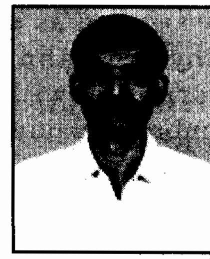
Arsenic in Food Chain



Shyamal Mukhopadhyay*

"Elevated concentration of arsenic has been found in the hair and urine samples of cows and buffaloes. SOES have found out that even if cows eat arsenic contaminated hay and drink contaminated water, their milk remains quite free from this element. Notwithstanding the fact that milk is free from high level of arsenic, arsenic poisoning of cow or buffalo and resultant ill effect on the health of these animals need to be looked in to."

INTRODUCTION

Jarina was born in a peasant family in a remote village of Bangladesh. At the age of 12 she was attacked with a strange disease. She felt feverish at night. After about a month her dark skin became darker. Her father, Jamir Ali, noticed the change and took her to village physicians. Jarina never recovered. Plenty of sores developed in the fingers of her hands and feet. She became skinnier and eventually one day she died (The Independednt, 2005). Reason for her death was not known until after several years School of Environmental Studies (SOES) of the University of Jadavpur, West Bengal, was able to find out by research that the said disease prevailing in Bangladesh and large part of West Bengal was actually arsenicosis, which is caused due to arsenic poisoning.

There are many more Jarinas, both in Bangladesh and West Bengal, who are victims of slow poisoning due to presence of arsenic in their drinking water. In Ramnagar village in West Bengal all the nine members of a family had arsenical skin lesions and seven of them died, five of them were below 30 years of age. Arsenic contamination in drinking water is a global problem, but no where in the world it is so severe as Bangladesh and West Bengal; where over 130 million (Das *et al*) reside in areas affected by arsenic in drinking water.

Officially, first case of arsenic poisoning was diagnosed in 1983 in West Bengal in the School of Tropical Medicine. Later it was found that there were many more such cases prior to this, but they were never clinically diagnosed as arsenic poisoning. The cases from Bangladesh were diagnosed in the early nineties, and it was found that the problem was of far more intensity and scale than West Bengal.

Arsenic works slowly on human health. Unsuspecting people would be drinking arsenic laced water for years without any discernible effect on their health. It is only after some years of exposure, depending upon the degree of contamination, the telltale lesions on the skin and other physical abnormalities show up. Although, these days, lesions are normally easily

[1] *Senior Manager (QPM), NDDB, Anand.*
E-mail: smuk@nddb.coop

recognized as a sure sign, many a time the other physical abnormalities become difficult to correlate with arsenic poisoning. Arsenic's embrace is quiet but deadly.

The issue of arsenic menace in water is not unknown to the dairy fraternity, particularly in the State of West Bengal, but it is not known if the magnitude and all other aspects of the problem are fully realized. This article makes an effort to put together all the facts at one place from available sources for greater awareness. It is believed that dissemination of correct information is vital for combating a problem which affects health of the masses and has deep socio-economic implication.

WHAT IS ARSENIC?

Arsenic is a poisonous metalloid that has many allotropic forms, i.e., yellow (molecular non-metallic) and several black and gray forms (metalloids) are a few that are seen. More commonly found arsenic compounds are in the form of arsenite and arsenate. Arsenic and its compounds are used as pesticides, herbicides and insecticides. Arsenic forms colourless crystalline oxides, i.e., As_2O_3 and As_2O_5, which are hygroscopic and readily soluble in water, to form acidic solutions (Wikipedia).

In subtoxic doses soluble arsenic compounds act as stimulant and were once popular in small doses as medicine by people in the mid 18th century. Arsenic compounds were also once used to dope race horses. In the Victorian era, white arsenic was mixed with vinegar and chalk and eaten by women to improve the complexion of their faces, making their skin paler to show they did not work in the fields. Arsenic was also rubbed in to the faces and arms of women to improve their complexion (Wikipedia).

