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Studies on Arsenic Pollution and Microalgal diversity of Drinking Water Habitats in Murshidabad, West Bengal, for Arsenic Removal

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Abstract

Arsenic is most toxic and carcinogenic chemical element and it is regarded by WHO as first priority pollutant. Arsenic is of concern in water treatment because of its health effects to the Human beings. This study was undertaken to understand the severity of the arsenic crisis in Murshidabad, one of the nine arsenic-affected districts in West Bengal, India. Five hand tube well water samples, one drinking water sample, one soil sample and four river water samples were collected from Murshidabad and analyzed for arsenic concentration by FI-HG-AAS method. Physio-Chemical parameters of the water samples were analyzed by YSI-field portable water analyzing kit. Microalgal samples were also collected from the water sampling sites and photographed using the OLYMPUS CH20i microscope with attached SONY digital still camera (DSC-W320) for morphological identification. *Chlorococcum* sp., *Chlorella Vulgaris* Beyerinck, *Oscillatoria acuminata* Gom, *Chroococcus* sp., *Scendesmus acutus* Meyen and *Oscillatoria* sp., were found to be most dominant species in the collection sites. Arsenic concentration analyzed in water samples Behrampur was having highest arsenic concentration 0.011 mg/l. Lowest arsenic concentration in analyzed water samples (<0.005) was found at Islampur, Balighat, Lalbag, Herampur-1, Herampur-2 and Howrah. Arsenic concentration analyzed in soil sample was found to be 0.79 mg/kg.

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Introduction:

Water is a precious commodity in the globe and most of the earth water is sea water. About 2.5% of the water is fresh water that does not contain significant levels of dissolved minerals or salt and two third of that is frozen in ice caps and glaciers. In total only 0.01% of the total water of the planet is accessible for consumption. Clean drinking water is a basic human need. Unfortunately, more than one in six people still lack reliable access to this precious resource in developing world.

Arsenic is a chemical element with symbol *As* and atomic number 33. Arsenic occurs in many minerals, usually in conjunction with sulfur and metals, and also as a pure elemental crystal. Arsenic is a metalloid and arsenic contamination of groundwater is a problem that affects millions of people across the world. Most reported arsenic problems are found in groundwater water supply systems and are caused by natural processes such as mineral weathering and dissolution resulting from a change in the geo-chemical environment to a reductive condition (**5**). The World Health Organization (WHO) ranked arsenic pollution as "the largest poisoning of a population in history" (Smith, *et. al.,* 2000). Owing to epidemiological evidence linking arsenic and cancer, the safe limit of arsenic in drinking water was reduced from 50 µg/L to 10 µg/L in 1993 by WHO (**3, 9**).

Nearly 3.3 million people face the risk in eight districts of West Bengal- North and South 24 Parganas, Murshidabad, Nadia, Malda, Howrah, Kolkata and Bardaman (**8**). Arsenic toxicity in ground water has affected major parts of the Bengal Basin covering Bangladesh and southern West Bengal as well as other parts of the world (**6**). It is a major environmental problem affecting Bengal. The presence of arsenic in ground water exceeding the permissible limit of 10 µg/L was recorded in West Bengal in 1978, and initial cases of arsenic poisoning was diagnosed in 1983 (**2**). Drinking water arsenic contamination affects millions, Impacts are global, Affected populations are likely to increase.

Murshidabad District is one of the worst affected areas of arsenic contamination in groundwater in the world and also one of the worst affected areas in the world by arsenicosis. The other affected areas are Malda, Nadia, and North and South 24 Parganas districts of West Bengal. Intake of arsenic induced ground water ingested through the food route can be a strong cause of arsenicosis. Drinking water rich in arsenic over a long period leads to arsenic poisoning or arsenicosis. Arsenicosis is the effect of arsenic poisoning, usually over a long period such as from 5 to 20 years. Drinking arsenic-rich water over a long period results in various health effects including skin problems (such as colour changes on the skin, and hard patches on the palms and soles of the feet), skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure and reproductive disorders. Arsenic in water used for irrigation varied from 0.10 to 0.59 mg/l. 'Boro' rice requires 1000 mm of irrigation water per season and arsenic loading ranged from 1.36 to 5.5 mg/kg/hectare/year. The groundwater in five Indian states (West Bengal, Bihar, Uttar Pradesh, Jharkhand, and Assam) and Bangladesh that lie in the Ganga-Meghna-Brahmaputra (GMB) plain are more or less arsenic contaminated (**1**). Of the five states of India, West Bengal is seriously affected by arsenic contamination in water samples.

