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Arsenic in Coconut Water: A Case Study

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Abstract: Coconut water samples collected from both high and low ground water arsenic contaminated area were analyzed and it was observed that concentration of arsenic varies from 0.000 to 0.170 ppm. Arsenic concentration in the coconut water of Char Bhabanathpur (Sonargaon), one of the most arsenic affected zones in Bangladesh, ranges from 0.005 to 0.170 ppm with an average value of 0.070 ppm, whereas zero or sometimes trace arsenic concentrations were observed in the coconut water of both Manikganj and Dinajpur Sadar. In our study, we notice that the concentration of arsenic in coconut water is related to the age of coconut where the concentration of arsenic increases linearly from baby coconut to matured coconut. The arsenic concentrations in soil adjacent to the coconut trees in Char Bhabanathpur area shows a positive correlation with the arsenic concentrations in coconut water but interestingly the trend does not exist in case of other two study areas. This indicates that bioaccumulation of arsenic at least in case of coconut has a strong relationship with the biogeochemistry of the relevant soil.

Key words: Arsenic, coconut water, bioaccumulation, biogeochemistry.

Introduction

To reduce the water-borne diseases, more than one million wells were installed in Bangladesh during 1970 and 1980 by some foreign aid agencies and Bangladeshi government and it eventually put millions of people of the country at the threat of arsenic poisoning instead (Clarke, 2001). Arsenic was first identified as a public health problem in West Bengal, India, where the geological formations, economic conditions, food habits, and tube wells are similar to those in Bangladesh. Facing a flood of cases in West Bengal, health workers started looking for similar problem in Bangladesh and arsenic contamination in the ground water of Bangladesh was first identified in the tubewell water in the Chapai Nawabganj district of the country (DPHE, 1993).

Mobilisation of arsenic in Bangladesh is a self organising process involving several types of biogeochemical transformations (Tareq et al., 2003). Due to the different types of geochemical conditions in different parts of Bangladesh, arsenic is distributed inconsistently all over the country (Safiullah et al., 2003; Safiullah, 2006; Nickson et al., 2000; Hasan et al., 2009). The ground water of the tableland and hill tract regions are generally free from arsenic contamination, while those of the flood plains are heavily arsenic contaminated, whereas the contamination status in coastal and the deltaic regions are intermediate (Chakraborti et al., 2010).

Much awareness has been created by some electronic and print media, seminar and conferences by the scientists as well as by some public and private social organisations. As a result, people of the arsenic affected areas are now more or less concerned about the devastating effect of arsenic poisoning and in some areas people have been avoiding arsenic contaminated water. In spite of such carefulness, some are till now getting affected by arsenic poisoning directly or indirectly and the number of arsenic affected patients are increasing day by day. Many research works have been carried out

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regarding how arsenic or other heavy metals are getting accumulated by various types of plants and on how it does go to the food chain finally (Maeda et al., 1992; Chen et al., 2008; Bhattacharya et al., 2009; Khan et al., 2010; Zheng et al., 2010; Das et al., 2004). Beside these, arsenic, like other naturally occurring minerals, tends to cycle in the environment; this cycling ensures that human beings are always, and unavoidably, exposed to arsenic poisoning (Roy and Saha, 2002).

Coconut is a very delicious fruit enriched in many essential minerals and vitamins. It is frequently taken up by people in many parts of the world. But much research has not been carried out to investigate the presence of arsenic in coconut water in particular and its uptake from the corresponding soil—the nutrient source for the coconut trees. The present study involves the bioaccumulation of arsenic in the water of various ages of coconut from different arsenic contaminated zones of Bangladesh.

