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WATER RESOURCES DEPARTMENT

AN OVERVIEW OF ARSENIC IN GROUNDWATER – TAMIL NADU

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INTRODUCTION

An attempt has been made to estimate the presence of heavy metal Arsenic in groundwater in the state of Tamil Nadu recently. Now-a-days the heavy metal Arsenic poses a health risk problem throughout the world.

Arsenic may be found in water which has flowed through arsenic-rich rocks. Severe health effects have been observed in populations drinking arsenic-rich water over long periods in countries world-wide.

SOURCE FOR ARSENIC IN GROUNDWATER

Arsenic is widely distributed throughout the earth's crust. It is introduced into water through the dissolution of minerals and ores, and concentrations in groundwater in some areas are elevated as a result of erosion from local rocks. Industrial effluents also contribute arsenic to water in some areas. Arsenic is also used commercially e.g. in alloying agents and wood preservatives. Also combustion of fossil fuels is a source of arsenic in the environment through disperses atmospheric deposition. Inorganic arsenic can occur in the environment in several forms but in natural waters, and thus in drinking-water, it is mostly found as trivalent arsenite (As(III)) or pentavalent arsenate (As (V)). Organic arsenic species, abundant in seafood, are very much less harmful to health, and are readily eliminated by the body. Drinking-water poses the greatest threat to public health from arsenic. Exposure at work and mining and industrial emissions may also be significant locally.

HEALTH EFFECTS

1. Chronic arsenic poisoning, as occurs after long-term exposure through drinking-water is very different to acute poisoning. Immediate symptoms on an acute poisoning typically include vomiting, oesophageal and abdominal pain, and bloody "rice water" diarrhoea. Chelation therapy may be effective in acute poisoning but should not be used against long-term poisoning.

2. The symptoms 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 on health of arsenic. Similarly, there is no method to identify those cases of internal cancer that were caused by arsenic from cancers induced by other factors.

3. 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).

4. Increased risks of lung and bladder cancer and of arsenic-associated skin lesions have been observed at drinking-water arsenic concentrations of less than 0.05 mg/L.

5. Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry, etc. with water containing arsenic do not pose human health risk.

6. Following long-term exposure, the first changes are usually observed in the skin: pigmentation changes, and then hyperkeratosis. Cancer is a late phenomenon, and usually takes more than 10 years to develop.

7. The relationship between arsenic exposure and other health effects is not clear-cut. For example, some studies have reported hypertensive and cardiovascular disease, diabetes and reproductive effects.

8. Exposure to arsenic via drinking-water has been shown to cause a severe disease of blood vessels leading to gangrene in China (Province of Taiwan), known as 'black foot disease'. This disease has not been observed in other parts of the world, and it is possible that malnutrition contributes to its development. However, studies in several countries have demonstrated that arsenic causes other, less severe forms of peripheral vascular disease.

9. According to some estimates, arsenic in drinking-water will cause 200,000 -- 270,000 deaths from cancer in Bangladesh alone (NRC, 1998; Smith, et al, 2000).

PREVENTION AND CONTROL

The most important remedial action is prevention of further exposure by providing safe drinking- water. The cost and difficulty of reducing arsenic in drinking-water increases as the targeted concentration lowers. It varies with the arsenic concentration in the source water, the chemical matrix of the water including interfering solutes, availability of alternative sources of low arsenic water, mitigation technologies, amount of water to be treated, etc.

Control of arsenic is more complex where drinking-water is obtained from many individual sources (such as hand-pumps and wells) as is common in rural areas. Low arsenic water is only needed for drinking and cooking. Arsenic-rich water can be used safely for laundry and bathing. Discrimination between high-arsenic and low-arsenic sources by painting the hand-pumps (e.g. red and green) can be an effective and low cost means to rapidly reduce exposure to arsenic when accompanied by effective health education.

