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- (54) **Title:** ARSENIC REMOVAL FILTER USING IRON POWDER, FERRIC HYDROXIDE COATED RICE HUSK ASH

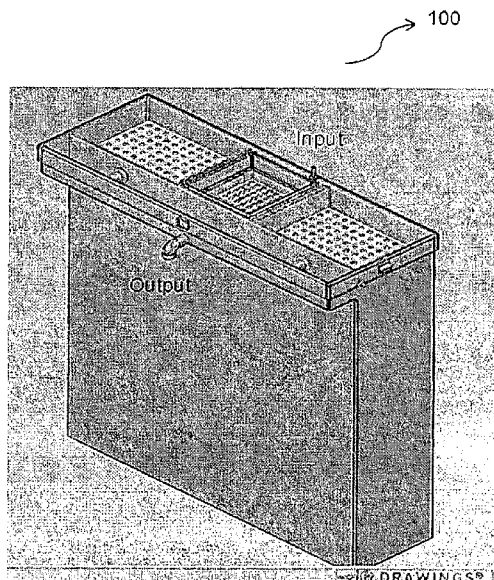


Figure 1

- (57) **Abstract:** The present invention provides an apparatus and method for removing contamination of iron and Arsenic from the drinking water. The said apparatus comprises dual filter stage i.e. pre-filter stage and main filter stage, wherein the pre-filter removes iron flocs and maintained pH to 6.0-8.5 range. This pH helps in improvement of the adsorption capacity of ferric hydroxide coated RHA. The said apparatus also removes clogging of filter from iron particles via a pre-filter stage.

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ARSENIC REMOVAL FILTER USING IRON POWDER, FERRIC HYDROXIDE COATED RICE HUSK ASH

FIELD OF THE INVENTION

The present invention relates to the field of filtration of drinking water. Particularly, the invention relates to a cost effective method and apparatus for removal of Arsenic and iron based contaminants from water.

The present invention is an improvement in or a modification of the invention described and claimed in an earlier Indian Patent No. 206230 filed on 19th December 2003, all the disclosures made therein are incorporated as reference in the present invention.

BACKGROUND OF THE INVENTION

Arsenic is a nonmetallic element and is fatal to human health. Use of deeper tube wells for water supply exposes people to high concentration of Arsenic, present in deeper levels of groundwater. As per a recent study over 137 million people in more than 70 countries are probably affected by Arsenic poisoning of drinking water. Lack of affordable and efficient Arsenic filtration apparatuses lead to consumption of Arsenic above tolerance levels resulting in chronic Arsenic poisoning. The chronic Arsenic poisoning leads to diseases like cancer of the skin, lungs, urinary blades, and kidney as well as other skin changes such as pigmentation, thickening and cardiovascular disease.

World health organization has specified the contamination specific nations and regions. The most effected regions are Bangladesh, Nepal and certain regions in India. The governments in collaboration with research organizations are making

effort to provide cheap and effective filtration apparatus for the people living in these areas.

Some of the common use filtration apparatus known to us will now be discussed to understand the available technical solutions and shortcomings in the state of the art.

Massachusetts Institute of Technology (MIT), in collaboration with the Environment and Public Health Organization (ENPHO) of Nepal developed an apparatus named Kanchan Arsenic filter (KAF). The KAF filter enables Arsenic from drinking water and also enables microbiological removal of treatment.

In some regions of India and Bangladesh people use a simple three-pitcher arsenic filtration apparatus locally known as '3-kalshi' filtration assembly. In 3- kalshi assembly, the first kalshi has iron chips and coarse sand, the second kalshi has wood charcoal and fine sand, and the third kalshi serves as collector for producing Arsenic free water.

In most of the cases ground water with Arsenic contamination also contains iron. The iron particles present in Arsenic contaminated water due to inertia clog the filtration bed, resulting in degeneration of the bed which ultimately leads to reduced adsorption capacity of the filtration bed. The reduced adsorption capacity of the filtration bed results in reduced adsorption of Arsenic therein.

Thus, the problem of clogging of iron bed largely remains unaddressed.

Some of the lacunae that exists in the prior arts discussed above are that the Kanchan and 3 kalshi filter contains at least 5-6 kg and 3 kg of iron nails, respectively. By adding sand & gravel (5-6 kg) the apparatus becomes even heavier. In 3 Kalshi (earthen pots), filter is made up of three pots kept on over another. The Arsenic

removal efficiency is low (50-70%) and the filter gets clogged due to presence of iron flocs in the water. The filtration rate is low and contact time is approximately 10-12 hrs in order to get 80% Arsenic removal.

