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Review

Review of arsenic contamination, exposure through water and food and low cost mitigation options for rural areas

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ABSTRACT

Arsenic (As) is a toxic metalloid found to be an important groundwater contaminant of mainly natural geogenic origin worldwide particularly in large deltas and along major rivers in poor regions of South- and East-Asia. Excessive and long-term human intake of toxic inorganic As with food and water is causing arsenicosis, which is disfiguring, disabling, and leading to potentially fatal diseases like skin- and internal cancers. It is estimated that more than 100 million people mainly in developing countries are at risk. The arsenicosis situation in affected countries has been named the largest chemical threat to public health ever experienced and arsenicosis is spreading to regions where near-sterile well water loaded with As has replaced microbial suspect surface water containing lower As concentrations. This review provides an overview of the state of the art knowledge on the water and food As intake and exposure, and how the As chemistry in water and food may influence chosen mitigation strategies. Although reports on severe health effects from exposure to As in water are abundant there are several weak points in our knowledge on causes and prevalence of arsenicosis in order to devise effective mitigation. The main mitigation strategies focus on drinking water based on exploration of As-free water and As removal from extracted water, whereas mitigation strategies on cooking water and reducing exposure through food are quite often overlooked. The experiences of adopted low cost methods for lowering the human intake of As in rural areas are critically evaluated in terms of public acceptance, sustainability and impact on arsenicosis.

Contents

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1. Introduction

This review deals with the relevant technical and societal options employed for relieving and preventing high human exposure of Arsenic (As) through water and food in poor rural regions of the world contaminated with As in groundwater and soils.

High natural concentrations of As in groundwater combined with the installation of several millions of tube wells mainly in South and East Asia has inadvertently led to one of the most serious environmental health problems in history (World Bank, 2005a,b). Excessive and long-term (such as 5–10 years) human intake of toxic inorganic As may cause arsenicosis, which is a common term used for As related health effects including skin problems, skin cancers, internal cancers (bladder, kidney, lung), diseases of the blood vessels of the legs and feet, and possibly diabetes, high blood pressure and reproductive disorders (WHO, 2011). Arsenicosis has dire consequences for the livelihood, family life and earning capability when individuals fall victim. In particular women are socially excluded when physical appearance is deteriorating. In a wider perspective excessive As contamination of a region may lead to societal stress, with severe poverty due to many disabled individuals and to lowered income as potentially contaminated agricultural produce may be shunned by the market (e.g. Brinkel et al., 2009).

Due to absence of taste, odour and colour, exposure to As is impossible for layman to detect and avoid. Applying the WHO provisional guideline for drinking water of 10 μg/l of As a population of more than 100 million people worldwide is at risk, and of these more than 45 million people mainly in developing countries from Asia are at risk of being exposed to more than 50 μg/l of As, which is the maximum concentration limit in drinking water in most of the countries in Asia (estimate based on the data from Ravenscroft et al., 2009).

The major arsenicosis regions are presently found in large deltas and/or along major rivers emerging from the Himalayas (Fendorf et al., 2010) such as in the Bengal delta (e.g. Chakraborti et al., 2010; Mukherjee et al., 2006), other parts of India (e.g. Acharyya and Shah, 2007; Saha, 2009; Shukla et al., 2010), Nepal (e.g. Thakur et al., 2011), Pakistan (e.g. Malik et al., 2009), Myanmar, Vietnam, Cambodia (e.g. Berg et al., 2007; Polya et al., 2008) and China (e.g. He and Charlet, 2013). The increasing awareness of the menace results in a wealth of scientific publications as clearly illustrated in a Web of Science search showing the dramatically increasing publication frequency since 1990 (Table 1).

Incidences of arsenicosis have been reported since 1885 with the first major incidence of naturally caused arsenicosis reported from Argentina in 1938 (cited from Mukherjee et al., 2006). As exposure in Taiwan in the 1960s also became well known (Tseng et al., 1968). However, as shown in Table 1 it was only in the late 1990s that As in groundwater was identified as the major cause of wide-scale As related health problems in the Bengal delta (Bangladesh and West Bengal in India). Arsenicosis is spreading to regions where near sterile groundwater containing As has replaced microbially suspect surface water with lower As concentrations (e.g. WHO, 2010). This shift is and was often spurred by the international aid agencies in the global effort to improve the health situation through improved water supply and sanitation in rural areas in developing countries. After recognising the unfortunate situation, many governments are assisted by international aid agencies and international organisations like the WHO, UNICEF and World Bank in attempts to mitigate the As problem primarily by finding alternative sources of drinking water and/or removal of As from drinking water. The global extent and severity of appearing arsenicosis is probably not yet fully revealed. Overwhelming evidence of non-occupational chronic As exposure to As through ingestion of drinking water with high As concentrations has been

Table 1
Numbers of As related articles published in international peer reviewed articles based on search results from Web of Science (Thomson Reuters, September 2013).

Arsenic related topic	Published articles			
	Up to 1990	1991–2000	2001–2010	2011–2013 (September)
Arsenic & groundwater	15	216	2096	903
Arsenic & Bangladesh	0	65	1254	477
Arsenic & food	64	236	774	367
Arsenic & mitigation	0	7	143	63
Arsenic & water & removal	20	199	1397	803