Alternative low-arsenic sources such as rain water and treated surface water may be available and appropriate in some circumstances. Where low arsenic water is not available, it is necessary to remove arsenic from drinking-water:

1. The technology for arsenic removal for piped water supply is moderately costly and requires technical expertise. It is inapplicable in some urban areas of developing countries and in most rural areas world-wide
2. New types of treatment technologies, including co-precipitation, ion exchange and activated alumina filtration are being field-tested.
3. There are no proven technologies for the removal of arsenic at water collection points such as wells, hand-pumps and springs.
4. Simple technologies for household removal of arsenic from water are few and have to be adapted to, and proven sustainable in each different setting.
5. Some studies have reported preliminary successes in using packets of chemicals for household treatment. Some mixtures combine arsenic removal with disinfection. One example, developed by the WHO/PAHO Pan American Center of Sanitary Engineering and Environmental Sciences in Lima, Peru (CEPIS), has proven successful in Latin America.

WHO'S ACTIVITIES ON ARSENIC

WHO's norms for drinking-water quality go back to 1958. The International Standards for Drinking-Water established 0.20 mg/L as an allowable concentration for arsenic in that year. In 1963 the standard was re-evaluated and reduced to 0.05 mg/L. In 1984, this was maintained as WHO's "Guideline Value"; and many countries have kept this as the national standard or as an interim target. According to the last edition of the WHO Guidelines for Drinking-Water Quality (1993):

1. Inorganic arsenic is a documented human carcinogen.
2. 0.01 mg/L was established as a provisional guideline value for arsenic.
3. Based on health criteria, the guideline value for arsenic in drinking-water would be less than 0.01mg/L.
4. Because the guideline value is restricted by measurement limitations, and 0.01 mg/L is the realistic limit to measurement, this is termed a provisional guideline value.

The *WHO Guidelines for Drinking-water Quality* is intended for use as a basis for the development of national standards in the context of local or national environmental, social, economic, and cultural conditions.

A UN report on arsenic in drinking-water has been prepared in cooperation with other UN agencies under the auspices of an inter-agency coordinating body (the Administrative Committee on Coordination's Sub-committee on Water Resources. It provides a synthesis of available information on chemical, toxicological, medical, epidemiological, nutritional and public health issues; develops a basic strategy to cope with the problem and advises on removal technologies and on water quality management.

Information on arsenic in drinking-water on a country-by-country basis is being collected and will be added to the UN report and made available on the web site.

As part of WHO's activities on the global burden of disease, an estimate of the disease burden associated with arsenic in drinking-water is in preparation. A report entitled "Towards an assessment of the socioeconomic impact of arsenic poisoning in Bangladesh" was released in 2000.

A United Nations Foundation grant for 2.5 million approved in July 2000, will enable UNICEF and WHO to support a project to provide clean drinking-water alternatives to 1.1 million people in three of the worst affected sub-districts in Bangladesh. The project utilizes an integrated approach involving communication, capacity building for arsenic mitigation of all stakeholders at subdistrict level and below, tube-well testing, patient management, and provision of alternative water supply options.

URGENT REQUIREMENTS

1. Large-scale support to the management of the problem in developing countries with substantial, severely affected populations.
2. Simple, reliable, low-cost equipment for field measurement.
3. Increased availability and dissemination of relevant information.
4. Robust affordable technologies for arsenic removal at wells and in households.

GLOBAL SITUATION

The delayed health effects of exposure to arsenic, the lack of common definitions and of local awareness as well as poor reporting in affected areas are major problems in determining the extent of the arsenic-in-drinking-water problem.

Reliable data on exposure and health effects are rarely available, but it is clear that there are many countries in the world where arsenic in drinking-water has been detected at concentration greater than the Guideline Value, 0.01 mg/L or the prevailing national standard. These include Argentina, Australia, Bangladesh, Chile, China, Hungary, India, Mexico, Peru, Thailand, and the United States of America. Countries where adverse health effects have been documented include Bangladesh, China, India (West Bengal), and the United States of America. Examples are:

1. Seven of 16 districts of West Bengal have been reported to have ground water arsenic concentrations above 0.05 mg/L; the total population in these seven districts is over 34 million (Mandal, et al, 1996) and it has been estimated that the population

actually using arsenic-rich water is more than 1 million (above 0.05 mg/L) and is 1.3 million (above 0.01 mg/L) (Chowdhury, et al, 1997).

