

# Modification of porous materials with Fe<sub>3</sub>O<sub>4</sub> nanoparticles for arsenic removal in drinking water

Allen Puente-Urbina, Virginia Montero-Campos  
Centro de Investigación y de Servicios Químicos y Microbiológicos (CEQIATEC)  
Escuela de Química, Instituto Tecnológico de Costa Rica.

The presence of arsenic in drinking water has been a problem in a lot of countries worldwide due to its influence on human health. In Costa Rica, according to the last Report on the State of Nation in Sustainable Human Development, 40,000 people have been exposed to arsenic in water at levels up to 187 µg/L over the last years.

Arsenic removal in drinking water can be accomplished using different methods, the use of modified porous materials is a favorable method considering that these materials take advantages of characteristics of porous supports.

Here we present the synthesis of magnetite nanoparticles, their use as modifiers for different porous materials, and the use of the composites obtained for arsenic removal in drinking water. In a first stage, single nanoparticles were synthesized using co-precipitation of Fe(II) and Fe(III) in alkaline media and stabilized with carboxylic acids (i.e. oleic acid, stearic acid, or lauric acid).

The transmission electron microscopy (TEM) and calculations from XRD data using Scherrer's equation indicate an average particle size of 13 nm and an average crystallite size of 10 nm, both independent of the stabilizer used.

