Arsenic Impurities in Ground Water

Abstract

Arsenic (As) is identified as a poison and carcinogen (cancer causing substance) if consumed in higher concentrations than permissible limits. In water, arsenic has no smell or taste and can only be detected through a chemical test. Hence arsenic is a silent and potential health hazard and its presence in high concentrations in ground water is of deep concern. Hence the public health concern and water quality impacts, the study of arsenic contamination and evaluation of this problem globally can be useful in studying comparative mitigation opportunities. In this paper we have studied the occurrence of arsenic and other impurities in ground water, generally used for drinking and irrigation in India. We have also discussed their impact on human health and the remedial procedures.

Key Words : Arsenic , water , contamination , impurities ,groundwater.

Neelam Sinha
Deptt. Of Physics,
S.D. College,
Muzaffarnagar

Piyush Sinha
School of Science,H.N.B. Garhwal University,Pauri campus.
piyushs03@gmail.com

Introduction

Water is the 'Universal Solvent' also called the 'Matrix of Life'. It is seldom found in totally pure state in nature. It always contains several impurities in the form of chemicals, gases and minerals in the air, soil and rocks etc. Water falling to earth as rain dissolves some gases in the atmosphere and when it falls on the earth and percolates through it, dissolves the minerals present in the earth. Some minerals cause hardness (Ca, Mg), color, (Fe), contamination (Ar, silicates) radioactivity (Ra, Rn) in the water. Some minerals produce characteristic taste and odour. Due to presence of dissolve gases such as sulphides; micro-organism, natural organic contaminations such as lignins, tannins and human acid, water is not found in pure state. Pure water is generally supposed to be flat in taste. Humans can also contaminate it through the improper use of pesticides or fertilizers and through the disposal of wastes. The concentration of minerals and impurities present in water are measured either as parts per million (ppm) or milligram per litre (mg / l). Some parameters are measured parts per billion (ppb) or microgram per litre (µg / l).Table (1) shows the different types of impurities found in water.

Other Impurities in Groundwater

CLASSIFICATION AND ORIGIN OF IMPURITIES FOUND IN WATER

Class of Impurity			Typical Impurities and their origins	
1. DISSOLVED	1.1	**Inorganic Salts**	1.1.1	Leaching of minerals and pick-up of atmospheric CO_2, leads to hardness, alkalinity and other mineral impurities.
			1.1.2	Fertiliser run-off, mostly phosphate (PO^{3-}_4), nitrate (NO_3^-) and sulphate (SO_4^{2-}).
			1.1.3	Proportion of inorganic salts in domestic waste returned to the water cycle, mostly sodium (Na^+), chloride (Cl^-) and phosphate (PO^{3-}_4).
			1.1.4	Industrial discharges of all kinds, especially from metal finishing trade.
			1.1.5	Salinity (principally chlorides) from sea water or saline groundwater intrusion.
			1.1.6	Breakdown products of organic nitrogen (N_2) yielding ammonium compounds and nitrates (NO_3^-).
	1.2	**Dissolved Organic Matter**	1.2.1	Natural impurities from decay of vegetable and animal matter, leading to colouring material and humic and fulvic acids.
			1.2.2	Domestic waste: general biological debris and decay products, soap, detergents.
			1.2.3	Industrial discharges from e.g. food processing and intensive agriculture, papermaking, organic chemical industry. Includes fats, oils and solvents.
			1.2.4	Residues of pesticides, herbicides etc.

