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Is Arsenic a Potential Threat for Human Health in Indonesia?

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Abstract—Arsenic is a poisonous pollutant which could be a threat to human life. World Health Organization (WHO) and International Agency for Research on Cancer (IARC) found that elemental arsenic and arsenic compounds cause cancer in humans. The exposure to human can be through food and water, primarily where the groundwater contains high arsenic. Arsenic can occur in two forms, organic and inorganic. The Earth's crust is the main natural source of inorganic arsenic which is released through volcanic action and also present in ground water. Indonesia is a developing country with high population growth rate and intensive industrial activities. Usage of ground water as a source for drinking water is potentially exposing the population to inorganic arsenic. Disposal from microchip factories, mining and wood processing, agriculture activities using arsenic pesticides, and oil refineries are the human activities which potentially release inorganic arsenic. Deep drilling and drawing water from sediment containing arsenic in lowlands such as the eastern part of Sumatera Island, the northern part of Java Island and other areas in Indonesia might potentially contaminate those areas with arsenic. This paper reviews the available information on levels, potential sources and distribution of As around Indonesian Archipelago.

Keywords: arsenic, levels, potential sources and threat, human health, Indonesia

INTRODUCTION

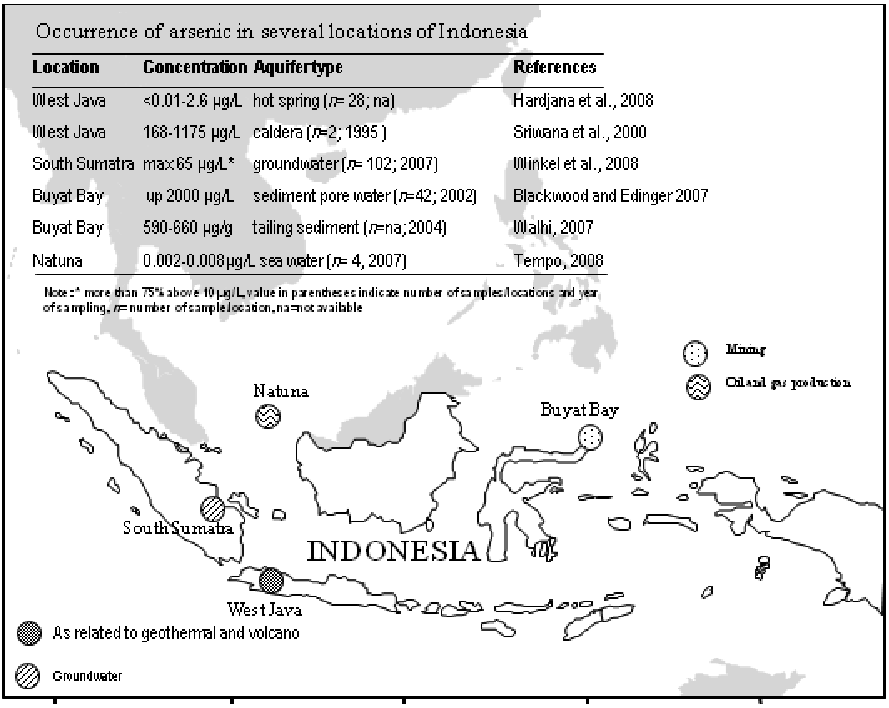
Arsenic (As) and its compounds have been identified as human carcinogens to which humans are exposed through food and water (mainly from groundwater contaminated by As (EPA, 2006). The short term effects of As contamination have been shown as; abdominal pain, change in skin color, vomiting, dryness/tightness in throat, thirst, convulsions, cramps, clammy sweats, etc. Long term exposure can cause skin cancer, kidney cancer, prostate cancer, bladder cancer, lung cancer, limb loss, immunological disorders, diabetes, reproductive and developmental problems, etc. (Smith and Steinmaus, 2008).

Environmental contamination by As and its potential health effects have been well documented in several Asian countries such as Bangladesh, India, Vietnam, China, Taiwan and Cambodia (Wu *et al.*, 1989; Tondel *et al.*, 1999; Liu *et al.*, 2002; Forsberg, 2003; Agusa *et al.*, 2007, 2009). For example, arsenicosis in human such as skin cancer has been found in China (Liu *et al.*, 2002) and Bangladesh (Forsberg, 2003). However, only very less data on the occurrence of As is available from Indonesia. This study aims to review the available information on As contamination in Indonesia with specific objectives to provide preliminary information on levels, potential sources and distribution, as well as to evaluate potential effects of As.

SOURCES, LEVELS AND DISTRIBUTION

There are very few studies on As contamination in Indonesian environment. Figure 1 shows the available information on the occurrence of As in several locations of Indonesia and their potential sources such as natural and anthropogenic activities.