Materials and Methods:

The sample collection was made during summer season in the month of May 2015. Five litters of water samples in sterile acid washed containers were collected from 10 different places of West Bengal, India and immediately water parameters were analyzed by field portable water analyzing YSI-Instrument. Five Grams of soil sample is collected from Balighat in a sterile polythene cover for arsenic analysis. Microalgal samples also were collected in collection tubes by filtration through mesh net from the water sampling sites and photographed using OLYMPUS CH20i microscope with attached SONY digital still camera (DSC-W320). The microalgal samples were then isolated by serial dilution, spread plate and streak plate method for further studies. Arsenic concentration was analyzed by FI-HG- method by using Atomic Absorption Spectroscopy (AAS). Arsenic test method followed for water samples is 3114-B-APHA 22nd Edn. 2012 and arsenic test method followed for soil samples is EPA 3050B-1996 (Rev-2) / EPA 7061A-1992 (Rev-1).

Results:

Five litters of water samples and microalgal samples from ten different places of West Bengal were collected and five Grams of soil sample was collected from Balighat.

The micro algal cells were isolated from collected water samples and stored at 4° C for further studies.

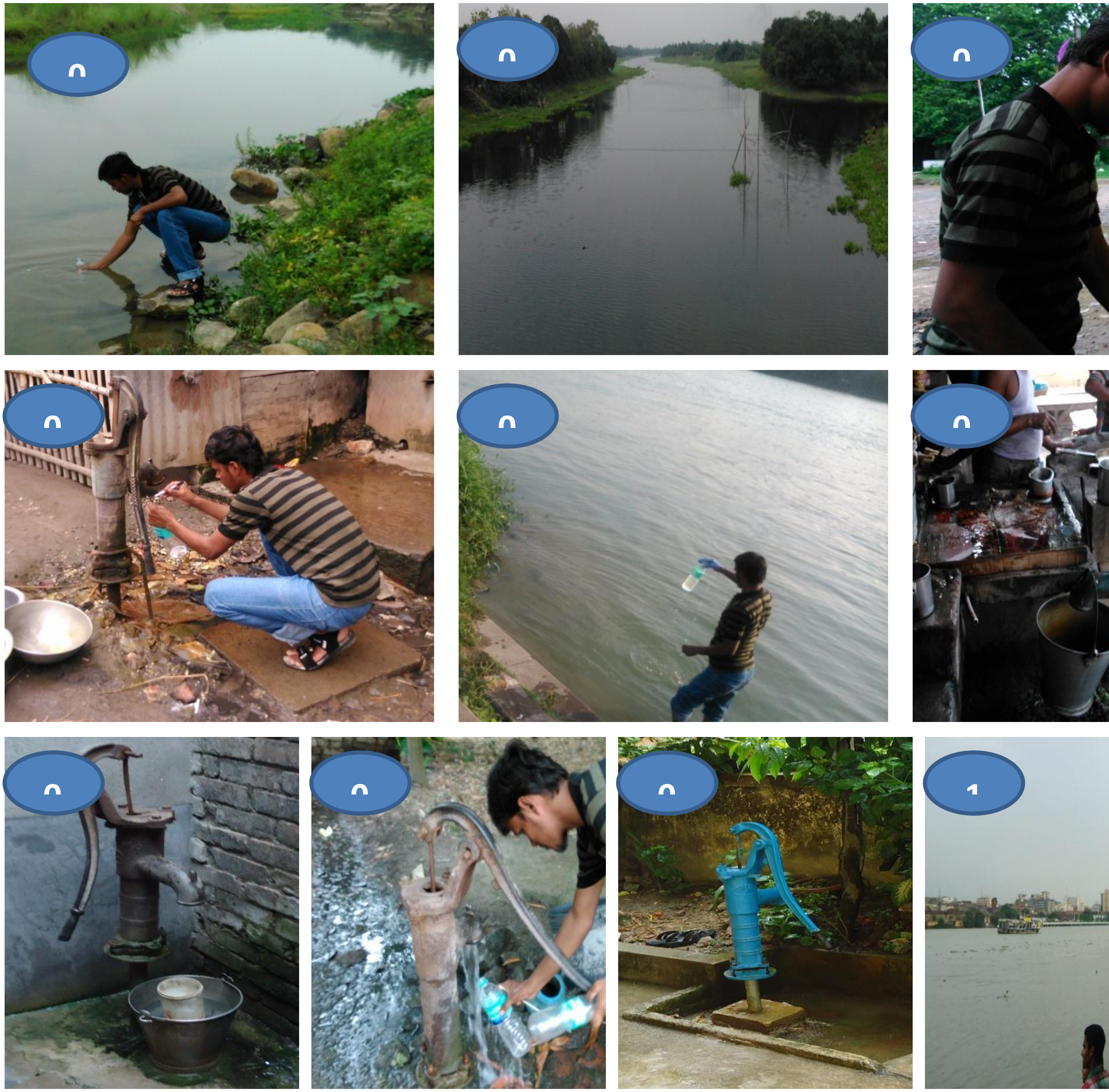

Fig. 1: Sample collection from ten different places of West Bengal, India.