Materials and Methods

Sampling sites were chosen on the basis of availability of coconut trees and in such a way that it covers the area uniformly. Total 28 coconut water samples were collected from three locations of Bangladesh (Figure 1): eight from Sonargaon, two from Harirampur, Manikganj and the rest of the samples are from Dinajpur Sadar. To investigate the bioaccumulation of arsenic by coconut water, soil samples were also collected two feet away from the coconut trees and at a depth of 2.0 feet from the surface layer. In addition, three coconut trees were chosen surrounded by the hottest spot in Char Bhabanathpur, Sonargaon observed by Mahmud-Ul-

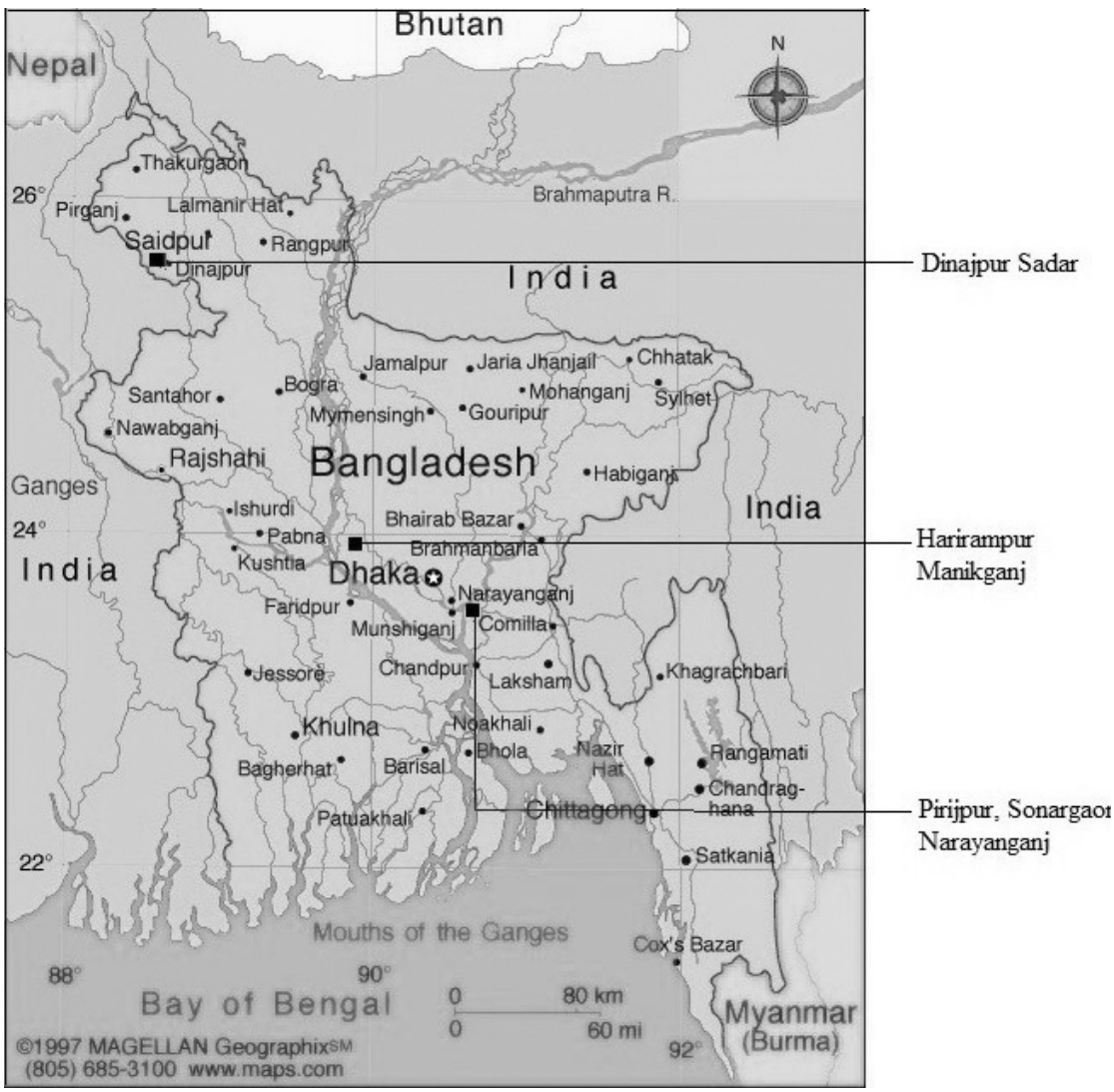

Figure 1: Location of the study area.