Elemental arsenic is found in many solid forms, viz., the yellow form is soft waxy and unstable. The gray, black or metallic forms have some what layered crystal structure with bonds extending throughout the crystal. Arsenic is widely distributed throughout the earth's crust and is introduced in to water through the dissolution of minerals and ores, and concentrations in ground water in some area are elevated as a result of erosion from local rocks. Drinking water poses the greatest threat to public health from arsenic.

SYMPTOMS OF ARSENIC POISONING

According to WHO, the symptom and signs that arsenic causes appear to differ between individuals, population groups and geographic areas. Thus there is no universal definition of the disease caused by arsenic. This complicates the assessment of the burden of arsenic on health. Long term exposure to arsenic via drinking water causes cancer of the skin, lungs, urinary bladder and kidney as well as other skin changes such as pigmentation changes and thickening (hyperkeratosis).

Absorption of arsenic, as indicated by WHO, through skin is minimal and thus hand washing, bathing with water containing arsenic do not pose human health risk (WHO, 2001), although some papers (Mortaza, a) hold a different view point. Others claim that too much arsenic in the body may affect nervous system and heart, and also cause high blood pressure, gangrene, bronchitis, asthma etc.

Chowdhury *et al* (2000) claimed that 25 per cent of 11,000 villagers in Bangladesh and 15 per cent of 29,000 villagers surveyed in West Bengal suffered skin lesions. The report claims that concentration above 0.30 mg/litre is associated with arsenical lesions, although lesions also occur at lower concentration when nutrition is poor, volume of water consumed is high, or contaminated water is consumed for long period.

The same research finding observed that concentration as high as 0.4 mg/litre may not produce lesion if the exposed person eat nutritious food. However, the paper does not indicate anything regarding duration of exposure, without which it becomes difficult to understand the effects of the various degree of contamination. The paper also says that skin lesions in earlier stages can be reversed with safe drinking water and nutritious food. With the same treatment, Keratosis, a more severe skin condition, may not disappear, but can be reduced.

In a paper published recently in the March, 2007 issue of Carcinogenesis, Oxford Journals (Banerjee *et al*, 2007), scientists from Kolkata carried out a research to find out as to why some people are more vulnerable than others in developing arsenic-triggered skin cancers. They claimed that although over 6 million people are exposed to high levels of arsenic in drinking water, only 15-20 per cent develop skin lesions. They studied 318 people, of which 165 were suffering from hyperkeratosis (a precursor to arsenic induced skin cancer) and the rest were without skin lesions. They found out that this phenomenon could be explained as a specific genetic variation in a gene (ERCC-2) that plays a part in DNA repair.

SAFE LIMIT OF ARSENIC IN WATER

World Health Organization (WHO) had first set safe limit of arsenic in drinking water to 0.20 mg/litre in the year 1958, which was later revised to 0.05 mg/litre in 1963. In line with the WHO guideline, many national standard bodies including, India and Bangladesh, had adopted 0.05 mg/litre as the safe limit in their standard.

In the year 1993, WHO further revised the safe limit to 0.01 mg/litre as a provisional guideline value. Interestingly, this was termed as a 'provisional guideline value' as there was limitation in measuring a concentration of less than 0.01 mg/litre that time (WHO, 2001). Subsequent to this, BIS has also lowered the maximum safe limit to 0.01 mg/litre. WHO documented inorganic arsenic as a human carcinogen.

ARSENIC POISONING IN WEST BENGAL

The area of West Bengal is 89193 Sq. Km having a population of 80.1 million. There are 19 districts, 341 blocks and 37910 villages in the State. The School Of Environmental Studies (SOES), Jadavpur University has been carrying out extensive studies (SOES Report, 2006), both in Bangladesh and West Bengal, to find out the level, spread and scale of contamination in the drinking water.