1.) Islampur, 2.) Balighat, 3.) Domkal, 4.) Behrampur, 5.) Lalbag, 6.) Chunakhali,

7.) Herampur-1, 8.) Herampur-2, 9.) Baruipur, 10.) Howrah

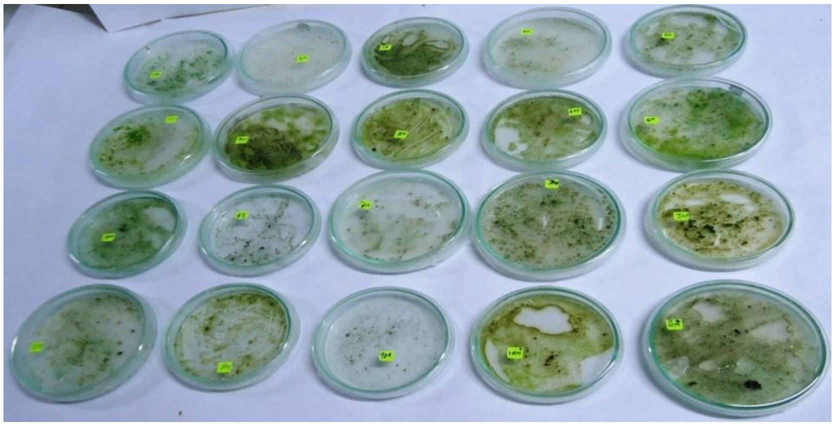

Fig. 2: Isolation of microalgal species in BBM medium by spread plate method from arsenic polluted areas.

