Study of Arsenic Removal with Ionic Exchange Resins in Drinking Water from Zimapan, Hidalgo State, Mexico

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Abstract

Anionic exchange resins were studied with respect to its capacity for arsenic removal in water. Water of well V from Zimapan, Hidalgo, Mexico, was used to in this research, because this water have a mean concentration of 480 ± 11 µg.L-1 of arsenic and it is available as drinking water. Three exchange resins employed were two strong anionic weak macroreticular (IRA-900) and other gel typo (IRA-400), as well as one third anionic, one weak macroreticular type (IRA-96). The experiments carried with this resins showing that IRA 900 has the highest efficiency in the process of arsenic removal from drinking water, because it showed a treatment capacity of 700 Vwater.Vresins-1; while that capacities of IRA-400 and IRA-96 resins were 320 and 52 Vwater.Vresins-1, respectively. The mean concentration of arsenic residue in the treated water was 24 µg.L-1, which is within the maximum level permissible by Mexican official norm for drinking water.

Key Words: Drinking water, arsenic, removal, exchange resins

1.0 Introduction

Zimapan's underground water presents, especially in the deep wells (Pérez et al., 2003), high contents of arsenic that exceed the limits of the Mexican current norm (Justo, 2000), due to the fact that it is a region where minerals PbS, CuS, Ag2S and ZnS are exploited. In addition, the region is associated with arsenicals minerals as arsenopyrite (FeS.FeAs2), which exhibit large water solubilities, depending pH ionic environment, soil conditions, temperature and presence of oxidizers and /or reducers (Martín, 2000; Hernández et Herrera, 2007).

The arsenic present in the water is principally As(V), in the form of H2AsO4- and HAsO42-, species less toxic than those of As(III) (Wasay et al., 1996; Elizalde et al., 2001; Pérez et al., 2003; Söros et al. 2003; Rivera et Piña, 2005 Mejías et al., 2009). The objective of this study was to compare the removal efficiency of arsenic contained in drinking water of the well V of Zimapan, Hidalgo, using three types of anionic exchange resins, two strong (IRA-900, IRA-400) and one weak (IRA-96) resins.

2.0 Materials and methods

The water of the well V contained an initial concentration of arsenic of 480 ± 11 µg L-1. We used two anionic basic strong resins of macroreticulated type (IRA-900) with functional group NH4+, Sigma mark, with size of particle 300-991 µm and other one type gel (IRA-400) with counterfoil of styrene divinilbenceno, with the same functional group, Fluka mark and size of particle 400-500 µm. The third anionic weakly basic resin of macroreticulated type (IRA-96) has active counterfoil of polyamine, Fluka mark and size particle 300-833 µm.

The resins were re-hydrated in distilled water and activated in solution of 4% NaCl, with constant agitation for 20 min. and washed with deionizated water. 25 mL of each resin was placed in glass columns of 50 mL; one made spend 100 mL of solution 4% NaCl to a flow of 2-3 mL.min-1. With the activated resins water of the well V was passed to the same flow and temperature conditions. The water fractions of 50 mL were collected (2Vwater.Vres-1), rejecting the odd fraction and analyzing the concentration of As(V) in the fractions . Every analyzed fraction is equivalent to 100 mL of water of the well V treated.

When the resins exhausted their capacities to retain As (efficiency <85%), they were washed by water and air to counter flow, stopping the water flow when the resin expanded to the double and was left washing only with air for 20 min. Later the air flow stopped and water passed, rejecting the residual material on the top part of the column. It was left to settle the resin and on the top part it him 100 mL of solution 4% NaCl was passed to the indicated flow The determination of As was performed by ICP with hydride generation, previous prereduction of the sample with KI and ascorbic acid to 5 % in the middle of HCl. The As retained in the resins was determined by the formula:

$$\%R = \frac{(Cmi - Cfe)}{Vm} * 100$$

where:

%R: Percentage of As retained in the resin for every fraction of water collected after the exchange; Cmi: Concentration of As in the initial sample in µg.L-1; Cfe: Concentration of As in the fraction eluted in µg.L-1. When %R diminishes gradually to minor values of 80% was considered to be a depletion of the capacity of retention of the resin, the process is stopped and the resin rejuvenation described above was initiated.

3.0 Results and discussion

The removal efficiency of As by the resins was variable. Nevertheless, the macroreticulated resin IRA-900 presented the highest efficiency. With this resin, 700 Vwater.Vres-1 of water was treated, reducing the concentration of 480 µg.L-1 to 24 µg.L-1 (shown in Figure 1). The anionic resin type gel IRA-400 presented a capacity of 320 Vwater.Vres-1, managing to treat 8.1 L of water in the same conditions, for what he proved to be one 50% minor in efficiency that IRA-900.

