



# Arsenic adsorption using copper (II) oxide nanoparticles

A. Goswami<sup>a</sup>, P.K. Raul<sup>b</sup>, M.K. Purkait<sup>a,\*</sup>

<sup>a</sup> Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati 781039, Assam, India

<sup>b</sup> Defence Research Laboratory, Tezpur, Assam, India

## ABSTRACT

Arsenic poisoning is a major problem in today's life. To reduce its concentration in drinking water, different metal based compounds were explored as arsenic adsorbents. In the present study, copper (II) oxide nanoparticles were prepared by thermal refluxing technique and used as an adsorbent for arsenic removal from water. Characterization of the adsorbent using TEM, BET, XRD and FTIR implied that the prepared adsorbent was in nano size and had excellent adsorption behavior with surface area of 52.11 m<sup>2</sup>/g. Systematic adsorption experiments were carried out with different process parameters such as contact time, adsorbent mass, pH, temperature and stirring speed and found that copper (II) oxide had very good efficiency towards arsenic adsorption. Thermodynamic parameters and adsorption kinetics were studied in detailed to know the nature and mechanism of adsorption. Results showed that the adsorption process followed pseudo second order kinetic and endothermic behavior. Adsorption equilibrium was studied with Langmuir and Freundlich isotherm models. The adsorption process followed Langmuir isotherm with an adsorption capacity of 1086.2 µg/g. A regeneration study was proposed in order to reuse the adsorbent for better economy of the process. Finally, a process design calculation is reported to know the amount of adsorbent required for efficient removal of arsenic from aqueous medium.

© 2011 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

**Keywords:** Arsenic; Copper (II) oxide; Adsorption; Kinetics; Isotherm

## 1. Introduction

Arsenic is one of the most harmful and toxic element found in nature. It is a slow poisoning element which affects the human health severely. Naturally arsenic is found in rocks and minerals. Due to weathering and erosion of rocks and soils and volcanic emissions, arsenic is in contact with the ground water and creates pollution. Apart from natural sources, arsenic contamination is also due to anthropogenic activities like arsenic pesticides, mining, industrial chemical waste and burning of fossil fuels. Industrially arsenic is mainly used as a wood preservative and hence, it has been used in dyes, paints and pigmenting substances. It is also used in glass-making, electronics manufacturing and leather tanning industries. A small amount of arsenic is used in both human and animal medications and care products, and it is present in many food supplement products also. Hence, long-term exposure to inorganic arsenic compounds can lead to various diseases such as conjunctivitis, hyperkeratosis, hyper pigmentation, cardiovascular diseases, disorders of the central nervous system and

peripheral vascular system, skin cancer and gangrene of the limbs (Bhattacharya et al., 2007). Thus treatment of arsenic contaminated water is necessary before intake.

Countries like Bangladesh (Harvey et al., 2006), China, India (Chatterjee et al., 1995), United States, Chile, Taiwan, Vietnam (Berg et al., 2001; Hug et al., 2008), Mexico, Argentina (Bundschuh et al., 2004), Poland, Canada, Hungary, New Zealand and Japan (Smedley and Kinniburgh, 2002) are affected with arsenic contamination. Among these, Bangladesh and West Bengal of India are highly arsenic polluted areas where arsenic concentration in water is much higher than that of WHO limit (10 µg/L) (WHO (Ed.), 2004). Naturally, arsenic occurs in different oxidation states. In water, it may appear in both organic and inorganic forms. Inorganic forms of arsenic such as As (III) and As (V) are the most harmful to human health. As (III) is significantly more toxic and mobile than As (V). It is also more difficult to remove by conventional treatment methods. Therefore, most purification techniques require pre-oxidation of As (III) to As (V) for effective arsenic removal, causing added complexity.

\* Corresponding author. Tel.: +91 361 258 2262; fax: +91 361 258 2291.

E-mail address: [mihir@iitg.ernet.in](mailto:mihir@iitg.ernet.in) (M.K. Purkait).

Received 24 August 2011; Received in revised form 4 December 2011; Accepted 6 December 2011

0263-8762/\$ – see front matter © 2011 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

doi:10.1016/j.cherd.2011.12.006