Thus there exists a need to solve the long standing problems for providing a method and apparatus for removal of Arsenic from water, wherein such apparatus remains unchanged and enables higher rates of filtration.

OBJECTIVES OF THE INVENTION

The primary objective of the present invention is to provide an apparatus and method for removal of Arsenic and iron contamination from drinking water, with simultaneous reduction in pH of the water.

Another significant objective of the invention is to provide an apparatus and method adapted in a manner that prevents clogging and sludge deposition in the apparatus.

Another objective of the invention is to provide an apparatus and method that is capable of removing Arsenic in Higher Concentration in less time from the contaminated water.

SUMMARY OF THE INVENTION

Before the present apparatuses and methods are described, it is to be understood that this invention is not limited to the particular apparatuses, and methodologies described, as there can be multiple possible implementation styles of the present invention which are not expressly illustrated in the present disclosure. It is also to be understood that the terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope of the present invention which will be limited only by the appended claims.

The present invention provides a combine filtration apparatus for tackling the clogging issue with highly porous bed of iron powder used as pre-filter which in turns removes 30-40% of Arsenic, and another stage of filtration for removal of arsenic using ferric hydroxide coated rice husk ash.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of preferred embodiments, are better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings a few exemplary constructions of the invention; however, it is to be understood that the invention is not limited to the specific apparatuses and methods disclosed in the drawings.

Figure 1 illustrates an apparatus for removal of arsenic and iron contamination from the water according to one exemplary embodiment of the invention.

Figure 2 illustrates inner portion of the apparatus according to one exemplary embodiment of the invention.

Figure 3 illustrates a method for removal of arsenic and iron contamination from the water according to one exemplary embodiment of the invention.

Figure 4 illustrates graphical comparison of the arsenic removal quantum according to one exemplary embodiment of the invention.

Figure 5 illustrate arsenic concentration to output water versus input water using iron powder and RHA bed.

Figure 6 illustrate arsenic removal form spiked ground water by ferric hydroxide coated RHA.

Figure 7 illustrate arsenic removal using iron powder bed and ferric hydroxide coated RHA

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments are described in detail using the drawings. Note that the disclosed invention is not limited to the following description and it will be easily understood by those skilled in the art that various changes and modifications can be made in modes and details without departing from the spirit and the scope of the disclosed invention. Therefore, the disclosed invention is not interpreted as being limited to the description of the embodiments below.

Figure 1 illustrates an apparatus for removal of arsenic and iron contamination from the water according to one exemplary embodiment of the invention. An apparatus 100 comprises a pre-filter chamber 103 and a main filter chamber 104. The said pre-filter chamber 103 comprises a metallic iron bed in combination with untreated rice husk ash (RHA) 102 as shown in figure 2 for continuously removing iron floc causing pH balancing of water fed into the pre-filter chamber 103 with enhanced arsenic adsorbability of the RHA and removal of arsenic. In a preferred embodiment of the invention the said metallic iron bed is selected from the group of iron powder, nail, iron wire and iron fillings scarp. In a preferred embodiment of the invention the pre filter chamber removes 90-95% iron from spiked ground water. The said main filter chamber 104 comprises a ferric hydroxide coated rice husk ash (RHA) 105 as shown in figure 2 adapted to receive pre-filtered water 120(a) and removing arsenic therefrom. In a preferred embodiment of the invention the said ferric hydroxide is

prepared by reacting at least one ferrous salt and at least one strong alkali like sodium hydroxide/ calcium hydroxide for coating on the rice husk ash substrate.

Figure 3 illustrates a method for removal of arsenic and iron contamination from the water according to one exemplary embodiment of the invention. In a preferred embodiment of the invention the arsenic contaminated water 120 enters in the pre-filter chamber 103. The metallic iron bed in combination with untreated rice husk ash (RHA) 102 is disposed in the prefilter-chamber and removes part of arsenic by adsorption in addition with iron impurities present in the water 120. The prefilter chamber will provide pre-filter water 120(a) as end results of its process.

In a preferred embodiment of the invention the removal of iron flocs in the prefilter stage causes creation of adsorption conducive water, wherein removal of iron contamination in water results in balanced pH (neutral) of water providing continuously improved adsorption capacity of ferric hydroxide coated RHA in the filtration stage. Highest adsorption capacity of ferric hydroxide coated RHA was observed for the pH range of 5.0 to 5.5.

In a preferred embodiment of the invention the said pH value of the pre-filtered water 120(a) is usually in range of 6.0 to 8.5 and preferably in the range of 6.0 to 8.5 that causes hiked adsorption capacity of the untreated RHA in pre-filter stage and ferric hydroxide coated RHA in the main stage.