2. According to a British Geological Survey study in 1998 on shallow tube-wells in 61 of the 64 districts in Bangladesh, 46% of the samples were above 0.010 mg/L and 27% were above 0.050 mg/L. When combined with the estimated 1999 population, it was estimated that the number of people exposed to arsenic concentrations above 0.05 mg/l is 28-35 million and the number of those exposed to more than 0.01 mg/l is 46-57 million (BGS, 2000).
3. Environment Protection Agency of The United States of America has estimated that some 13 million of the population of USA, mostly in the western states, are exposed to arsenic in drinking- water at 0.01 mg/L, although concentrations appear to be typically much lower than those encountered in areas such as Bangladesh and West Bengal. (USEPA, 2001)

ARSENIC IN BANGLADESH

In Bangladesh, West Bengal (India) and some other areas, most drinking-water used to be collected from open dug wells and ponds with little or no arsenic, but with contaminated water transmitting diseases such as diarrhoea, dysentery, typhoid, cholera and hepatitis. Programmes to provide "safe" drinking-water over the past 30 years have helped to control these diseases, but in some areas they have had the unexpected side-effect of exposing the population to another health problem - arsenic.

Arsenic in drinking-water in Bangladesh is attracting much attention for a number of reasons. It is a new, unfamiliar problem to the population, including concerned professionals. There are millions of people who may be affected by drinking arsenic-rich water. Last, but not least, fear for future adverse health effects as a result of water already consumed.

BACKGROUND

1. In recent years, extensive well drilling programme has contributed to a significant decrease in the incidence of diarrhoeal diseases.
2. It has been suggested that there are between 8-12 million shallow tube-wells in Bangladesh. Up to 90% of the Bangladesh population of 130 million prefer to drink well water. Piped water supplies are available only to a little more than 10% of the total population living in the large agglomerations and some district towns.
3. Until the discovery of arsenic in groundwater in 1993, well water was regarded as safe for drinking.
4. It is now generally agreed that the arsenic contamination of groundwater in Bangladesh is of geological origin. The arsenic derives from the geological strata underlying Bangladesh.

SITUATION

1. The most commonly manifested disease so far is skin lesions. Over the next decade, skin and internal cancers are likely to become the principal human health concern arising from arsenic.
2. According to one estimate, at least 100,000 cases of skin lesions caused by arsenic have occurred and there may be many more (Smith, et al, 2000).
3. The number of people drinking arsenic-rich water in Bangladesh has increased dramatically since the 1970s due to well-drilling and population growth.
4. The impact of arsenic extends from immediate health effect to extensive social and economic hardship that effects especially the poor. Costs of health care, inability of affected persons to engage in productive activities and potential social exclusion are important factors.
5. The national standard for drinking-water in Bangladesh is 0.05 mg/L, same as in India.
6. District and sub-district health officials and workers lack sufficient knowledge as to the identification and prevention of arsenic poisoning.
7. The poor availability of reliable information hinders action at all levels and may lead to panic, exacerbated if misleading reports are made. Effective information channels have yet to be established to those affected and concerned.

REMEDIAL ACTIONS

1. Within Bangladesh, a number of governmental technical and advisory committees have been formed and a co-ordinating mechanism established among the interested external support agencies. These committees include the Governmental Arsenic Co-ordinating Committee headed by the Minister of Health & Family Welfare (MHFW) and several technical committees. One of the positive outcomes of this collaboration (including work with local institutes) has been the testing of new types of treatment technologies.
2. So far, many initiatives have focused on water quality testing and control with a view to supplying arsenic-free drinking-water, thereby reducing the risk of further arsenic-related disease. The amount of testing required and the need to provide effective feedback to those using well water, suggest use of field testing kits.
3. Only a few proven sustainable options are available to provide safe drinking-water in Bangladesh. These include: obtaining low-arsenic groundwater through accessing safe shallow groundwater or deeper aquifers (greater than 200 m); rain water harvesting; pond-sand-filtration; household chemical treatment; and piped water supply from safe or treated sources.