The macroreticulated resin IRA-96 presented a capacity of 52 Vwater.Vres-1 that corresponds to 1.3 L of water treated in equal conditions. The process of retention of As was repeated itself after the resins became exhausted and were regenerated, obtaining similar results that confirm the capacities of these resins (Figure 2).

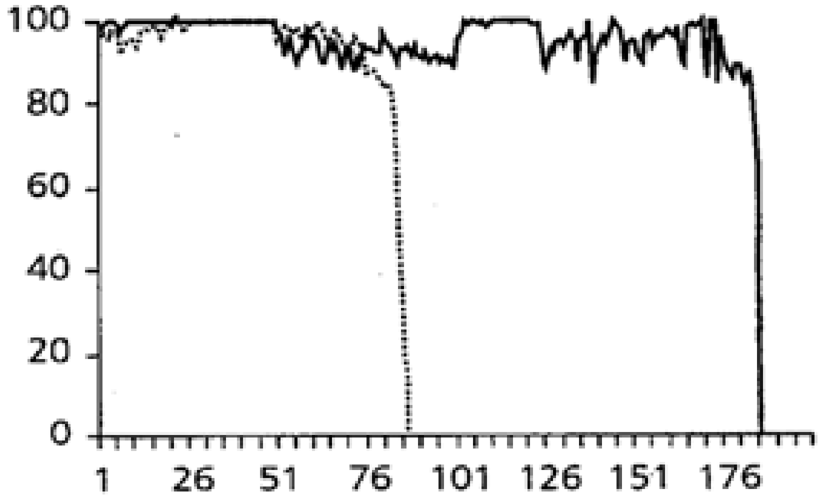

Figure 1. Arsenic percentage fixed in strong anionic resins IRA-900 macroreticular___and IRA-400 gel type…….
Each fraction is 100 mL of treated water

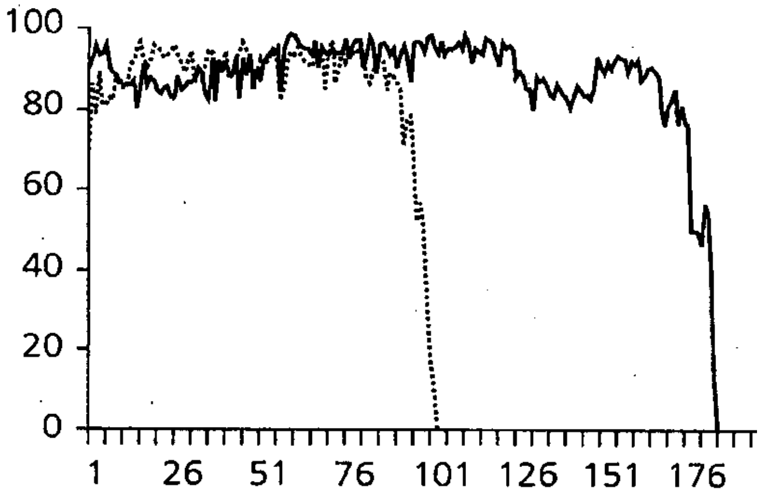

Figure 2. Arsenic percentage fixed in strong anionic regenerated resins
IRA-900 macroreticular___ and IRA-400 gel type…….
Each fraction is 100 mL of treated water

The theoretical capacity of anionic exchange of the resin IRA-900, according to the manufacturer, is of 1.0 meq.mL^{-1} (Rohm *et* Hass, 1982; Vagliasindi *et* Benjamin, 1998). Nevertheless the real capacity of retention of As calculated in the shape of $HAsO_4^{2-}$ was 0.6 meq.mL^{-1}, as a consequence of the competition that the anions have arsenate with other anions as CO_3^{2-}, HCO_3^{-}, PO_4^{3-} and SO_4^{2-}, in the process of exchange (Wasay *et al.*, 1996).

4.0 Conclusions

Of the three anionic resins tested, IRA-900 presented the highestcapacity of retention of arsenic, since a volume of 25mL of resin in the treatment of 17 L of water (700 $V_{water}.V_{res}^{-1}$) with a flow of 2-3 mL.min^{-1} to temperature set. In spite of the fact that the royal capacity of elimination of As with the resin IRA-900 is minor that the reflected one in the literature, can be in use for realizing studies to level of pilot plant or to apply directly in a plant purificadora for elimination of As. Three types of anionic resin used manage to reduce the levels of As(V) contents in the water of the well V de Zimapan from 480 µg.L^{-1} to minor values of 25 µg.L^{-1}, with different efficiencies for every resin.

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