In a preferred embodiment of the invention, at the pre-filter chamber 103 the said metallic iron is loosely packed along with untreated RHA 102 causing ample space creation for clogging prevention and enhanced contact surface area with the water allowing reduced contact time.

In a preferred embodiment of the invention the reduced contact time resulting in increased flow rates in the range of 10 Liter to 15 Liter per hour, wherein the Iron bed increases the overall adsorption capacity of the filter not the efficiency.

The efficiencies of RHA+Iron bed vs. RHA alone are almost same. The arsenic adsorption capacity ranges from 1.1-1.2 mg/g of adsorbent.

According to one exemplary embodiment of the invention the main filter chamber 104 removes remaining arsenic from the pre-filtered water 120(a) via the ferric hydroxide coated rice husk ash (RHA) 105 which increases the overall adsorption capacity of the apparatus 100.

In a preferred embodiment of the invention the combined filtration capacity of both the stages is in the range of 3000L of 300 ppb arsenic spiked ground water. This is based on the capacity of the iron+ coated RHA bed. Arsenic in input water was 300 ppb reduced to 10 ppb. The net reduction is 290 ppb per liter of water. The amount of arsenic removed by 1100 g of coated RHA is $290 \times 3000\text{L} = 870000 \text{ mg} = 870 \text{ mg}$. Adsorption capacity = $870/1100 = 0.8 \text{ mg/g}$.

In a preferred embodiment of the invention the two stage apparatus being compact and economical, the combined weight of the raw material therein is in the range of 1800gm to 8000gm wherein the iron bed ranges from 600-700 g of iron bed and coated RHA ranges from 1100-1200g.

In a preferred embodiment of the invention a metallic iron bed in combination with untreated rice husk ash (RHA) 102 removes the remaining arsenic was removed (99.67%) from ground water to below 10 ppb.

In a preferred embodiment of the invention the pre-filter chamber 103 removes arsenic (~30-50%) and iron (99%). In iron coated RHA bed 102 the remaining arsenic

was removed (95.0-99.67%) from ground water to below 10 ppb. The two stage filter makes its economically viable and practical arsenic removing filter/apparatus.

In a preferred embodiment of the invention the apparatus 100 uses 600 g of metallic iron with 100g of raw rice husk ash (RHA) for pre filter and 1100 g of coated rice husk ash (RHA), to make it light weight, compact, economical, etc. to treat 3000L of 300 ppb arsenic spiked ground water to below 10 ppb. The arsenic adsorption capacity of 0.8 - 0.82mg/g of adsorbent (based on weight of coated RHA) for ground water and 1.1-1.2 mg/g for arsenic spiked tap water.

In a preferred embodiment of the invention the input to filter is arsenic spiked ground water in the range of 300-2000 ppb. The water passed through the both filter beds (shown in Figure 3) 3) The filtered bed reduced arsenic in filtered water to less than 10 ppb. The arsenic removal efficiency of the combine filters is found to be 90-96%.

Example 1

About 50 g of iron powder/ scrap/ wire and 10 g of RHA was used to make column of 5 cm height. A 300 ppb of arsenic spiked ground water is passed through iron powder bed at the flow rate of 200-250 mL per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The arsenic spiked water continued to passed through the iron bed till the out put arsenic concentration reaches more than 50 ppb. The pH of input ground water was in the range of 7.8 -8.8 which comes down to 7- 7.5 range for the out put water.

The out put water has arsenic concentration below 10 ppb for 40L of input water passed. The results are given in Fig 5.

Example 2

About 50 g of iron powder/ scrap/ wire and 10 g of RHA was used to make column of 5 cm height. A 300 ppb of arsenic spiked ground water is passed through iron powder bed at the flow rate of 1.5 to 2.0 L per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The pH of input ground water was in the range of 7.8 -8.8 which comes down to 7.5- 8.5 range for the out put water. The out put water has arsenic was in the range of 120-150 ppb. For lower contact time or higher flow rate, the arsenic removal by iron column is 35-50%.

Example 3

About 20 g of coated rice husk ash was used to make column of 5 cm height. 300 ppb of arsenic spiked tap water is passed through coated rice husk ash bed at the flow rate of 1.0 to 1.2 L per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The arsenic spiked water continued to pass through the coated rice husk ash bed till the out put arsenic concentration reaches more than 50 ppb. Around 70L of 300 ppb of arsenic spiked tap water was treated using 20 g of coated rice husk ash to below 10 ppb of arsenic content. The pH of input and out put ground water was in the range of 6.8 -7.5.