They have covered all the 19 districts of West Bengal covering 241 blocks (out of total 341), and 7823 villages (out of total 37910). They have reportedly analyzed 1,40,150 samples from hand tube wells, and as per available data, 48.1 per cent had arsenic level above 0.01 mg/litre (WHO & BIS limit), 23.8 per cent above 0.050 mg/litre, 3.3 per cent above 0.3 mg/litre (concentration predicting overt skin lesions) and 0.13 per cent (187 samples) more than 1 mg/litre. The maximum concentration of 3.7 mg/litre was found in the tube well of the family where seven out of nine members died of arsenic poisoning.

Depending on the severity of contamination, SOES has classified the districts in to three categories: severely affected, mildly affected and arsenic safe. The districts are as under:

(1) **Severely Affected:** Nine districts, viz., Malda, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas, Bardhaman, Howrah, Hooghly and Kolkata. Out of the 1,35,555 samples analyzed from these districts, 49.7 per cent had concentration above 0.01 mg/litre and 24.7 per cent above 0.05 mg/litre.

(2) **Mildly Affected:** Five districts, viz., Koch Bihar, Jalpaiguri, Darjiling, North Dinajpur and South Dinajpur. Out of the 2923 water samples analyzed from these districts, 9.8 per cent had concentration between 0.004 to 0.01 mg/litre, 5.7 per cent above 0.01 mg/litre and 0.2 per cent above 0.05 mg/litre.

(3) **Arsenic Safe:** Five districts, i.e., Bankura, Birbhum, Purulia, Medinipur East and Medinipur West. Total 1672 samples tested from these districts had concentration level less than 0.003 mg/litre.

SOES claims to have surveyed 7823 villages for arsenic contamination and screened 96000 people for arsenic ailment. Number of registered patients with clinical manifestations is 9356, out of which 778 are children. A total number of 39624 samples of hair, nail and urine have been analyzed and toxic level of arsenic was detected in the 91, 97 and 92 per cent of the hair, nail and urine samples respectively.

Government of West Bengal has acknowledged (Pashchim Banga, 2006) existence of the problem in 79 blocks of Malda, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas (most of it), Bardhaman (partially), Howrah and Hooghly. The government claims to have opened arsenicosis clinic in the primary health centres of these 79 blocks. Similar clinics have been opened in 16 sub divisional, 7 district, 4 medical college and 6 State general hospitals. The State government is running 20 water testing laboratories with the help of UNICEF. Besides, it is reported that paramedics have been engaged for door to door awareness campaign about arsenic and guiding them about the do's and don'ts.

ARSENIC POISONING IN BANGLADESH

In Bangladesh, more than 90 per cent of the population gets their drinking water from more than a million tube-wells that were installed under anti-diarrhoeal campaign (Mortaza, b). This was one of the few success stories of the Bangladesh public health sector, but little did they realize that they were jumping into fire from the frying pan.

Today, out of 64 districts of Bangladesh, 47 (Das *et al*) (some paper says 53 (Matamat.Com), some 54 (The Independent, 2000), and yet some 59 (Water and Sanitation Program, 2000; Safiuddin *et al*, 2001)) are affected with arsenic contamination in their drinking water from tube wells. SOES, Jadavpur University analysed 52000 tube well water samples from Bangladesh. Forty-three per cent samples had arsenic concentration above 0.01 mg/litre and 31 per cent above 0.050 mg/litre; and the affected populations were estimated to be 52 and 32 million respectively (Chakraborty, 2006).

ARSENIC MENACE IN OTHER PARTS OF INDIA AND THE GLOBE

The menace of arsenic is not limited to West Bengal and Bangladesh only. Part of Uttar Pradesh, Bihar, Jharkhand and Assam in the Ganga-Meghna-Brahmaputra plain (GMB) are also affected, although in a far less scale and intensity than West Bengal and Bangladesh. The environmental scientists from SOES have indicated that an estimated 500,000 Sq. Km of area in the GMB plain and 450 million populations may be under risk of ground water arsenic contamination (Mukherjee *et al*).

