Introduction

The major source of freshwater in many parts of the world for meeting the requirements of daily purposes including agriculture is groundwater. The dependency on groundwater leads to approximately one-third of the world’s population for drinking purposes.1 A large area of the world experiences a huge contamination in groundwater due to mixing of different toxic and minerals and heavy metals either naturally or unorganized development of human civilization.2,3 The Arsenic is one of the most important and fatal among these minerals. The high concentrations of arsenic (As) in drinking water in inorganic form causing skin, liver, lungs and other organs damages in several parts of the world.4 There are more than 25% of domestic wells presented in alluvial aquifers of this state carry arsenic in drinking water beyond the permissible limit of WHO, 1993 (0.01mg/L).5,6 West Bengal lies within the Ganga–Brahmaputra delta basin has high contamination of arsenic (<0.05mg/ml) mainly in groundwater.7 West Bengal can be divided into three arsenic prone zones i.e. highly affected areas cover eastern side of Bhagirathi River; mildly affected areas include northern part of the Bhagirathi river and the unaffected region carries western part of the state. This study reveals the condition of arsenic toxicity and stratigraphic and lithological condition in West Bengal, a state of India and the fatal effect on human health due to arsenic toxicity.

Distribution of arsenic polluted area in west Bengal

In India Arsenic contamination in ground water was first reported in West Bengal in 19789 and it includes79 blocks in 8 districts among 26 districts where arsenic concentration in ground water exceeded 50µg/L. According to Das, 2015, this problem is expanding rapidly and in 2006 almost 3235 villages were affected including North 24 Parganas, South 24 Parganas, Nadia, Murshidabad and Burdwan, Howrah, Hooghly and Maldah districts (Table 1). The severely affected districts are Murshidabad, Maldah, Nadia, North and South 24 Parganas, Burdwan, Howrah and Hooghly. The values of arsenic contaminated ground water of the affected districts are discussed below in Table 2. In course of this study, the numbers of affected blocks under the affected districts were too high. Almost all the districts contains over 50% to 100% arsenic contaminated block. The condition of arsenic contamination in block level is discussed herewith in Table 3.9

Table 1 Progressive spread of arsenic contamination in West Bengal

| Date       | No. of affected districts | No. of affected blocks | No. of villages | No. of affected municipalities |
|------------|----------------------------|------------------------|----------------|-------------------------------|
| MAY,1993   | 7                          | 34                     | 78             | 3                             |
| SEPT,1995  | 7                          | 56                     | 388            | 9                             |
| DEC,1997   | 8                          | 61                     | 1302           | 9                             |
| DEC,1998   | 8                          | 65                     | 1312           | 9                             |
| DEC,1999   | 8                          | 67                     | 1550           | 11                            |
| DEC,2001   | 8                          | 75                     | 2065           | 11                            |
| DEC,2002   | 8                          | 75                     | 2579           | 11                            |
Table 2: Arsenic concentration in different districts of West Bengal up to 2006

| Districts            | Permissible limit (BSI) | Arsenic concentration in mg/L |
|----------------------|-------------------------|-------------------------------|
| South 24 Parganas    | 0.06-3.20               |                               |
| North 24 Parganas    | 0.06-1.28               |                               |
| Maldah               | 0.05-1.434              |                               |
| Nadia                | 0.05-1.00               |                               |
| Murshidabad          | 0.05-0.90               |                               |
| Burdwan              | 0.10-0.50               |                               |
| Howrah               | 0.09                    |                               |
| Hooghly              | 0.6                     |                               |

Source: Planning commission of India (2007).

Table 3: No. of Arsenic affected blocks in different districts of West Bengal in 2006

| District          | Total No. of blocks | No. of blocks affected |
|-------------------|---------------------|------------------------|
| MALDAH            | 15                  | 7                      |
| MURSHIDABAD       | 26                  | 19                     |
| NADIA             | 17                  | 17                     |
| N.24 PARGANAS     | 22                  | 19                     |
| S.24 PARGANAS     | 29                  | 9                      |
| BURDWAN           | 31                  | 5                      |

Table 4: Stratigraphic status of Raninagar, District Murshidabad, West Bengal, Inland region north.