Hoque (2010) and coconut water samples were collected from 30, 90 and 180 days of old coconuts. The water samples were filtered and high-density polyethylene bottles (rinsed with 1% HNO_3 followed by rinsing with distilled water) were used for the collections and were also sealed to prevent possible air oxidation. Samples were stored at controlled temperature and analyzed within a week of collection. However, the storage conditions were beyond our control during the air shifting time.

For the collection of soil samples, stainless steel Ekman grab sampler was used and the samples were transferred to new polyethylene bags. The sampler was cleaned with ambient water for individual sample collection to prevent possible crass contamination. Dried soil samples (105ºC) were ground with a mortar and screened through a 2.0 mm sieve to obtain a homogeneous powder. Samples were then preserved in airtight plastic vials inside desiccators before the determination of arsenic. The soil samples were digested following the standard procedure using the mixture of perchloric acid and concentrated nitric acid. Arsenic concentration was measured by using Merckoquant arsenic test kit (ord. no. 1.17927.0001) with a detection limit of 0.005 ppm. This cost effective, user friendly and reliable method for arsenic determination has been accepted by many researchers (Safiullah, 2006; Sarkar et al., 2011; Geen et al., 2005) which involves the generation of arsine (AsH_3) gas from the reaction between arsenic species, mainly in inorganic form, with Zn and HCl. The arsine gas is then exposed to a test strip impregnated with $HgBr_2$ that changes colour with increased arsine level. The colour produced is compared with the specific colour scale for the quantisation of arsenic.

Results and Discussions

Soil samples adjacent to coconut trees were collected to estimate the concentration of arsenic in it along with the corresponding coconut water. From the results, it is evident that the concentration of arsenic in coconut water varies from 0.005 to 0.100 ppm and in soil it ranges from 0.400 to 0.600 ppm in Charbhabanathpur, Sonargaon**.** Figure 2 shows the arsenic concentrations in coconut water and in the soil adjacent to coconut trees of three different locations of the study area.

From Figure 2, it is clear that the uptake of arsenic by coconut water is strongly related to the concentration of arsenic in the relevant soil. To see the regional variation of arsenic concentration in soil and in coconut water, soil samples from Dinajpur and from Harirampur, Manikganj

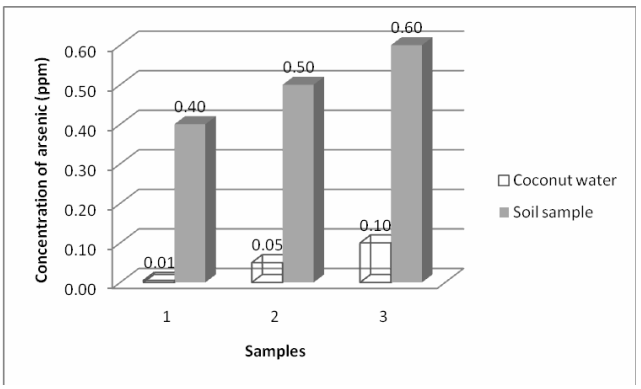

Figure 2: Concentration of arsenic in coconut water and in the relevant soil of Sonargaon area.

(low and high groundwater arsenic contaminated zone respectively) were collected also from the same depth adjacent to coconut trees as mentioned earlier. The analytical results for soil and the corresponding coconut water samples of Harirampur shows that coconut water aged up to 180 days contained trace level of arsenic though a significant amount of arsenic is present in soil and also in the ground water of the area.

Such results for Dinajpur Sadar have been presented by Figure 3 and it seems that although the presence of arsenic in soils ranges from 0.100 to 0.400 ppm, coconut trees are not accumulating arsenic as explained by the zero concentration of arsenic in all the coconut water samples collected from the area (Table 1).