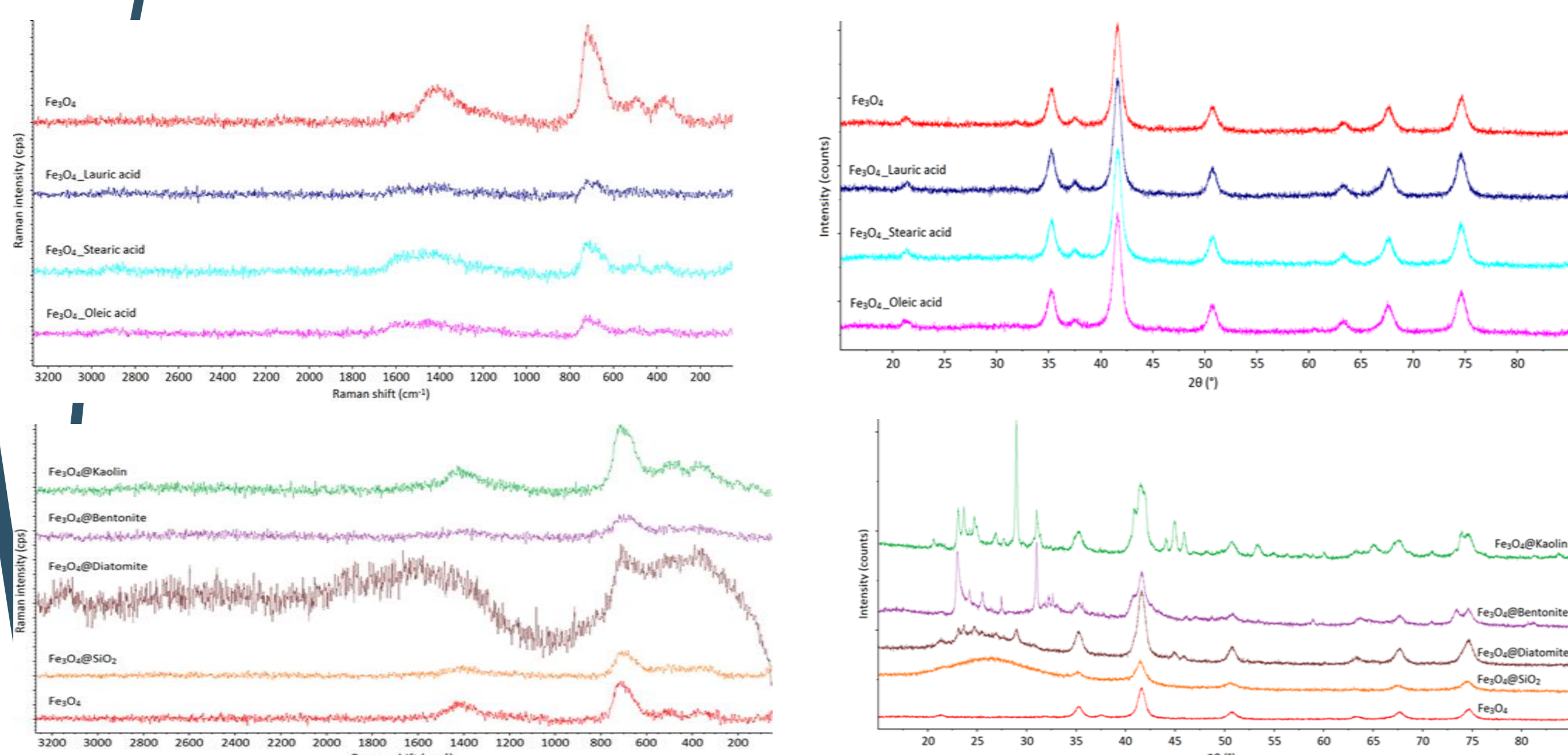
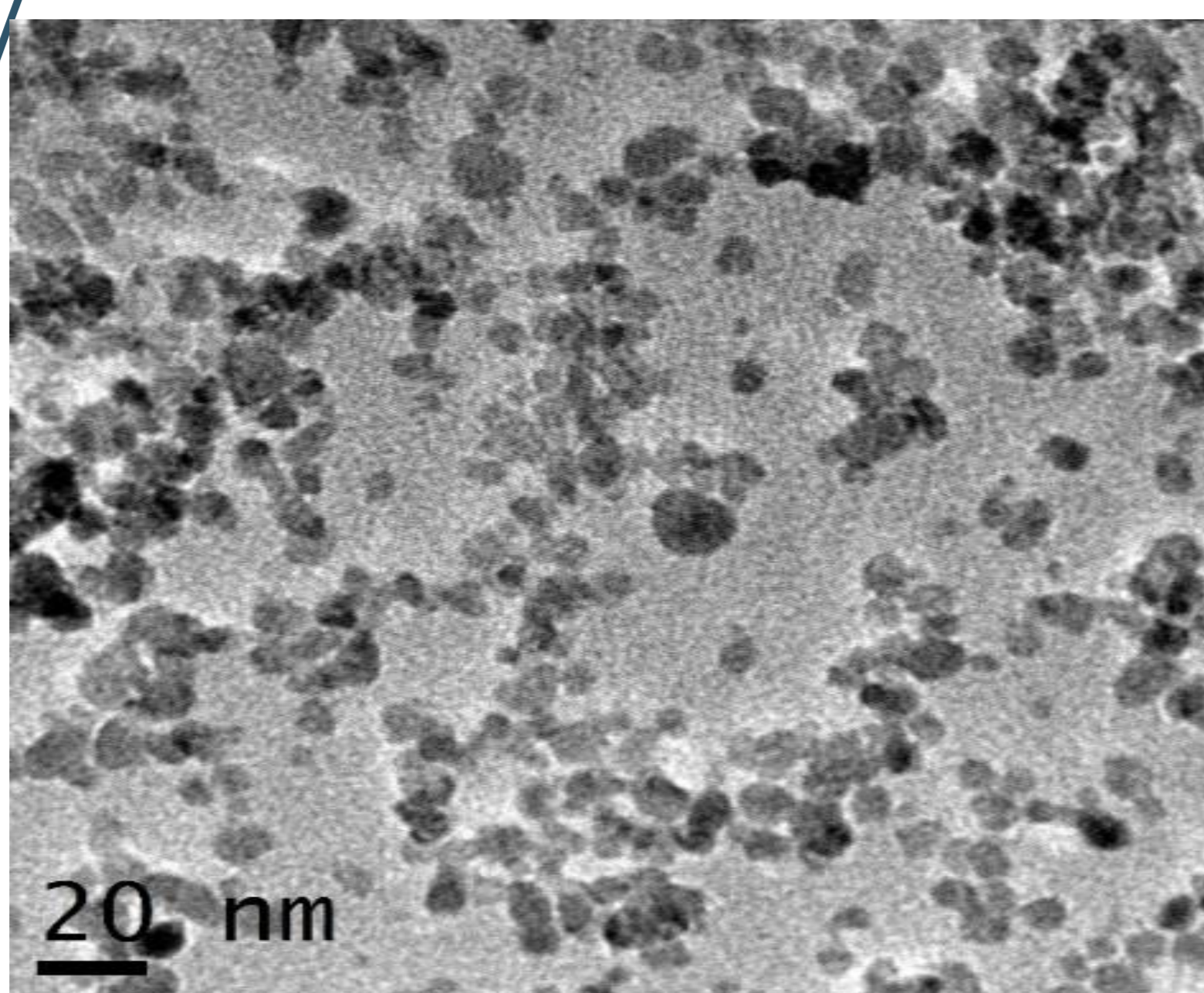


Fig. 1 Raman spectra of single Fe<sub>3</sub>O<sub>4</sub> nanoparticles,  
Fig. 2 XRD patterns of single Fe<sub>3</sub>O<sub>4</sub> nanoparticles,  
Fig. 3 Raman spectra of magnetic composites.  
Fig. 4 XRD diffraction patterns of magnetic composites.

