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Efficiency Of Micro-Nanobubbles for Wastewater Treatment in Puerto Bermúdez, Oxapampa, Pasco

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Resumen

En nuestro país, los vertimientos de aguas servidas afectan los cuerpos de agua, a la salud pública y como también a los diferentes ecosistemas sin tener ningún tipo de tratamiento. Por ello se planteó un tratamiento diferente y eficaz para la minimización de los coliformes totales presentes en los efluentes de Puerto Bermúdez, Oxapampa, Perú con la generación de micro-nanoburbujas de aire. Se determinó el grado de contaminación mostrada en los diferentes parámetros ya sean físico-químicos y también biológicos; así como su minimización en los impactos para obtener un mejor calidad de vida.
La investigación fue experimental, se hizo el armado del generador de micro-nanoburbujas de aire para la realización del tratamiento por dosificación. Se realizaron los análisis respectivos para determinar el grado de contaminación y así tratarlas con micro-nanoburbujas en diferentes cantidades y para tener el mejor resultado. Los resultados del tratamiento con micro-nanoburbujas de aire fueron favorables. Se logró una eficiencia de 66.21%.

Palabras clave: micro-nanoburbuja, coliformes totales, parámetros físico-químicos, parámetros biológicos.

Abstract

In our country, the wastewater discharges affect to water bodies, public health and as well as different ecosystems without any kind of treatment. For this reason, a different and effective treatment is proposed for the minimization of total coliforms present in the wastewater from Puerto Bermudez, Oxapampa, Peru with the generation of air micro-nanobubbles. The degree of contamination shown in the different physico-chemical and biological parameters was determined; as well as their impact's minimization to obtain a better quality of life.
The research was experimental, the assembly of the air micro-nanobubbles generator was done to get treatment by dosage. The analysis were carried out to determine the degree of contamination and thus treat them with air micro-nanobubbles in different quantities and thus have the best result. The results of the treatment with air micro-nanobubbles were favorable. The efficiency achieved was 66.21%.

Keywords: micro-nanobubbles, Total coliforms, physico-chemical parameters, biological parameters.

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1. Introduction

The WHO (2015) estimates an approximate 842 000 inhabitants worldwide die annually from the disease of diarrhea. This is a result of the unhealthiness of these waters, a lack of sanitation as the lack of poor hygiene in the hands. However, this disease is preventable if the competent authorities and entities take corrective measures in the health and hygiene necessary, with the commitment of the population preventing the deaths of 361 000 children less than five years of age annually.

The problem now exists in populated centers of the regions of Peru as Bermudez Port, Oxapampa, Peru, and their sewage is discharged directly to the channels and streams that run around the populated center; causing contamination to water bodies, their biodiversity and the health of the population and thus giving as an alternative of decontamination using the technique of Micro-Nanobubbles (MNBs) for their disinfection.

The environmental nanotechnology is a technological discipline which study properties of natural and man-made nanomaterials, applications, techniques for their characterization, integration processes and transformation into ecosystems (Valverde, 2016). Microbubbles have the ability to change the normal characteristic of water (Tsuge, 2014).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). Microbubbles (MBs) possess special properties such as the capacity for generating free radicals (Sadatomi et al., 2007), self-pressurization, and carrying a negative charge. Such properties have attracted much attention in the fields of food science and agriculture (Takahashi and others 2007a). MNBs have now attracted attention for applications in engineering areas such as the sewage treatment of wastewater by air flotation (Choung et al 1993, Fan et al. 2010). Ozone (O_3) is a strong oxidizing agent commonly used for sterilization, virus inactivation, deodorization, bleaching (decoloration), and decomposition of organic matter (Takahashi and others 2007a).
Thermotolerant coliforms using air-ozone nanobubbles decreased from 1400 NMP / 100mL to 56 NMP / 100mL, achieving an efficiency of 96%, (BVSDE, 2006; Abate and Valverde, 2017). Air-ozone micronanobubbles can reduce coliforms in domestic residual water (Cruz & Valverde, 2016).

