Review Article

Arsenic Contaminated Groundwater Hazardous To Human Beings

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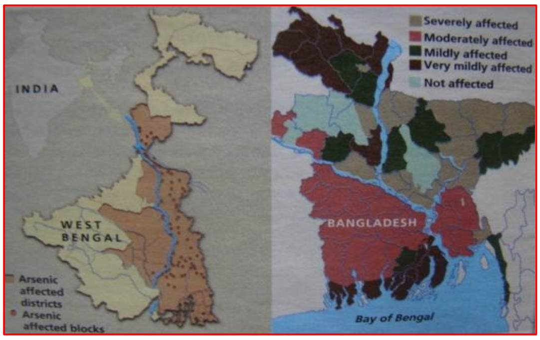
The arsenic affinity: Studies have shown rice as a major exposure route for Arsenic (As) in humans. A new study has revealed why rice is particularly efficient in accumulating As from soil and how to prevent such accumulations[1]. [AS FOUND IN RICE PRDUCTS TOO: Studies have revealed high As levels in rice and rice products such as rice bran and rice crackers. A study published in April 2008 in the *Proceedings of National Academy of Sciences* (PNAS) reported high levels of As in baby rice sold in super markets in the UK. The samples of products tested came from Japan and the UK. 35 per cent of baby rice samples tested had an average As level of 0.11-0.25mg / kg. However, this is not the first time that the dangers of As in rice have been highlighted. Based on analysis of samples collected through a survey of household in Nadia district of West Bengal, researchers from University Manchester, UK, have linked As to prevalence of cancer in the region (*Journal of Applied Geochemistry*).] To explain why rice has an affinity of As compare to other cereal crops, the researchers examined the role of to protein transporters- Lsi 1 and Lsi 2. Known to transport silica (in the form of silicic acid) into plants, these transporters belong to a family of proteins that form pores in a biological membrane. In accordance with the study, Lsi 1 adds entry of As from the soil to the roots while Lsi 2 facilitates its entry from the roots to shoot and grain. Both the proteins (Lsi 1 and Lsi 2) mediate transportation of silicic acid from the shoots via the roots while in the absence of silicic acid there was preference for As, explained the research published online *Proceedings of National Academy of Sciences* (July 14, 2008).

For the study, the researchers compared As accumulation between wild variety of rice and their mutant varieties where genes responsible for Lsi 1 and Lsi 2 protein transporters were knocked out. In the mutant variety where only Lsi 1 was removed, As in the shoots and the roots was 71 per cent and 53 per cent lower than wild variety. When Lsi 2 was knocked out, As in the shoots was 75 per cent lower relative to the wild variety of rice. When researchers grew mutant and wild varieties in the field, mutant variety had 13- 19 per cent lower concentrations of As than wild variety. According to the lead author of the study, Jian Feng Ma, Research Institute for Bio-resources (RIB) , Okaya University, Japan) mutation in Lsi 2 has greater impact on As accumulation in shoots and grain in field-grown rice than Lsi 1 as the former is responsible for taking As to grains and shoots. Ensure silica availability: when silicic acid was added to the medium, As concentration in the wild-type shoots decreased significantly. “Since silicic acid and As are carried by the same trasporters, both of them compete for uptake. When the soil is rich in silica, the uptake of As is reduced," Ma reported.[2-4]

Arsenic -poisoning affects millions worldwide and is very common in Bangla Desh and West Bengal in India. In both regions, rice is the major part of the diet. Professor S C Santra (Department of Environmental Science, Kalyani University (KU), Kolkata) states, As transport in rice roots shares the same pathway as silicic acid. This explains why rice is efficient in As accumulation. There are other crops that can accumulate As. But the rate of a5bsorption varies from plant to plant. Even with the race, different varieties have different accumulation rate. For As-reduction, Ma suggests: water logged conditions allow certain microbes to work on arsenite to release As which is taken by rice. These microbes work in anaerobic conditions. So growing rice aerobically in raised beds, reduce its mobilization. This process can decrease As transfer from soil to grain. The other approach could be to create transgenic- rice to avoid absorption. The Chinese Academy of Eco- Environmental Science have shown that when rice grows in flooded fields, iron deposits are trapped in their roots, which protects rice plants from As contamination. It was also shown that more iron deposits form when phosphorous levels in soil are low. This implies that if a low- phosphorous chemical fertilizer is used, arsenic may be blocked from moving to rice seeds. The issue of As- contamination assumes more alarming proportions given a study conducted by researchers at the University of Aberdeen, UK which showed that Indian rice contains high levels of arsenites (iii) and arsenates (v)[5-7].



DISRUPTION OF SYNTHESIS IN AMINO ACIDS OF RICE BY ARSENIC

Arsenic accumulation in rice is something that is largely unexplored. A study has now found that the arsenic can disrupt amino acid synthesis in the grain, a staple diet for many. This can reduce the levels of essential and non-essential amino acids found mainly in rice which are essential for a healthy life. Essential amino acids like lysine, phenylealanine, histidine and methionine not only improve digestion, stimulate hormonal release and enhance memory, they are also the building blocks of all proteins. Deficiency of glutamic acid, a non-essential amino acid, has been linked to Parkinson's disease.