Dinajpur is a less groundwater arsenic affected area in Bangladesh (Chakraborti et al., 2010) with a zero arsenic concentration in the coconut water. On the other hand, both soil and ground water of Harirampur contain significant amount of arsenic (Mahmud-Ul-Hoque, 2010) but a trace level of arsenic was observed in the coconut water even aged up to 180 days. Based on these results, it can be concluded that groundwater

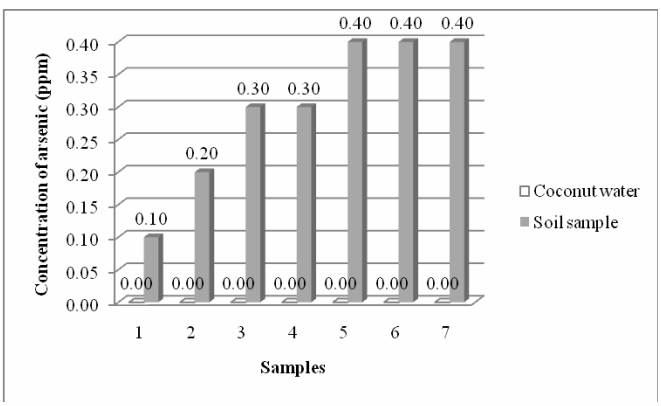

Figure 3: Concentration of arsenic in soil and corresponding coconut water in Dinajpur Sadar.

Table 1: Detailed analytical results for the presence of arsenic in coconut water

Sampling site	*Sample name*	*Age of the coconut (days)*	*Arsenic conc. (ppm)*
	SCW-1A	30	0.005
	SCW-1B	90	0.050
	SCW-1C	180	0.100
	SCW-2A	30	0.007
	SCW-2B	90	0.100
Char	SCW-2C	180	0.150
Bhabanathpur,	SCW-3A	30	0.005
Sonargaon	SCW-3B	90	0.030
	SCW-3C	180	0.050
	SCW-4C	180	0.005
	SCW-5C	180	0.050
	SCW-6C	180	0.050
	SCW-7C	180	0.170
	SCW-8C	180	0.170
Harirampur	SCW-9C	180	Trace
	SCW-10C	180	Trace
	SCW-1A	30	0.000
	SCW-1B	90	0.000
	SCW-1C	180	0.000
	SCW-2A	30	0.000
	SCW-2B	90	0.000
Dinajpur Sadar	SCW-2C	180	0.000
	SCW-3A	30	0.000
	SCW-3B	90	0.000
	SCW-3C	180	Trace
	SCW-4A	30	0.000
	SCW-4B	90	0.000
	SCW-4C	180	0.000

arsenic is not the only factor for the bioaccumulation of arsenic. Many research works have been done and it is documented that accumulation of arsenic by plants is positively correlated with the concentration of arsenic in soil (Kurosawa et al., 2008; Bhattacharya et al., 2009). But the absence of arsenic in the coconut water of Dinajpur area indicates that soil characteristics and geochemical factors are mainly responsible for the bioaccumulation of arsenic especially by the coconut water undertaken in the present study.

Pirijpur is one of the arsenic prone areas in Sonargaon. No survey has been conducted to investigate the arsenic in coconut water, rice, date juice and other locally produced vegetables from this area. In many cases, people of the locality are not drinking the arsenic contaminated tubewell water but the number of arsenic patients is increasing day by day according to the local health department. The local people have expressed also the same opinion. JSSKS, one of the NGOs surveyed Char Bhabanathpur and found many serious arsenic patients in the village. This may be due to the uptake of arsenic contaminated food grains by the locals.

