MICROBES REVIEW

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I received a fax of Amitava Banerjie's article on "MICROBES AT WORK – How does insoluble arsenic contaminate water?" published in the Telegraph on March 18, 2002. It is not clear to me upon reading the article whether it is meant to be a scientific article or science fiction. Arsenic in groundwater in different parts of Bengal is a serious health hazard and a burning issue. As this subject becomes "hot", people in all disciplines start to say something or to write something that is nothing more than an opinion based on limited knowledge. Misleading articles or statement by so-called "experts" sometimes create confusion and cause more problems than solutions.

According to Mr. Banerjie's article, a team of experts led by Dr. Ravi Shanker of the Geological Survey of India made a statement that microbes play an important role in the dissolution process to release arsenic in groundwater. Is this a site-specific case study or a general statement based on some research carried out in other parts of the world where the geological setting may be different? Microbial enhancement of arsenic mobility does not work in all geological environments and scientists are in the process of further studies on this subject. Mr. Banerjie's article does not reveal what types of studies Dr. Shanker carried out regarding the biochemistry and molecular biology of microbial arsenate transformation. For example, multiple studies that are underway in the USA show that some species of bacteria are capable of respiring oxyanions of arsenic in certain natural environments. This work requires a sophisticated level of examination, including phylogenetic analysis, ultra structural characterization (i.e., transmission electron microscopy), and biochemical analysis, including the biochemistry of arsenate. If GSI has carried out any research on the microbial enhancement of arsenic in and around the Greater Calcutta area in different geological units, then it should be published and made available to the scientific world. It is very important to know the origin(s) of arsenic in the groundwater and sediment before suggesting any remediation. Thus, the origin of Dr. Shanker's statement - whether site specific, or comments from articles on research work in other parts of the globe in different geological formations - needs to be known.

Mr. Banerjie goes on to state: "Over pumping has lowered the underground water level. As the water level falls, arsenic bearing aquifers dry out. Oxygen penetrates the rock, and oxidizes the pyrites. Acid released during the process reacts with the arsenic compounds, making them soluble in water." Again, is this a site-specific statement or a generalization? As you may be aware, most of the tube wells in and around the CMDA area draw water from the confined aquifers. The water levels in the tube wells are mainly potentiometric surface (i.e., pressure surface). The result is that when the water level (potentiometric surface) falls considerably, the water bearing formation will not dry out. Therefore, the release of arsenic from the formation through oxidation does not apply to most of the CMDA area. A site-specific case study is required to learn the environmental geochemistry, to understand the reactions of various minerals affiliated with arsenic compounds, and to determine the influences of biological activity on the migration of arsenic metalloids. This is not the place to discuss this subject in detail; nevertheless, it would be very helpful to know the results of any GSI research work on MICROBES or REDOX potential.

Has any organization (including GSI) carried out any TCLP or leachability tests by reducing the pH level two points? The main purpose of this test is to determine whether arsenic can be leached from the aquifers to the groundwater. The result of making conclusions without the support of scientific data is total misunderstanding and confusion. Apparently, Dr. Shanker's statement has led some scientists to believe that the origin of arsenic in groundwater, particularly the widespread distribution of arsenic in the Bengal Basin, is partly from microbial transformations. Based on extensive field investigations and having witnessed thousands of tube well installations in and around Greater Calcutta, I suggest that the widespread arsenic contamination in groundwater is partly due to cross-contamination and migration of contaminated water, both horizontally and vertically. Cross-contamination occurs due to the faulty construction of tube wells. Without paying any attention to the subsurface geology, drillers install wells through different aquifers. Vertical migration from upper (contaminated) aquifers to lower (non-impacted aquifers) is very common in this area. Horizontal migration is mainly due to over pumping. A cone of depression from well to well creates a hydraulic gradient and lateral movement of groundwater from contaminated to non-contaminated areas. The use of groundwater from the shallow aquifers through the construction of carefully protected dug wells may not be a permanent solution but it can be a temporary fix for remote villages. Carefully protected dug wells may not supply large communities but may be very useful for small-scale communities.

Groundwater is the only sub-surface resource that is replenished every year from precipitation. If 10% of the annual rainfall enters the groundwater, the fresh water contribution is enormous. As more than half the aquifers are non-impacted, the scientists' job is the location of those aquifers for safe drinking water. When someone in a senior position (e.g., Director General of GSI, the Director of University Study Groups, or a Principal Scientist of some private organization) makes a statement, average people will believe it. In short, my appeal to the scientific community is this: set aside the non-scientific attitude and the promotion of individual egos in the interest of solving the very serious and chronic problem of arsenic in groundwater. Piecemeal investigation and/or wildcat development cannot solve this serious problem. Proper aquifer evaluation, aquifer delineation, aquifer utilization, and well construction will help to solve this serious problem.

A comprehensive "Water Master Plan" should be developed with the help of geologists, hydrogeologists, chemists, environmental engineers, and economists, so that clean surface and sub-surface water is available and can be used. This investigation should include all thirteen priority pollutant metals and not just arsenic. We have no subsurface correlation data between lithological units; no mass balance studies; no leachability tests, no area-wise correlation between formation arsenic and groundwater; no unit-wise groundwater flow data; no water balance studies, no vertical migration patterns; no horizontal accumulative draw down and lateral migration data; no individual aquifer tests (although the whole profile is saturated in a deltaic area, economical withdrawal may occur only from silt and sand layers); no mechanism to draw water from the clay horizon (the clay horizon may not be capable of producing enough water for use, but can produce enough arsenic-impacted water to contaminate the main aquifers); no individual layer analysis; no upgradient and downgradient concentration correlation to isolate the non-impacted layer(s) from the impacted aquifer(s), and so forth. Simply collecting water samples from the existing tube wells and analyzing the samples for the presence/absence of arsenic will not give a clear picture of that area because the design of the tube wells is not known. Most of the tube wells installed previously in the area of concern penetrated through multiple layers without any protection between the impacted and non-impacted aquifers. Water samples from these wells are generally designated as composite samples, and composite samples may not represent the aquifer.

This is a multi-disciplinary problem. A permanent solution – which we will have to do at any cost today or tomorrow – requires studies of the area of concern by different experts and a full exchange of information. Proper management can solve the problem permanently. The utilization of groundwater through dug wells and rainwater harvesting can solve the drinking water needs for many villages, whereas the unscientific development of tube wells without proper construction creates serious environmental hazards. To pump water from the deep aquifers without the proper precautions will bring arsenic-contaminated water to the surface and ultimately into the food chain.