

The effect of carbon steel-wool in removal of arsenic from drinking water

V. Campos

Abstract This paper attempts to prove that the removal of arsenic in drinking water is a combination of the granular activated carbon and carbon steel-wool. The steel-wool filter is the most important in residential applications. The single most important consideration is the empty bed contact time. Removal of inorganic arsenic to parts per million (ppm) or parts per billion (ppb) levels within 15 to 30 min is fairly common. Immobilization techniques are likely to continue to gain importance in the world.

Keywords Arsenic in drinking water · Remediation · Steel-wool

Introduction

For many years the attention of the scientific community was focused on the element mercury (Hg). This was triggered by its toxicological relevance, which became known to the public with the outbreak of the Minamata disease in 1956. Today, arsenic (As) is in the focus of public attention, mainly due to the almost epidemic health problems of hundreds of thousands of people in Bangladesh and West Bengal who ingest contaminated groundwater (Albernathy and others 1997). Although As (III) is more toxic, human metabolism of As (V) involves reduction to As (III) before undergoing detoxification by methylation. Long-term exposure to low concentrations of arsenic in drinking water can lead to skin, bladder, lung, and prostate cancer. Non-cancer effects of ingesting arsenic at low levels include cardiovascular disease, diabetes, and anemia, as well as reproductive and developmental, immunological, and neurological effects (Renzoni and others 1994).

Arsenic is a metalloid element that has been notorious for its toxicity. It is introduced into natural waters from a variety of sources and causes various adverse effects on living bodies when its concentration exceeds the permissible limit of $50 \mu\text{g L}^{-1}$, the standard for arsenic set by the US Environmental Protection Agency (EPA). Occurrence of arsenic in groundwater can be attributed to natural sources or be induced by anthropogenic activities or through a combined effect (Bhattacharya and others 1995; Scott and others 1997).

The Brazilian ceramic industry has been producing terracotta gravity water filters for more than 50 years. Older people in rural areas of many cities were in the habit of keeping drinking water on clay material as they believed in the refreshing and purifying properties of micropore filter candles, which remain on the bottom half of the terracotta unit and are constantly refreshed by the water's evaporation through the clay. The filter candles are filled with granular activated carbon (GAC). The granular activated carbon is a charcoal that comes from coconut shells and is known all over the world and is becoming widely used for water systems (Fig. 1). This paper shows that the removal of arsenic in drinking water is thus a combination of the effects of granular activated carbon and steel-wool (Fig. 2). Low cost in-home treatment methods are required for rapid removal of arsenic from contaminated drinking waters. The affected population normally reside in rural and mining villages with little money. The key factors for successful implementation of steel-wool processes are efficient removal of the arsenic from the drinking water and an affordable cost. The method is based on use of steel-wool as a cleaning agent and has proved to work on a larger scale.

Samples were weighed and placed in tubes, and 50 mL of solution containing the solutes was added. The pH of the mixtures of all of the experiments ranged from 6.1 to 6.8. An equilibration interval of 15 min was established by preliminary kinetic studies with all solutions on adsorbent material. The suspensions were mixed with a temperature-controlled water bath operated at $25 \pm 0.5 \text{ }^\circ\text{C}$. After 15 min the suspensions were placed in a centrifuge for 5 min, then decanted for analysis. The solute solutions were made with a K-based compound (AsH_2KO_4). For the batch sorption experiments different pre-treatments were necessary, arsenic amounts were equivalent to 0.5 to 10 mg L^{-1} . The amount of arsenic adsorbed by materials (steel-wool and GAC) is given in Fig. 3.