Arsenic in drinking water of concentration above the WHO guideline value of 0.01 mg/litre or the prevailing national standard, has been reported in the countries such as Argentina, Australia, Chile, China, Hungary, Mexico, Peru, Taiwan, inner Mongolia, Thailand and United States of America; although adverse health effects have only been reported from India, Bangladesh, China and USA (WHO, 2001; Chowdhury *et al*, 2000).

WHO SUFFERS MOST FROM ARSENIC POISONING?

The worst sufferer of arsenic contamination is the half fed rural mass. Arsenic poisoning does havoc on the people suffering from malnutrition. Experts recommend that in order to recover, an arsenic-patient should eat nutritious food, especially vegetables containing vitamins A and E, and fruits, drink arsenic-free water and take light exercises. The affected one has to be under constant supervision of a physician (The Independent, 2005).

With poor economic condition of majority of the people in the affected areas, all the above advices would go in vain. In a rural set up, arsenic poisoning is not only a death sentence for the affected person, but a social curse also. Due to lack of awareness, arsenicosis is often misunderstood as leprosy or other communicable disease and patients are socially ostracized.

Affected families are sometimes denied access to neighbour's tube well, not invited in social functions and people refuse to enter in to marital relationship with the family members. Children find it difficult to be accepted among their mates in the school. Many marital bonds have severed due to arsenicosis (Ohiduzzaman, 2000; Chakraborty).

THEORIES OF ARSENIC POISONING IN GROUND WATER

The scientific fraternity across the globe has almost unanimously accepted the natural geological origin theory as the possible reason for arsenic contamination, although anthropological reasons such as Green Revolution (in India as well as Bangladesh) might have contributed to the intensity and spread of the problem.

The ultimate origin of arsenic is probably the rocks of the Himalayas, which were eroded in the recent geological past and re-deposited by the ancient courses of the rivers, mainly the Ganges (Mortaza, a). Over extraction of ground water through hand tube wells for drinking purpose and agricultural pumps for irrigation results in to draw down and lowering of water table exposing arsenic bearing rocks to air. This causes rapid diffusion of oxygen within the pore spaces of the soil as well as an increase in dissolved oxygen in the upper part of the ground water. Oxygen oxidizes the arsenic in the arsenopyrites and releases it in to the water in the form of hydrated arsenate, which is highly soluble (Safiuddin, 2001; Mortaza, a).

Some scientists propagated oxyhydroxide reduction theory as the possible mechanism of arsenic contamination. According to this, arsenic is derived by desorption from ferric hydroxide minerals under reducing conditions. Ferric hydroxide minerals are present as coatings in the aquifer sediments. In anaerobic ground water, these sedimentary minerals release its scavenged arsenic (Safiuddin, 2001). As per this theory ground water extraction does not have any bearing on arsenic contamination (Water and Sanitation Program, 2000).

The other sources of arsenic could be industrial effluents, wastes from pesticides industries, pesticides, phosphate based fertilizers, waste from metal alloy industries, commercial use of arsenic in wood preservation etc. to name a few. A Kolkata based manufacturer of arsenic based pesticide poisoned the ground water in a large area by dumping arsenical waste carelessly over past 25 years (Chatterjee & Mukherjee; Mortaza, b). There were nearly 1000 reported cases of acute arsenic poisoning from the vicinity of the factory. Indiscriminate use of pesticides and disposal of arsenic treated wood also pose serious threat to the environment. Despite all these, the anthropological reasons do not explain the regional extent of the problem in Bangladesh and West Bengal.

Most of the researchers have pointed out that arsenic contamination is restricted to the upper 100 to 150 metres of the soil layer and offers prospects of obtaining arsenic free water from deeper layers.

IS MILK SAFE IN THE ARSENIC AFFECTED AREAS?

