



**NAME: DEBOJYOTI MANDAL**

**ROLL NUMBER: 193115-21-0009**

**REGISTRATION NUMBER: 115-1112-0281-19**

**UNIVERSITY OF CALCUTTA**

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# Status of arsenic toxicity in ground water in West Bengal

## Abstract

Arsenic toxicity is a great threat in human civilization specially in West Bengal, India. Almost half of the state is under the toxicity of this heavy metal. Several lithological and stratigraphic studies revealed the stratigraphic position and the possibility of arsenic contamination in the lower gangetic delta region. A number of physiological anomalies in the human system such as Skin, respiratory, cardiovascular, Hematological disorder have been observed due to the chronic exposure to this. Apart from these disorders diabetes, genotoxic and cancer related complications have been arisen due to the exposure of arsenic. The present study revealed the present status of arsenic toxicity, stratigraphic condition of this state and the physiobiochemical consequence of chronic exposure of arsenic toxicity on human health.

## 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.<sup>1</sup> 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.<sup>2,3</sup> 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.<sup>4</sup> 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, 2017 (0.01 mg/L).<sup>5,6</sup> West Bengal lies within the Ganga-Brahmaputra delta basin has high contamination of arsenic (<0.05mg/ml) mainly in groundwater.<sup>7</sup> West Bengal can be divided into three arsenic prone zones<sup>8</sup> 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 litho logical 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

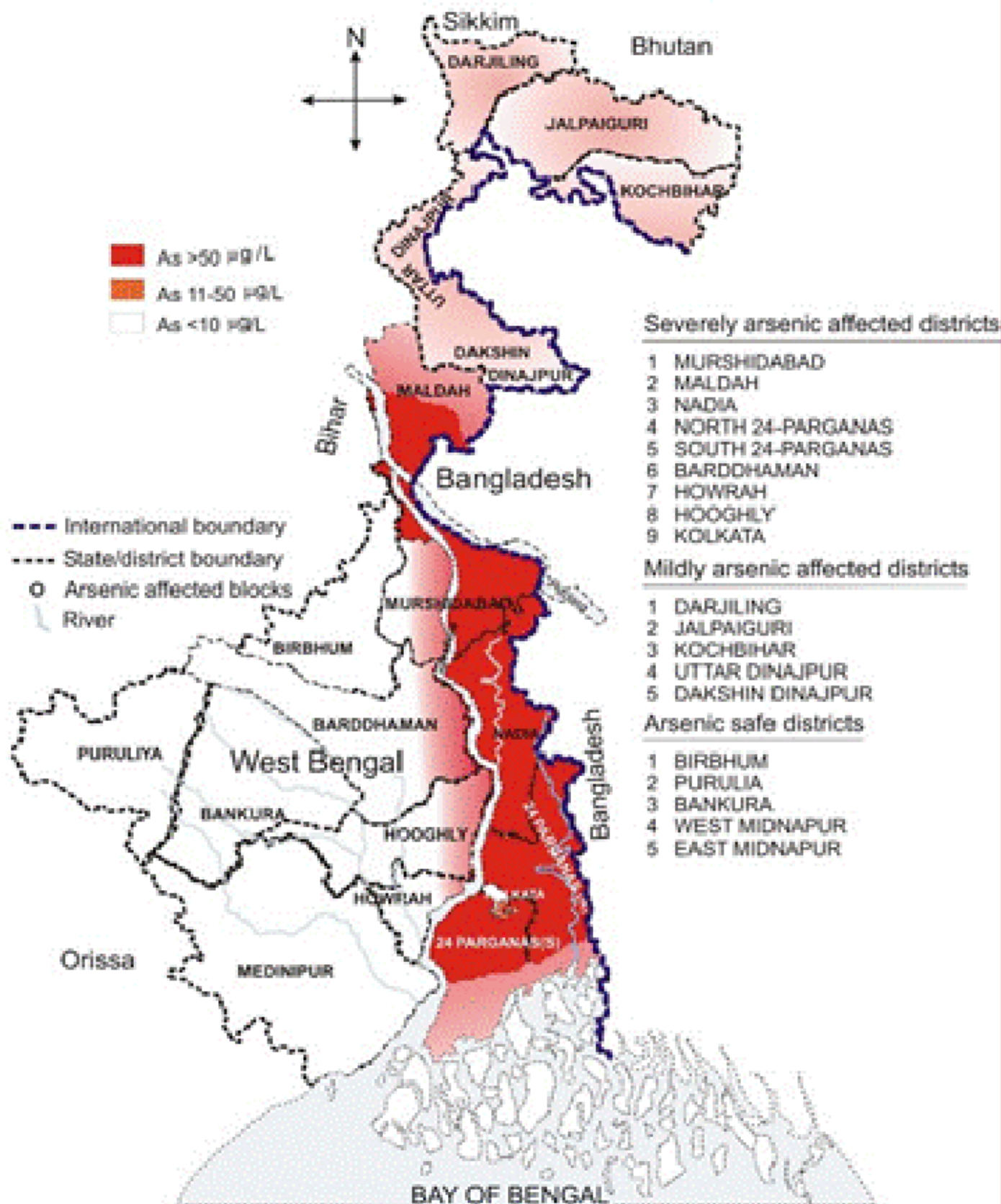
In India Arsenic contamination in ground water was first reported in West Bengal in 1978<sup>9</sup> and it includes 79 blocks in 8 districts among 26 districts where arsenic concentration in ground water exceeded 50µg/L. According to Das, 2015, this problem is expanding rapidly and in 2006 almost 3235 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 district contains over 50% to 100% arsenic contaminated block. The condition of arsenic contamination in block level is discussed herewith in ([Table 3](#)).<sup>9</sup>

