm), dissolved Oxygen (mg/L), Total Solids (mg/L), Total Suspended Solids (mg/L), Lead (mg/L) and Zinc (mg/L).

Treatment with air micro-nanobubbles

An air micro-nanobubble generating equipment was used.

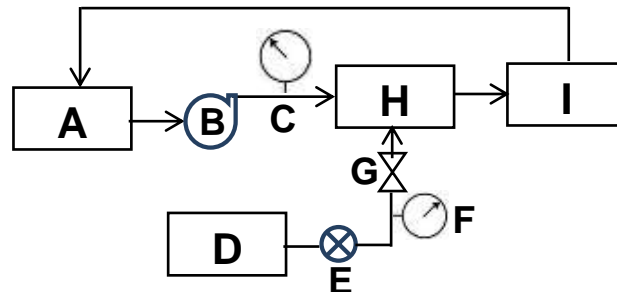


Figure 2. Presentation of the micro-nano bubble generating equipment. Where, A: water tank, B: pump, C: flowmeter, D: air generator, E: pressure valve, F: pressure manometer, G: valve (general), H: MNBs generator, I: wastewater with air MNBs.

To determine the size of the micro-nano bubbles, It was used a Boeco's triocular microscope, from 5-megapixel camera.

To carry out the treatment and generate the micro-nano bubbles, a pressure of 20 to 25 PSI was taken into account; with a flow rate of 4 L/min.

The average measurement of micro-nanobubble was 2.2 μm .

Final Analysis from parameters of the prepared samples

The parameters for final analysis are:

COD (mg/L), pH (unit pH), Temperature ($^{\circ}\text{C}$), Turbidity (NTU), Organic Matter (mg/L O_2).

Treatment efficiency on COD and organic matter.

To measure the MNBs treatment's efficiency on COD was used the equation 1:

$$\% \text{Remotion}(\text{COD}) = \frac{[\text{COD}]_{\text{initial}} - [\text{COD}]_{\text{end}}}{[\text{COD}]_{\text{initial}}} * 100 \quad (1)$$

To measure the MNBs treatment's efficiency on organic matter (OM) was used the equation 2:

$$\% \text{Remotion}(\text{OM}) = \frac{[\text{OM}]_{\text{initial}} - [\text{OM}]_{\text{end}}}{[\text{OM}]_{\text{initial}}} * 100 \quad (2)$$

3. Results

3.1. Initial analysis of parameters

The results obtained from the analyzes of the initial sample are shown in the following table

Table 1. Results from pre – treatment analysis

Parameter	Unit	Initial Sample
Temperature	°C	21
pH	pH	11,99
Turbidity	NTU	170
Electrical conductivity	mS/cm	4,06
dissolved Oxygen	mg OD/L	< 0,1
Total Solids	mg/L	4740
Total Suspended Solids	mg/L	251
Lead	mg/L	51,300
Zinc	mg/L	17,601

3.2. Application of treatment with air micronanobubbles

The application of the treatment was carried out through the micronanobubble generator, patented by PhD. Jhonny Valverde Flores, which works continuously through a recirculation circuit.

The treatment was performed in 3 repetitions, using for each of them, 18 liters of water, in intervals of 10 minutes, 15 minutes and 20 minutes.



Figure 3. Application of the treatment and sample extraction

3.3. Analysis of the sample of the mining effluent after the application of the treatment

The results of the analysis of the samples after the treatment are shown below:

Table 2. Results of the analysis of the post-treatment samples

Samples	Time	Temperature (°C)	pH	Turbidity (NTU)	Electrical conductivity (mS/cm)	dissolved Oxygen (mg/L)	Totals Solids (mg/L)	Total Suspended Solids (mg/L)	Lead (mg/L)	Zinc (mg/L)
Report 1	R1-10	22	11.72	15.93	2.39	8.53	4120	31	0.98	0.128
	R1-15	22	11.76	23.4	2.38	8.49	4040	33	0.91	0.136
	R1-20	21.6	11.78	29.2	2.38	8.61	4160	16	0.97	0.151
Report 2	R2-10	21.5	11.88	28.7	2.52	8.58	4300	34	1.12	0.222
	R2-15	21.9	11.85	38.8	2.52	8.43	4100	24	1.09	0.199
	R2-20	22	11.83	54.9	2.51	8.4	4040	25	1.1	0.222
Report 3	R3-10	22.1	11.85	55.9	2.52	8.64	3940	42	1.65	0.392
	R3-15	22.4	11.86	63.3	2.52	8.5	4020	25	1.68	0.386
	R3-20	22.4	11.83	67.9	2.52	8.57	4100	23	2.09	0.527

The temperature did not suffer important variations since in all the samples the temperature oscillated between 21 and 22.4 °C

The pH decreased after the treatment reaching its lowest value of 11.72 in Report 1 with 10 minutes (R1-10)

Turbidity varied after treatment decreasing from its initial value of 170 NTU to its lowest value of 15.93 NTU.

In report 1, the lowest values of electrical conductivity were obtained (r1-15 and R1-20).

The amount of dissolved oxygen increased in large quantity after treatment reaching up to 8.4 mg/L (R2-20).

The lowest concentration of total solids in 3940 mg/L (R3-10).

The concentration of suspended solids varied significantly after having carried out the treatment, decreasing to the lowest value of 16 mg/L in Report 1, with 20 minutes (R1-20).

The concentration of lead decreased significantly after treatment reaching its lowest value in Report 1, (R1-15) with a concentration of 0.910 mg/L.

Zinc concentration varied after treatment decreasing to 0.128 mg/L in Report 1, (R1-10).

Treatment efficiency on Lead- and Zinc remotion.

To calculate treatment's efficiency with ozone-air MNBs on Lead as % Remotion was used the equation 1:

$$\% \text{ remotion (Lead)} = (51.3 - 1.29) * 100 / 51.3 = 97.485 \%$$

To calculate treatment's efficiency with ozone-air MNBs on Zinc as % Remotion was used the equation 1:

$$\% \text{ remotion (Zinc)} = (17.601 - 0.26) * 100 / 17.601 = 98.523 \%$$

4. Conclusions

- The removal of lead and zinc from mining effluents using air micronanobubbles is possible, since the initial concentration of lead could be observed as 51.3 mg/L and after treatment reduced to 1.29 mg/L (97.485%) and in the case of zinc, which had an initial concentration of 17.601 mg/L and reduced to 0.26 mg/L (98.523%). Regarding the physicochemical properties of the mining effluent, it was observed that the temperature varied from 21 ° C to 22 ° C, the pH from 11.99 to an average of 11.82; turbidity from 170 NTU to 42 NTU, dissolved oxygen from <0.1 to 8.53 mg/L; total suspended solids from 251 mg/L to an average of 28.11.
- The most optimal time to remove lead and zinc from the mining effluent was 15 minutes since during this time the lowest concentration levels of both metals were obtained.

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