In order to quantify the efficiency of the nanoparticles on the support material and to scale up the results to a field device, the determination of the efficiency of the composite material (Fe<sub>3</sub>O<sub>4</sub>@SiO<sub>2</sub>) was carried out in a prototype laboratory consisting of a continuous flow system.

Filter testing was performed starting with 25 filters per time, down to a minimum of 5 filters, concluding that this last number of filters of the composite material may have acted efficiently in the prototype. Work was carried out with continuous flow at a ratio of 0.015 L/min, tested with a laboratory solution of arsenic at 43.7 ± 2.1 mg/L.

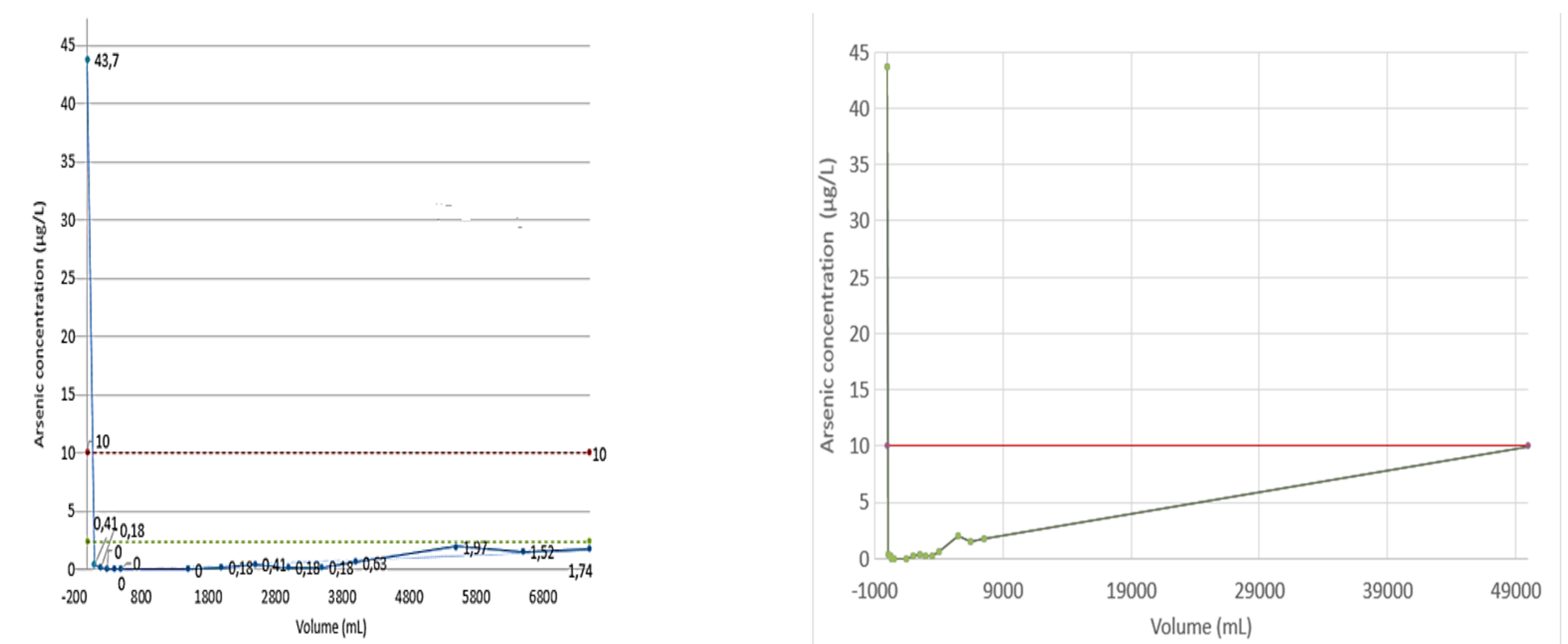


Figure 5. Stability test of the composite material Fe<sub>3</sub>O<sub>4</sub>@SiO<sub>2</sub>. The red line indicates the maximum allowed by legislation in Costa Rica, which is 10 µg/L. Figure 6. Stability test of the composite material Fe<sub>3</sub>O<sub>4</sub>@SiO<sub>2</sub>. Figure 7. Arsenic removal at arsenic treatment system in Bebedero, Cañas. After 8 L the cleaning filters are changed, thus showing their incidence on the system performance is important.

