

Reduction of organic and biological pollutants from affluents of the Ancón wastewater treatment plant using microanobubbles of air and graphene

[Reducción de contaminantes orgánicos y biológicos de afluentes de la planta de tratamiento de aguas residuales de Ancón utilizando micronanoburbujas de aire y grafeno]

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Resumen

El objetivo de esta investigación fue reducir la carga orgánica y biológica de afluentes de la Planta de Tratamiento de Aguas Residuales Ancón utilizando micronanoburbujas de aire y grafeno. Se tomó una muestra preliminar del afluente (3L), la cual tuvo una concentración inicial de Demanda Bioquímica de Oxígeno (DBO5) de 410 mg/L, Demanda Química de Oxígeno (DQO) de 483 mg/L, Coliformes Termotolerantes de 44,000 NMP/100mL y turbidez de 63.33 NTU. La parte experimental se realizó con 03 muestras de 20 litros con 03 repeticiones con tiempo de tratamiento de 20, 40 y 60 minutos aplicando nanoburbujas de aire y 6, 12 y 18 gramos de grafeno respectivamente. Los resultados de las muestras tratadas fueron: 87 mg/L que representa el 78.8% de reducción de Demanda Bioquímica de Oxígeno (DBO5), 114 mg/L que representa el 76.4 % de reducción de Demanda Química de Oxígeno (DQO), 2,900 NMP/100mL que representa el 93.41% de reducción de Coliformes Termotolerantes y 12.4 NTU que representa el 80.11% de reducción de turbidez.

Palabras clave: Micronanoburbujas, grafeno, contaminantes orgánicos y biológicos, aguas residuales.

Abstract

The objective of this research was to reduce the organic and biological load of tributaries of the Ancón Wastewater Treatment Plant using microanobubbles of air and graphene. A preliminary sample of the affluent (3L) was taken, which had an initial concentration of Biochemical Oxygen Demand (BOD5) of 410 mg/L, Chemical Oxygen Demand (COD) of 483 mg/L, Thermotolerant Coliforms of 44,000 NMP/100mL and turbidity of 63.33 NTU. The experimental part was carried out with 03 samples of 20 liters with 03 repetitions with a treatment time of 20, 40 and 60 minutes applying air nanobubbles and 6, 12 and 18 grams of graphene respectively. The results of the treated samples were: 87 mg/L representing 78.8% reduction in Biochemical Oxygen Demand (BOD5), 114 mg/L representing 76.4% reduction in Chemical Oxygen Demand (COD), 2,900 NMP/100mL that represents 93.41% reduction of Thermotolerant Coliforms and 12.4 NTU that represents 80.11% reduction of turbidity.

Keywords: Micronanobubbles, graphene, organic and biological pollutants, wastewater

1. Introduction

In recent years there is a lack of environmental awareness, due to population growth and industrialization, where large amounts of wastewater are generated daily. Most of these waters are discharged directly without previous treatment to the receiving bodies; This being one of the main pollution factors in our ecosystem, affecting water quality and putting the health of the population at risk (OEFA, 2014)

Faced with these problems, many researchers propose the use of new treatment technologies that mean less budget, time and that are friendly to the environment. The COD was reduced by 66.17% in the M2 sample, the BOD5 by 69.41% in the M1 sample and the SST by 98.57% in the M2 sample in hair samples using micronanobubbles (Aguilar, 2016). COD was reduced by 66.86% (from 173 mg/L to 57.33 mg/L) in a time of 15 minutes in river water samples using microanobubbles of air and ozone (Salguero and Valverde, 2017). Turbidity was reduced by 96% (from 27.57 NTU to 1.06 NTU), electrical conductivity by 65% (from 49.01 $\mu\text{S}/\text{cm}$ to 17.04 $\mu\text{S}/\text{cm}$), BOD5 by 70% (from 2.42 mg/L to 0.72 mg/L) and salts in 47% (from 34.46 g/L to 18.41 g/L) in sea waters using graphene (Tapia and Valverde, 2017). The parameters of sample 1 such as turbidity decreased by 78.7% (from 467.4 NTU to 78 NTU), BOD5 by 45.12% (from 474 mg/L to 140 mg/L) and COD 44.03% (from 503.44 mg/L to 158.66 mg/L) in Sanguaza waters using air micro-nanobubbles at 60 minutes (Ventura and Valverde, 2017).

2. Materials and Methods

The present investigation is a pre-experimental design. The sample was 60L to develop the experimental process and 3L for the initial analysis.