Researchers have generally reassured the purity of milk from milch animals from those areas where arsenic in drinking water were above the acceptable level. In one study (Chakraborty) conducted by SOES in North 24 Parghanas (WB), it was found that the cows and buffaloes took in the greatest amount of arsenic through food items. These animals generally drink about 40 litres of water and about 4 to 5 kgs of hay every day. It was seen that in fields on an average 1900 mg of arsenic was present in every kg of hay. Where as a human being takes in 1200 mg of arsenic every day in the study area, cows and buffaloes take about 18000 mg of arsenic daily. Elevated concentration of arsenic has been found in the hair and urine samples of cows and buffaloes. SOES have found out that even if cows eat arsenic contaminated hay and drink contaminated water, their milk remains quite free from this element.

However, some time they found arsenic in elevated level in cow milk, which they attributed to water adulteration by the milkmen. Notwithstanding the fact that milk is free from high level of arsenic, arsenic poisoning of cow or buffalo and resultant ill effect on the health of these animals need to be looked in to. A study (Source, 2007) conducted by Minnesota University in the year 2003 also came to the similar conclusion as SOES. They claimed that "arsenic does not transfer in to dairy products, even from cattle exposed to arsenic at 10 times the human drinking water standard."

Another experiment was conducted with lactating cows for contamination of milk from arsenic fed to them (Calvert & Smith, 1980). Significantly, higher levels of arsenic in milk were observed for cows fed with either 3.2 or 4.8 mg of arsenic per kg of body weight from arsanilic acid or 3-nitro-4-hydroxyphenylarsonic acid (3-nitro) respectively. Milk arsenic from 3-nitro returned to pre-experiment level within 5 days after arsenic was removed from the feed after 28 days of feeding. In the experiment conducted with arsanalic acid, arsenic feeding was stopped after 5 days and milk arsenic level returned to pre-experiment level within 7 days. In case of 3-nitro, the arsenic content had plateaued after 14 days of feeding. The summary of the paper available in the net does not provide the exact level of contamination in milk. Another important finding was, although there was increased level of arsenic in liver, kidney and blood of the animals (lactating cow and sheep), muscle arsenic was relatively unaffected with increasing level of arsenic in feed from both the sources.

In another study (National Academies Press, 1980), arsenic was administered by gelatin capsules in amounts of 0, 1.6, or 3.2 mg per kg of body weight to cows for 5 days. Milk arsenic increased from 0.015 to 0.026 mg/litre for arsanalic acid only at the highest level. Jersey cows fed 0, 0.026, 0.015, or 0.103 mg arsenic per kg of body weight as lead arsenate for 126 days, all had arsenic levels below 0.05 mg/litre in milk. Arsenic, as lead arsenate, at a level of 4.68 mg/kg of body weight (approximately 200 mg/litre of dietary arsenic) was fed to cows without any adverse health effects.

IS MOTHER'S MILK SAFE?

A research for finding out contamination of mother's milk was conducted in the North-East zone of Argentina (Concha *et al*, 1998), where high levels of arsenic were found in drinking water (around 0.2 mg/litre). It was revealed that the breast milk from lactating mothers contained low levels of arsenic (0.017 mg/litre) although arsenic content in their blood and urine samples were high (averaging 0.010 and 0.320 mg/litre respectively). Hence, the research team concluded that despite high level of arsenic in drinking water, inorganic arsenic is not secreted in milk in significant quantities.

Another study (Sternowsky *et al*, 2002) was conducted in Germany to assess arsenic contamination of breast milk in an area where arsenic content in soil and ground water was found to be high. The area was used for dumping chemical weapons after the World War II. Thirty-six lactating women were chosen and samples were analyzed for arsenic. Samples were collected at different stages of lactation period. In 154, out of 187 samples collected, arsenic was not detected (less than 0.0003 mg/litre). The highest concentration detected was 0.0028 mg/litre. Daily intake of arsenic by the infants was estimated. The paper noted "the calculated daily intake of arsenic was in the range of 0.02 to 0.06 micro gram/kg body weight, which is far below the lower limit of daily permissible intake for adults (WHO/JECFA recommendation 1993) of 15 micro gram/kg/week".

