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Effect of Nanoclays and Biomass in the Performance of Biosand Filter

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Abstract

In this study, the performance of an intermediate-scale biosand filter modified with nanoclays and rice husks (used as filter media) was evaluated through the determination of pathogen removal efficiency and physicochemical properties of filtered water. There were carried out the physicochemical (pH, Electrical conductivity and turbidity) and microbiological analysis (total and fecal coliforms) on the filtered water samples collected in a period of 21 days. Favorable results were obtained in both physicochemical and microbiological parameters within the permitted levels.

Keywords: Biosand filter, Nanoclays, Rice Husks, Water, Coliforms

1. Introduction

There are regions without potable water supply or with a deficient state of the aqueducts in several places of Colombia, as Casanare, Guajira and some towns of State of Bolívar. The amounts of contaminants in water from wells or effluents, make it unfit for human consumption, therefore, there is the necessity to seek and develop efficient, appropriate and economical technologies that allow to obtain a suitable water for human consumption inside the houses.

Biosand filters are an alternative for obtaining water suitable for human consumption in poorest areas, these filters have the characteristics of removing viruses and bacteria with some limitations in the initial stage, taking 4 to 6 weeks to form its biolayer in the filter sand (which has the function of removing pathogens) [1-2]. In the present work, the performance of the biosand filter was evaluated modified with nanoclays and rice husk to estimate the removal of total coliforms and fecal Coliforms. The physical parameters such as turbidity, pH and electrical conductivity were measured in the samples of filtered water and well water.

2. Materials and Methods

2.1 Materials

A biofilter of pilot size designed by students of the University of Cartagena was used [3], it was built based on the procedure indicated by the CAWST manual for the construction of biofilters in cement [4].
Industrial grade silica sand (20-30 mesh) and clay, were used as the main filtering medium. These materials were acquired in the surroundings of the city of Cartagena (Colombia). In a previous analysis, we determined that clay was suitable to obtain the montmorillonite fraction.

2.2 Preparation of biomass

The biomass was acquired from the waste from the rice production process in the southeastern part of Colombia. The rice husk was completely washed and dried out in the sun for two days, following disinfection by UV radiation, prior to be used as filtration medium. The dried biomass was ground in a ball mill to a uniform size, it was then used as bed in the biosand filter [5].

2.3 Preparation of Nanoclays

For the elaboration of the nanoclays, we followed the method suggested by Perugachi Benalcázar (2006). Briefly, three main procedures were carried out:

Obtaining the clay fraction

The initial sample of clay comprises three basic components: sand, silt and clay. To obtain the clay fraction, initially organic matter and carbonates that do not allow the suspension of clay particles were eliminated applying Pipette Method.

Obtaining of montmorillonite

Once the clay fraction was obtained, the montmorillonite proportion of sodium character was extracted, exchanging the calcium cation for the sodium cation, and eliminating residues by density difference.

Preparation of Nanoclays

For the modification of the nanomolecular scale clay, a cation or organic modification was added to the clay by using Arquad HTL8-MS, it was supplied by AZCO NOBEL.