For the development of this research several stages were carried out:

- Stage 1. Collection of samples: The sampling point was taken at the Ancón Wastewater Treatment Plant, located in the province of Lima, Ancón district.
- Stage 2. Initial analysis of the parameters of the collected samples: 3L of wastewater was taken. Then it was taken to the Nanotechnology laboratory.
- Stage 3. Treatment with micronanobubbles of air and graphene: For the treatment with microanobubbles of air, a patented equipment by Dr. Jhonny Valverde Flores was used for this type of treatment. Subsequently, the graphene filtration equipment was used in quantities of 6.12 and 18 g. in 20, 40 and 60 minutes.
- Stage 4. Final analysis of the samples. The sample after treatment was analyzed, to then be compared with the initial analyzes and thus analyze the reduction percentages of the parameters.

3. Results and discussions

Treatment with micronanobubbles of air and graphene

The nanobubble generator patented by Dr. Jhonny Valverde Flores was used in a period of 20, 40 and 60 minutes.



Figure 1. Initial samples without treatment.

In Figure 1 the initial samples of the tributaries are observed before the treatment with micronanobubbles of air and graphene, where a high turbidity can be observed according to the color they present.



Figure 2. Final samples after treatment with micronanobubbles and graphene

Figure 2 shows the samples of the tributaries after treatment with micronanobubbles of air and graphene, where a reduction in pollutants can be seen according to the color they present.

Table 1: Turbidity removal percentage

Sample	Turbidity (NTU)	Removal (%)
Initial sample1	62.33	
M1T1	23.4	62.46
M1T2	18.02	71.09
M1T1	12.4	80.11
Initial sample2	62.33	
M2T1	23.5	62.3
M2T2	18.07	71.01

M2T3	12.6	79.79
Initial sample3	62.33	
M3T1	23.7	61.98
M3T2	18.2	70.8
M3T3	12.7	79.72

Table 1 shows the Turbidity removal which was determined for each sample, noting that the greatest turbidity removal occurred in sample 1 in the third time of 60 minutes and with 18 g of graphene whose values are 80.11% (from 62.33 NTU to 12.4 NTU).

Table 2: Percentage of removal of BOD5

Samples	BOD5 (mg/L)	Removal (%)
Initial sample1	280	
M1T1	153	38.29
M1T2	97	59.27
M1T3	57	78.78
Initial sample2	280	
M2T1	157	37.80
M2T2	99	58.78
M2T3	59	78.29
Initial sample3	280	
4M3T1	158	37.56
M3T2	101	58.29
M3T3	61	77.80

Table 2 shows the removal of BOD5 which was determined for each sample, noting that the maximum removal value occurred in sample 1 in the third time of 60 minutes and with 18 g. graphene whose values are 78.78% (from 280 mg / L to 57 mg / L).

Table 3: COD removal percentage

Samples	COD (mg/L)	Removal (%)
Initial sample1	483	
M1T1	282	41.61
M1T2	165	65.84
M1T3	114	76.40
Initial sample2	483	

M2T1	284	41.20
M2T2	167	65.42
M2T3	117	75.78
Initial sample3	483	
M3T1	285	40.99
M3T2	169	65.01
M3T3	119	75.36

Table 3 shows the COD removal which was determined for each sample, observing that the maximum removal value is found in sample 1 in the third time of 60 minutes and with 18g of graphene whose values are 76.40% (of 483mg / L to 114 mg / L).

Table 4: Percentage of removal of Thermotolerant Coliforms

Samples	Thermotolerant coliforms (NMP/100 mL)	Removal (%)
Initial sample1	4.4×10^4	
M1T1	2.0×10^4	54.55
M1T2	1.1×10^4	75.00
M1T3	2.9×10^3	93.41
Initial sample2	4.4×10^4	
M2T1	2.1×10^4	52.27
M2T2	1.3×10^4	70.45
M2T3	3.2×10^3	92.73
Initial sample3	4.4×10^4	
M3T1	2.2×10^4	50.00
M3T2	1.3×10^4	70.45
M3T3	3.2×10^3	92.73

Micronano Bubbles Characterization:

Table 5. Characterization of the micronanobubbles

Micronanobubbles	Units	Value
Bubble diameter	µm	1.55
Ascent speed	m/s	1.25
MNBs pressure	atm	2.38
Flow	L/s	1.5

Graphene characterization:

To determine the characteristics of graphene, an analysis of a graphene sample was carried out using the Raman Spectroscopy method, it was carried out in the laboratory of the PUCP materials characterization center.

