Distribution and Mobilization of Arsenic with Other Elements in the Borehole Sediment of the Major River System of Bangladesh

การกระจายตัวและการเคลื่อนย้ายของสารหนูและแร่ธาตุอื่นๆ ในหลุมตะกอนของระบบแม่น้ำหลักในประเทศบังคลาเทศ

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Abstract

Geological study of the Holocene sediments of the Padma , Jumuna and Meghna rivers connecting board Tista fan and Brahmaputra flood plain in north eastern Bangladesh. Arsenic occurs in large quantities in the earth's crust and in trace quantities in rocks, soil and ground water. All the sediments were collected at several depths ranging from 1 to 6 m using 1.5 inches diameter pipe through normal digging procedure. The aim of the research is to evaluate concentration of arsenic and other heavy elements (Fe, Mn, Cr, Cu and Ni), to understand the geological vertical and geochemical horizontal mobilization of arsenic along with low lying deltaic plain and to investigate the correlation of arsenic with these metals. Higher amontod arsenic found in the sediment of the river Padma compared to Jumuna and Meghna. Arsenic has correlated with iron concentration and less with cupper and manganese.

Keywords: Arsenic, Sediments, Major river, Other metals, Bangladesh

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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาทางธรณีวิทยาของตะกอนโฮโลซีนในแม่น้ำพัตมา จูมูนา และเม็คนา ที่เชื่อมต่อที่ราบทิสต้าและที่ราบน้ำท่วมบราห์มาพุตราทางตะวันออกเฉียงเหนือของประเทศบังคลาเทศ สารหนูถูกผลิตขึ้นในเปลือกโลกและรอยหิน ดิน และน้ำบาดาลเป็นปริมาณมาก ตะกอนทั้งหมดถูกเก็บจากความลึกหลายระดับตั้งแต่ 1 ถึง 6 เมตร ด้วยขั้นตอนการขุดแบบปกติ โดยใช้ท่อขนาดเส้นผ่าศูนย์กลาง 1.5 นิ้ว ท่อผ่าน งานวิจัยนี้มีวัตถุประสงค์เพื่อประเมินความเข้มข้นของสารหนูและแร่ธาตุหนักอื่นๆ (เช่น เหล็ก แมงกานีส โครเมียม ทองแดง และนิกเกิล) เพื่อให้เข้าใจการเคลื่อนย้ายทางธรณีวิทยาและธรณีเคมีของสารหนูทั้งทางแนวตั้งและแนวนอนตามแนวที่ราบต่ำสามเหลี่ยมปากแม่น้ำ รวมทั้ง เพื่อประเมินความสัมพันธ์ระหว่างสารหนูและโลหะหนักดังกล่าว ผลการสำรวจพบว่า ตะกอนจากแม่น้ำพัตมามีปริมาณสารหนูมากกว่าตะกอนจากแม่น้ำจูมูนาและแม็คนา โดยพบความสัมพันธ์ระหว่างสารหนูกับความเข้มข้นของธาตุเหล็กในระดับที่สูงกว่าทองแดงและแมงกานีส

คำสำคัญ : สารหนู ตะกอน แม่น้ำหลัก โลหะอื่นๆ ประเทศบังคลาเทศ

Introduction

Bangladesh being located downstream of the mighty rivers, the Ganges and the Brahmaputra, works as a retention basin of excess water carried by the river system for final discharge in the Bay of Bengal. The Ganga- Padma andBrahmaputra-Jamuna river systems drain a huge area of land outside the territory of Bangladesh. There are some direct and indirect references of occurrence of arsenic and arsenic related minerals in the upstream of the rivers carrying water and sediments in Bangladesh (DPHE, BGS and MML, 1999). The Ganga- Padma and Brahmaputra- Jamuna river systems in Bangladesh carry 2.4 billion tons of sediments, a part of which is deposited in the flood plains each year (Ahmed & Ravenscroft, 2000). The comparison between deeply flooded areas in Bangladesh and the areas having more than 10 and 50 percent of the tube-wells producing arsenic more than 0.05 mg/l as demarcated in Figure 1, which shows that the deeply flooded areas are mainly arsenic problem areas of Bangladesh (Ahmed & Ravenscroft, 2000). The reducing soil environment in the deeply flooded areas appears to be conducive to the release of arsenic in groundwater. The tubewells sunk in shallow aquifers in the Ganges and Meghna flood plains except in coastal areas are the worst affected.

Figure 1 Sediment collection by normal digging procedure

The Bengal Delta Plain (BDP) is one of the biggest deltas in the world and through which the rivers Padma (Ganges), Jamuna (Brahmaputra) and Meghna coming from India falls into the Bay of Bengal. The districts near the above floods plain are contaminated with arsenic. UNICEF reported that 4.7 million (55%) of the 8.6 million wells are affected with arsenic (UNICEF, 2006). The rivers generate large amounts of sediments each year and therefore alluvial sediments dominate the geology. The main part of the BDP is located in Bangladesh. The Bengal basin has one border to the north to the Shillong plateau (an extension to the Himalayas) and another to the east through the Tripura Hills. The third border is constituted by the Indian shield Arsenic occurs as a major constituent in more than 200 minerals, including elemental arsenic, arsenides, sulphides, oxides, arsenates and arsenites. The most abundant arsenic ore mineral is arsenopyrite, FeAsS. The concentration of arsenic in sedimentary rocks is typically in the range 5-10 mg kg-1 (Webster, 1999).