Example 4

About 20 g of coated rice husk ash was used to make columns of 5 cm height. 300 ppb of arsenic spiked tap water of various pH 5, 6, 7 and 8 were passed through coated rice husk ash columns. The flow rate of input water was maintained at 1.0 to 1.2 L per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The arsenic spiked water continued to pass through the coated rice husk ash bed till the out put arsenic concentration reaches more than 50 ppb. The

result of effect of input water pH is shown in Table 1. The maximum arsenic removal capacity was found to be for pH of 5 of input water and it reduces with increase in pH

Table 1. Effect of input water pH on the adsorption capacity of ferric hydroxide coated RHA

Sl. No.	pH of input tap water	Volume of water treated by 20 g of ferric hydroxide coated RHA, L	adsorption capacity, mg/g
1	5	80	1.16
2	6	75	1.09
3	7	70	1.02
4	8	60	0.87

Example 5

About 20 g of coated rice husk ash was used to make column of 5 cm height. A 300 ppb of arsenic spiked ground water is passed through iron powder bed at the flow rate of 1.0 to 1.2 L per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The arsenic spiked water continued to pass through the iron bed till the out put arsenic concentration reaches more than 50 ppb. The pH of input and out put ground water was in the range of 7.8 -8.5. Around 40L of 300 ppb of arsenic spiked ground water was treated using 20 g of coated rice husk ash to below 10 ppb of arsenic content. It was observed that there was 55-58% reduction in the arsenic removal capacity of coated RHA when the arsenic spiked input water was changed to ground from tap water. This is due to two reasons, the total dissolved solids (TDS) in ground water was 2000-2500 as compared to TDS of tap water was 170-200. The pH of ground water was 7.8 -8.5 while the pH of tap water was 6.8 -7.5. The results are given in Fig 6.

Example 6

Two columns were prepared. In first column about 50 g of iron powder/ scrap/ wire and 10 g of RHA was used to make column of 5 cm height. The second column was made up 20 g of ferric hydroxide coated RHA was used to make column of 5 cm height. A 300 ppb of arsenic spiked ground water is passed through iron powder bed and ferric hydroxide coated RHA at the flow rate of 1.5 to 2.0 L per hour. The out put water was collected and analyze for arsenic at every 5 L of water passed. The arsenic spiked water continued to pass through the iron bed till the out put arsenic concentration reaches more than 50 ppb. The pH of input ground water was in the range of 7.8 -8.8 which comes down to 7- 7.5 range for the out put water. Around 65L of 300 ppb of arsenic spiked tap water was treated using combination of iron bed and coated rice husk ash bed to below 10 ppb of arsenic content.

Example 7

Filter beds were prepared using iron power and coated RHA. In first column about 150 g of iron powder/ scrap/ wire and 50g of RHA was used to make column of 15 cm height. The second column was made up 600 g of ferric hydroxide coated RHA was used to make column of 30 cm height. A 300 ppb of arsenic spiked ground water is passed through iron powder bed and ferric hydroxide coated RHA at the flow rate of 5 to 6 L per hour as shown in Fig 3. The out put water was collected and analyze for arsenic at every 100 L of water passed. The arsenic spiked water continued to pass through the iron bed till the out put arsenic concentration reaches more than 50 ppb. The pH of input ground water was in the range of 7.8 -8.8 which comes down to 7- 7.5 range for the out put water. Around 1500L of 300 ppb of arsenic spiked tap water was treated using combination of iron bed and coated rice husk ash bed to below 10 ppb of arsenic content.

The preceding description has been presented with reference to various embodiments of the invention. Persons skilled in the art and technology to which this invention pertains will appreciate that alterations and changes in the described apparatuses and methods of operation can be practiced without meaningfully departing from the principle and scope of this invention.

ADVANTAGES OF THE INVENTION

- 1) The present apparatus avoids clogging due to loose packing of a metallic iron bed in combination with untreated rice husk ash (RHA);
- 2) The present apparatus reduces the contact time and increases flow rates to 10-12 L/hr;
- 3) The present apparatus reduces 99.67% arsenic from the contaminated water resulting in Arsenic concentration below 10ppb which is within safety limit of human consumption ;
- 4) The present apparatus provides pre-filter which removes iron flocs and maintained pH to 6.5-7.5 range; and
- 5) The present apparatus is independent of input arsenic levels and can treat ~5000 ppb of Arsenic levels.