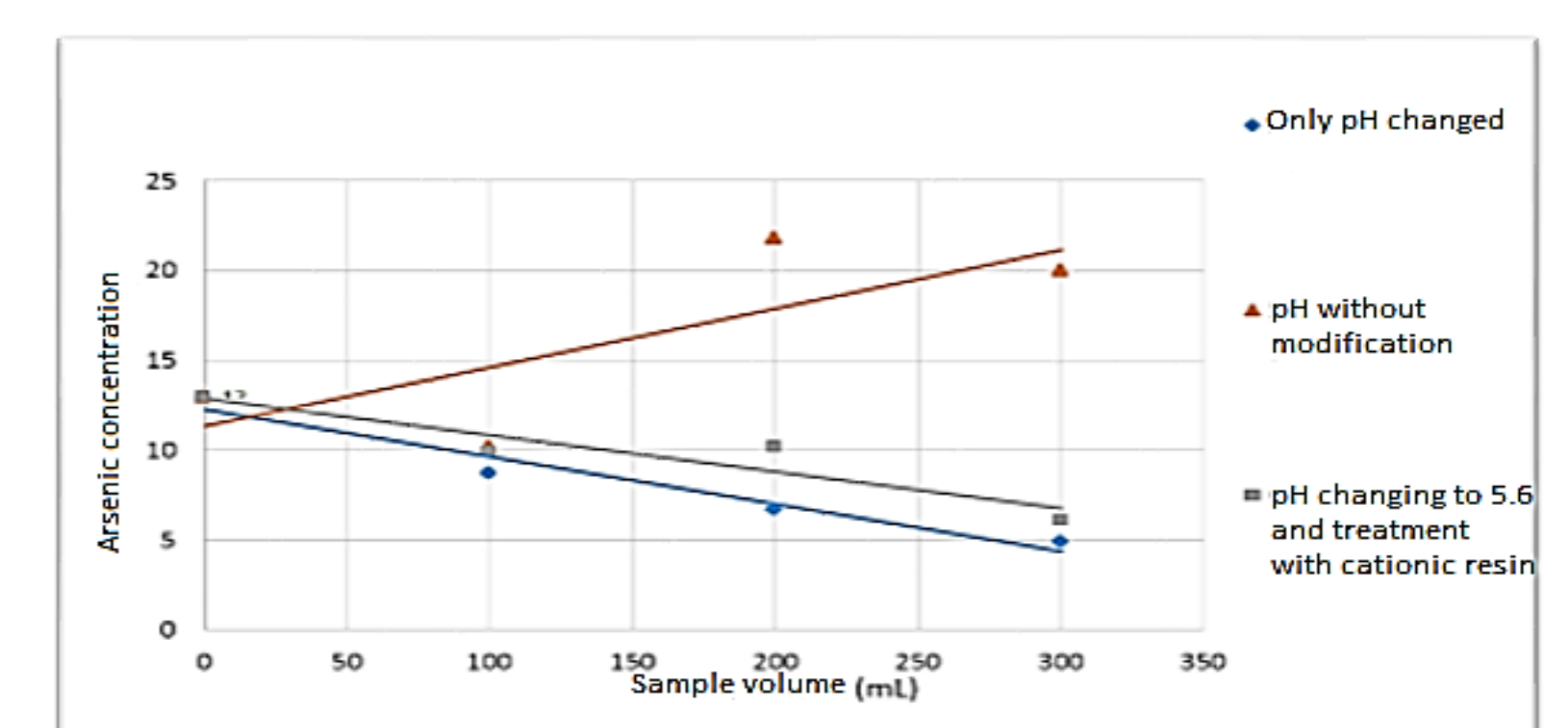
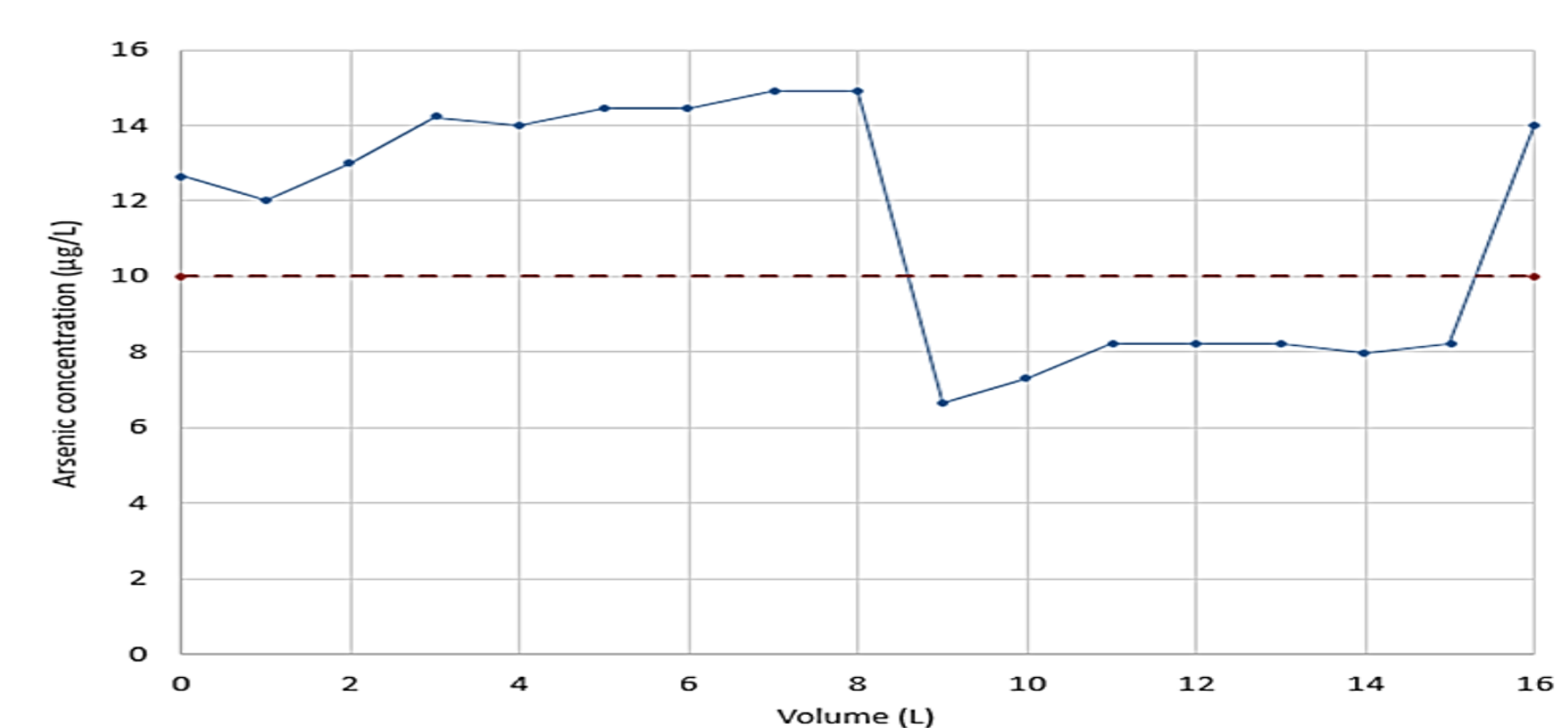


Figure 8. Comparison of water treatments at the arsenic treatment system in Bebedero, with and without modification of the pH and cationic exchange treatment.

The present work offers a highly efficient technological and low cost system that can be placed at the water outlet of wells prior to water disinfection. This method also prevents release of nanoparticles, taking into account basic principles of nanotoxicology and respect for the environment. Once treated and chlorinated afterwards, the water may be safely consumed by the population.

We would like to thank Vicerrectoría de Investigación y Extensión from Tecnológico de Costa Rica for their financial support. The researchers Dr Ricardo Starbird Pérez and MSc. Jorge Calvo Gutierrez, Ing. Luis Fernando Alvarado from Microscopy Laboratory, for their contributions to research. We are also grateful to the students Ana Victoria Cubero, José Pablo Cerdas, Ana Lucía Moya, Kalet Hernández and Marit Möller for their assistance.