| Unit              | Depth range (m) b.g.l. | Generalized lithology                        | Range of arsenic in ground water (mg/l) |
|-------------------|------------------------|----------------------------------------------|----------------------------------------|
| III (Not developed or condensed section) | 0-6 | Clay or sandy clay | 0.2-6.0 |
| II                | 6-50                   | Fine to medium grained sand with clay intercalations | 3.2-9.3 |
| I                 | 40-70                  | Medium grained sand                          | 2.0-5.2 (not sampled)                  |
| Disconformity Upper Tertiary | -10 | Silty clay          | Not sampled                              |

Average Arsenic content: Clay: 12ppm, sand: 4.8ppm

Table 5: Stratigraphic status of Ashoknagar, Halderbagan, District 24 parganas (north) West Bengal, Inland region central.

| Unit | Depth range (m) b.g.l. | Generalized lithology                | Range of arsenic in ground water (mg/l) |
|------|------------------------|--------------------------------------|----------------------------------------|
| III  | 0-20                   | Clay                                 | 0.1 – 6.2                              |
|      | 20-55                  | Fine to medium grained sand with clay bands | 0.1-25.0                          |
| II   | 55-70                  | Clay with fine grained sand           | 2.0-15.0                              |
| I    | 70-115                 | Fine to medium grained sand with clay | 0.5-5.5                                |

Average Arsenic content: Clay: 9.5ppm, sand: 3.8ppm

Effect of arsenic pollution in human health

A prolonged and chronic exposure of arsenic in humans through drinking water, medications or occupational and environment affects multi organ system of human body (Figure 1).
Skin and systemic manifestations

The specific skin diseases are pigmentation and keratosis, which are caused by chronic arsenic toxicity. The first population-based survey in West Bengal to assess the prevalence of keratosis and pigmentation was carried on 4,093 females and 3,590 males who were exposed to arsenic toxicity. The result revealed that men took the same exposure of arsenic through drinking water had two to three times more toxicity on both keratosis and pigmentation than the females. Chronic arsenic toxicity also produces various systemic manifestations over and above skin lesions in association with arsenical skin lesions.

Respiratory disease

Non-malignant lung diseases are caused due to long exposure of arsenic contaminated drinking water (800 mg/L). About 38% of the arsenic exposed persons were experienced chronic cough, compared with 3.1% of the unexposed one. Chronic lung diseases were common in 57% of the exposure of chronic arsenic toxicity through arsenic contaminated drinking water in West Bengal.

Gastrointestinal disease

Dyspepsia one of the most dominated (38.4%) gastrointestinal syndrome for chronic arsenic toxicity. Gastroenteritis also caused by chronic arsenic sis through the drinking of arsenic-contaminated water with a concentration greater than 50 mg/L.

Diseases of nervous system

Peripheral neuropathy is caused by chronic exposure of arsenic through drinking water. Peripheral neuritis characterized by paresthesia (tingling, numbness, limb weakness, and others) was present in 47.4% of total patients of chronic arsenic sis in West Bengal, India. Several reports revealed that increased incidence of cerebrovascular disease in patients suffering from chronic arsenic sis. There are also other neural complications such as peripheral neuritis, sleep disturbances, weakness, and cognitive and memory impairment also reported.

Cardiovascular disease

The important complications of chronic arsenic toxicity is Blackfoot disease (BFD), a peripheral vascular disease. The prevalence of BFD has been reported as 8.9% of the affected people in arsenic. Another peripheral vascular disorder such as Raynaud’s syndrome and acrocyanosis with varying degrees of severity have also been reported in West Bengal. Apart from that arsenic toxicity also increases around 6.2% of the prevalence of hypertension in West Bengal.

Haematological effects

Acute and chronic arsenic poisoning leads to anemia, leucopenia, and thrombocytopenia and other haematological abnormalities. West Bengal carries average 50% anemia were caused in the exposure to arsenic-contaminated groundwater (200-2,000 mg/L). Cumulative arsenic exposure and prevalence of diabetes mellitus were showed dose response relationship in arsenic endemic areas. In Bangladesh, diabetes mellitus prevalence also increased significantly where arsenic-contaminated water was taken as drinking water. There is no such report of diabetes mellitus caused by arsenic sis in West Bengal.

Arsenosis and cancer

Exposure to arsenic leads severe carcinogenicity in humans through drinking water. This carcinogenicity is principally responsible in skin, urinary bladder, and lungs, among them 4.35% of skin cancer and 0.78% of internal cancers were detected in arsenic-affected villages in West Bengal through arsenic contamination.