MEASUREMENT

1. Accurate measurement of arsenic in drinking-water at levels relevant to health requires laboratory analysis, using sophisticated and expensive techniques and facilities as well as trained staff not easily available or affordable in many parts of the world.
2. Analytical quality control and external validation remain problematic.
3. Field test kits can detect high levels of arsenic but are typically unreliable at lower concentrations of concern for human health. Reliability of field methods is yet to be fully evaluated.

METHODOLOGY

About 412 groundwater samples were collected in the entire state of Tamil Nadu. These samples were analysed using sophisticated Atomic Absorption Spectrophotometer (Perkin Elmer) using expensive techniques of Mercury Hydride System (MHS) with a well trained and skilled staff, since the presence of Arsenic in the groundwater sample was very low in quantity.

DISCUSSION

The data were compiled district wise and the range of Arsenic present in the groundwater samples (microgram/Litre) are given in the statement.

As per Bureau of Indian Standards (BIS), the maximum permissible limit of Arsenic in the drinking water is 0.05 mg/L (50 µg/L).

A bar chart showing the presence of Arsenic in the districts of Tamil Nadu with the permissible limit of BIS limit is appended with this report.

CONCLUSION

1. **From the data it is seen that Arsenic present in the groundwater sample of Tamil Nadu within the safe limit of 0.05 mg/L (50 µg/L) as fixed by the Bureau of Indian Standards for the drinking water.**

2. However the highest amount of Arsenic 8.62, 16.67 and 11.5 µg/L have been noticed in the districts of Kancheepuram, Perambalur and Virudhunagar respectively.

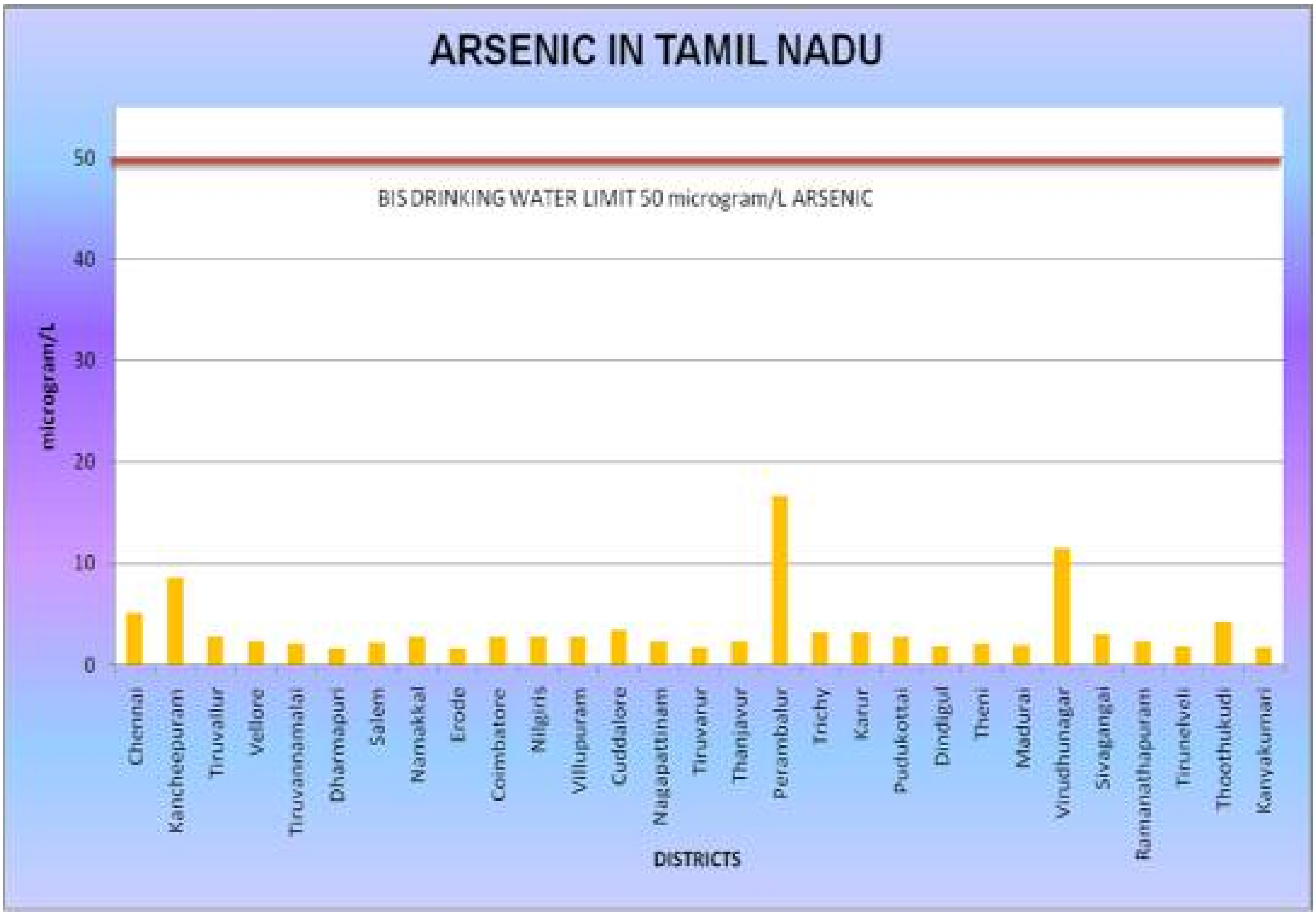
3. In Theni and Erode district the lowest amount of Arsenic 1.00 µg/L have been noticed.

