Arsenic contamination situation in Mekong delta and local methods for arsenic treatment

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Abstract

Arsenic is one of the most seriously toxicants in global environment. Humans can be mainly exposed to arsenic through water and contaminated water. Most arsenic is seen after arsenic exposure from drinking water. Mekong delta has been under risk from the arsenic contamination. The recent analyses indicated that high levels of arsenic contamination. The groundwater used for drinking water supply in some place reaches to 321 µg/L (Shinkai et al., 2007). Our survey and investigation from 2009 - 2014 also indicated that the arsenic contamination in not only in groundwater but also surface water with high concentration (Tuan, 2014). It is a severe risk for communities in Mekong delta. To help people in contaminated areas, we successfully designed the simple and cheap unit, which can remove the arsenic from the contaminated water by available materials in Mekong delta (Tuan, 2012). Model has been manipulated and multiplied in some regions in Mekong delta with larger scale which initially resolve arsenic problems in some communities.

Keywords: Arsenic, Mekong delta, Contamination, Model application

1. INTRODUCTION

People in the world are living in environmental risk, face up with water lack and poor quality water source is a serious problem for countries. Arsenic contaminated water source is a typical example, a trouble for some nations, especially Bangladesh, India, and China...Bangladesh where people found out the arsenic contamination in ground water. 98 percent of ground well water in countryside has been used for drinking and daily life was contaminated. Concentration of arsenic is higher than 0.05 mg/L – a Bangladesh standard, was found in 61/64 districts, 25% samples over 0.05 mg/L and 42% samples over 0.01 mg/L – WHO standard (Rahman, 2004).

In Vietnam, arsenic contamination was found out in ground water in Red river and Mekong deltas. Data collected from a survey of 12,461 drilled wells in 12 provinces showed that wells in Northern were contaminated more than that in Southern. Survey was conducted by Biotechnology, Vietnam Academic of Science and Technology on Thai Nguyen, Quang Ninh, Ha Tay, Ha Noi, Hue, Ho Chi Minh, Long An, Dong Thap and An Giang provinces (Thao, 2005).

In Tien Giang Province, data from a survey show that 392/1132 of drilled wells in 2004, 2005, 2006 were contaminated by ferrous and arsenic (Center for Preventive Medicine). Arsenic concentration ranges from 0.025 – 0.15 mg/L in Chau Thanh Dist. (12 samples), Cho Gao Dist. (12 samples). Especially, a survey by Center for Dept. of Resources and Environment, An Giang province indicated that 12 water supply plants which have arsenic contaminated water with 0.05 – 0.34 mg/L which over than that of Vietnamese and WHO standards.

Obviously, Mekong and Red River deltas have been under

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risk from the arsenic contamination. The recent analyses indicated that high levels of arsenic contamination in Mekong delta. The groundwater used for drinking water supply in some place reaches to 321 μg/L (Shinkai et al., 2007). Our survey and investigation in 2009 also indicated that the arsenic contamination in not only in groundwater but also surface water. It is a severe risk for communities in Mekong delta. To help people in contaminated areas, we design the simple and cheap unit, which can remove the arsenic from the contaminated water by available materials in Mekong delta. As a result, our filter unit can remove nearly 95 percent of arsenic in potable water and reduced the level of arsenic to WHO provisional guidelines (10 μg/L). The filter unit will be applicable for many areas in Vietnam and the other in the world.

As^{+3} is difficult to be removed than As^{+5}. According to EPA (2005), there are seven methods to remove arsenic from ground water: (1) oxidation-filter, ion exchange, activated aluminum absorption, flocculation-filter, upflow filter, growth flocculation, and electrolysis. In Vietnam, arsenic contamination in ground water was warned for long but there are no water supply plants that are responsible to treat arsenic. These plants have been in charge to treat ferrous but not efficient and difficult to be controlled (Con, 2008).

Many kinds of material were used to remove arsenic from contaminated water such as activated alumina, some polymer... and some high technologies such as nano membrane, reserve osmosis have been also used but they are so expensive for countryside people. Therefore, it is urgent to have some techniques and materials to remove arsenic from arsenic contaminated water sources. Each technology fixes the different condition and has to use chemicals. The present study was conducted to satisfy the requirement of arsenic removal with high efficiency, low cost materials, and easily operation. No chemical or little chemical used, available materials in nature, easily operation that are the advantages of this study and able to be applied in reality.