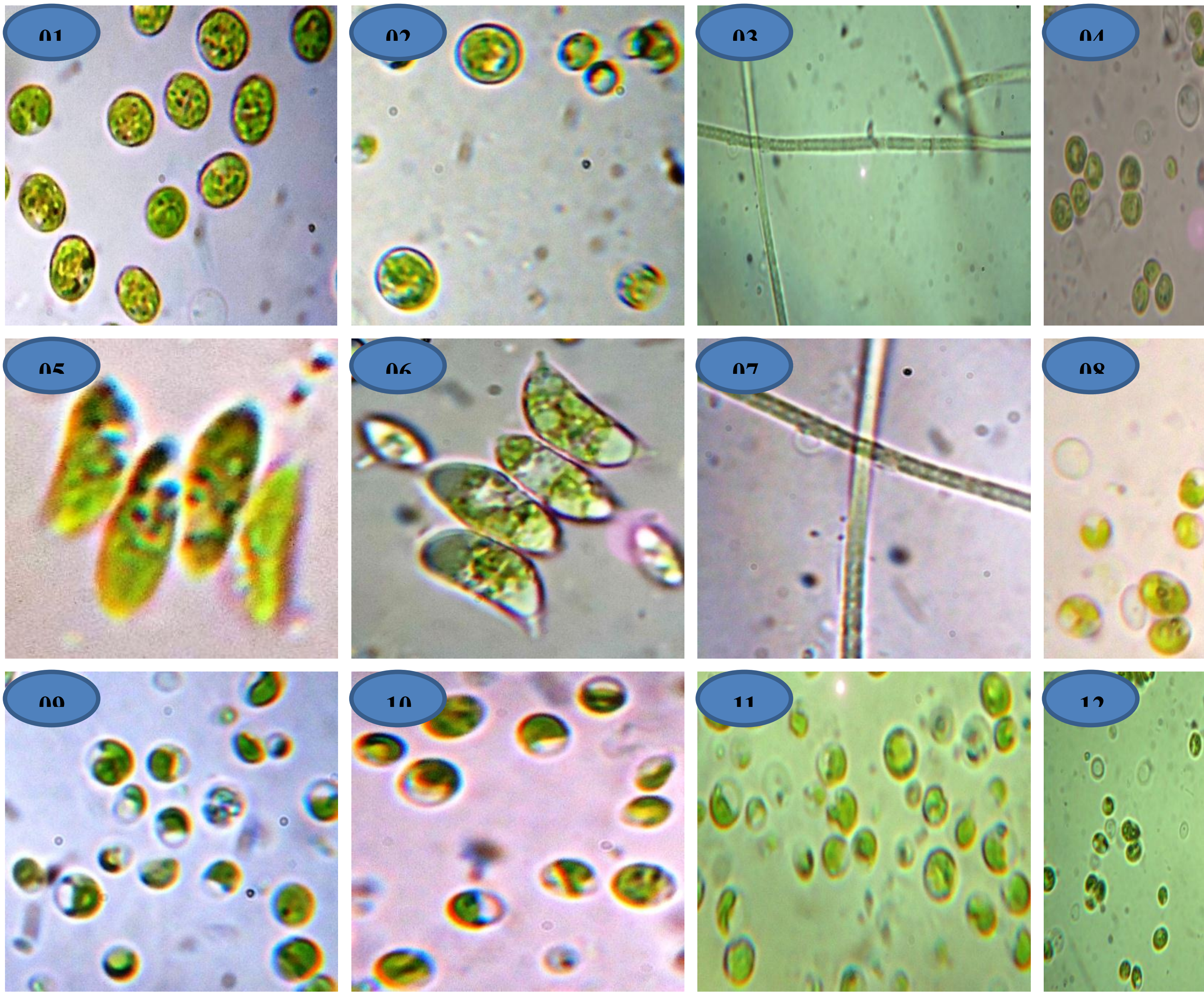

Fig. 3: Morphologically identified microalgal strains from arsenic polluted sites.

1.) *Chlorococcum* sp., 2.) *Chlorella Vulgaris* Beyerinck, 3.) *Oscillatoria acuminata* Gom, 4.) *Chroococcus* sp., 5.) *Scendesmus acutus* Meyen, 6.) *Scendesmus* sp., 7.) *Oscillatoria* sp., 8-11.) *Chlorella* sp., 12.) *Chroococcus* sp.

The microalgal samples were observed under microscope and photographed and morphologically identified using standard monographs. *Chlorococcum* sp., *Chlorella Vulgaris* Beyerinck, *Oscillatoria acuminata* Gom, *Chroococcus* sp., *Scendesmus acutus* Meyen and *Oscillatoria* sp., were found to be most dominant species in the collection sites.

Arsenic concentrations of water and soil samples were analyzed and results were compared. Arsenic concentration in soil sample collected from Balighat was found to be 0.79 (mg/kg). Maximum arsenic concentration (0.011mg/l) in water samples was recorded at Behrampur and minimum concentration (<0.005 mg/l) was recorded at Islampur, Domkal, Lalbag, Herampur-1, Herampur-2 and Howrah.

Sl. No.	Water Sample Collection Place	Arsenic mg/l
1	Islampur	BDL (DL:0.005)
2	Balighat	0.006
3	Domkal	BDL (DL:0.005)
4	Behrampur	**0.011**
5	Lalbag	BDL (DL:0.005)
6	Chunakhali	0.006
7	Herampur-1	BDL (DL:0.005)
8	Herampur-2	BDL (DL:0.005)
9	Baruipur	0.007
10	Howrah	BDL (DL:0.005)
11	Balighat (Soil Sample)	0.79 (mg/kg)

Table 2: Comparison of arsenic concentrations present in the water samples collected from different places of West Bengal, India.

Note: BDL - Below Detection Limit; DL - Detection limit

The Physio-Chemical parameters of the water samples were analyzed and results were compared. The maximum temperature (32.08) observed in analyzed water sample was found at Domkal and minimum temperature (31.26) was found at Lalbag. Maximum Conductivity (1.414) was found at Herampur-1 and minimum conductivity (0.295) was found at Lalbag. Maximum Conductivity in Milli Siemens (1.59) was found at Herampur-1 and minimum (0.33) was found at

Lalbag. Maximum resistivity (3034.16) was found at Lalbag and Minimum (628.346) was found at Herampur-1. Maximum TDS (0.92) was found at Herampur-1 and minimum (0.191) was found at Lalbag. Maximum salinity (0.7) was found at Herampur-1 and minimum (0.13) was found at Lalbag. Maximum dissolved oxygen percentage (73.6) was found at Lalbag and minimum (11.9) was found at Baruipur. Maximum dissolved oxygen in milligrams (5.44) was found at Lalbag and minimum (0.87) was found at Baruipur. Maximum dissolved oxygen in charge (23.7) was found at Islampur and Balighat and minimum (16.5) was found at Baruipur. Maximum pH (7.67) was found at Lalbag and minimum (7.38) was found at Herampur-2. Maximum pH in milli volts (-62.9) was found at Lalbag and minimum (-80.3) was found at Herampur-2. Maximum oxidation reduction potential (ORP) (-169.3) was found at Herampur-1 and minimum (-208.4) was found at Howrah.