ARSENIC CONCENTRATION IN TAMIL NADU

PERMISSIBLE LIMIT (50 µg/l)

S.No	District	Concentration Range in µg/l	S.No	District	Concentration Range in µg/l
1	Chennai	1.40 - 5.15	16	Thanjavur	1.09 - 2.26
2	Kancheepuram	1.07 - 8.62	17	Perambalur	1.90 - 16.67
3	Tiruvallur	1.05 - 2.75	18	Trichy	1.10 - 3.20
4	Vellore	1.32 - 2.34	19	Karur	1.05 - 3.20
5	Tiruvannamalai	1.59 - 2.12	20	Pudukottai	1.53 - 2.74
6	Dharmapuri	1.40 - 1.57	21	Dindigul	1.01 - 1.87
7	Salem	1.45 - 2.20	22	Theni	1.00 - 2.10
8	Namakkal	1.52 - 2.71	23	Madurai	1.31 - 1.95
9	Erode	1.00 - 1.66	24	Virudhunagar	1.23 - 11.5
10	Coimbatore	1.11 - 2.73	25	Sivagangai	1.17 - 2.96
11	Nilgiris	1.61 - 2.78	26	Ramanathapuram	1.13 - 2.32
12	Villupuram	1.26 - 2.75	27	Tirunelveli	1.04 - 1.89
13	Cuddalore	1.10 - 3.40	28	Thoothukudi	1.28 - 4.24
14	Nagapattinam	1.13 - 2.26	29	Kanyakumari	1.13 - 1.69
15	Tiruvarur	1.08 - 1.78			

ARSENIC LEVEL IN TAMILNADU IS WITHIN SAFE LIMIT



ARSENIC IN TAMIL NADU
BIS DRINKING WATER LIMIT 50 microgram/L ARSENIC
microgram/L
50
40
30
20
10
0
Chennai
Kancheepuram
Tiruvallur
Vellore
Tiruvannamalai
Dharmapuri
Salem
Namakkal
Erode
Coimbatore
Nilgiris
Villupuram
Cuddalore
Nagapattinam
Tiruvarur
Thanjavur
Perambalur
Trichy
Karur
Pudukottai
Dindigul
Theni
Madurai
Virudhunagar
Sivagangai
Ramanathapuram
Tirunelveli
Thoothukudi
Kanyakumari
DISTRICTS