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# Application of silver nanoparticles synthetized by electrolysis for the reduction of *Escherichia coli* from seawater at laboratory level

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**Resumen**

La presente investigación consiste en reducir la cantidad de bacterias E.coli presentes en el agua de mar con la aplicación de nanoparticulas de plata sintetizada por electrolisis, a nivel de laboratorio. La metodología utilizada en la presente investigación es el método electrolítico ya que nos permite sintetizar de manera muy sencilla y práctica las nanopartículas. Además de ello, son efectivas como antibacterianas. El proceso se realizó con dos electrodos de plata introducidos en una celda electrolítica, donde un electrodo pasa por el proceso oxidación y la otra reducción, dicho proceso se realizó en guas de mar. El resultado obtenido fue de 140 NMP/100 mL a 1.8 NMP/100 mL de Escherichia coli representando un 99% de disminución, permitiendo determinar que este proceso fue efectivo para la reducción de la bacteria escherichia coli en aguas de mar.

**Palabras clave**: *E.coli,* nanoparticulas, plata, electrolisis

**Abstract**

The present research consists of reducing the amount of *Escherichia coli* (*E.coli)* bacteria present in seawater with the application of silver nanoparticles synthesized by electrolysis at the laboratory level. The methodology used is the electrolytic method since it allows us to synthesize the nanoparticles in a very simple and practical way. In addition to this, they are effective as antibacterial. The process was carried out with two silver electrodes introduced in an electrolytic cell, where one electrode goes through the oxidation process and the other reduction, this process was done in sea guides. The result obtained was 140 CFU/100 mL at 1.8 CFU/100 mL of *E.coli* representing a 99% decrease, allowing to determine that this process was effective for the reduction of the bacterium *E.coli* in sea water.

**Keywords**: *E.coli*, nanoparticles, silver, electrolysis

## 1. Introduction

Ancón Bay is 43 km away from the center of Lima. Currently it is one of the most visited resorts in Lima for holidaymakers because it has a calm sea and light waves, it also has several tourist and fishing attractions. This condition that meets the spa makes the treatment of the waters of this area is a current need because due to the danger it represents is one of the causes of health of the population and marine fauna found throughout this bay.

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*Echerichia coli (E. coli)* is a bacteria considered as contamination indicator by matter of fecal origin, able to grow in the presence of bile salts easy to detect in laboratories, it also has the ability to develop at a temperature from 43 until 45 °C, belongs to the group of fecal coliforms: *Escherichia coli, Enterobacter, Klebsiella, Citrobacter*. (Pascual and Calderon, 2000).

The presence of *E. coli* deteriorates the quality of water and affects public health, becoming highly important due to its incidence in nosocomial diseases, as well as other diseases such as meningitis, hepatitis, gastroenteritis, encephalitis and respiratory diseases that are transmitted especially orally - fecal (Pelaez et al, 2016).

Electrochemistry is primarily a change in electrical charge, through a solution that results in oxidation and reduction.
The electrochemistry is subdivided into electrolysis (electrolytic cell) and electrochemical cell (galvanic cell).
The electrochemical reactions have the following characteristics:

- The reaction does not occur spontaneously.
- Chemical transformation occurs by electron transfer through electrodes.
- Electric power is not obtained.
- The application of an external energy source produces a chemical reaction.

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).

Compounds such as silver sulfadiazine, metallic silver, and other salts such as silver acetate and silver nitrate, have antibacterial properties which are listed by Martindale, The Extra Pharmacopoeia. For this reason, it is said that silver is part of the lists of essential medicines of the World Health Organization. The released silver ions interact with structures inside and on the pathogen's membrane, inhibiting their activity (Ayala, 2010)

Silver nanoparticles at different concentrations generate the antibacterial inhibition of yeast, *E.coli and S. aereus* (Kin, et al, 2007). Starwicks obtained Ag nanoparticles in organic solvents (Starowicz et al., 2005)

## 2. Materials and Methods

In table 1, It is shown observation point of the monitoring point.

Table 1. Observation point of the monitoring point

| Nº | CODE | Coordinates UTM | | District | Province | Department | Point Description |
|---|---|---|---|---|---|---|---|
| | | East | North | | | | |
| PBA | 001 | 0, 261,477 | 8,697,888 | Ancon | Lima | Lima | up 200 m from the beach. |

### Constructions of the electrolytic cell

The electrolytic cell has a container with silver electrodes inside, whose total volume is 739 mL, the electrode plates are separated from each other by a PVC membrane with a thickness of 6

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mm. It also has two holes to place the pH electrode and thermometer. An electronic SP brand transformer was used to vary the voltage

Figure 1. Electrolytic equipment

**Characterization of silver nanoparticles**

The characterization of silver nanoparticles was made using the Boeco Germany three-dimensional microscope, model N-120T, of classification Ac-100-240 V, lamp S-LED W1. Likewise, the 5 MP camera with 40x magnification was used, Electron Eyempiece YJEYE01-130, the measurement was made with the DigitalCam software.