WE CLAIM:

1. An apparatus for removal of arsenic and iron contamination from water and simultaneous reduction in pH thereof, the said apparatus comprising:
a pre-filter chamber, further comprising a metallic iron bed combined with untreated Rice Husk Ash, the said pre-filtered chamber characterized in being capable of removing iron floc in input water; and
a main filter chamber comprising a ferric hydroxide coated Rice Husk Ash adapted to
receive water from pre-filter chamber water and capable of eliminating arsenic therefrom to the levels below 10ppb.
2. The apparatus of claim 1, wherein removal of iron contamination in water results in balancing pH of water ranging from 6 to 8.5.
3. The apparatus of claim 1, wherein the metallic iron bed is selected from the group of iron powder, iron nails, iron wire or iron fillings scrap.
4. The apparatus of claim 1, wherein the pre filter chamber removes up to 90-95% iron from the ground water.
5. The apparatus of claim 1, wherein the said pH value of the pre-filtered water is preferably in the range of 6 to 8.5 resulting in hiked arsenic adsorption capacity of the untreated RHA in pre-filter chamber and main filter chamber.
6. The apparatus of claim 1, wherein in the pre-filter chamber the said metallic iron bed is loosely packed with untreated RHA in a predetermined proportion 1:1 by volume causing ample inter particle space creation in the chamber.

7. The apparatus of claim 1, wherein the arsenic adsorption capacity ranges from 0.75 to 3.0 mg/g.
8. A method for removal of arsenic and iron contamination from the water with simultaneous reduction in pH thereof, the said method comprising steps of ;
 - a) pre-filtering of contaminated water by allowing the water to flow through a metallic iron bed in combination with untreated rice husk ash for continuously removing iron floc causing pH balancing of water fed in the pre-filter with enhanced arsenic adsorbability of the rice husk ash (RHA) and removal of arsenic thereby; and
 - b) Filtering of pre-filtered water by allowing the pre-filtered water to flow through a main filter chamber comprising a ferric hydroxide coated Rice Husk Ash (RHA) thereby eliminate Arsenic therefrom to level below 10ppb.
9. The method of claim 9, wherein removal of iron contamination in water results in balancing pH of water ranging from 6 to 8.5.
10. The method of claim 9, wherein the metallic iron bed is selected from the group of iron powder, iron nails, iron wire and iron fillings scrap.
11. The method of claim 9, wherein the pre filter chamber removes up to 90-95% iron from the ground water.
12. The method of claim 9, wherein the said pH value of the pre-filtered water is preferably in the range of 6.0 to 8.5 resulting in hiked arsenic adsorption capacity of the untreated RHA in pre-filter chamber and main filter chamber.

13. The method of claim 9, wherein in the pre-filtration chamber the said metallic iron is loosely packed with untreated RHA in a predetermined proportion causing ample inter particle space creation in the chamber.
14. The method of claim 9, wherein the Arsenic adsorption capacity ranges from 0.75 to 3.0.

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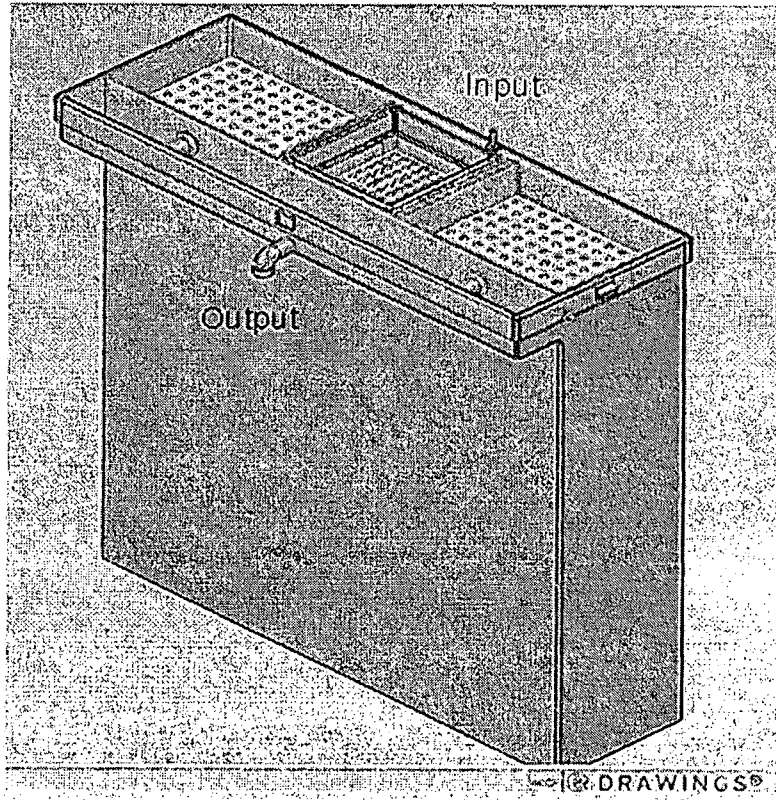