The presence of arsenic in coconut water in different ages of coconut were also investigated with the samples collected from Charbhabanathpur and it was found that concentrations of arsenic are higher or sometimes equal than the set standard by World Health Organization (0.01 ppm) (WHO, 1994) and the Bangladesh limit for arsenic in drinking water (0.05 ppm) (The Environmental Conservation Rules, 1997). The samples were collected from the places where coconut trees were located adjacent to the hottest spot (2.5 ppm arsenic concentration in ground water) identified earlier (Mahmud-Ul-Hoque, 2010). Other samples were collected from the places where hot spot is a bit far from the trees. Three categories of coconut water were considered in our study depending on the age of coconut of the same trees. Baby coconut having

aged up to 30 days, middle aged coconut having aged up to 90 days and matured (ripped) coconut having age up to 180 days were considered for the survey. The analytical results on coconut waters collected from all parts of the study area are shown in Table 1 which indicates that bioaccumulation of arsenic by coconut water is significant in Pirijpur, Sonargaon.

The level of arsenic in coconut water varies in different ages of the coconut where the concentration of arsenic in coconut water is comparatively high in the matured (180 days) coconut than that observed in middle aged one (90 days). Baby coconuts (30 days) were found to contain least arsenic concentration compared to the other two types mentioned previously. A significant correlation between the age of coconut and the concentration of arsenic in its water can be shown by Figure 4.

The coconut waters collected from Harirampur were found to contain trace level of arsenic whereas those from Dinajpur Sadar were found to contain no arsenic in any ages of coconut. Surprisingly, though significant amount of arsenic is present in the soil of Dinajpur Sadar, arsenic is not getting accumulated by the coconut trees from the area. With equivalent soil arsenic concentrations, uptake of soil arsenic by plants depends on the various factors including soil composition. Almost similar study was carried out by Jones in 2006 and he reported that plants grown on sands or sandy loam soil usually have higher total arsenic contents than those grown on heavier-textured soils.

Recently, a survey has been conducted by an American group under the Academy of Healthy Water Ecosystem and Environment Corporation (AHWEEC) based in Kansas Province of the United States of America. The study team conducted a survey in Mallikpur of Court Chandpur under Jhenidhah District, Bangladesh and the report was published in a Bangladeshi newspaper, *The Daily Naya Diganta*. The scientists claimed that the presence of arsenic in some fruit juice is significantly high which is beyond tolerable limit of the human consumption (*The Daily Naya Diganta*, 2010). However, no such study was conducted so far to see the presence of arsenic in coconut water in Bangladesh. This is a new dimension of the problems added in the catastrophe of arsenic in this country.

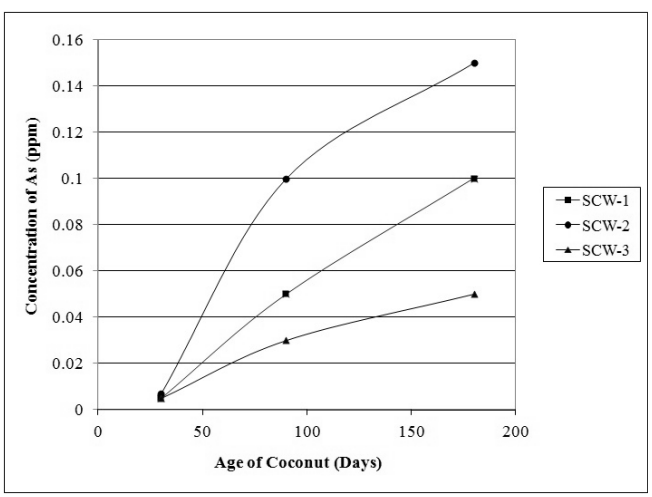

Figure 4: Concentration of arsenic in coconut water as a function of the age of coconut.

Conclusion

Although the presence of arsenic in coconut water seems to be unusual, our study reveals that it may contain up to 0.170 ppm arsenic. The accumulation of arsenic by the coconuts largely depends on some biogeochemical factors including the soil characteristics. However, for better understanding, further research with huge amount of plant, soil and water samples from different locations should be carried out.

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