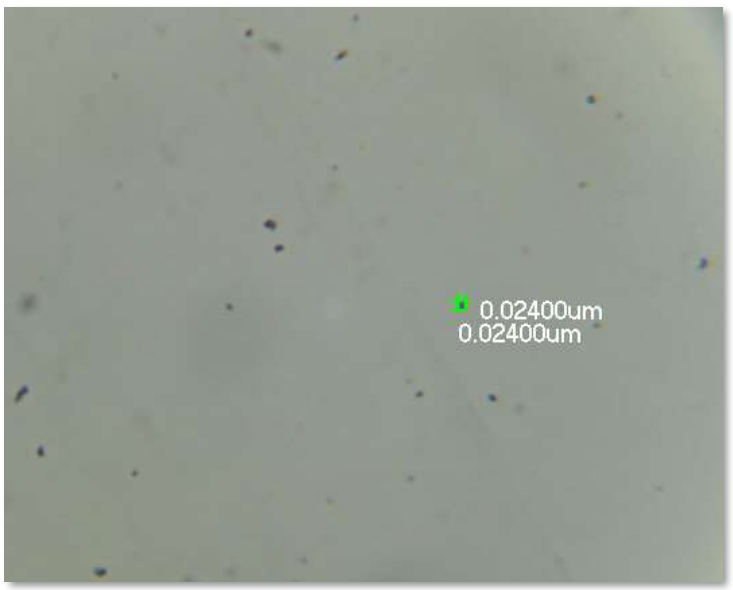


Figure 2. Diameter of the silver micronanoparticle

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The characterization of silver micronanoparticles in a drop of sample

| Characteristics | Results |
|---|---|
| silver nanoparticle amount | 37 |
| Average diameter of nanoparticle | 24 nm |

**Treatment with silver nanoparticles**

700 mL of seawater was collected. Then he was taken to the electrolytic cell installed with the stabilizer. Here, two previously designed silver electrodes are inserted, sealing the lid tightly. The electrodes are connected to the stabilizer's crocodile and the polarity is set at the initial voltage of 15 V. Repeat the procedure every 5 voltages of 15 V up to 25 V and with a repetition of 4 minutes in 3 times of 12, 16 and 20 in each voltage. The pH and temperature are measured.
The final sample is collected in the 500 mL sterile glass bottle for laboratory analysis.

## 3. Results

The result of the presence of *Escherichia coli* before and after treatment is shown in Table 2.

Table 2. Presence of *Escherichia coli* before and after treatment

| V (Volts) | Time (min) | initial *E.coli* (CFU) | Final *E.coli* (CFU) |
|---|---|---|---|
| **15** | 12 | 140 | <1.8 |
| | 16 | 140 | <1.8 |
| | 20 | 140 | <1.8 |
| **20** | 12 | 140 | <1.8 |
| | 16 | 140 | <1.8 |
| | 20 | 140 | <1.8 |
| **25** | 12 | 140 | <1.8 |
| | 16 | 140 | <1.8 |
| | 20 | 140 | <1.8 |

Physicochemical and bacteriological parameters after applying nano silver particles at different voltages and times are shown in Table 3.

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Table 3. Physicochemical and bacteriological parameters after applying nano silver particles at different voltages and times

| V (Volts) | Time (min) | pH | Temperature (°C) | Turbidity (NTU) | Electrical Conductivity | Salinity (%) | *E.coli* (CFU) |
|---|---|---|---|---|---|---|---|
| **0** | **0** | **8.14** | **17.31** | **0.55** | **32.3** | **34.7** | **140** |
| 15 | 12 | 10.4 | 23.1 | 10.1 | 32.6 | 34 | <1.8 |
| | 16 | 10.42 | 23.2 | 4.25 | 32.7 | 34 | <1.8 |
| | 20 | 10.37 | 24.3 | 1.59 | 32.9 | 34.2 | <1.8 |
| 20 | 12 | 10.34 | 24.7 | 11.33 | 32.7 | 33.8 | <1.8 |
| | 16 | 10.39 | 22.6 | 12.54 | 32.7 | 34 | <1.8 |
| | 20 | 10.45 | 23.6 | 4.08 | 32.9 | 35.4 | <1.8 |
| 25 | 12 | 10.5 | 22.3 | 12.53 | 32.9 | 34.2 | <1.8 |
| | 16 | 10.5 | 22.8 | 8.87 | 33.1 | 34.4 | <1.8 |
| | 20 | 10.47 | 23.8 | 1.11 | 33.1 | 34.6 | <1.8 |

When increasing the voltage it is observed that the pH increases (at 25 V, in 20 min the pH reaches up to 10.47), the temperature increases (at 20 V, in 12 min the temperature reaches up to 24.7 ºC), the turbidity increases ( at 20 V, turbidity reaches 12.54 NTU in 16 min), electrical conductivity increases (at 25 V, electrical conductivity reaches 33.1 in 16 min), salinity increases (at 20 V, in 20 min. salinity reaches up to 35.4), and *E. coli* decreases (at 15 V, in 12 min the E. coli reaches up to <1.8 CFU).

## 4. Conclusions

- The concentration of *E.coli* was determined to exceed the ECA; in the waters of Ancon Bay.
- Within the physicochemical parameters of water, the turbidity decreases to an amount of 1.59 in 15 volts, 4.08 in 20 volts and 1.11 NTU in 25 volts.
- Before treatment, the presence of *E. coli* was 140 CFU, after treatment a reduction of 1.8 CFU was found. Therefore the nanoparticle method by electrolysis is a viable and effective alternative for the reduction of *E.coli* in seawater

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