Arsenic contamination of groundwater in large areas of Bangladesh and West Bengal, India has received much attention and is considered as one of the worst environmental disasters in the world 1-2. Arsenic is widely distributed as a trace constituent in rocks and weathered soils. In Chapai-Nawabganj, Northwestern Bangladesh, arsenic may be derived from the weathering of rocks exposed along the Himalayan orogenic belt, or oxidation of metal sulfides. However, the poor cor-

relation between dissolved sulfate and arsenic in the groundwater of Bangladesh argues against metal sulfides as the main source of arsenic. Released of arsenic is strongly sorbed by stream sediments and Fe oxides under aerobic conditions when it is transported by surface water. As-sorbed sediments are then deposited with organic matter in alluvial settings. The process of As mobilization in alluvial sediments is complex, it may occur as Fe and Mn oxides are reductively reduced by Fe(III)-reducing bacteria under moderately reducing conditions Alternatively, arsenic may be mobilized by ionic competition of other ions (e.g., nitrate, carbonate, and silicate) on sorbing sites of oxides. Thus the fate and mobility of arsenic is dependent on the biogeochemical transformations and desorption that occur in the sediments

Materials and Methods

Sampling

To see the distribution and mobilization of arsenic along with river way three main river and some sub-river have been considered to the study. The silt and borehole sediments have been considered as a sample of the work. The Padma, Jamuna and Meghna rivers are big rivers of Bangladesh. The river Dharla, Surma, Kushiara, Tista also has considered as the sampling station, because these rivers are the parts of the three main rivers. The borehole sediments were collected from the above mentioned rivers. The sediments were collected from 6 meter depth by the normal digging procedure. The silt and upper soil were collected from edge of the bank of rivers. The first sampling was carried from the entering area of Padma River (Chapai-nawabgonj) and last was done from the Manikgonj where the Padma and Jamuna met with each others. The Dharla and Tista are the part of Jamuna river and Surma Kushiara are the parts of Meghna Rivers. The same procedure was followed each sampling locations and samples were carried to the Dhaka university for further analysis of arsenic.

Digestion Procedure

The sediment samples were digested following the HNO3 and HClO4 Digestion method. Both the acids were analytical reagent grade. Accurately weighed amount (0.1g) of the sample was taken in a Teflon acid bomb. 3.0 ml of nitric acid and 2.0 ml

of perchloric acid were added to the sample. Then the acid bomb was placed in an oven for heating at 200°c for two hours. After digestion, the sample was cooled, filtered and transferred to a 25.0ml volumetric flask. The solution was then made up to the mark with the help of distilled de-ionized water. Arsenic was determined by Ag-DDTC with UV visible spectrophotometric method and Fe, Cu and Mn were determined by flame-AAS.

Results and Discussion

Arsenic was first detected in Chapai-nawabgonj. Chapai-nawabgonj is nearest district of West Bengal. Arsenic was first detected in west bengal before Bangladesh. Arsenic was not only detected in Chapai-nawabgonj but also found in tube well water to the nearest distracts. Arsenic is found in tube well water to the nearest districts at the bank of river Padma. It is proven that there is a certain role of the Padma River for distribution of arsenic in tube well water. Later on, it was observed that the nearest district of the river Jamuna and Meghna were mostly arsenic affected. Arsenic has not distributed in ground water but also it has mobilized to the lower stream of the above mentioned rivers.

The average concentration of arsenic was found in the sediments of Padma compared to the sediment of Jumuna and Meghna. The Padma are originated from Ganga River. The sediment containing arsenic is flown from the Himalayas and deposited to lower steam which in Bangladesh. However, the river Jumuna and Meghna are also entering Bangladesh in the northern part of India. The concentration of arsenic in groundwater and sediments originally found fewer amounts at the northern part of Bangladesh. It has been indicated that the tube well water of West Bengal in India were contaminated with arsenic. The river Padma has entered into Bangladesh through west Bengal. Arsenic concentration of the Padma River was greater than the river of Jamuna and Meghna.

In edge soil which was collected from the bank of river and upper soil samples, As, Fe and Mn varies in concentration coherently while Cr, Cu, and Ni do not show the same trend of borehole sediment. Statistical analysis shows that arsenic is strongly correlated with Mn but weakly correlated with other elements including Fe, Cr, Cu and Ni. This correlation along with physical and chemical

investigation indicates Mn its oxidative state plays significant role in contamination of borehole sediments in the study area of river system of Bangladesh.

Conclusions

Arsenic is a toxic metal and found in groundwater tube-well in Bangladesh. The drinking water comes from deeper soil and that contains arsenic, as a results, most of the tube-wells in Bangladesh are contaminated with arsenic. The tube wells near the river's bank areas are mostly contaminated, it indicated that, river systems of Bangladesh is one of the cause for arsenic contamination in drinking tube-well water.

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