2. RESEARCH METHODS

2.1 Field survey

Data were collected in An Giang, Tien Giang and Dong Thap provinces by field survey to assess the situation of arsenic contamination. Samples were collected and analyzed in standard laboratory by Atomic Absorption Spectrometry.

2.2 Set up model

Model set up and run in laboratory before applying in reality. Relying on the arsenic concentration in analyzed water, experiments were run in Environmental Technology Laboratory, Faculty of Environment and Natural Resources, HCMC, Vietnam.

Water was contaminated by arsenic with concentration 19.27 ppb, pH at 6.8 – 7.0. Columns were packed with different materials as Ferrous contaminated sand; Activated carbon, Activated carbon and ferrous contaminated sand; Laterite; Brick; Laterite, brick and ferrous contaminated sand.

Arsenic contaminated water of inflow and outflow was analyzed at Analysis Center for Chemistry, Nong Lam University, Vietnam. Arsenic was measured by Atomic Adsorption Spectrometry method (AAS).

Model was run stably with arsenic and a flow rate 2.2 L/min in 2 days. Model was let for a rest in 1 day, and then run out the water. The arsenic contaminated water with arsenic 19.27 ppb was applied in model in 30 days at a flow rate 2.2 L/min, samples were analyzed. Samples were daily collected and analyzed.

2.3 Application

Arsenic treatment pilots were applied in where arsenic contamination at high concentration. Two kinds of pilot were applied: one for household, and the other for communities.

3. RESULTS AND DISCUSSION

3.1 Arsenic contamination in Mekong delta

Evaluation of arsenic contaminated concurrence in Tien Giang, An Giang and Dong Thap provinces. The analyzed results indicated that there is arsenic contamination in the provinces was occurring seriously, especially in An Giang and Dong Thap. Arsenic concentration in Tien Giang range from 2 – 25 ppb, in Dong Thap from 5 – 50 ppb, but in An Giang, arsenic was so high, ranging from 20 to 150 ppb, some sample over 500 ppb (Fig. 1).

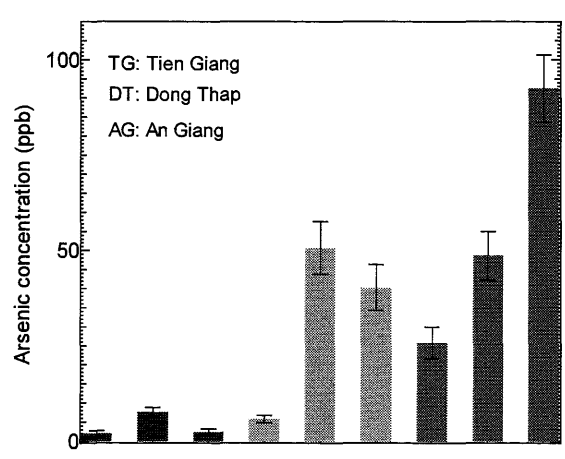

Fig. 1 Arsenic contamination in Mekong delta (case study Tien Giang, An Giang and Dong Thap provinces)

Arsenic contamination should be a big problem for Mekong delta. Communities are usually use water for their activities such as drink and cooking. High arsenic concentration in water will results in many problems for communities in the future. Some symptom were discovered in research region such as skin disease, keratoses (Fig. 2).

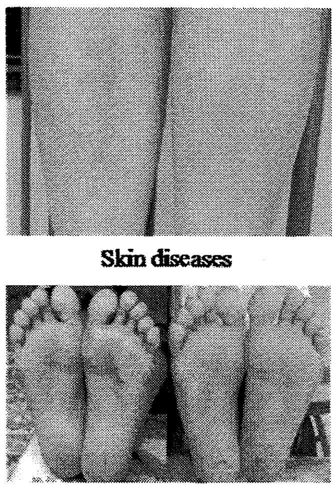

Fig. 2 Some symptom were discovered in community by arsenic contamination

3.2 Model running results

After running arsenic contaminated water through the material columns, there were five samples having arsenic concentration meet WHO standard (< 10 ppb). The material composed from sand, brick and laterite getting highest efficiency by 100 %, next the ferrous contaminated sand by 98.55 %, and lowest is activated carbon by 34.46 %, with outlet concentration at 12.63 ppb. The rest sample had efficiencies from 52 to 90 %, and meet WHO standard (Fig. 3).