Date	No. of Affected Districts	No. of Affected Block	No. of villages	No. of Affected Municipalites
MAY,1993	7	34	78	3
SEP, 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
MAY,2006	8	79	3235	11

**Table 1** Progressive Spread of Arsenic contamination in We

## GROUNDWATER ARSENIC CONTAMINATION STATUS IN WEST BENGAL-INDIA

[Total number of arsenic affected districts 9 and blocks 111]



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	0.05mg/L	0.05-1.00
Murshidabad		0.05-0.90
Burdwan		0.10-0.50
Howrah		0.09
Hooghly		0.6

**Table 2** Arsenic Concentration in Different districts of West Bengal up to 2006  
**Source:** Planning Commission of India (2007)

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

### Stratigraphy and lithology of arsenic contaminated aquifers

The stratigraphic analysis of arsenic prone aquifer zones of the southern part of West Bengal occurred beneath the alluvial plain. Soil thickness of the young delta plain (YDP) is 1-2 m thick with a top of soft Fe-Mn concretions up to 0.2 m, and lower section contains calcretes. In West Bengal, part of the Bengal basin of Bhagirathi, morpho stratigraphic units of the subsurface continuity have been established,<sup>10,11</sup> whereas, lower subsurface units from YDP do not out cropped. The recognition of the quaternary section was difficult, but in many boreholes of western gangetic plains the sequence is mostly clay and sand. These have formed in saline water and contain microfossils locally to an Upper Pliocene age.<sup>12</sup> The presence of the Toba-ash bed marker (75,000 years b.p.) has been recorded to present in the basal parts of the quaternary profile of the Brahmani and Barakar River sections, slightly to the west of the Ganga-Brahmaputra basin margin.<sup>13</sup> The arsenic-bearing aquifers are present in the Holocene sediments beneath YDP. Arsenic toxic YDP sediments partly encroached into the Barind area which is presented in north of Ganges channel, e.g. the Malda district of West

Bengal.<sup>14</sup> These Holocene valleys are filled with silt and clay which are deposited in deeply eroded and incised Barind sediments<sup>15</sup> of Pleistocene age. Based on lithology revealed from drilling of groundwater and heavy mineral contents, the arsenic affected district of West Bengal have been classified into three stratigraphic zones broadly based on the subsurface sediments beneath the YDP of northern and southern West Bengal (Tables 4 & 5).<sup>16-18</sup>

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 graineds and with clay intercalations	3.2-93.1
I	40-70	Medium grained sand	2.0-5.2 (not sampled)
Disconformity Upper Tertiary	-10	Silty clay	Not sampled
Average Arsenic content: Clay: 12 ppm, sand: 4.8 ppm			

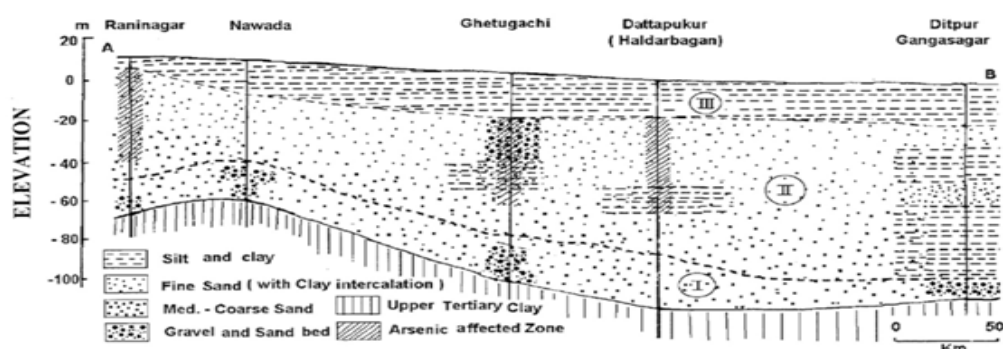
**Table 4** Stratigraphic status of Raninagar, District Murshidabad, West Bengal, Inland region north<sup>16</sup>