Sl.No.	Place	Temp.	Cond.	Cond. (mS/cm)	Resis.	TDS	Salinity	DO (%)	DO (mg/L)	DO (ch)	pH	pH (mV)	ORP (mV)
1.	**Islampur**	31.93	0.565	0.639	1564.35	0.367	0.27	68	5.27	**23.7**	7.52	-71.4	-178.2
2.	**Domkal**	**32.08**	0.718	0.816	1227	0.467	0.35	64.8	4.69	22.6	7.53	-71.9	-186.8
3.	**Balighat**	32	0.507	0.575	1739.6	0.33	0.24	69.6	5.08	**23.7**	7.61	-76.8	-199.7
4.	**Behrampur**	31.89	1.263	1.431	699.489	0.822	0.62	24.4	1.78	19.6	7.44	-66	-189.9
5.	**Lalbag**	**31.26**	**0.295**	**0.33**	**3034.16**	**0.191**	**0.13**	**73.6**	**5.44**	21.6	**7.67**	**-80.3**	-189.7
6.	**Chunakhali**	31.95	0.882	0.999	1002.42	0.574	0.43	25.4	2.27	17.5	7.47	-68	-180.7
7.	**Herampur-1**	31.55	**1.414**	**1.59**	**628.346**	**0.92**	**0.7**	26.4	2.49	19.6	7.4	-63.7	**-169.3**
8.	**Herampur-2**	31.61	1.183	1.332	750.686	0.769	0.58	22.9	1.7	17.5	**7.38**	**-62.9**	-192.6
9.	**Baruipur**	31.78	0.989	1.117	895.077	0.643	0.48	**11.9**	**0.87**	**16.5**	7.39	-63.3	-204.2
10.	**Howrah**	31.49	0.341	0.372	2678.64	0.221	0.16	19.7	1.56	17.5	7.61	-76.1	**-208.4**

Table-1: Comparison of water parameters analyzed from water samples by YSI-Multiparameter Water analyzing kit. Maximum values are marked as red in color and minimum values are marked as green in color.

Discussion:

The analysis of total 3800 biologic (nail, urine, and hair) samples from arsenic-affected villages in Murshidabad has revealed that 95% of the nail and 94% of the urine samples contained arsenic above the normal levels and 75% of the hair samples were found to have arsenic above the toxic level (**4**). In Murshidabad nearly 56 percent of drinking water samples are having more than 0.05 mg/l of arsenic. Drinking water has become urgent for human consumption. According to the water test report of Public Health Engineering Department in Murshidabad District 28,357 water samples have arsenic concentration above 0.05 mg/l in groundwater (**7**). Currently available technology in West Bengal for arsenic removal is a chemical based method which includes co-precipitation and adsorption.

This technology is more expensive and also requires more amounts of chemicals such as alum, sodium hypochloride, activated alumina, aluminium sulphate and bleaching powder. It is well known that many rice and its paddy fields were significantly contaminated by arsenic. Arsenic could be transformed by microalgae in the paddy fields from arsenate to arsenite, and then methylated until volatile organic *As.* Provision of clean drinking water remains a world-wide necessity, especially so for arsenic-affected regions where numerous physio-chemical methods have been developed for water remediation including adsorption, ion exchange, biosorption, solar stills, etc. Of these, several methods employ regeneration of media necessitating arsenic monitoring on a continuous basis, hence involving skilled operation or alternatively removal of arsenic-enriched concentrated brine into the environment.

Algae play an important role in controlling metal concentration in lakes and oceans. Their ability to absorption metals and taking up toxic elements from the environment has been recognized for many years. Algae possess the ability to take up toxic elements from the environment, resulting in higher concentrations than those in the surrounding water. According to this function and biotransformation mechanism of *As* by microalgae in the paddy fields, this study would be very much useful to scientific community and also to the society. In this study *Chlorococcum* sp., *Chlorella Vulgaris* Beyerinck, *Oscillatoria acuminata* Gom, *Chroococcus* sp., *Scendesmus acutus* Meyen and *Oscillatoria* sp., were found to be most dominant species in the collection sites. These microalgal species could be used to reduce the arsenic concentration in the drinking water habitats.

Conclusion:

Water treatment for arsenic removal is essential and it will be useful for the society. Therefore development of arsenic and iron removal technology in arsenic affected region in West Bengal is needed. Detoxification or removal of arsenic by using microalgae will be the best, eco friendly and cost efficient technology.

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