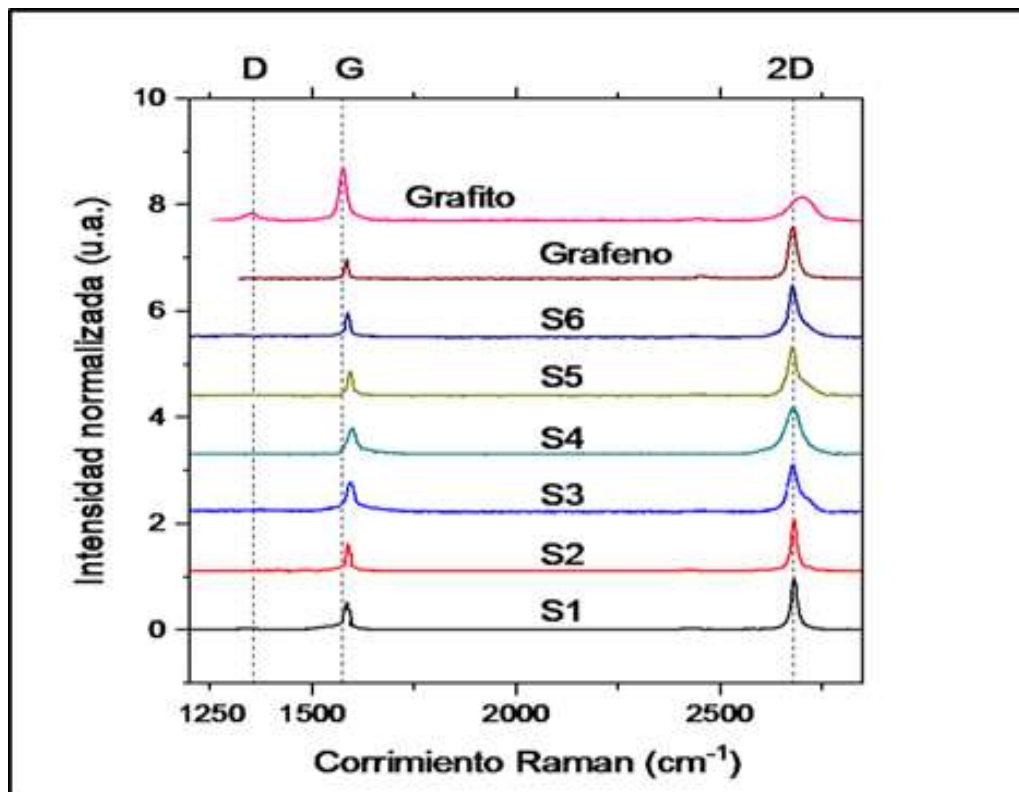


Figure 3. Raman spectrum in the G and 2D band of the graphene sample
Source: Service given by PUCP Materials Characterization Center, 2019

Figure 3 shows the Raman spectra of the graphene samples measured at a range of 1000 to 3000 cm^{-1} , where the shape and intensity of graphene peaks in the GY 2D bands show significant changes in shape and intensity. The most intense characteristics are in the 2D peak that oscillate from 1600 to 2800 cm^{-1} whose frequency values are higher than those of the G peak, these oscillate between 1600 to 1800 cm^{-1} .

4. Conclusions

- It was possible to significantly reduce the physical characteristics of the Ancón wastewater sample: For turbidity by 80.11% (from 63.33 NTU to 12.4 NTU).
- It was possible to significantly reduce the organic load of the Ancón wastewater samples: For BOD5 by 78.8% (from 280 mg/L to 57 mg/L). As for the COD, it was possible to reduce it by 76.4% (from 483 mg/L to 114 mg/L).

- It was possible to significantly reduce the biological load of the wastewater sample from Ancón: For Thermotolerant coliforms to 93.41% of (44,000 NMP/100mL to 2,900 NMP/100mL).
- It can be concluded statistically according to the results obtained in the time of 60 minutes with 18 grams of graphene, a greater effectiveness in the removal of pollutants was achieved, having 80.11% for turbidity (from 63.33NTU to 12.4 NTU), BOD5 in 78.8% (from 280 mg/L to 57 mg/L), COD was reduced by 76.4% (from 483 mg/L to 114 mg/L) and For Thermotolerant coliforms to 93.41% of (44,000 NMP/100mL to 2,900 NMP/100mL).

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