The micro-bubble generation technology in water is applied in Health, especially when person has cardiovascular problems (Valverde, 2016).

2. Materials and Methods

i) Collection of marine water sample
The wastewater samples were collected, following the indications of the Quality Monitoring National Protocol of Water from Peru.

ii) Sample analysis in laboratory
The total coliforms were analyzed by an accredited laboratory. Also field parameters as Temperature, pH, Turbidity, Electrical Conductivity, BOD_5, COD, Dissolved Oxygen, and Total coliforms were measured.

iii) Fabrication of air-ozone micro-nanobubbles (MNBs)
The research was carried out ex-situ, in laboratory, where the whole system was first assembled to generate and to use the air micro-nanobubbles in wastewater. The patent obtained by Dr. Eng. Jhonny Valverde Flores was used to generate air MNBs. The schematic diagram of experimental apparatus for preparation of MNBs solutions is shown in Figure 1.

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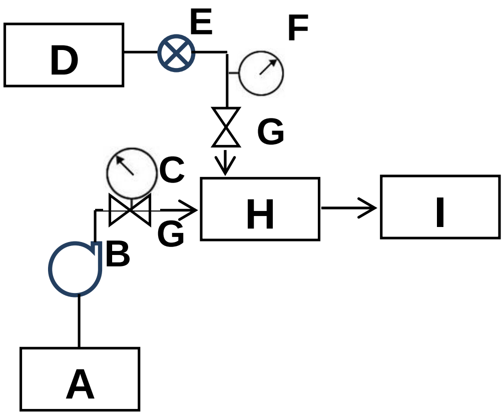

Figure1. Schematic diagram for the wastewater treatment. Where, A: water tank, B: pump, C: flowmeter, D: air generator, E: pressure valve, F: pressure manometer, G: valve (general), H: MNBs generator, I: wastewater with MNBs.

The obtained average diameter of a MNB was 7 µm, the water flow was 4.67 L/s, the gas pressure was 90 PSI.

Figure 2. Average diameter of a MNB size is 7 µm

iv) Treatment of the sample

Four samples (One initial sample and three samples after treatment) were dosed in order to evaluate the best reduction of total coliforms into the wastewater. Sample 1 is called S1 [300 mL (wastewater) + 700

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mL (water with MNB)], Sample 2 is called S2 [400 mL (wastewater) + 600 mL (water with MNB)], and Sample 3 is called S3 [900 mL (wastewater) + 100 mL (water with MNB)].

Figure 3. Preparation of Sample 1, Sample 2 and Sample 3.

v) Treatment's efficiency in laboratory
Results of the three samples in different concentrations were analyzed after of using air micro-nanobubbles.

To measure the MNBs treatment's efficiency on total coliforms (TC) was used the equation 1:

$$\% \, Remotion(TC) = \frac{[Total\ coliforms]_{initial} - [Total\ coliforms]_{end}}{[Total\ coliforms]_{initial}} * 100 \qquad (1)$$

3. Results and discussion

3.1. Treatment of Samples

Samples of Physico-Chemical parameters from wastewater with total coliforms before and after of treatment.

Table 1. Physico-Chemical Parameters

Parameters	Units	EQS*	Initial Sample	Sample 1 300 mL (wastewater) + 700 mL (water with MNB)	Sample 2 400 mL (wastewater) + 600 mL (water with MNB)	Sample 3 900 mL (wastewater) + 100 mL (water with MNB)
Temperature	ºC	<35	23.9	26.5	26.9	26.3
pH	-	6 a 9	6.77	6.7	6.72	6.75
Turbidity	NTU	100	199	49.4	88.3	93.1
Electrical Conductivity	µS/cm	1000	32.1	850	656	443

Note: *EQS is Environmental Quality Standard

The physic-Chemical parameters measured were: temperature, pH, Turbidity, and electrical conductivity. The temperature in S2 (26.9 ºC) was a little higher than temperatures of S1 (26.5 ºC) and S3 (26.3 ºC). The turbidity in S1 (49.4 NTU) was lower than the initial turbidity (199 NTU). The electrical conductivity in S1 was higher (850 µS/cm) than the initial electrical conductivity in (32 µS/cm). See Table 1.