For the study, researchers from India and the UK analysed arsenic and amino acid contents in 16 rice genotypes grown in arsenic-contaminated soils in West Bengal. They chose three regions—Chinsurah in Hooghly district, Purbosthali in Bardhaman district and Birnagar in Nadia district. They found that the levels of arsenic in groundwater of the three sites were 17, 27 and 53 microgramme/litre (mg/l) respectively. The concentrations of arsenic in soil varied from 10.4 mg/l in Chinsurah to 12.6 mg/l in Purbosthali and 15.5 mg/l in Birnagar. The acceptable limit for arsenic in groundwater, according to WHO, is 50 mg/l and the permissible limit of soil arsenic as set by the European Union is 20 mg/kg soil.

The rice genotypes were then divided into two categories based on the arsenic accumulation behaviour—low arsenic accumulating rice genotypes (LAARGs) and high arsenic accumulating rice genotypes (HAARGs). The researchers found that the levels of essential and non-essential amino acid differed significantly in HAARGs and LAARGs. In most of the genotypes the levels of amino acids reduced significantly as the arsenic concentration rose. The researchers say this is due to the heavy metal altering the degradation of the proteins and subsequently leading to inhibition of amino acid synthesis. The levels of essential and non-essential amino acids in rice were the highest in Chinsurah.

They also found rice varieties that resisted arsenic accumulation in areas with high levels of the heavy metal in soil and vice-versa. The study will be published in the October 1 issue of *Environment International*.The findings can act as a guide to identifying rice varieties suitable for growing so that the grain has minimum arsenic concentration and highest levels of required amino acids, says Rudro Deo Tripathi, scientist at National Botanical Research Institute.

IRON OUT ARSENIC

The millions of As victims living in Bangladesh and India have another option for obtaining clean drinking water. Finely divided (Iron Oxide Nano Particles) IONs can remove As from contaminated water. Iron-containing compounds have been employed in purifying groundwater. By the property of adsorption, As can bind to the solid surface of iron. Small iron oxide/or hydroxide particles are released into groundwater. The As adsorbed iron compounds are then filtered out, thus purifying the water. This led the researchers to explore the potential of IONPs in As removal because use of nanoparticles could help increase the surface area. Finely divided loose nanopowder is mixed with Sodium arsenite solution in a test bottle and the bottle was shaken. The study found that adsorption reached maximum level (96 per cent removal) with 2gm/l of IONPs.

"Large bare surfaces of IONPs have been found to be an effective adsorbent for the trace removal of As-contaminated water," stated lead researcher S K Roy from the Department of Metallurgical and Materials Engineering, IIT (Indian Institute of Technology) Kharagpur. IONPs are easy-to-produce and economically viable for mass use, revealed the research published in the 2009 issue of the *Journal of Environmental Science and Health.* IONPs as possess magnetic properties. Chances of induction of harmful effects of iron oxide on humans remains rectified as IONPs are filtered out completely from the aqueous solution employing magnetic separation.

Also: A sample filter based on sand and iron filings could effectively prevent millions of people being poisoned by As in the water they drink. The filter is a tube filled with sand and iron filings, designed to fit easily in a well outlet. In the presence of $BaSO_4$, which can beaded if it isn't already present in water. The iron particles oxidise and react with As to form arsenopyrite – a compound containing iron, As and S. Moreover, it's insoluble in water and so it precipitates out and remains trapped in the filter. According to estimate, a filter installed in a heavily contaminated well in Bangladesh ought to function for at least 20 years on as little as a tonne of iron. The cost of supplying one person with drinking water for a year will be very cheap. The same technology may soon find use in other places where As contaminates potable water, which is fairly common problem in mining zones. A prototype filter is being designed producing 5500 litres of clean potable water/day, which is quite sufficient for many as 150 people[8-9].

REFERENCES

1. Banerjee H and Bhattacharyya K. Everyman's Science. 2011;21:93-97.
2. Singh AK and Chinnusamy V. Indian Farming. 2006;56:1120-1128
3. Smedley PL and Kinniburgh DG. Applied Geochemistry. 2002; 17:517-568.
4. Bhattacharya P, Chatterjee D and Jacks G. Water Resource Development. 1977;13:79-92.
5. Onishi H. Handbook of Geochemistry, ed. Wedepohl, R. H. Springer, New York, 1969;20-24.
6. Ghosh K, Das I, Saha GC, Banik S, Ghosh S, Majhi NC and Sanyal SK. Journal of Indian Chemical Society. 2004; 81:1063-1072.
7. Abedin MA, Feldmann J and Meharg AA. Plant Physiology.2002; 128, pp. 1120-1128.
8. Maheshwari R**.** The Ecotech. 2001; 2(1):85-97.
9. Maheshwari R. Indo-Global Research Journal of Pharmaceutical Sciences. 2011; 1(3):173-176.