Figure 1

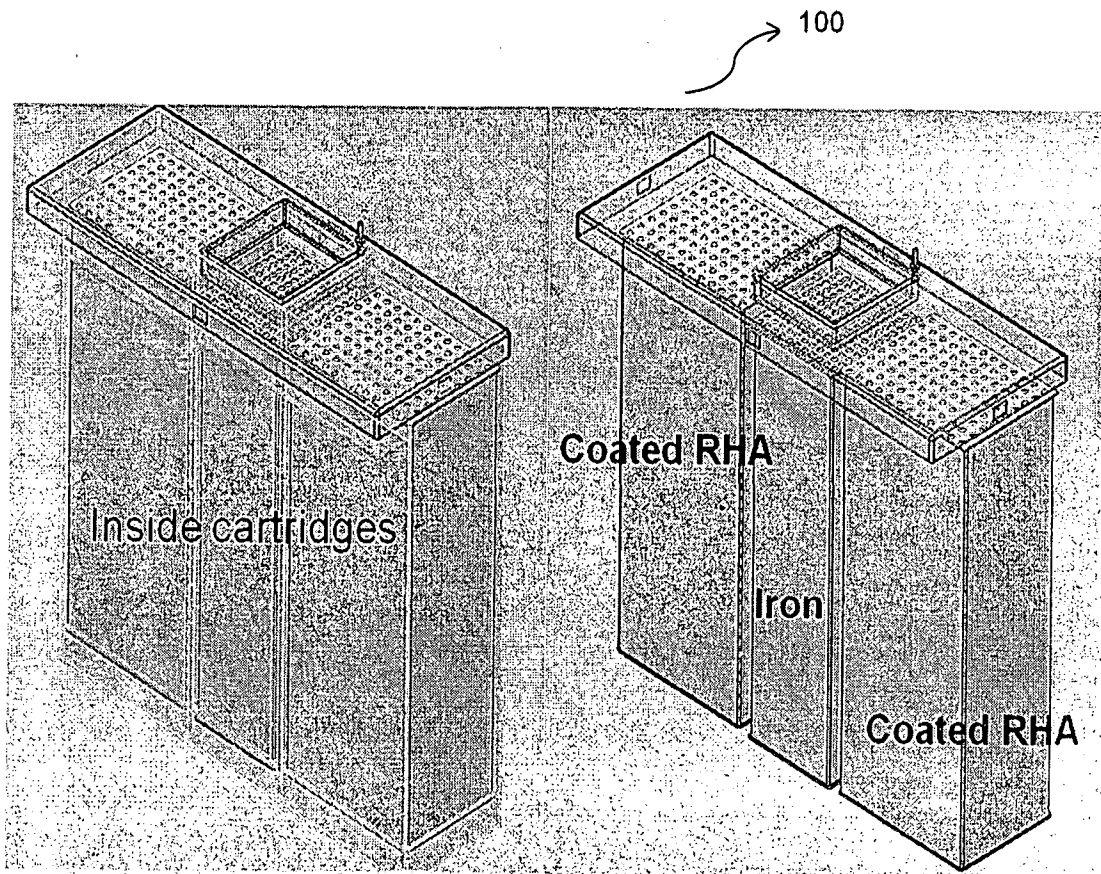


Figure 2

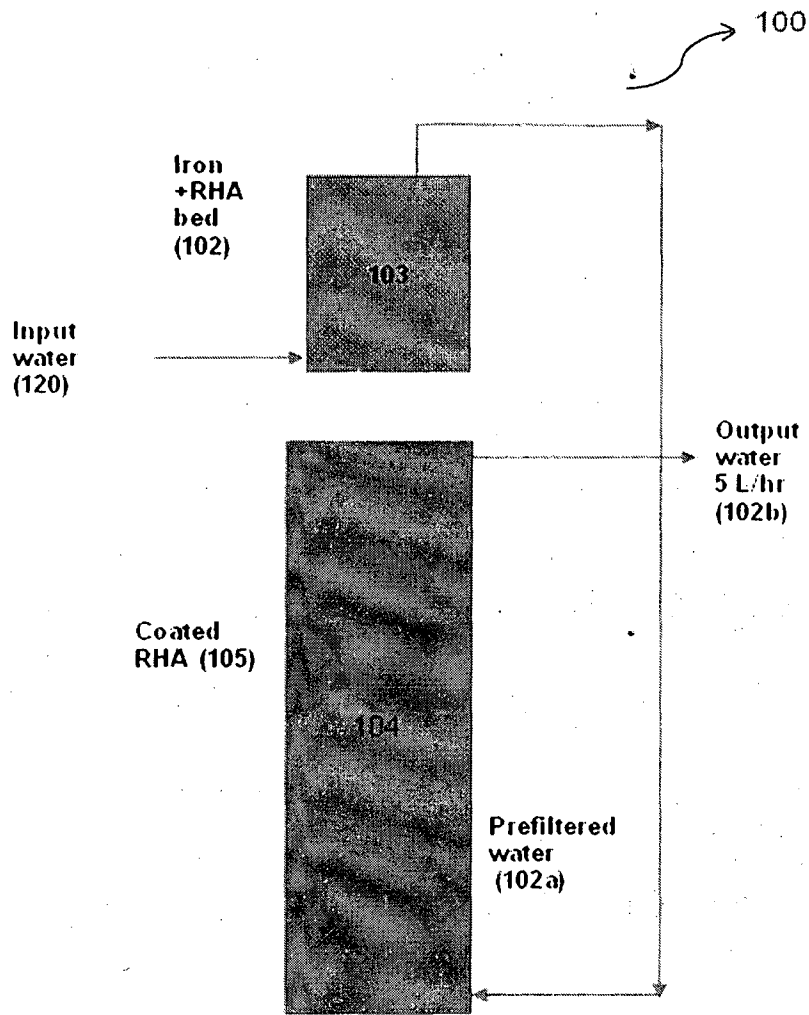


