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Demonstration of household water filter device for Arsenic removal in the Gazipur district of U. P. state, India

Akshay Singh Tomar,[a] Priyanka Arya,[a] Surender Kumar,[b] Archana Singh[b] & I B Singh[b]*

[a]Academy of Scientific and Innovative Research (AcSIR), CSIR – Advanced Materials and Processes Research Institute, CSIR-AMPRI campus, Bhopal - 462026, India

[b]CSIR-Advanced Materials and Processes Research Institute, Bhopal- 462026 (Madhya Pradesh) India

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Millions of people in different states of India are suffering from the arsenicosis problem. There is an urgent need to solve this problem so far to the fullest extent to provide arsenic free water especially at household or domestic level. CSIR-AMPRI has developed a nano-adsorbent containing novel domestic water filter device that has been demonstrated to treat 3000-3500 L of <300 µg/L arsenic contaminated water. The device works with no need of any electrical energy at flow rate of 3-5 L/h. The present work is the case study of demonstration/installation of the develop device in the arsenic contaminated village, Karkatpur in the Gazipur district of the Uttar Pradesh, India. The developed filter device has been run for more than 3 months, where arsenic contamination level is <300 µg/L. The turbidity of water which mainly present due to the iron contamination along with arsenic in water is found to increase the choking of the filter after three months of installation.

Keywords: Arsenicosis, Nano-adsorbent, Arsenic, Cartridge, Water filter, Demonstration

1 Introduction

Arsenic occurs naturally in the earth crust and surrounding environment. Either by various natural activities like dissolution of rocks or human activities results in release of arsenic in water. Arsenic-contaminated drinking water can cause adverse health effects. Arsenic plays crucial role in making disturbance in RNA and DNA structure, which consequently lead to cancer. Increasing birth of exceptional child, low birth weight, malformed child and dead births were found due to effect of arsenic[1-5].

The arsenic contamination in groundwater is found to be more severing in the bank of Ganga-Brahmaputra fluvial plains in India and Padma-Meghna fluvial plains in Bangladesh. Their toxic effect to the human health is known as one of the biggest world natural groundwater calamities to the mankind. In India, seven states namely- Uttar Pradesh, West Bengal, Jharkhand, Bihar, Assam, Manipur and Chhattisgarh states have so far been reported affected heavily by arsenic contamination where, the arsenic concentration in ground water exceeds to the permissible limit of 10 µg/L (Drinking Water Specifications, IS revised 10500). People in these affected states have chronically been exposed to drinking arsenic contaminated ground water. Over the last 30 years, a number of precautionary measures like supplying of arsenic free water to the affected people, development of arsenic removal devices and their implementation at the field, etc. have been initiated in these areas. Various treatment technologies, based on oxidation, co-precipitation, adsorption, ion exchange and membrane process, has been developed but the question, regarding the efficiency and applicability/ appropriateness of the technologies is remained unsolved [6-10].

Among the different arsenic removal processes, technology based on adsorption is one of the more popular methods for the removal of arsenic. Though activated alumina is acceptable adsorbent but its low adsorbent capacity is limitation for use in development of alumina based water purification technology. It has been observed that gamma phase of nano alumina shows much better efficiency than activated alumina particles present in micrometer size [11,12]. Their unique features like high catalytic potential and reactivity, large surface area etc., makes nanoalumina efficient adsorbent of which even a small quantity can result in efficient removal of arsenic of a large volume of contaminated water. Along with the water treatment efficiency the whole synthesis process and the filtration device is cost effective. CSIR-AMPRI has managed to develop a

*Corresponding author (Email: ibsingh58@yahoo.com)

synthesis process where the naoalumina that posses an excellent arsenic removal capacity (25-30 µg/L) which is synthesized by a cost effective method (~ 700 Rs/kg) in bulk scale using inexpensive raw materials like aluminium salt, sodium hydroxide. The household filtration device was developed by incorporating synthesized nanoalumina in the single sediment removal water filter through nanocoating methodology. The present work is focused on the installation of filter devices in the Gazipur district of Uttar-Pradesh where the ground was found to be heavily affected by arsenic presence.

Geographical details of Ghazipur: Ghazipur is a district of Uttar-Pradesh. It is a part of the Varanasi division. The district has six tehsils. It has total geographical area of 3,384 km^2.

Geographical details of Karkatpur: Karkatpur is a small village in Karanda block in Ghazipur district of Uttar-Pradesh state in India. It comes under Karkatpur Panchayath. It belongs to Varanasi Division. It is located 17 km towards west from District headquarters Ghazipur. 342 km from State capital Lucknow. Karkatpur is surrounded by Zamania block towards east, dhanapur block towards west, devkali block towards west, Ghazipur block towards north. The village is situated 100 m away from the bank of the Ganges river.