POISONING OF CROPS AND VEGETABLES

Works have revealed that huge amounts of arsenic are entering crops through irrigation water. SOES study (Chakraborty) has estimated that in one village in North 24 Parghanas (WB) one third of the total amount of arsenic entering the body comes from the arsenic affected food items, like rice, leafy vegetables, spinach, arum and other items of daily diets. Vegetables that grow underground contain greater amount of arsenic than others do.

In the above mentioned village 85 per cent of the contamination in vegetables was due to arsenite and arsenate; highly poisonous compounds, which are generally believed to be present in less quantity in vegetables. Researchers claim that contamination in rice in West Bengal and Bangladesh is not much above permissible level but the combined intake of arsenic through vegetables and cereals can have adverse impact on health.

A FAO journal (Spotlight, 2006) mentions about some studies where correlation has been established between arsenic in soil and reduction in crop yields, particularly rice. Therefore, arsenic in soil is a threat to food security also. Arsenic content in different varieties of rice in Bangladesh were found to be as high as 1.8 parts per million compared to levels of just 0.05 parts per million in Europe and the US. Contamination in leafy vegetables was reported to be double or triple the value in rice.

TREATMENT OF ARSENIC CONTAMINATION IN WATER

The cost and difficulty of reducing arsenic in drinking water increases as the targeted concentration lowers. There are no proven technologies for the removal of arsenic at water collection points, i.e., tube wells, hand pumps and springs. Experts have suggested various use-point treatment methods (Water and Sanitation Programs, 2000). These are adsorption-co-precipitation method using iron and aluminium salts, adsorption on activated alumina/activated carbon/activated boxite, reverse osmosis, ion exchange, oxidation followed by filtration etc.

The United States Environmental Protection Agency (USEPA) suggested coagulation with iron and aluminium salts and lime softening as the most effective treatment process for meeting the standard of 0.05 mg/litre. Many simple and less expensive forms of arsenic removal methods have been tried out. '3 pitchers unit' containing briquettes, cast iron turnings and sand in the first pitcher, and briquettes, wood charcoal and sand in the second. The 'two buckets' unit using principle of co-precipitation and coagulation, 'Ram Krishna Mission unit' containing two clay pitchers with *Tripura* candle filter, and Co-precipitation using tablet reagents — 'Tablet with two jars' system developed by SOES were also in use in thousands.

Other systems tried out were units using imported proprietary chemicals (having better adsorption properties than activated alumina) brought out by some private companies and *Amal* domestic water purifiers brought out by Oxide (India). It is claimed that thousands of these systems are in use, but all these systems reportedly have their limitations in terms of effectiveness, cost, availability, and ease of maintenance etc.

Scientists at Rice University, Houston, adopted Nanotechnology to treat arsenic contamination in water (Sinha, 2006). They used magnetite crystals smaller than 12×10^{-9} metres to strip arsenic from water. The nano-particles gather arsenic ions present in water, which then are removed with the help of a magnet. It is not known if this has been tried out in the actual field condition.

Two systems were propagated in West Bengal for community level treatment of water (Das *et al*). These were oxidation and co-precipitation system developed by All India Institute of Hygiene and Public Health, Kolkata, and adsorption system developed by the Civil Engineering Department, BE College, Shibpur. It is not known, if proper field trial of these systems were conducted, or even if it was done, reports could not be found. SOES had studied 7 installations of the two systems, but no conclusion can be drawn from the study. A city water supply plant (Faridpur) in Bangladesh reduces arsenic concentration from 0.220 mg/litre to below required standard after Sunlight/air oxidation and sedimentation treatment.

WHAT DO WE DO AT THE MACRO LEVEL?