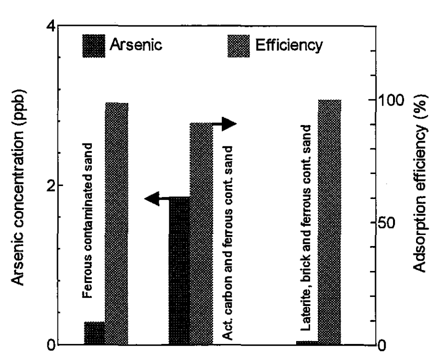

Fig. 3 Arsenic adsorption on the surface of materials depends on the interaction of arsenic (III)/(V) and materials

For *ferrous contaminated sand*, the arsenic adsorption efficiency is really high at 98.55%, arsenic concentration at outlet only 0.28 ppb which reaches WHO standard as well as Vietnamese standard (< 10 ppb). That material play a role as supporting substrate where arsenic attaches and the material surface contain pores which increase stacking ability of arsenic. Besides, material collected from Mekong delta and its surface contaminated ferrous actually. While arsenic contaminated water passed through, Fe (II) hydroxide will be oxidized by oxygen in water or in air to become Fe (III) hydroxide. Fe (III) hydroxide continuously precipitates on material and constitutes thin layer. Arsenic (V) and arsenic (III) in water will be absorbed by Fe (III) hydroxide and this compound will be kept on material. The reaction in material column is shown as equations below:

$$Fe\,(II) + O_2 \rightarrow Fe\,(III)$$

$$Fe\,(III) + As\,(III) \rightarrow Fe\,(II) + As\,(V)$$

$$Fe\,(II) + O_2 \rightarrow Fe\,(III)$$

$$Fe\,(III) + As\,(V) \rightarrow FeAsO_4$$

$FeAsO_4$ precipitates with Fe $(OH)_3$ and will be kept on the material surface. As the result, arsenic in contaminated water was removed or adsorbed by ferrous contaminate sand material.

For *activated carbon*, the adsorptive efficiency was really low, 34.46%. Arsenic concentration remained after filtration by column was 12.63 ppb higher than that of standard for potable water. That was because of activate carbon is neutral although it contains many pores in its structure. In filtration process activated carbon can absorb some soluble substances in water resulting in the pores having no more space for arsenic adsorption.

Activated carbon is porous material containing many kinds of pores with different diameters. Under electron microscope, activate carbon has a structure like ant's nest. Therefore it has large contacting surface to adsorb contaminants. However, activated carbon was used in those experiments has a diameter from 3 to 5 mm, and arsenic contaminated water passing through spaces among particles instead of going into pores. Moreover, the main reason is that activated carbon only adsorbs the high electrolytes instead of low electrolytes as arsenic. As the result, arsenic was absorbed by activated carbon at low efficiency.

For *carbon and ferrous contaminated sand material*, the result indicated that arsenic was adsorbed with nearly high efficiency at 90.35%. Arsenic in outlet was 1.86 ppb.

Material was packed by 2 layers with thickness of activated carbon and ferrous contaminated sand was 20 cm and 25 cm, respectively. Activated carbon adsorbs high electrolyte substances. Therefore, arsenic was only kept a little on activated carbon layer. In that case, activated carbon played a role as supporting filter which adsorbs contaminant in water. Arsenic contaminated water continues to run down to ferrous contaminated sand and arsenic was kept on second layer with high efficiency in 4 days running.

With *laterite*, filtering efficiency was 51.69%, and arsenic concentration at outlet was 9.31 ppb, which satisfies WHO standard. That is also a material can be used for arsenic adsorption. For material structure, laterite is porous, containing many spaces and its chemical composition is ferrous abundant. When arsenic contaminates water runs into material, reaction can be occurred as:

$$H_3AsO_3 + O_2 \rightarrow 2H_2AsO_4^- + 2H^+$$

$$Fe(OH)_3 + H_3AsO_4 \rightarrow FeAsO_4.2H_20 + H_2O$$

Arsenic co-precipitate with Fe^{3+} and create a complex which attach to laterite layer with high concentration. However, for long time filtration, laterite could be broken down into smaller partical and runs down with attached arsenic, resulting in reducing the filtering efficiency of laterite material.