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
II	20-55	Fine to medium grained sand with clay bands	0.1-25.0
	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: 9.5 ppm, sand: 3.8 ppm			

**Table 5** Stratigraphic status of Ashoknagar, Halderbagan, District 24 parganas (north) West Bengal, Inland region central<sup>16</sup>

## 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).



**Figure 1** Stratigraphic and lithological organization of West Bengal.<sup>18</sup>

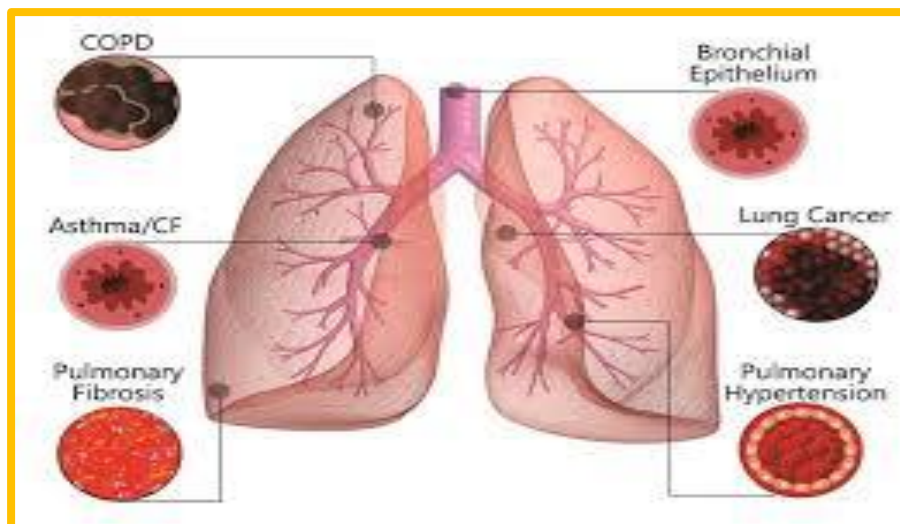
## Skin and systemic manifestations

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.<sup>19</sup> 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.<sup>20</sup> Chronic arsenic toxicity also produces various systemic manifestations over and above skin lesions in association with arsenical skin lesions.<sup>21</sup>



## Respiratory disease

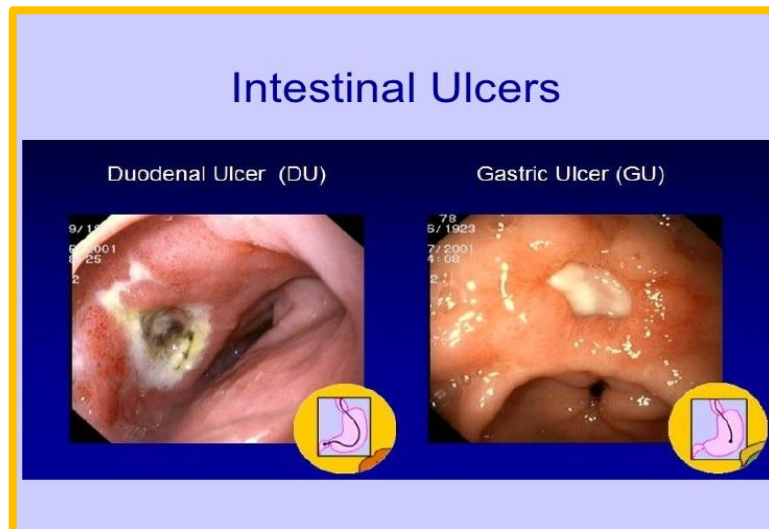
Non-malignant lung diseases are caused due to long exposure of arsenic contaminated drinking water (800 mg/L). About 38% of the arsenic exposed persons were experienced chronic cough, compared with 3.1% of the unexposed one.<sup>22</sup> Chronic lung diseases were common in 57% of the exposure of chronic arsenic toxicity through arsenic contaminated drinking water in West Bengal.