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Table 2. Biological Parameters

Parameters	Units	EQS*	Initial Sample	Sample 1 300 mL (wastewater) + 700 mL (water with MNB)	Sample 2 400 mL (wastewater) + 600 mL (water with MNB)	Sample 3 900 mL (wastewater) + 100 mL (water with MNB)
Biological Oxygen Demand (BOD)	mg/L	10	9	4	4	7
Chemical Oxygen Demand (COD)	mg/L	40	23	8	11	15
Dissolved Oxygen (DO)	mg/L	>5	7.27	8.64	8.45	8.06

The Biological parameters measured were: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO). The Biological Oxygen Demand (BOD) in S1 and S2 (4 mg/L both of them) was lower than the initial Biological Oxygen Demand (10 mg/L). The Chemical Oxygen Demand (COD) in S1 (8 mg/L) was lower than the initial Chemical Oxygen Demand (23 mg/L). The Dissolved Oxygen (DO) in S1 (8.64 mg/L) was higher than the initial Dissolved Oxygen (DO). in (7.27 mg/L). See Table 2.

Table 3. Treatment's efficiency

Parameters	Units	EQS*	Initial Sample	Sample 1 300 mL (wastewater) + 700 mL (water with MNB)	Sample 2 400 mL (wastewater) + 600 mL (water with MNB)	Sample 3 900 mL (wastewater) + 100 mL (water with MNB)
Total coliforms	CFU/100mL	5000	14500	4900	8000	12000

The total coliforms in S1 (4900 CFU/100mL) was lower than the initial total coliforms (14500 CFU/100mL). se Table 3.

Table 4. Comparison from Dose vs. Total coliforms (S1, S2 and S3)

	Dose (mL)		total coliforms (CFU/100 mL)	EQS
	wastewater	MNB		
initial sample			14500	
Sample 1	300	700	4900	Yes
Sample 2	400	600	8000	No
Sample 3	900	100	12000	No

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At the beginning, the initial sample had 14500 CFU/100 mL. After of applying MNBs into the Sample 1, Sample 2 and Sample 3, the results in S1 was within EQS. See Table 4.

3.2. Treatment's efficiency in laboratory

To calculate the MNBs treatment's efficiency on total coliforms in S1 as % Remotion was used the equation1:

% remotion = (14500 – 4900)*100/ 14500 = 66.21 %

Then was calculated the Sample 2 and Sample 3. As a resume the efficiency is seen in table 5.

Table 5. Efficiency of the Samples (1, 2 and 3)

	Dose (mL)		total coliforms (NMP/100 mL)	EF (%)
	Sample	MNB		
initial sample			14500	
Sample 1	750	250	4900	66.21
Sample 2	500	500	8000	44.83
Sample 3	250	750	12000	17.24

The efficiency in Sample 1 was 66.21%, in Sample 2 was 44.83% and in Sample 3 was 17.24%

4. Conclusions

- There are reductions of total coliforms presents in domestic wastewater. The initial total coliforms 14500 CFU /100 mL, after applying the air micro-nanobubbles, the coliforms concentration was reduced. The reduction of total coliforms in Sample 1 was 4900 CFU / 100 mL, in Sample 2 the reduction was 8000 CFU / 100 mL, and in Sample 3 the reduction was 12000 CFU / 100 mL.
- The three treatments were obtained from different measures. The total coliforms in S2 and S3 were out of the Water's Environmental Quality Standard (EQS) for category A2 related to surface water, which is 5000 CFU/100mL. However S1 was within the EQS.
- The best treatment reduction Efficiency of total coliforms in domestic wastewater was in S1 by applying air micro-nanobubbles. It was obtained 66.21% for total coliforms.

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