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Treatment of wastewater with chloroform from an environmental laboratory using air micro-nanobubbles

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Resumen

En la investigación se realizó el tratamiento de las aguas residuales con Cloroformo generados en un laboratorio ambiental mediante las micro-nano burbujas de aire. Para el análisis preliminar se tomaron 40 mL de muestra. Se analizaron los parámetros iniciales como: pH, conductividad eléctrica, oxígeno disuelto y temperatura. Los tratamientos fueron en tres tiempos 20, 40 y 60 minutos y se realizaron tres corridas. Finalmente se hicieron las mediciones finales obteniendo resultados favorables para el caso del parámetro Cloroformo la reducción fue de 0.8 mg/L a 0.2 mg/L y el pH se mejoró de un 4.69 a 6.85, determinando de esta forma que la tecnología de las Micro-nano burbujas sí reduce las concentraciones del contaminante Cloroformo presentes en el agua.

Palabras clave: Cloroformo, Micro-nano burbujas, aire

Abstract

The present study aims to treat wastewater with Chloroform generated in an environmental laboratory by air micro-nanobubbles. For the preliminary analysis, 40 ml of sample was taken, which was analyzed by chromatography, the other selected parameters were made with a very calibrated multiparameter, the micro-nanobubble generator had a capacity of 18 liters, so 60 liters of water were collected. Sample of which 6 liters were taken to measure the initial parameters such as: pH, electrical conductivity, dissolved oxygen and temperature. The remaining 54 liters were used for the treatments, the treatments were in three times 20, 40 and 60 minutes and three runs were achieved, finally, the final measurements were made, obtaining favorable results for the Chloroform parameter, the reduction of 0.8 mg/L to 0.2 mg/L and the pH was improved from a 4.69 to 6.85, determining the way in which Micro-nanobubble technology reduces the levels of Chloroform present in water.

Keywords: Chloroform, Micro-nano bubbles, air

1. Introduction

According to reports of the Health Organization about 2 million people consume polluted water and this polluted resource can cause many diseases which cause deaths of more than half a million per year caused by diarrhea as a result of unsafe water consumption, this problem is due to poor management of industrial waste, urban and these also leads to many more people living in danger of pollution and disease. (WHO, 2017).

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In our country there are 91 accredited environmental laboratories of which 69 of them are in Lima and perform their environmental services in testing and calibration. All of them, use organic substances for the treatment and extraction of samples aggravating the problems of pollution, affecting the health of people and the environment. It can be observed that more than 50% of them do not have procedures to deal with the waste they generate (MINAM, 2009). For this reason, the environmental services laboratory dedicated to the sampling and analysis of samples is considered an industry, which discards organic solvent residues such as Chloroform that require treatment.

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).

Some authors treated: marine waters (Abate and Valverde, 2017), river waters (Reyes and Valverde, 2017; Salguero and Valverde, 2017), hospital wastewater (Menéndez and Valverde, 2017), industrial wastewater (Ventura and Valverde, 2017; Valenzuela and Valverde, 2018), pharmaceutical wastewater (Mendez and Valverde, 2017).

Chloroform ($CHCl_3$), also called trichloromethane, is a liquid, volatile organic compound with a sweet, non-flammable odor. This substance is usually mixed with a stabilizer such as ethanol. It is used in industry and laboratories as a solvent. It can be found in water naturally or as a product of water chlorination or by spills in wastewater. Chloroform in contact with oxygen and hot surfaces can decompose forming toxic fumes such as HCl or chlorine vapors and can react violently with strong bases and oxidants. (INSHT, 2007).

According to the International Agency for Research on Cancer, better known as IARC, Chloroform is classified as a possible carcinogen for humans, according to the agency is classified in group 2B, which indicates information still limited in humans, but sufficient evidence in animals. The harmfulness of Chloroform in animals that have been exposed to experiments is seen that the most vulnerable organs are the kidneys and liver, expressed in tumors. Exposure to this contaminant can be through three different routes: oral, inhalation and dermal absorption. There are studies which indicate that exposure through consumption of water treated with chlorine is the result of the sum of the three routes mentioned above, although so far the regulations are based on low risk through oral contact. According to the latest studies it is becoming evident that there is an exposure by all three routes, so there is the possibility of knowing better the exposure beyond the regulations in the limits of by-products in treatment plants. (Martin de Olmedo et al, 2016). According to D.S N° 004-2017-MINAM, the ECA of chloroform must be less than 0.3 mg/L.

2. Materials and Methods

The study population is the wastewater with Chloroform from an environmental services laboratory discarded after the treatment of water samples. For the treatment by means of the technology of air micro nanobubbles the volume of sample to realize will be of 54 liters of sample.
The average diameter of the Micro-nanobubbles was 2.43 microns.
The final ascension velocity was 3.19x10-6 m/s for a micro bubble of 2.43 microns.
The internal pressure of the MNB was 2.633 atm.