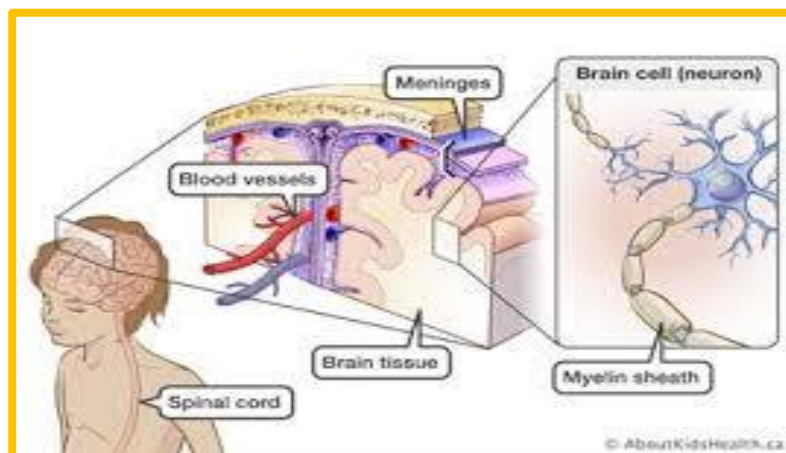
## Gastrointestinal disease

Dyspepsia one of the most dominated (38.4%) gastrointestinal syndrome for chronic arsenic toxicity.<sup>19</sup> Gastroenteritis also caused by chronic arsenic sis through the drinking of arsenic-contaminated water with a concentration greater than 50 mg/L.<sup>23</sup>



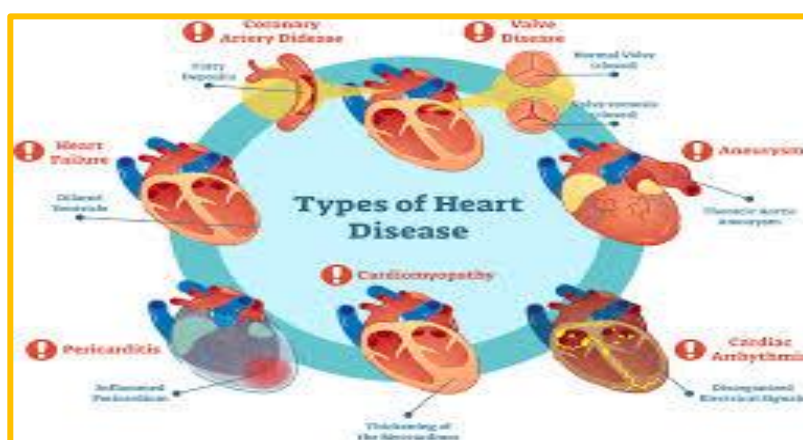
## Diseases of nervous system

Peripheral neuropathy is caused by chronic exposure of arsenic through drinking water.<sup>23-28</sup> 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.<sup>23,27,29</sup> There are also other neural complications such as peripheral neuritis, sleep disturbances, weakness, and cognitive and memory impairment also reported.<sup>20</sup>



## 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.<sup>20</sup> 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.<sup>19</sup>



## Haematological effects

Acute and chronic arsenic poisoning leads to anemia, leucopenia, and thrombocytopenia and other haematological abnormalities.<sup>30</sup> West Bengal carries average 50% anemia were caused in the exposure to arsenic-contaminated groundwater (200-2,000 mg/L).<sup>19,31</sup>

## Diabetes

Cumulative arsenic exposure and prevalence of diabetes mellitus were showed dose response relationship in arsenic endemic areas.<sup>32</sup> In Bangladesh, diabetes mellitus prevalence also increased significantly where arsenic-contaminated water was taken as drinking water.<sup>33</sup> There is no such report of diabetes mellitus caused by arsenic in West Bengal.<sup>2</sup>



## Arsenicosis and cancer

Exposure to arsenic leads severe carcinogenicity in humans through drinking water.<sup>34</sup> 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.<sup>35</sup>

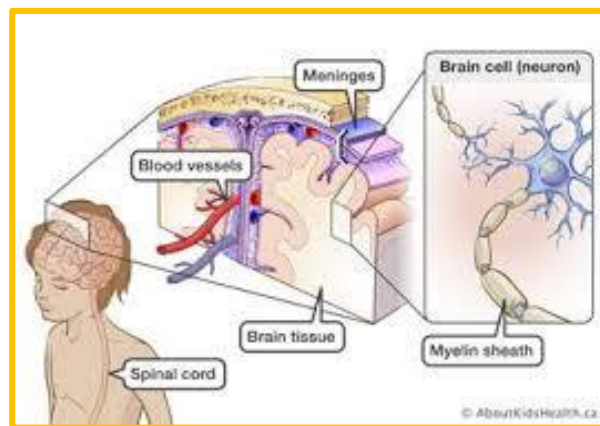
## Genotoxic effects

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.<sup>34,36,37</sup> 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.<sup>38</sup>



## Conclusion

Chronic arsenic toxicity through the ingestion of arsenic-contaminated groundwater makes a fatal hazard in human health throughout the world. Various skin, liver, cardiovascular, 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.<sup>39</sup> 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



## Acknowledgement

I express my deep gratitude to our sirs and madams of Botany department for providing valuable guidance, constant help and encouragement in concluding this project.

I would also like to thank our Principal- Dr. Indranil Kar, our HOD – Dr. Jayanta Sikdar for giving me active support in this regard.

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