Rain water harvesting has been strongly recommended by SOES and other institutions and experts (The Financial Express, 2000; Water and Sanitation Program, 2000; WHO, 2001; The Independent, 2005; Chakraborty; Mortaza, a; Mukherjee and Chakraborty). Particularly for Bangladesh and West Bengal areas, where average annual rainfall is 2000 mm, this solution seems to be appropriate. SOES claims that this is a common practice in the arsenic affected areas of Thailand (Mukherjee and Chakraborty). Given the economic condition of the village population, this solution may not be feasible for large chunk of population, unless financial aids or subsidies are provided. Moreover, alternate source also should be available once water stored in this manner is exhausted.

Community level arsenic treatment plants have been set up at some places for distribution of arsenic free water. Drawing water from arsenic free areas and distribution to affected areas has also been suggested by SOES. Considering the vast geographical areas, economic condition of rural people and involvement of high initial and recurring costs, these suggestions seem to be difficult ones to implement.

Another solution is to go for extraction of water from deeper aquifers (Water and Sanitation Program, 2000; Chakraborty, 2006) as it has been found that even in the affected areas, deeper aquifers (more than 200 metres) are generally free from arsenic. This also requires careful consideration of all aspects associated with it before adopting as a lasting solution to the problem. Scientists warn that unconfined deeper aquifers do not guarantee arsenic free water (Mukherjee & Chakraborty).

SOES suggests even to go back to dug well system (Chakraborty, 2006; Mukherjee & Chakraborty;) wherever it is found free of arsenic. They claimed to have studied many shallow dug wells in arsenic affected areas of West Bengal, UP and Bihar and have found that 90 per cent of the shallow dug wells are relatively free from arsenic. They have even recommended to go back to using surface water such as ponds, lakes etc (The Financial Express, 2000; Mortaza, a; Mortaza, b; Mukherjee & Chakraborty). Per capita surface water available in West Bengal is 7000 Cu.M and in Bangladesh it is 11,000 Cu.M (Mukherjee & Chakraborty). They have argued that treating water for bacteriological contamination is relatively an easy task than treating for arsenic removal. SOES recommends proper watershed management with effective withdrawal regulations. They recommend use of available surface water and rainwater after treatment.

Disposal of residual sludge from community level treatment plants is also a serious matter. One of the plants in Bangladesh (Meherpur) has used a large RCC tank for dumping the waste, which can store 50 years of waste generated (mortaza, a). Sludge from treatment plant can also be placed on heap of cow dung where arsenic is converted by bacteria in to volatile less-toxic organic form (Mortaza, a).

The task in hand is enormous, and does not have an easy and ready made solution. Solutions must be looked for both prevention as well as treatment of the poisoning. In fact, prevention of poisoning is critical to long term solution. While the role of the non governmental agencies is laudable, the respective governments have to take the lead role to fight out the menace. An expert committee may be formed, which should work out within a few months a definite time bound action plan. A strong implementation structure and mechanism need to be set up for implementation of the plan. The efforts of the non governmental agencies can be dove-tailed with the government actions. It is important that the fund allocated by the government be proportional to the magnitude of the problem, and hence sizable resources should be directed towards the prevention and cure of arsenic poisoning. Finally, there should be a mechanism to review the impact of the measures implemented periodically, for suitable revision of the action plan for better effectiveness and efficiency.

CONCLUSION

It is said that when tube wells were first introduced in rural Bengal, people called it 'devil's water' (Chakraborty) and were reluctant to accept it. Today, they find it indispensable for their drinking water requirement, but scientists are calling the contaminated water as 'devil's water', and people can not believe it!

The agencies and individuals who have rung the alarm bells of impending danger have been often accused by some people of exaggerating the menace to out of proportion. Spread and intensity of the problem have been doubted. Many examples of contradictory inferences on the tests performed on many tube well water samples have been cited (Ray, 2003). Despite all that, all have agreed that there is a problem and the magnitude of the problem is unprecedented. We need a long term planning, viable technology, implementing machinery and above all the will to combat the menace.

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