For brick, with filtration efficiency 61.08%, arsenic concentration 7.5 ppb at outlet, brick has average filtering efficiency but meet WHO standard for drinking water. Brick after milling into smaller particles has 2 – 4 mm in diameter. Material is high permeable for water, sporous and containing iron, manganese...Iron in brick includes Fe (III) and Fe (II), while be oxidizing Fe (II) become Fe(III) in precipitation state. Fe (III) contacts arsenic to form $FeAsO_4$ which attach to brick particles. Therefore, arsenic contaminated water significantly reduces. Brick has a lifetime longer than laterite, filteration efficiency higher than that of laterite for long time.

With the composition of *sand, brick and laterite* in column, result indicated that experimental material got highest efficiency (100%), and did not remain arsenic at outlet. That can be explained as: formation of three kinds of material from upper laterite, center brick, and lower sand, while arsenic contaminated water running form up to down, at laterite layer containing Fe, Mn..., Fe, Mn will be oxidize, then contacte arsenic to form $FeAsO_4$ precipitation and be kept partly there and on the following lower layer. While continously running brick which containing much Fe (II) be oxidized into $Fe(OH)_3$ and arsenic react with Fe(III) to form $FeAsO_4$ precipitation. A mount of arsenic will be kept on this layer. Finally, while running through sand layer, sand has many small spores playing a role of supporting layer where $FeAsO_4$ coagulants attach. Mowever, sand collected from Mekong delta where ferrous contaminated water appears casually. Sand surface can be contaminated by ferrous and reaction for keeping arsenic on material easily occurs, then $FeAsO_4$ coagulants fix to materials. As the result, three layers all can react with arsenic to keep it on their surface with high efficiency.

3.3 Arsenic treatment application

Model run successfully in laboratory was applied in reality by two method: (1) for household (Fig. 4) and (2) for communities (Fig. 5).

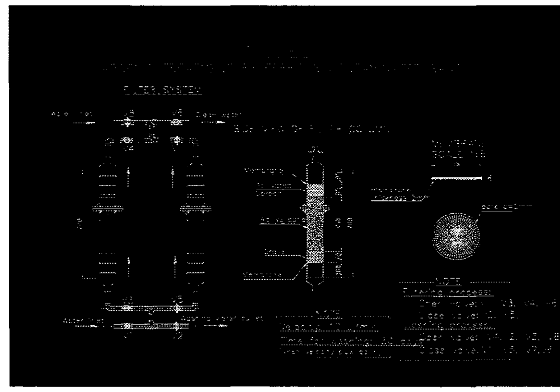

Fig. 4 Model applied for household

Fig. 5 Model applied for communities

Application of arsenic treatment in household and in communities was conducted successfully. All model can take in charge of arsenic treatment efficiently. Arsenic concentration in outlet of model is below 5 ppb. The model not only treat arsenic but also reduce iron ion in water. That work initially make people believe in simple and safe technology. Besides, model were determined as cheapest in market at the moment.

4. CONCLUSION

Arsenic comtamination in Mekong delta is worry thing at the moment. Data indicated that some regions in Mekong delta were contaminated arsenic with high concentration and some symptom were discovered in research fields.

The adsorption efficiency of arsenic will significantly increase by using laterite, brick and ferrous contaminated sand (100%) and ferrous contaminated sand (98.55%), but the second materials was more stable than the first and time for operation is also longer. Therefore, ferrous contaminated sand was chose for designing filter model which used for households in Mekong delta.

In utilization, people recognize the filtering model is able to remove ferrous efficiently. In arsenic contaminated regions, there are usually an amount of ferrous in water. Relying on the co-precipitaion of arsenic and ferrous and natural oxidation of arsenic and ferrous, the proposed model is useful for arsenic removal with low cost design and operation. That is the need of countryside people. Model never use any chemical to improve the efficiency, thus it is friendly for environment.

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