2.4 Biofilter design

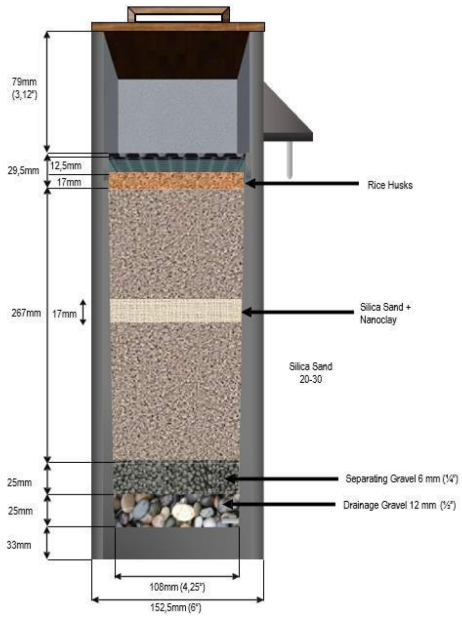
The materials in the filter were arranged in layers (Fig. 1), as follows: *i)* at the top of the filter there is a diffuser layer, to form an even distribution of the flow water that guarantees its passage to the sand layer without disturbing the biological layer that is expected to form, *ii)* a 1.25 cm water column, where the biolayer will form for the removal of microorganisms from the filter, this layer can take up to 30 days to set up and the effectiveness of the filter for the removal of pathogens before this period is only 30 -70% [4]; *iii.* a 1.7 cm layer of the treated rice husk that is expected to promote the growth of the biolayer and improve the pathogen removal capabilities; *iv.* a first layer of 12.5 cm silica sand, the sand was subjected to an ultraviolet washing and drying process according to the instructions in the CAWST manual. This layer induces the mechanical entrapment of the microorganisms still present in the water or its death due to lack of food and oxygen, it is also important for the removal of suspended solids [4]; *v.* a 1.7 cm layer of silica sand mixed with the modified nanoclay for the removal of cations. This is done in this way to avoid plugging the filter due to the expansion of the nanoclay in contact with water; *vi*. a second 12.5 cm layer of silica sand and two layers of 2.5 cm of gravel to retain the sand column: the first with particle size less than 6 mm and the second with particle size less than 12 mm.

2.5 Preparation of effluent

The water used in the test was collected from a water well located in the road between the municipality of Turbaco (Bolívar) and the city of Cartagena, due to the evidence found about contaminated groundwater by using septic tanks in Turbaco [7].

Samples were collected from the water well each seven days for the tests; this samples were tested in the filter the days 0, 1, 2, 7, 14 and 21. The pH and conductivity were analyzed using a Consort C931 and the turbidity were tested with a portable turbidimeter TB1 in the laboratories of University of Cartagena; the presence of coliforms was analyzed in 100ml of sample. Two samples were collected each day: the well water and the water treated from the filter. Bacteriological tests were realized each trial day based on the microbiological parameters of drinking water established by the Republic of Colombia in the Resolution 2115 of 2007 [8].

Figure 1. Design of biosand filter modified with nanoclays and biomass.



3. Results and Discussion

3.1 Analysis of Acidity and Alkalinity

The performance of the samples of water in the tests in relation to the pH value are similar, trending to be neutral (pH of 7). For the filtered water these values may be due to the presence of the materials that conforms the fill in of the filter, possibly the filter mediums, that may content compounds which in presence of water may detach soluble components that increasing the pH.

The Colombian Technical Standards (*Norma Técnica Colombiana*) indicates in the report of official standards for quality of water in Colombia that drinkable water may content pH values of 6.5 to 9.0 [9]. The recorded values in the days of operation of the filter both for the well water and filtered water are located within the borders established by the standards. This behavior is indicated is the Figure 2.

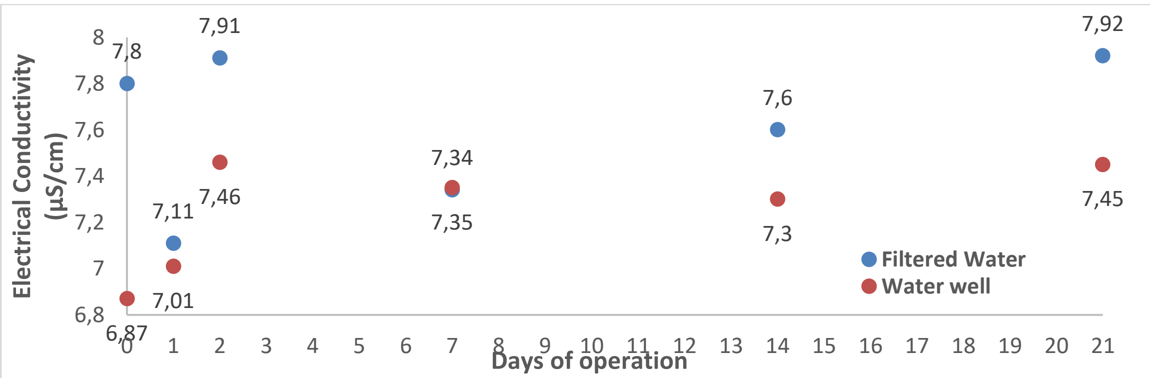


Figure 2. pH values for water respect of time (days)