The earth's crust is a natural source of inorganic arsenic, released through volcanic activities and seepage to ground water (Smedley and Kinniburgh, 2002; Greenfacts, 2008), while some of the anthropogenic activities which release As to the environment are microchip factory waste disposal, mining and wood processing, agriculture activities by usage of pesticides, oil refineries, etc. (Mukherjee *et al.*, 2006). Naturally occurring arsenic in ground water in association with geothermal activity is recognized to be one of the significant sources (Smedley and Kinniburgh, 2002). These regions are found near plate margins where the geothermal gradients may be extremely high. In regions with high-temperature gradient, subterranean faults and cracks allow meteoric water to seep underground where it is heated by magma or hot rocks. Heated water can circulate back to the surface through the host rock. As geothermal water ascends to the surface it reacts with the wall rocks causing mineral dissolution (Webster and Nordstrom, 2003). Therefore, geothermal waters generally contain high concentrations of arsenic and heavy metals. There are about 251 potential geothermal energies distributed in 26 provinces of Indonesia (Dwipa and Simanjuntak, 2003), which can be a potential natural source of As (Smedley and Kinniburgh, 2002). Arsenic association with natural sources from geothermal and other volcanic activities has been reported from some locations in Indonesia including hotsprings from parts of West Java Province (Sriwana *et al.*, 1998; Hardjana *et al.*, 2008) and groundwater from parts of South Sumatra Province (Winkel *et al.*, 2008). In an earlier study, Sriwana *et al.* (1998) reported high concentrations of As in caldera of Kawah Putih (West Java) up to 1170 μg/g. In a study on As contamination in water collected at several locations of high geothermal activities in the West Java Province showed concentrations of arsenic (As^{3+}) between <0.10–2.6 μg/l (Hardjana *et al.*, 2008). Furthermore, recent groundwater investigations in the lowlands of the South Sumatra have indicated that an area of nearly 100,000 km^2 is vulnerable to As contamination, under reducing aquifer conditions (Winkel *et al.*, 2008). Analysis of groundwater samples from 102 randomly selected wells located in the Holocene swamp



Occurrence of arsenic in several locations of Indonesia

Location	Concentration	Aquifer type	References
West Java	<0.01-2.6 μg/L	hot spring (*n*= 28; na)	Hardjana et al., 2008
West Java	168-1175 μg/L	caldera (*n*=2; 1995)	Sriwana et al., 2000
South Sumatra	max 65 μg/L*	groundwater (*n*= 102; 2007)	Winkel et al., 2008
Buyat Bay	up 2000 μg/L	sediment pore water (*n*=42; 2002)	Blackwood and Edinger 2007
Buyat Bay	590-660 μg/g	tailing sediment (*n*=na; 2004)	Walhi, 2007
Natuna	0.002-0.008 μg/L	sea water (*n*= 4, 2007)	Tempo, 2008

Note :* more than 75% above 10 μg/L,value in parentheses indicate number of samples/locations and year of sampling, *n*= number of sample location, na=not available

Fig. 1. Summary of documented occurrence of arsenic in the aquifers of Indonesia and its potential sources (natural: geothermal and volcanic activities, anthropogenic: mining- and oil/gas production-related sources).

deposits showed As concentrations above the WHO drinking water guideline (>10 μg/l) with a maximum of 65 μg/l. In addition, these ground waters indicated elevated levels of manganese, selenium and boron.

With regard to the arsenic problems associated with human activities in Indonesia, only two case studies were reported. High concentration of As (up to 2000 μg/l) was found in sediment pore water collected from Buyat Bay (North Sulawesi Province) which is affected by disposal of gold-mine tailings (Blackwood and Edinger, 2007). In another report, seabed (sediment) from this location also showed elevated levels of As, as high as 666 μg/g (Walhi, 2004). Recent survey on seawater quality by the Ministry of Environment of Indonesia in areas close to oil and gas production (Conoco Philips, Star Energy, Exxon Mobil and Kondur Petroleum areas) of Natuna Waters (eastern part of Sumatera Island) showed low concentrations of As ranging from 0.002 to 0.008 μg/l (Tempo, 2008).

RISK ASSESSMENT AND ITS POTENTIAL EFFECTS

Groundwater samples from South Sumatra province contained As above the WHO drinking water guideline (>10 μg/l); and also the sediments collected from

Buyat Bay (North Sulawesi Province) had very high concentration of As (up to 666 μg/g) exceeding the threshold levels suggested as the ASEAN standard for polluted marine sediment (50 μg/g), and US, Canadian, New Zealand, Australian standards for ecological probable effects level (42 μg/g) (Walhi, 2004) showing the fact that some areas in Indonesia on high risk contamination of As.

Humans are exposed to As through various exposure routes such as food, water and their ambient environment. Dietary intake and drinking water are the major routes of As exposure for human. Chronic exposure to inorganic As may give rise to several health effects including skin lesions (melanosis, keratosis, hyperpigmentation); induce problems in respiratory, cardiovascular, hematopoietic, nervous and reproductive systems; and also can cause cancers in different organs such as skin, lung, kidney, bladder, etc. The health effects of As exposure have been reported in various regions worldwide, but no data has been reported for Indonesians. Recently, skin diseases have been commonly found in the residents living in coastal areas of Buyat Bay where high concentration of As was reported in the environment, however further studies on link between the skin disease and As contamination are needed.

SUMMARY

Although, there are many potential sources of As, only very few studies on this pollutant are available in Indonesia. Among these, some locations in Indonesia have been reported to contain high concentration of As in their environment such as groundwater (South Sumatra Province) and marine sediment (Buyat Bay-North Sulawesi Province) exceeding the guideline standards. Indeed, the abundance of their sources and the absence of adequate data and available preliminary findings clearly raise concern for more detailed studies on the environmental contamination and human health effects due to As in the entire chain of islands in the Indonesian Archipelago.

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