2. SUSPEN	2.1	**Colloids (Organic and Inorganic)**	2.1.1 2.1.2 2.1.3 2.1.4	Inorganic Colloids such as clay, and iron (Fe) or manganese (Mn) oxides. Natural organic macro-molecules and particles (cf 1.2.1). Industrial wastes from e.g. china, clay or paper processing. A component of sewage solids.
DED	2.2	**Suspended Inorganic Matter**	2.2.1 2.2.2	Natural materials, mostly sand. Industrial materials from coal washings, mining waste, lime and other sludges, oxide dust, fly ash, flue washings etc.
	2.3	**Suspended Organic Matter**	2.3.1 2.3.2	Plant and animal particles (cf 1.2.1) Industrial and Domestic products (cf 1.2.3 and 2.1.4)
3.	3.1	**Micro Organisms**	3.1.1	Algae, viruses, bacteria, protozoa, microfungi, etc. occur in all natural waters and some fraction at least remains behind unless it is specifically removed. Occurrence is promoted by nutrients (cf esp. 1.1.2) and favourable breeding grounds e.g. domestic sewage. Exposure to light promotes algae growth.
LIVING MATTER			3.1.2 3.1.3	Iron (Fe) bacteria in ferruginous wells and iron pipes. Sulphur (S) bacteria (in anaerobic conditions).
ER	3.2	**Larger Life Forms**	3.2.1 3.2.2	Fish, newts, worms, crustacea, insect larvae, water lice etc. breed in large numbers where food is plentiful. Aquatic plants, floating and rooted.
4. GASES	4.	**Gases**		O_2 and CO_2 occurs in all natural waters. Some underground sources contain high CO_2, a few contain H_2S. NH_3 can result from biological decay or from industrial discharge. Cooling towers pick up CO_2 and, in some industrial sites, SO_2. Cl_2 is often used deliberately. Algal growth removes CO_2 and may raise O_2 to super-saturation in daytime, with some reversal at night.

Table 1

Water supplies in India are drawn from three principal sources - groundwater, upland surface water and lowland surface water - each with its own set of characteristics. If raw water comes from underground sources - such as deep wells, boreholes or springs - it is likely to be rich in minerals, and to have high total dissolved solids (TDS) and hardness levels. The organic content, however, is generally low as most of the organic matter will have been filtered out as the water percolated down through the rock strata.

Waters taken from upland streams and lakes usually have a meagre mineral content and low TDS and hardness levels. However, they are rich in natural organic matter - especially humic and fulvic acids - which tend to give them a yellowish tinge. Surface water derived from Lowland sources sometimes originates from springs and so has the same general characteristics as groundwater. River and canal waters, especially in industrial areas, tend to accumulate man-made pollutants, while recycled river water normally has high TDS levels.

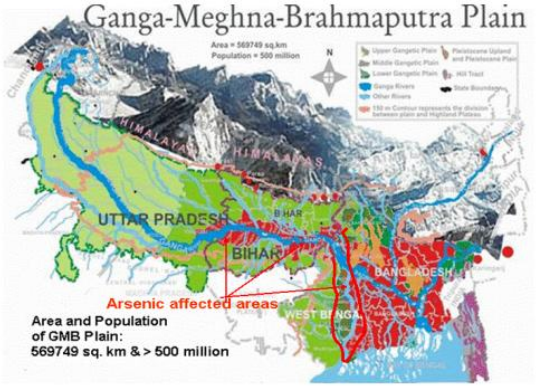
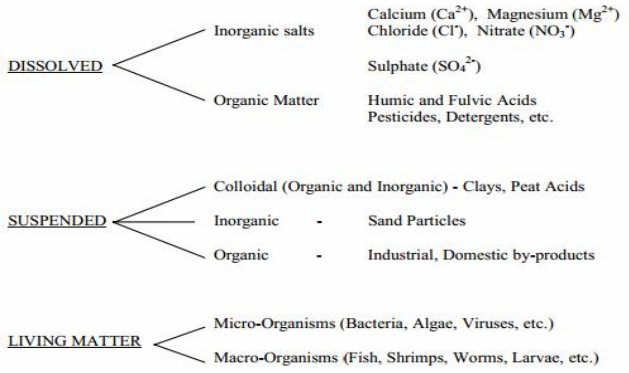


Figure 1: Arsenic affected stretches in Ganga Plains in India with reference to Ganga-Meghna-Brahmaputra Plains.

The impurities present in raw waters can be classified as follows:



Occurrence of Arsenic

Except these impurities in the flood plane aquifer the arsenic combination of shallow tube well water in excess of acceptable limit has become a major public health problem in the country. Thousands of people have already shown the symptoms of arsenic poisoning and several millions are at risk due to arsenic contamination from drinking tube well water. Arsenic also occurs naturally in rocks, soil, water, air plants and animals. Natural activities such as volcanic action erosion of rocks and forest fires can release arsenic into the environment .Industrial product like wood preservatives, dyes, paints, herbicides, pharmaceuticals and semiconductors also contain arsenic. The man made sources of arsenic in the environment include mining and smelting operations; agricultural applications; burning of fossil fuels and wastes; pulp and paper production; cement manufacturing etc.