Figure 3

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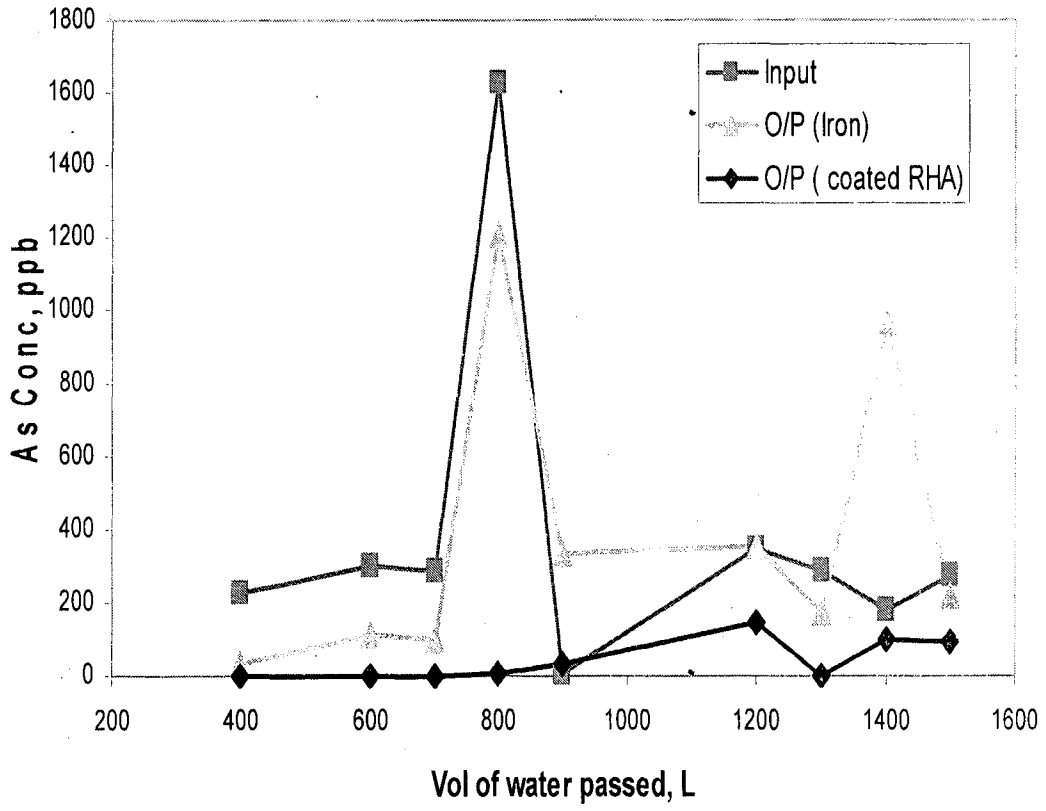


