day at 200 ppm compared to the lower levels of treatments.

Further, the residual deposit of HMB was assayed for contact toxicity on *S. oryzae*, *R. dominica* and *T. castaneum*[16]. The effective deposits (ED) for 50% and 95% mortalities were derived from a probit analysis of the data[17]. There were differences in the susceptibility of the three insects to the test compounds. *T. castaneum* was highly susceptible at $ED_{50}$ and $ED_{95}$ values of 1.64 $\mu g/cm^2$ and 6.24 $\mu g/cm^2$, respectively. The least susceptible among the three was *S. oryzae*. The fiducidal limits were between 1.46 and 1.83.

To determine whether HMB exerted vapour toxicity, adult *S. oryzae* were exposed to HMB vapours at a level of 50 $\mu g/cm^3$. No mortality was observed even after 48 h. However, in contrast, 95% kill was obtained at 12.65 $\mu g/cm^3$ equivalent, calculated from the contact toxicity assay described earlier. It seems that the toxicity of the root powder of *D. hamiltonii* and its active compound HMB was by contact. Whole grains treated with powdered root and extracts, kept for over three years did not show any fungal infestation and also retained their germination capacity, whereas the control samples were totally destroyed by infestation in 6 months.

This investigation clearly establishes the insecticidal property of *D. hamiltonii* roots for its efficacy against stored food grain pests, with advantages of simplicity of application, reduced oviposition and emergence of progeny, and retention of viability of seeds. Besides the fact that these roots have been traditionally pickled and consumed precludes any danger of residual toxicity to humans unlike synthetic insecticides.


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# Arsenic groundwater contamination and sufferings of people in Rajnandgaon district, Madhya Pradesh, India

Arsenic contamination of groundwater and sufferings of the people of West Bengal are well documented[1–9]. The present situation in West Bengal is that about 5 million people in 978 villages of 67 blocks from 9 districts including the southern part of Calcutta, are drinking contaminated water containing arsenic above 0.05 mg/l and around 300,000 people are suspected to be suffering from arsenical skin lesions. Our neighbouring country, Bangladesh is also seriously affected and is considered to be the world's largest arsenic-affected area[10,11]. Other than West Bengal, reports of contamination in Chandigarh were published in 1976 (ref. 12) but no information has emerged thereafter. Here we report arsenic contamination of groundwater and the plight of the people from Koudikasa village, Rajnandgaon district, Madhya Pradesh.

This district is situated in the south-eastern part of Madhya Pradesh. It is an agrarian district having dense forest. The total population of the district is about 1.5 million. Except two towns – Rajnandgaon and Khairagarh, the entire district depends on tubewells and dug-wells. The tubewells are fitted with hand-pumps or power pumps. The total depth of the tubewells range from 10 to 75 m, but most of them are less than 50 m. Some of the power pump tubewells are of bigger diameter (15 cm). Water samples from Chowki block 146 have been analysed. The distribution of arsenic concentration is shown in Table 1. It can be seen from the table that only a few of tubewells and dug-wells contain water with very high levels of arsenic and people drinking water from these wells suffer from arsenical skin lesions. The total population of Chowki

**Table 1.** Concentration range (mg/l) of arsenic in 146 groundwater samples collected from 22 villages of Chowki block, Rajnandgaon district, Madhya Pradesh

| Village | No. of water samples analysed | Concentration range of arsenic (mg/l) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | < 0.01 | 0.01–0.049 | 0.05–0.099 | 0.10–0.299 | 0.30–0.499 | 0.50–0.699 | 0.70–0.999 |
| Kaudikasa | 12 | 2 | 4 | – | 1 + 1* | 1 | 1* | 2 |
| Kunderatola | 4 | 1 | 1 + 2* | | | | | |
| Mulhetitola | 13 | 6 | 4 + 2* | 1* | | | | |
| Bodal | 6 | 5 | 1 | | | | | |
| Taramtola | 7 | 5 | 1 + 1* | | | | | |
| Gotul Munda | 6 | 6 | | | | | | |
| Dewarsur | 7 | 5 | 1 | 1 | | | | |
| Bharritola | 6 | 1 | 5 | | | | | |
| Metepar | 7 | 7 | | | | | | |
| Nichekohda | 10 | 10 | | | | | | |
| Bhagwantola | 8 | 5 | 3 | | | | | |
| Meregaon | 3 | | | 3 | | | | |
| Bihari Kala | 4 | 4 | | | | | | |
| Khursitikul | 6 | 6 | | | | | | |
| Araj Kund | 9 | 9 | | | | | | |
| Kumhali | 2 | 2 | | | | | | |
| Pipar Khar | 6 | 6 | | | | | | |
| Goulitola | 6 | 6 | | | | | | |
| Gopalin Chuwa | 10 | 10 | | | | | | |
| Parsa Tola | 6 | 6 | | | | | | |
| Pandritara | 5 | 4 | | 1 | | | | |
| Kalkasa | 3 | 3 | | | | | | |
| Total 22 | 146 | 109 | 25 | 6 | 2 | 1 | 1 | 2 |

*Dug-well.