Figure 2

Impact on Human Health

Arsenic contamination has recently received worldwide attention because of the nature of its health effects. The problem is severe in South Asia, particularly in Bangladesh and eastern parts of India, where the impacts on water quality and public health are seen in disastrous proportions. Arsenic contamination in drinking water causes a disease called arsenicosis, for which there is no effective treatment yet known. Its presence also causes skin, lungs, bladder and kidney cancer as well as pigmentation changes, skin thickening, neurological disorders, muscular weakness, loss of Figure 3

appetite and nausea. So, provision of arsenic free water is urgently needed to mitigate arsenic toxicity and protection of health and well being of rural people living in acute arsenic problems in flood prone areas. Arsenic contamination is by far the biggest mass poisoning case in the world putting 20 millions people from West Bengal, and Bangladesh at risk through some other estimates put this figure at 36 million people. The alternative method may be the treatment of ground water by low cost methods, rain water harvesting and water from deep aquifers would be potential sources of water supply to avoid water ingestion through shallow tube well water.

Figure 3

Figure 4

Removal Techniques

In India ground water quality monitoring is primarily concern of the Central Ground Water Board and State Ground Water agencies. Where each of them set up their monitoring network. One can remove arsenic impurities in water upto a certain extent under RO system. Under RO systems water is made to pass through a membrane having a pore size of .0001 micron under high pressure. Only 5-10% ions are able to slip across the membrane, which is well within acceptable level as per all standards including WHO, BIS etc. RO system is suitable for removing several of toxic substances present in water in dissolved form, including fluoride, fertilizer and pesticides residues and heavy metals. A household arsenic treatment method is the ferric chloride co-agulation system. This involves precipitation of arsenic by adding a packet of co-agulant in 25 liter of tube well water and subsequent filteration of the water through a sand filter. It showed that arsenic concentration in treated water was nearly 1/20th that of raw water. It can be removed by oxidation with chlorine or potassium permagnet also.

Conclusion

We have seen that the ground water contains impurities in different form. But the presence of impurities of arsenic in the ground water in several countries is alarming. In India high level of arsenic above the permissible level of 50 parts per billion are found in the alluvial plains of Ganges covering six districts of West Bengal. In 40 districts from 13 states viz Andhra Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh Orissa, Punjab, Rajasthan, Tamil Nadu, West Bengal and five block of Delhi presence of heavy metals is found in ground water .

References

1. EPA. "Protecting Water Quality from Agricultural Runoff." Fact Sheet No. EPA-841-F-05-001. March 2005
2. A.M. Nurul, K. Satoshi, K. Taichi, B. Aleya, K. Hideyuki, S. Tohru,O. Kiyohisa, Removal of arsenic in aqueous solutions by adsorption onto waste rice husk, Ind. Eng. Chem. Res. 45 (24) (2006) 8105– 8110.
3. S. Paraeniemi, S. Hannonen, H. Mustalahti, M. Ahlgren, Zirconium loaded activated charcoal as

an adsorbent for arsenic, selenium, and mercury, Fres. J. Anal. Chem. 349 (7) (1994) 510–515.
4. L. Helsen, Sampling technologies and air pollution control devices for gaseous and particulate arsenic: a review, Environ. Pollut. 137 (2) (2005) 305–315.
5. B.K. Mandal, K.T. Suzuki, Arsenic round the world: a review, Talanta 58 (2002) 201–235.
6. A. Kabata-Pendias, H. Pendias, Trace elements in soils and plants, CRC Press, Boca Raton, FL, 2000
7. P.L. Smedley, D.G. Kinniburgh, Sources and behaviour of arsenic in natural water, Chapter 1 in United Nations Synthesis Report on Arsenic in Drinking Water, 2005.
8. N.N. Greenwood, A. Earnshaw, Chemistry of Elements, Pergamon Press, Oxford, 1984 (Chapter 13).
9. S.Wang, C.N. Mulligan, Occurrence of arsenic contamination in Canada: 3127 sources, behavior and distribution, Sci. Total Environ. 366 (2006) 701–721.
10. www.gov.ns.ca/nse/water/arsenicremovalreverse.asp - May 16, 2013
11. United States Environmental Protection Agency (EPA). Washington, DC. "The National Water Quality Inventory: Report to Congress for the 2002 Reporting Cycle – A Profile." October 2007. Fact Sheet No. EPA 841-F-07-003.