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V. Campos
Department of Environmental Geology,
Geosciences Institute, São Paulo University,
Rua Kyoto, 98-Jardim Japão, São Paulo, Brazil
E-mail: vcampos@usp.br

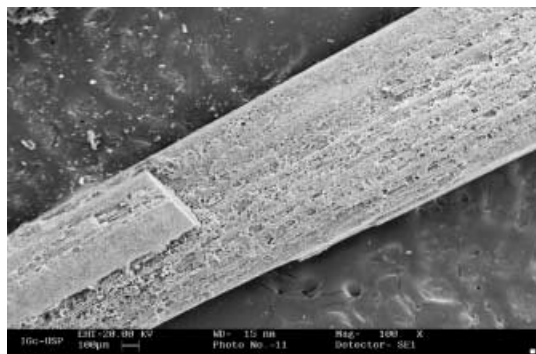


Fig. 1

Scanning electron micrograph of typical structure of granular activated carbon (GAC)

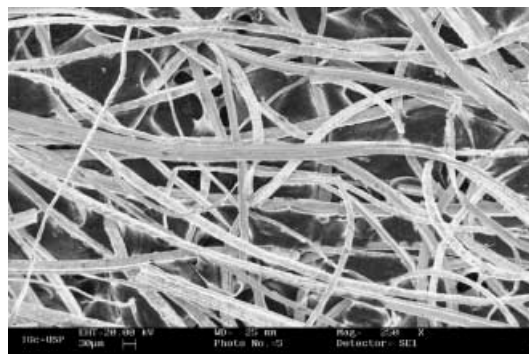


Fig. 2

Scanning electron micrograph of typical structure of steel-wool

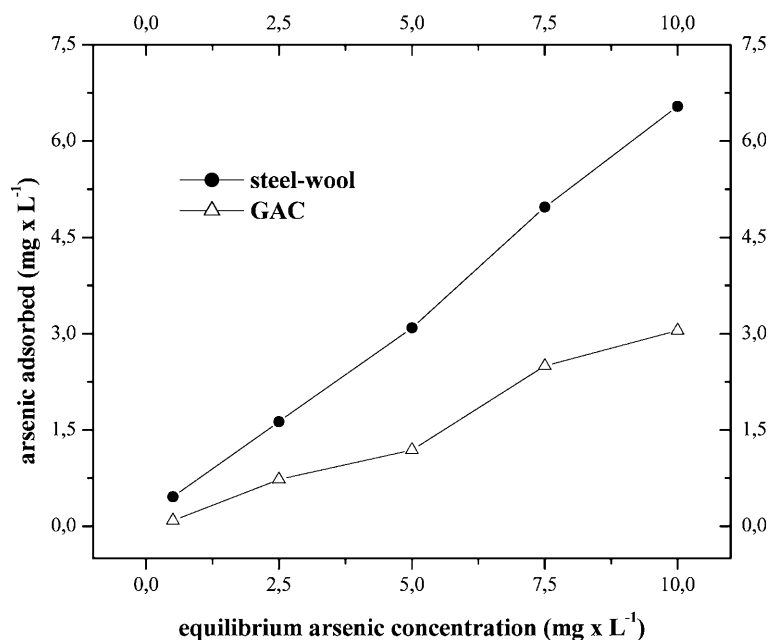


Fig. 3

The amount of arsenic adsorbed by steel-wool and GAC is a function of concentration (mg L^{-1}). It is important to note that the increased concentration accompanied an increase in adsorption of arsenic

With the reaction of arsenic with steel-wool, the rapid retention of the steel-wool was observed. The mechanism of adsorption can occur under low concentrations (0.5 mg L^{-1} As, in this case) at normal conditions of pH (6.4 to 7.2).

The ability of activated carbon to adsorb arsenic is directly related to its porous nature. In describing the porosity, several characteristics are important: pore size, pore volume, surface area, and spatial distribution of pores within the carbon particle. Scanning electron microscopy reveals information on the size and shape of pores. In the macropores, the specific surface area is small and contributes very little to adsorption.

The adsorption capacity of the steel-wool is high due to electrochemical reactions of iron–arsenic (redox processes at steel-wool surface).

The amount sorbed on the two materials were not of the same order of magnitude but the combination of GAC, ceramic candles and steel-wool can remove arsenic from drinking water.

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