**Table 2.** Dermatological investigation of villages in Koudikasa for arsenical skin lesions and arsenic in hair, nail, urine and skin-scales

| | |
|---|---|
| No. of adults examined | 150 |
| % of adults having arsenical skin lesions | 42 |
| No. of children (below 12 years) examined | 58 |
| % of children having skin lesions | 9 |
| No. of people whose hair was analysed | 86 |
| % of people having arsenic above toxic level* in the hair | 75 |
| No. of people whose nails were analysed | 90 |
| % of people having arsenic above recommended level** in the nail | 91 |
| No. of people whose skin-scales# were analysed | 19 |
| % of people having arsenic above 1.0 mg/kg in the skin-scale | 100 |
| Total no. of urine samples analysed | 66 |
| % of urine samples having arsenic above normal level*** | 89 |

*Normal amount of arsenic in hair is about 0.08–0.25 mg/kg with 1.0 mg/kg indicating toxicity.

**Normal arsenic content of nails is 0.43–1.08 mg/kg.

***Normal excretion levels of arsenic in urine range from 5 to 40 µg per day (1.5 l).

#There is no normal value for skin-scale in literature.

block is 75,898 and that of the Koudikasa village is about 2000. This is a very preliminary study though a detailed one is needed to know the overall situation regarding water contamination in Chowki block and Rajnandgaon district.

Most of the villagers of Koudikasa use water from a forest dug-well which now contains about 0.52 mg/l of arsenic. The PHED tubewell which the villagers were using along with the forest dug-well was found to contain about 0.88 mg/l of arsenic and was sealed 2 months back. From our preliminary analysis, Koudikasa appears to be the most affected village. With the help of a medical team we randomly examined adults and children for arsenical skin lesions and collected hair, nail, urine, skin-scale from the villagers. The results of this investigation are shown in Table 2. From the analyses of hair and nail, it appears that most of the people have arsenic body burden. Out of the total number of adults and children examined at random, 42% and 9%, respectively have arsenical skin lesions. 75% of the people have arsenic in the hair above the toxic level and 91% in the nail above the normal level. Further, 89% of the population had arsenic in the urine above the normal level and very high levels of arsenic (1500 µg/l) were also observed. Neurological studies were performed on 62 persons with arsenical skin lesions and 34% have shown positive indication.

We have observed from our West Bengal and Bangladesh experience that, normally, children below 11 years do not show arsenical skin lesions. However, if the arsenic in drinking water is high, around 1.0 mg/l, children may develop skin lesions. This may happen even if the arsenic level is low (around 0.5 mg/l) but if the nutritional status is also low. In Koudikasa, we found about 9% of the children examined had arsenical skin lesions, but that does not mean the rest are out of danger. If they have high arsenic body burden and still continue to drink contaminated water, they may develop the skin lesions and other complica-

tions. In Koudikasa, we found an orphan having arsenical skin lesions and she was just 10 years old. She lost her parents, and villagers said they too had arsenical skin lesions when they died.

A young man has severe arsenical skin lesions in Koudikasa. He said he came to this village a few years back and after drinking the tubewell water [the most affected family used to drink (arsenic around 0.88 mg/l)] he got the skin lesions within three years. His one daughter (out of two) and wife had mild skin lesions. The reason the young man got severe skin lesions is, he drinks about 6 litre of water per day. Hair and nail analyses show all of them have high arsenic body burden.

From our past experience, we have observed that if proper sample collection, preservation and analysis are not done, differences in analytical reports of water are very common. The PHED of Rajnandgaon is facing the same problem. Results of two samples analysed from four different laboratories do not agree with each other. Analytical results of arsenic in urine, hair, nail, skin-scales from different laboratories need to be checked before reporting, and samples are to be evaluated against Standard Reference Material.

The source of arsenic is not yet clear. However, from a preliminary investigation and considering the geological formation of the area, it appears that the source of arsenic in Rajnandgaon district may not be the same as that of West Bengal and Bangladesh. The following information we have gathered may help identify the source. (i) Many villagers from Koudikasa go to nearby streams, small canals (Bhagawantala, Basta), and Shibnath river to collect gold particles; (ii) Bodal is about 5 km away from Koudikasa, where the Atomic Energy Commission had set up uranium mines from 1982 to 1989. Heaps of underground sediment are lying on the surface in Bodal; (iii) No information is available about the use of arsenical pesticide or herbicide in the area. Analyses of arsenic contamination in West Bengal and Bangladesh, showed dug-wells or surface water having about 0.01 mg/l arsenic to maximum of 0.05 mg/l due to direct contamination from a highly-contaminated tubewell nearby. The forest dug-well in Koudikasa contains high arsenic (0.52 mg/l). Normally, if the dug-well water contains high amounts of iron, then arsenic is co-precipitated and goes to sediment where it may react with microbe for elimination. All the dug-wells we had analysed in Chowki block contain less than 0.1 mg/l of iron.

There is no medicine yet for chronic arsenic poisoning. The only remedy is safe water, nutritious food and physical exercise. We have found from preliminary analysis of Chowki block that only a few villages have contaminated groundwater. After launching an awareness programme, the contaminated tubewells are to be sealed (as the numbers are not so high) and the safe tubewells are to be tested every 3 months to see whether there is contamination or not.

We have also found that many villagers in Koudikasa have serious arsenical keratosis. If severe keratosis is considered as a sign of cancer, then many people are in danger. We have found a few people with suspected Bowens and Squamous Cell Carcinoma. However, people with such ulcers are to be pathologically tested and treated.

Arsenic calamity in West Bengal was known during 1978–1980 and was officially documented by K. C. Saha in 1983. What is surprising is that though skin lesions in Koudikasa villagers were noticed in the early seventies, they were officially confirmed to be due to arsenic toxicity only 6 months ago. We do not know how many more states in India may have similar arsenic contamination of groundwater. We withdraw billions of cubic meters of groundwater for agriculture and public consumption but do not care to test its quality.


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