Genotoxic effects

A long-term exposure of arsenic through drinking water expresses genotoxic effects which includes increased rate of chromosomal aberrations and micronuclei formation in buccal and urothelial
cells.\textsuperscript{14,26,37} In West Bengal, the frequencies of formation of micronuclei were significantly high in peripheral lymphocytes, oral mucosa and urothelial cells and this effect is near 5-fold higher to exposed persons than unexposed ones.\textsuperscript{38}

**Conclusion**

Chronic arsenic toxicity through the ingestion of arsenic-contaminated groundwater makes a fatal hazard in human health throughout the world. Various skin, liver, cardiovasucular, lungs, gastrointestinal disorders might become too much alarming in modern busy lifestyle. Different neurological anomalies and genotoxicity may lead to severe cause of genetic aberrations.\textsuperscript{39} The lithological and stratigraphic data revealed that the Ganga- Brahmaputra delta region is too much threatened because of the low thickness of lithological orientation. In this context, the key approach.

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**Conflict of interest**

The author declares no conflict of interest.

**References**

1. Anonymous UNEP. Conference of plenipotentiaries to adopt the protocol concerning pollution from land-based sources and activities to the convention for the protection and development of the marine environment of the wider Caribbean region. USA; 1999. p. 1–7.
2. Ravenscroft P, Brammer H, Richards KS. Arsenic Pollution: A Global Synthesis. USA: Blackwell–Wiley; 2009.
3. Onodera J, Takahashi K, Jordan RW. Eocene silicoflagellate and ebridi paleoceanography in the central Arctic Ocean. Paleoceanography. 2008;23(1):1–9.
4. Smith AH, Hopenhayn-Rich C, Bates MN, et al. Cancer risks from arsenic in drinking water. Environ Health Perspect. 1992;97:259–267.
5. Yu WH, Harvey CM, Harvey CF. Arsenic in groundwater in Bangladesh: A geostatistical and epidemiological framework for evaluating health effects and potential remedies. Water Resour Res. 2003;39(6):1146.
6. Guidelines for Drinking water Quality. 4th ed. Switzerland: World Health Organisation (WHO); 2017. p. 1–564.
7. Mukherjee A, Fryar RD, Rowe HD. Regional-scale stable isotopic signatures of recharge and deep groundwater in the arsenic affected areas of West Bengal, India. Journal of Hydrology. 2008;334:151–161.
8. Sengupta MK, Hossain A, Ahamed S, et al. Groundwater arsenic contamination situation in West–Bengal, India:a nineteen–year study. Bhubaneswar: 2009;24(2,3).
9. Das A. Ground Water Arsenic Contamination–A Study of Major Arsenic Affected Districts of West Bengal. Int J Sci Res. 2015;4(6):2993–2996.
10. Bhattacharya A, Banerjee SN. Quaternary geology and geomorphology of the Ajay–Bhagirathi valley, Birbhum and Murshidabad districts, West Bengal. Indian J Earth Sci. 1979;2:51–61.
11. Niyogi D. Quaternary geology of the coastal plain in West Bengal and Orissa. Indian J Earth Sci. 1975;2:51–61.
12. Sengupta S. Geological and geophysical studies in western part of Bengal basin, India. Bull Am Assoc Petrol Geol. 1966;50(5):1001–1017.
13. Acharyya SK, Basu PK. Toba ash on the Indian subcontinent and its implication for correlation of late Pleistocene alluvium. Quat Res. 1993;40:10–19.
14. Monsur MH. An introduction to the Quaternary geology of Bangladesh. Bangladesh: Rehana Akhter; 1995. 70 p.
15. Morgan JP, McIntire WC. Quaternary geology of the Bengal basin, East Pakistan and India. Bull Geol Soc Am. 1959;70(3):319–342.
16. Biswas AB, Roy RN. A study on the depositional processes and heavy mineral assemblage of the Quaternary sediments from Murshidabad district, West Bengal. Proc Indian Natl Sci Acad. 1976;42(5):372–386.
17. Deshmukh DS, Prasad KN, Niyogi BN, et al. Geology and groundwater resources of alluvial areas of West Bengal. Bull Geol Surv India Ser B. 1973;34:1–451.
18. Acharyya SK, Lahiri S, Raymahashay BC, et al. Arsenic toxicity of groundwater in parts of the Bengal basin in India and Bangladesh: the role of Quaternary stratigraphy and Holocene sea–level fluctuation. Environmental Geology. 1999;39(10):1127–1137.
19. Guha Mazumder DN, Haque R, Ghosh N, et al. Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India. Int J Epidemiol. 1998;27(5):871–877.
20. Guha Mazumder D, Dasgupta UB. Chronic arsenic toxicity: Studies in West Bengal, India. Kaohsiung Journal of Medical Sciences. 2011;27(9):360–370.
21. Majumder KK, Guha Mazumder DN, Ghose N, et al. Systemic manifestations in chronic arsenic toxicity in absence of skin lesions in West Bengal. Indian J Med Res. 2009;129(1):75–82.
22. Borgomo JM, Vicent P, Venturino H, et al. Arsenic in the drinking water of the city of Antofagasta: epidemiological and clinical study before and after the installation of a treatment plant. Environ Health Perspect. 1977;19:103–105.
23. Ma HZ, Xia YJ, Wu KG, et al. Human exposure to arsenic and health effects in Bayingnormen, Inner Mongolia. In: Chappell WR, Abernathy CO, editors. Arsenic exposure and health effects. The Netherlands; 1999. p. 127–131.
24. Ahmad SA, Sayed MHSU, Hadi SA, et al. Arsenicosis in a village in Bangladesh. Int J Environ Health Res. 1999;9(3):187–195.
25. Cebrian ME, Albores A, Aguilar M, et al. Chronic arsenic poisoning in the north of Mexico. Hum Toxicol. 1983;2(1):121–133.
26. Saha KC. Melanokeratosis from arsenic contaminated tube well water. Indian J Dermatol. 1984;29(4):37–46.
27. Hotta T. Clinical aspects of chronic arsenic poisoning due to environmental and occupational pollution in and around a small refining spot. Nippon Taishitsugaku Zasshi. 1989;53:49–70.
28. Kilburn KH. Neurobehavioural impairment from long–term residential arsenic exposure. In: Abernathy CO, Calderon RL, editors. Arsenic exposure and health effects. UK; 1997. p. 159–177.
29. Chen CJ, Chiou HY, Huang WJ, et al. Systemic non–carcinogenic effects and developmental toxicity of inorganic arsenic. In: Abernathy CO, Calderon RL, editors. Arsenic exposure and health effects. UK; 1997. p. 124–134.
30. Arsenic in drinking water: USA: NRC (National Research Council), National Academic Press; 1999. p. 27–82.
31. Guha Mazumder DN, Chakraborty AK, Ghosh A, et al. Chronic arsenic toxicity from drinking tube–well water in rural West Bengal. Bull World Health Organ. 1988;66(4):499–506.
32. Lai MS, Hsueh YM, Chen CJ, et al. Ingested inorganic arsenic and prevalence of diabetes mellitus. Am J Epidemiol. 1994;139(95):484–492.
33. Rahman M, Tondel M, Ahmad SA, et al. Diabetes mellitus associated with arsenic exposure in Bangladesh. Am J Epidemiol. 1998;148(92):198–203.

