A new material could effectively treatment of arsenic-contaminated water

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ABSTRACT: Arsenic-contaminated water is one of the seriously environmental problems around the world. Developing arsenic removal materials have become the major focuses. Mesopaper, which is synthesized by nano-scale porous powder and paper in a sandwich structure, have been developed recently. In this study, we selected three arsenic-contaminated water samples, including two samples collected from different Chinese arsenic-endemic areas and one sample collected from Chinese Shimen realgar mine, to test its effectiveness in arsenic removal. Our findings have shown that arsenic concentrations of the three samples were significantly decreased after filter through one layer and two layers of Mesopaper. The arsenic removal efficiency for the two layers of Mesopaper was significantly higher than that shown in one layer. Additionally, the adsorbed arsenic leaching rate of nano-scale powder, which the active media for arsenic removal in Mesopaper, in different pH value solutions were all relatively low. Together, all above findings have suggested that the Mesopaper has high effectiveness in treatment of arsenic-contaminated water and without secondary arsenic pollution.

1 INTRODUCTION

Arsenic is a naturally occurring metalloid and ubiquitously distributed in the environment. People could exposure to arsenic via water, air and soil. On the global scale, drinking arsenic contaminated water is the most common way for people exposure to arsenic (Naujokas *et al.*, 2013; Tang *et al.*, 2016). It has been well known that long-term arsenic exposure could induce enormous health hazards. And therefore, developing technologies and materials that could treatment of arsenic-contaminated water could be the only effective option to minimize the health hazards. Up to now, technologies including oxidation, phytoremediation, coagulation-flocculation, adsorption and membrane have been used to remove arsenic from contaminated drinking water (Singh *et al.*, 2015). A number of materials developed based on these technologies have also been reported. However, most of these materials could not achieve satisfactory arsenic removal results in field testing and their by-products could be further potential secondary arsenic pollution. The two drawbacks have become major limitations for these materials applied in practice. In this report, we describe a new material named as Mesopaper that can effectively remove arsenic from natural water and we hope it will give a new insight on the arsenic removal.

2 METHODS/EXPERIMENTAL

2.1 Synthesis of Mesopaper

The Mesopaper is synthesized by nano-scale powder and paper in sandwich structure. The nano-scale

powder is composed of porous ceramic coated with nano zero-valent iron (NZVI), clay and carbon. The detailed processes for producing the Mesopaper has been listed in patent PCT/US17/53452.

2.2 Water samples collection

In this study, we selected three natural arsenic-contaminated water samples, including two groundwater samples and one mine wastewater sample, to test the removal efficacy of the Mesopaper. The groundwater samples were collected from Sasuoma Village located in Gansu Province and Gangfangying Village located in Inner Mongolia Autonomous Region, respectively. The two regions are both naturally serious arsenic pollution areas in China. The mine wastewater sample was collected from Shimen realgar mine, located in Hunan Province in central south China. The Shimen realgar mine area is the largest realgar deposit in Asia and had been halted production in 2011. However, a large amount of arsenic residue waste and arsenic ash were dumped on the soil surface and subjected to erosion and weathering processes, causing long-term and severe impact on local environment. Therefore, the arsenic content in the water in the mine area was extensively high. All of the three water samples were collected and then transported to our laboratory.

2.3 Arsenic filtration experiment

A square box with basal area of 88 cm² was used as filter container. The Mesopaper was folded well and putted in the filter and to ensure no water leakage.

Table 1. The arsenic concentrations of water before and after filtered through Mesopaper.

	Gansu ($\mu\text{g L}^{-1}$)		Innner Mongolia ($\mu\text{g L}^{-1}$)		Hunan ($\mu\text{g L}^{-1}$)	
	One layer	Two layer	One layer	Two layer	One layer	Two layer
Startup	729	729	1658	1658	86580	86580
0.2 L	3	0	26	0	47849	1125
0.4 L	5	0	82	5	79454	27277
0.6 L	13	0	557	38	80745	53796
0.8 L	21	0	685	80	77566	65696
1.0 L	33	0	843	129	82520	68370

And then, 1 liter (L) water sample was prepared and poured through the Mesopaper, with 0.2 L every time. The arsenic concentrations were determined at accumulated filtration volume of 0.2 L, 0.4 L, 0.6 L, 0.8 L and 1 L. In this study, we tested the arsenic removal efficiency of one layer and two layers of Mesopaper, respectively.

2.4 Arsenic leaching experiment

The major activated media for Mesopaper to remove arsenic is the nano-scale powder. And then, we directly tested the arsenic leaching rate of nano-scale powder equipped with enough arsenic. 2 g nano-scale powder that had been adsorbed nearly 3.56 mg arsenic were weighted and putted into 100 mL solutions with different pH values of 3, 5, 7 and 9, respectively. After stirring for 5 minutes, the supernatant liquid was extracted to determination of arsenic concentrations.

2.5 Arsenic determination

The arsenic concentrations of all water samples in this report were measured using hydride generation-atomic fluorescence spectroscopy (HF-AFS).

3 RESULTS AND DISCUSSION

3.1 Arsenic removal efficiency

Table 1 displays the removal effect of As by Mesopaper. It was obvious that the arsenic concentrations of the three samples were all significantly decreased after filter through one layer and two layers of Mesopaper. In Gansu samples, for example, more than 90% arsenic was adsorbed by one-layer Mesopaper and the final arsenic concentrations was below $10 \mu\text{g L}^{-1}$ at the sampling point of 0.2 L and 0.4 L. In addition, our findings have also suggested that the arsenic removal efficiency for two layers of Mesopaper was

Table 2. The arsenic leaching rate of nano-scale powder.

pH values	Arsenic concentration ($\mu\text{g L}^{-1}$)	Arsenic leaching rate (%)
3	150	0.42
5	10	0.03
7	7.5	0.02
9	10	0.03

Note: The arsenic leaching rate were calculated as [(arsenic concentration * 100 mL)/3.56 mg].

significantly higher than that shown in one layer. We supposed that the better efficiency might be associated with the relatively much more nano-scale powder and large surface area presented in two layers of Mesopaper. Together, all above findings have suggested that the Mesopaper has highly effective in treatment of field arsenic-contaminated water.

3.2 Arsenic leaching rate

As it listed in Table 2, the arsenic leaching rate in solutions with pH values of 3, 5, 7 and 9 were all relatively low. The findings give evidence on that the nano-scale powder used in Mesopaper has no secondary arsenic pollution.

4 CONCLUSIONS

The Mesopaper has high effectiveness in treatment of field arsenic-contaminated water and without secondary arsenic pollution.

ACKNOWLEDGEMENTS

This work was sponsored by National Natural Science Foundation of China (Code number: 81703172).

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