3.2 Electrical Conductivity Analysis

The Figure 3 shows the values of electrical conductivity in units of µS/cm for well water and filtered water, a decrease in filtered water respect to untreated water was observed. The Colombian Technical Standards [9] report than the maximum value of electrical conductivity for drinkable water must be 1000 µS/cm in normal conditions, therefore, considering this standard both water well and filtered water are suitability for human consumption. The filtered water presented at day 0 a value close to permitted maximum because the bed filter may contain ions that were washed.

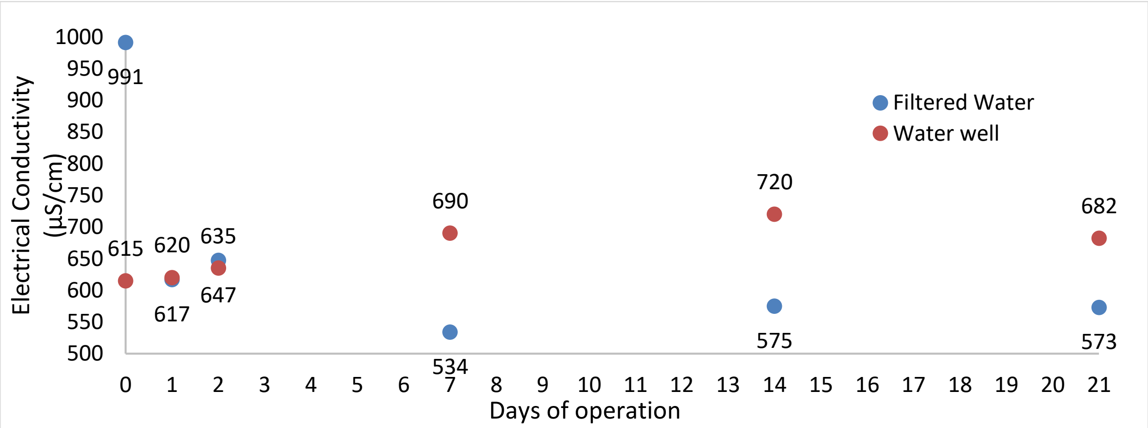


Figure 3. Electrical conductivity of water respect of time (days)

3.3 Turbidity Analysis

The Figure 4 shows that the well water was maintained a value of turbidity 0.04 NTU (Nephelometric Turbidity Units) for all days of operation. Instead for the water treated in the filter, it was observed on day 0 a relatively high value of 43 NTU, this could be seen in the water which had a light yellow color, this was attributed to the rice husk as it was just the case on the first day and it may have been due to remaining residue on the husk. The turbidity of filtered water decreased in the following days until permited levels, this values on turbidity wasn't significant if we don't take into account the results of day 0 due to the aforementioned reasons. In descending flow filters, turbidity levels tend to be higher for biosand filters because the water that comes out of it usually drags particles from the filtering beds, however the filter tends to improve the turbidity of the treated water [5].

The maximum turbidity level permitted is 2 NTU according Resolution Number 2115 (22 JUNE 2007) of *Ministerio de La Protección Social Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, from Colombia [8]. Therefore both the filtered water and the well water are between the established ranges, although the filter lasts a few days before dropping the turbidity level of the filtered water to acceptable values.