Citation: Adhikary R, Mandal V. Status of arsenic toxicity in ground water in west bengal, india: a review. MOJ Toxicol. 2017;3(5):104–108. DOI: 10.15406/mojitoxicol.2017.03.00063
34. Some drinking-water disinfectants and contaminants, including arsenic. IARC Monogr Eval Carcinog Risks Hum. 2004;84:1–477.

35. Saha KC. Saha’s grading of arsenicosis progression and treatment. In: Chappell WR, Abernathy CO, editors. Arsenic exposure and health effects. Oxford, UK; 2003. p. 391–414.

36. Warner ML, Moor LE, Smith MT, et al. Increased micronuclei in exfoliated bladder cells of individuals who chronically ingest arsenic contaminated water in Nevada. Cancer Epidemiol Biomarkers Prev. 1994;3(7):583–590.

37. Gonsebatt ME, Vega L, Salazar AM, et al. Cytogenetic effects in human exposure to arsenic. Mutat Res. 1997;386(3):219–228.

38. Basu A, Ghosh P, Das JK, et al. Micronuclei as biomarkers of carcinogen exposure in populations exposed to arsenic through drinking water in West Bengal, India: a comparative study in 3 cell types. Cancer Epidemiol Biomarkers Prev. 2004;13(5):820–827.

39. Guha Mazumder DN. Criteria for case definition of arsenicosis. In: Chappell WR, Abernathy CO, editors. Arsenic exposure and health effects. Oxford, UK; 2003. p. 117–135.