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Reduction of COD and TSS of waste effluents from a sugar industry through the use of air micro-nanobubbles

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Resumen

La industria azucarera utiliza gran cantidad de volúmenes de agua para su proceso de producción. El vertimiento de los efluentes es uno de los principales problemas que afecta mayormente a los ríos, mares, teniendo como consecuencia el alto nivel de contaminación que capta la vida vegetal y acuática. En esta investigación se tiene como objetivo reducir la concentración de la demanda química de oxígeno y sólidos suspendidos totales, mediante el tratamiento de las nanoburbujas de aire. La experimentación se realizó con una muestra de efluente azucarero teniendo como valor de concentración inicial de la Demanda Química de Oxigeno de 412.15 mg O_2/L. y Sólidos Suspendidos Totales de 620 mg SST/L. Después de haber tratado las aguas en un tiempo de 90minutos se obtuvo como resultado final que la Demanda Química de Oxigeno fue 66.13 mg O_2/L y los Sólidos Suspendidos Totales 131 mg SST/L, mejorando la calidad agua como también para la reutilización para otro tipo de uso.

Palabras clave: Demanda Química de Oxígeno, Sólidos Suspendidos Totales, efluente residual, micro nanoburbujas, aire.

Abstract

The sugar industry uses large volumes of water for its production process. The discharge of effluents is one of the main problems that affects mainly rivers, seas, resulting in the high level of pollution that captures plant and aquatic life. The objective of this research is to reduce the concentration of Chemical Oxygen Demand and Total Suspended Solids by treating air nanobubbles. The experiment was carried out with a sample of sugar process effluent having as the initial concentration value of the Chemical Oxygen Demand of 412.15 mg O_2/L. and Total Suspended Solids of 620 mg TSS/L. After treating the water in a time of 90 minutes it was obtained as final result the Chemical Oxygen Demand was 66.13 mg O_2 /L and Total Suspended Solids 131 mg TSS/L, improving water quality as well as for reuse for another type of use.

Keywords: Chemical Oxygen Demand, Total Suspended Solids, residual effluent, micronano bubbles, air.

1. Introduction

In recent years, the industrial development in our country has increased, generating the greater demand for production, and consumption of water resources for the products process and derivatives. However the effluents growth of Industries generates a potential environmental damage, taking into account that 70% of waste residues and toxic substances generated in

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production are discharged directly into the sea, river or other receiving body without any prior treatment generating a negative impact.

The wastewater of the sugar industry from each stage is discharged or discharged many times into receiving bodies, causing significant damage for the aquatic ecosystem, as well as alterations of flora and fauna. Therefore, it is necessary to treat in order to reduce the environmental impact.

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

This is an applied research. The population is the effluents volume of the company that generates in its production 743m^3/h. The sample was 60 liters of effluent that are discharged directly into the sea. Three different times were taken (30 minutes, 60 minutes and 90 minutes).

The steps of the investigation were:

Step 1: Initial sampling
In this step, the sample point was identified from the waste effluent that is discharged directly to the sea. The polyethylene recipients with volume of 1L of sample were used for Total Suspended Solids and recipients with volume of 200 mL of sample were used for COD. Then recipients were labeled and subsequently placed in a cooler.

Figure 1. Initial Sample

In figure 1, the canal is observed through which the residual effluent passes.

The field analysis of the parameters is carried out: Temperature (°C), Hydrogen potential (pH), Electrical conductivity (EC).

Step 2: Treatment with air micro-nanobubbles

For the treatment of the effluents, a single sampling point was carried out, which were carried in three hermetic containers with a capacity of 20 L each one, and then they were transferred to the

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laboratory. Then It was used the micro-nanobubble generating equipment patented by PhD. Jhonny Valverde Flores to carry out the wastewater treatment in three different times (30 minutes, 60 minutes and 90 minutes).

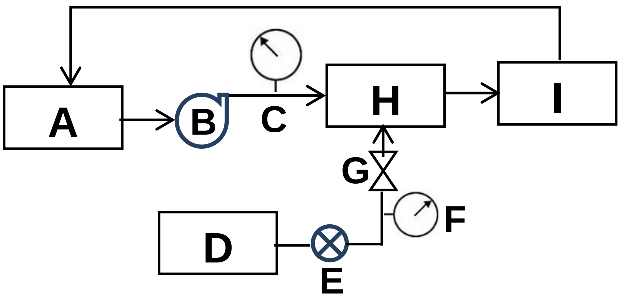

Figure 2. Presentation of the micro-nano bubble generating equipment. Where, A: water tank, B: pump, C: flowmeter, D: air generator, E: pressure valve, F: pressure manometer, G: valve (general), H: MNBs generator, I: wastewater with air MNBs.

The micro-nanobubbles were characterized, obtaining the following results:
• Average diameter of the micro-nanobubbles: 2.75 µm
• Ascent velocity of the micronanobubbles:
$V30 = 6.324 \times 10^{-6}$ m/s (in 30 minutes)
$V60 = 4.642 \times 10^{-6}$ m/s (in 60 minutes)
$V90 = 4.089 \times 10^{-6}$ m/s (in 90 minutes)
• Internal pressure of the micro-nanobubbles: 1.046 atm (at 90 minutes)

Step 3: Analysis of the final sample
A final analysis of the physico-chemical parameters was carried out after the treatment of the water by the air micro-nanobubbles.

3. Results

Initial analysis of the residual water sample
In this step, the initial analysis of the residual water sample was performed, obtaining the result in Table 1.