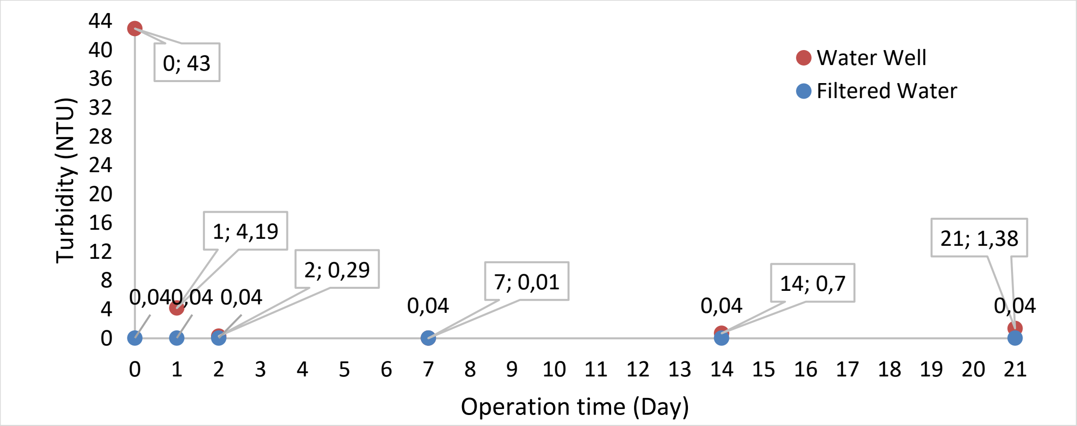


Figure 4. Turbidity of water across the operation time of the filter

3.4 Bacteriologic Analysis

The presence of microorganisms for the tests days indicated that the total coliforms ranged between 10 and 20000 Colony-Forming Units (CFU) in the well water, therefore the filtered water didn't show presence of microorganism. Figure 5 shows the trend of total coliform removal across the operation days of the filter.

The test for fecal coliforms is important because it indicates the presence of pathogens from fecal origin in the water, in Figure 5, the fecal coliforms were detected in a range between 0 to 2000 CFU for well water, however in the filtered water, fecal coliforms were not found, figure 5 shows the behavior of fecal coliform removal by using the filter.

The Colombian Technical Standards (*Norma Técnica Colombiana*) states that the values for fecal coliforms in drinking water should be 0 CFU/100ml, therefore in this aspect the filtered water is safe for human consumption.

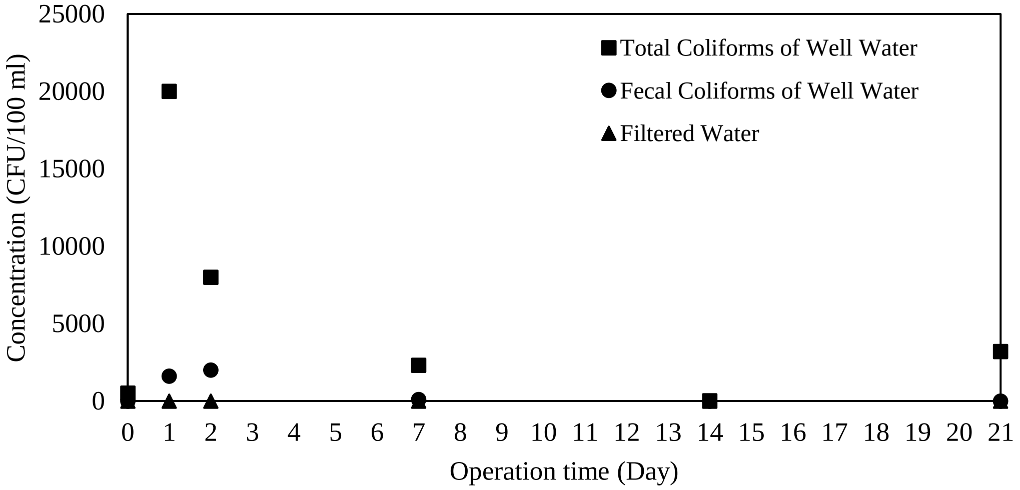


Figure 5. Total Coliforms in water during test days

4. Conclusions

According to the results the modified biosand filter presents an acceptable performance since the first day of operation, ensuring a safe supply of drinking water for the user, this opens up the possibility of applying these applied modifications in this type of filters for remote areas or places where a supply of safe drinking water is hard or impossible. The parameters of pH, conductivity and turbidity are between the allowed levels, however due to observed changes on turbidity it is recommended that the rice husk is changed every seven days.

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