The following stages were considered for the development of this research:

Stage 1: Analysis of the sample before treatment.
The sample was collected from the chloroform wastewater discarded by the environmental laboratory as a result of the analysis of the water samples. For treatment with micro-nano bubble

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technology, 60 liters were collected, of which 40 mL were taken to be sent to the laboratory and the pre-treatment analysis was performed by chromatography.

Figure 1. Sampling wastewater with chloroform

Stage 2: Treatment using air nanobubble technology
The micro-nano bubble generator was used to generate continuous circulation bubbles adapted by a reflux system, the operating pressure was 90 PSI fed by a compressor at two inlets. The basic system of the Micro-nano bubble generator is described below.

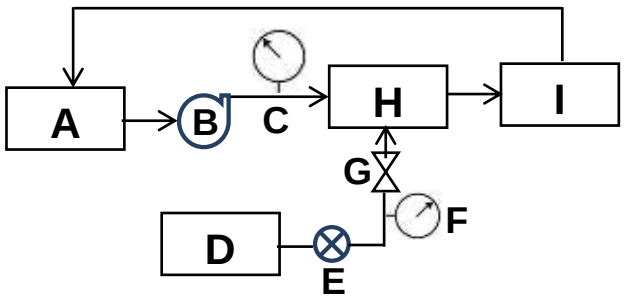

Figure 2. Presentation of the micro-nano bubble generating equipment. Where, A: water tank, B: pump, C: flowmeter, D: air generator, E: pressure valve, F: pressure manometer, G: valve (general), H: MNBs generator, I: wastewater with air MNBs

Stage 3. Analysis of the sample after treatment.
Once the characterization of the Micro-nano bubbles was finished, three repetitions were performed in three times; 20, 40 and 60 minutes. Subsequently, the samples were taken and sent to the laboratory.

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Figure 3. Post-treatment samples taken in 40 mL vials for laboratory analysis.

Post-treatment samples were collected in amber vials provided by the laboratory. These were labeled with the following information: required analysis parameter, name of the analyst, type of sample, date and time, sampling code or point, and type of preservative.

3. Results

Analysis of the sample before treatment.

Pre-treatment analysis of samples was performed in an accredited laboratory. The test report shows the initial values of pH (4.69), Dissolved Oxygen (7.23 mg/L), Electrical Conductivity (145.4 uS/cm), Temperature (20.3 °C) and Chloroform (0.8 mg/L).

Table 1. Initial concentrations reported by the Laboratory

Parametros	Unidades	MI-01
Cloroformo	mg/L	0.8
pH	Unidades de pH	4,69
T°	°C	20.3
Conductividad eléctrica	mS/cm	145.4
Oxígeno Disuelto	mg/L	7.23

Analysis of the sample after treatment

Samples were sent to the environmental laboratory for analysis and reports of final concentrations. The table shows the results within 20, 40 and 60 minutes of pH, Temperature, Electrical Conductivity, Dissolved Oxygen and Chloroform. With respect to chloroform, it was reduced from 0.8 mg/L to 0.2 mg/L.

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Table 2. Final parameter concentrations reported by the laboratory

Pruebas	Tiempos (minutos)	pH	Temperatura (°C)	Conductividad eléctrica (uS/cm)	Oxígeno disuelto (mg/L)	Cloroformo (mg/L)
Tratamiento 01	20	4.75	21.1	145.3	7.89	0.74
	40	6.22	21.3	144.7	7.99	0.35
	60	6.75	23.3	144	8.1	0.22
Tratamiento 02	20	4.69	20.9	144.5	7.35	0.8
	40	4.8	21.7	145.3	7.45	0.4
	60	6.85	22.3	143.7	7.88	0.25
Tratamiento 03	20	4.65	22	143	7.39	0.68
	40	5.77	23.3	144.3	7.7	0.3
	60	6.3	23	144	8.5	0.2

4. Conclusions

From the results obtained in the present investigation, the following conclusion was reached:

- The parameter Chloroform decreased from an initial concentration of 0.8 mg/L to a final concentration of 0.2 mg/L, in a treatment time of 60 minutes. Treatment with air micro-nanobubble technology demonstrates that reduce the chloroform contaminant in wastewater.
- The values of physical parameters such as: the temperature of the wastewater with chloroform after treatment with air micro-nano bubbles ranged from 20.3 °C to 23 °C as and the electrical conductivity ranged from 145.4 uS/cm to 144 uS/cm after 60 minutes of treatment.
- Chemical parameters such as: pH ranged from 4.69 to 6.85 and Dissolved Oxygen ranged from 7.23 mg/L to 8.5 mg/L after 60 minutes, where it is determined that increased oxygen in the water leads to oxidation of contaminants

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