Figure 4

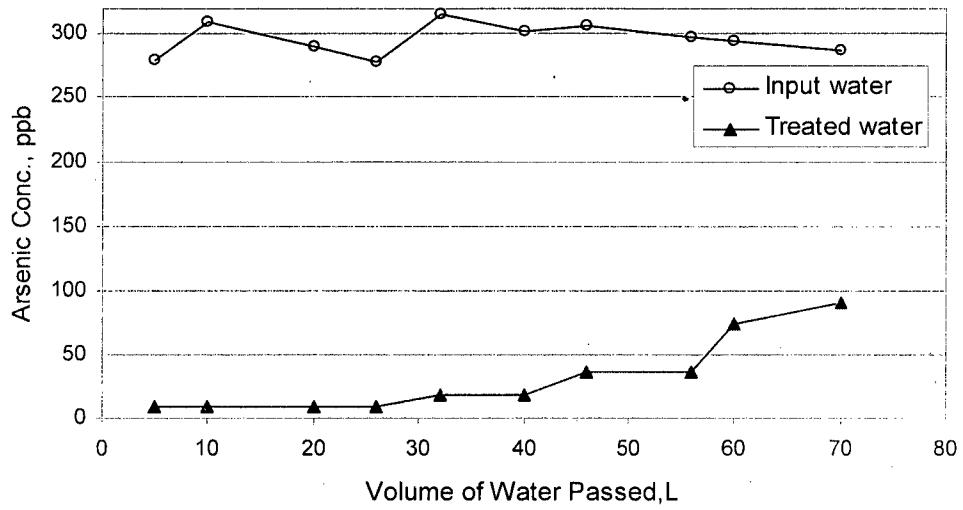


Figure 5

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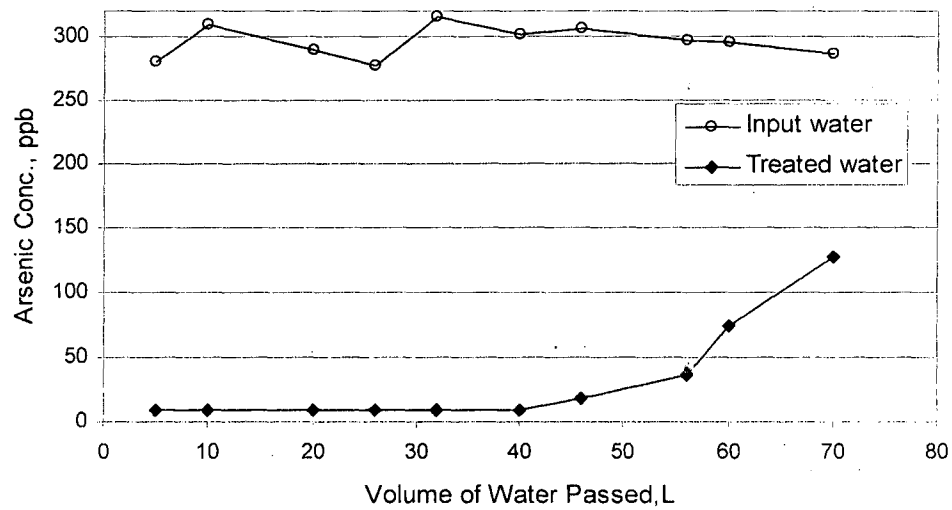


Figure 6

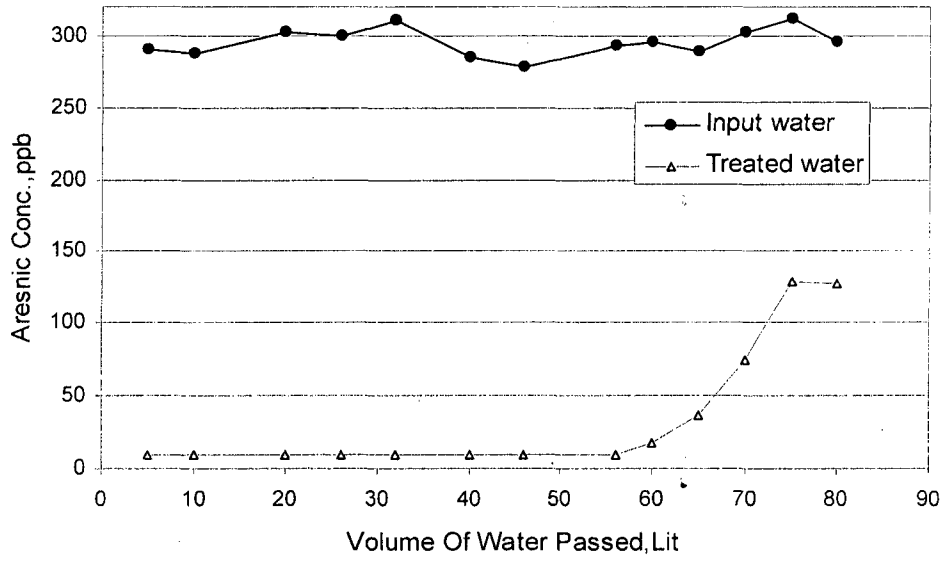


Figure 7