Table 1. Initial analysis results of the sample

Parameter	initial Analisys	Unit
Chemical Oxygen Demand	412.15	mgO2 / L
Total Suspended Solids	620	mgTSS/ L
Ph	8.92	Unidad de pH
Temperature	23.1	°C
Electrical Conductivity	1041	uS/cm

Analysis after treatment with air micro-nanobubbles
After having carried out the treatment, each parameter was analyzed.

In Table 2, it is observed that the initial pH sample was 8.92, after 30 minutes the average pH was 6.68, after 60 minutes the average pH was 6.78 and after 90 minutes the average pH was 6.43.

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Table 2. pH results after treatment with air micronanobubbles

Time (minutes)	Initial pH	R1	R2	R3	Average pH
30	8.92	6.7	6.68	6.65	6.68
60	8.92	6.9	6.8	6.63	6.78
90	8.92	6.5	6.45	6.34	6.43

Where:
R1, R2 and R3 = Repetition
Table 3 shows that the initial temperature was 23.1 °C, after 30 minutes and 60 minutes the average temperature was 23.1 °C, and after 90 minutes the average temperature was 22.8 °C.

Table 3. Temperature results after the treatment of air micronanobubbles

Time (minutes)	**Initial Temperature (°C)**	**R1 (°C)**	**R2 (°C)**	**R3 (°C)**	**Average Temperature (°C)**
30	23.1	23.1	23.1	23.1	23.1
60	23.1	23.1	23.1	23.1	23.1
90	23.1	22.8	22.8	22.8	22.8

Where:
R1, R2 and R3 = Repetition

In Table 4, it is observed that the initial electrical conductivity was 1041 µS/cm, after 30 minutes the EC was 746.33 µS/cm, 60 minutes the EC was 738.67 µS/cm, and 90 minutes the EC was 655 µS/cm.

Table 4. Results of Electrical Conductivity after the treatment of air micronanobubbles

Time (minutes)	**Initial EC (µS/cm)**	**R1 (µS/cm)**	**R2 (µS/cm)**	**R3 (µS/cm)**	**Average EC (µS/cm)**
30	1041	748	746	745	746.33
60	1041	743	739	734	738.67
90	1041	658	654	653	655

Where:
R1, R2 and R3 = Repetition

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Percentage of COD reduction due to the treatment of air micro-nanobubbles

$$E = \frac{(1- DQO\ mgO_2/L\ (Treatment)}{DQO\ mgO_2/L\ (without\ Treatment)} \times 100$$

For 30 minutes

$$R\% = \left(1 - \frac{76.97\ mgO_2/L}{412.15\ mgO_2/L} \times 100 \right) = 81\%$$

It is concluded that the reduction of Chemical Oxygen Demand through the air micro-nanobubbles treatment in time of 30 minutes is 81%. The same steps are taken to determine the percentage of COD reduction in 60 minutes and COD in 90 minutes.

In Table 5, it is observed that the initial COD was 412.15 mg O_2/L, after 30 minutes it was 76.97 mg O_2/L obtaining an 81% of reduction, after 60 minutes the COD was 74.33 mg O_2/L, obtaining 82% of reduction, after 90 minutes the COD was 66.13 mg O_2/L, obtaining an 84% of reduction.

Table 5. COD results after treatment of air micronanobubbles

Time (minutes)	Initial COD (mg O_2/L)	R1 (mg O_2/L)	R2 (mg O_2/L)	R3 (mg O_2/L)	Average COD (mg O_2/L)	% Reduction
30	412.15	77.5	76.8	76.6	76.97	81
60	412.15	75.5	74.8	72.7	74.33	82
90	412.15	67.7	66.2	64.5	66.13	84

Where:
R1, R2 and R3 = Repetition

Percentage of TSS reduction due to the treatment of air micro-nanobubbles

$$R\% = \frac{(1- TSS\ mgO_2/L\ (Treatment)}{TSS\ mgO_2/L\ (without\ Treatment)} \times 100$$

For 30 minutes

$$R\% = \left(1 - \frac{457.17\ mg\ TSS/L}{620\ mg\ TSS/L} \times 100 \right) = 26\%$$

It is concluded that the reduction of the TSS by means of the air micro-nanobubbles treatment in the time of 30 minutes is 26%. The same steps are taken to determine the percentage reduction of TSS in 60 minutes and TSS in 90 minutes.

In Table 6, it is observed that the initial sample of the TSS was 620 mg TSS/L, after 30 minutes it was 457.17 mg TSS/L obtaining a 26% reduction of the TSS, after 60 minutes it was 193.00 mg TSS/L, obtaining a 69% reduction of the TSS, and after 90 minutes it was 131.3 mg TSS/L, obtaining a 79% reduction of the TSS.

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Table 6. Results of the TSS after the treatment of air micronanobubbles

Time (minutes)	Initial TSS (mg TSS /L)	R1 (mg TSS/L)	R2 (mg TSS/L)	R3 (mg TSS/L)	Average TSS (mg TSS/L)	% Reduction
30	620	625.5	485	261	457.17	26
60	620	215	190.5	173.5	193.00	69
90	620	147	134	113	131.3	79

Where:
R1, R2 and R3 = Repetition

4. Conclusions

- After having carried out the treatment with air micro-nanobubbles in the industrial effluents, the physical parameters decreased pH (from 8.92 to 6.68), the temperature was maintained at 23 °C, the electrical conductivity decreased (from 1041 μS/cm to 746 μS/cm).
- The highest percentage of reduction of the Chemical Oxygen Demand at 90 minutes was 85% (from 412.15 mg O_2/L to 66.13 mg O_2/L).
- The highest percentage reduction of Total Suspended Solids at 90 minutes was 79% (from 620 mg TSS/L to 131.3 mg TSS/L).

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