2 Synthesis of Nanoalumina Particle and Filtration Device

Firstly, nanoalumina particle in the gamma phase was synthesized by simple precipitation method using aluminium salt and sodium hydroxide at control pH 7. The synthesised alumina nanoparticles, cartridges containing perforated tube surrounded by the alumina coated sediment cloth, connecting tube, overhead tank with 20 L capacity and filtered water storage tank. The arsenic quantification of the untreated and different volumes of treated water was done using Hach model testing kit catalogue number 2800000. The synthesized nanoparticles were incorporated into simple sediment removal filter through nano coating methodology. After incorporation nanoparticles in the filter, two filters each containing 150 gm of nanoalumina was kept in the series. One filter was the simple filter with no nanoparticles used to remove turbidity of water. The filtration device was installed in Karkatpur village in the month of May 2018.

3 Water Source

The water source was the handpump whole water done at 100 feet depth at the government primary school at the Karkatpur village.

Filtration device consists of overhead tank where the contaminated water was stored. It was connected to the inlet of the filter. The overhead tank was placed at the height of 4 feet from the filtration unit. The inlet of the overhead tank containing untreated water was connected to the filter unit, the outlet of which goes to the storage tank where arsenic free clean water was stored. The filters containing nanoalumina can also remove heavy metals like arsenic, fluoride, chromium etc from water.

4 Physicochemical Characterization of Water Sample

The ground water samples collected from the handpump of the primary school was used directly to testify the suitability of the developed filter for the arsenic removal under the natural field. The different properties of the raw water and the different volumes of treated water are listed in Table 1.

4.1 pH

The pH value indicates the concentration of H+ ions present in the water. This is an important parameter to determine the quality of water as well as the working efficiency of the developed nanoadsorbent. pH of the raw water was found to be 7.1 and as can be seen in the table that the pH of the water remains unaltered throughout the filtration process.

4.2 Total dissolved solid (TDS)

The total dissolved solid refers to any inorganic and organic solute in the water. The TDS of the treated water was found to slightly increased.

4.3 Salinity

Salinity depends on the total dissolved salt in water. The salinity of the water also remains same before and after the treatment.

Table 1 — Physico-chemical properties of different volume of water before and after treatment.

Water volume (L)	pH		TDS (ppm)		Salinity (ppm)		Conductivity (µs)		As (µg/L)	
	Before	After	Before	After	Before	After	Before	After	Before	After
1000	7.12	6.9	410	500	220	230	565	570	350	10
1500	7.2	7	400	450	210	215	552	561	350	18
3000	7.21	7.1	390	410	201	210	560	565	350	50

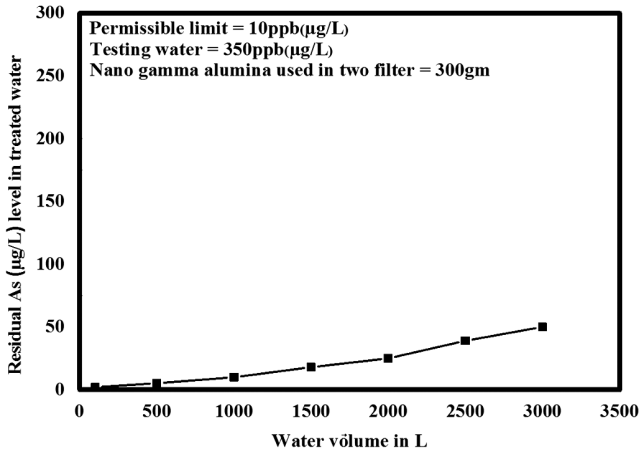

Figure 1 — Plot between residual arsenic level and water volume passed through filter.

4.4 Conductivity

The conductivity of the water depends on the dissolved solid ions. The conductivity of the treated water also showed slight increase which is in consistent with the TDS results obtained.

4.5 Arsenic removal studies

The raw water contains the 350 µg/L of the arsenic. The treatment of 100 L of water results in the almost 100 % removal of Arsenic with presence of ~2 µg/L As in the treated water. Going up to the 1500 L treatment results in 90 % removal of Arsenic that goes to 85 % removal efficiency for the 3000 L of water and the residual Arsenic exceeds the permissible limit. Arsenic removal efficiency can be seen from Figure 1.

5 Conclusions

In present study, the novel nanoadsorbent based sediment filter was tested directly in the field. The results showed that after a single device with two cartridges containing nanoalumina can treat 3000-3500 L of water with <300 µg/L arsenic. After 3000 L treatment recharge may needed to further remove As from water. This will be our future study interest. Interestingly, the presence of other ions in water did not affect the efficiency of the filter. The developed device was demonstrated to work efficiently in the field area without need of any electricity. The present work will be a significant step towards the development of the cost effective filtration device.

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