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MICROALGAL DIVERSITY, ARSENIC WATER POLLUTION AND ITS HEALTH EFFECTS OF THE PEOPLE IN MURSHIDABAD DISTRICT, WEST BENGAL, INDIA

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ABSTRACT

Arsenic poisoning leads to adverse health effects to the humans and ecosystem. The effects of arsenic on human health have been reported as one of the world's biggest natural groundwater calamities to the mankind. Groundwater arsenic contamination is a serious problem and threat in India especially for the people who live and drinks arsenic contaminated water for prolonged period in Murshidabad district, West Bengal. Microalgae are highly diverse microscopic photosynthetic organisms which utilize sunlight and carbon dioxide for the synthesis of food and have been used as a prominent natural resource for Phycoremediation of polluted water resources. The current research have been done to analyze arsenic concentrations in water samples, vegetables, edible leafs, grains and soil samples. Microalgal species found in the arsenic contaminated sampling sites were morphologically identified and recorded. The research work was also focused on to study and records the health effects and details of arsenicosis affected patients from Murshidabad district. The concentration of arsenic on various environmental samples were analyzed and recorded. Details of arsenic affected persons in various villages of Murshidabad district were collected and documented. The arsenic concentration detected in environmental samples of Murshidabad district is more than permissible limit and the problems faced by the arsenicosis affected people in Murshidabad district is very serious issue. The present study concludes that a low cost or costless, environment friendly and biological method has to be found and implemented in arsenic affected areas of Murshidabad district, West Bengal, India.

KEYWORDS: Arsenic, Arsenicosis, Arsenic In Edible Samples, Physio-Chemical Water Parameters, Microalgae.

INTRODUCTION

Arsenic is metalloid, poisonous chemical element, highly toxic in its inorganic form which is naturally present at high levels in the groundwater of a number of countries

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especially found in high concentrations in several districts of West Bengal, India. West Bengal is extremely rich in natural water resources. Drinking water with arsenic contamination more than permissible limits (high-level, <10 µg/l) in West Bengal, India is a significant public health concern. Arsenic-polluted water linked to cancer. Arsenic contaminated water used for prolonged period for drinking, food preparation and irrigation of food crops poses the greatest threat to public health by causing "arsenicosis" disease which cause cancer and skin lesions and may also been associated with cardiovascular disease, diabetes, coma and even death. Arsenicosis also produces protean manifestations like weakness, chronic respiratory disease, peripheral neuropathy, liver fibrosis and peripheral vascular disease.

During the last four decades arsenic contamination of groundwater in nine districts of West Bengal, India has become a serious problem. About 20% population of West Bengal in nine districts (Malda, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas, Kolkata, Howrah, Hoogly and Burdwan) are affected by arsenic problem. Still there is not enough technology to encounter to the arsenic exposed people. (Santra, 2017). The West Bengal State Government estimated that at least 79 blocks (administrative units) across the state to be severely affected, involving 26 million individuals across 2600 villages. Indeed, it remains a great concern that the research community has failed to implement a sustainable solution to provide arsenic free drinking water for the public even 30 years after the first diagnosed human case leading to detection of the prevalent environmental arsenicosis in this region. (Paul *et al*., 2013). Further, many of the people in the arsenic affected villages are not aware of the water contamination of their home tubewells with arsenic. Arsenic affected people with severe skin lesions and systemic manifestations like lung disease and neuropathy are having unbearable suffering (Mazumder *et al*., 2010).

Mukherjee *et al*., 2009 have collected and analyzed 29,668 hand tubewell water samples from 1,833 villages/wards of 2,414 villages from all the 26 blocks of Murshidabad district in West Bengal, India and they have found that arsenic concentration in 25 blocks above 10 µg/L and in 24 blocks above 50µg/L. Their studies revealed that 15,953 (53.8%) of the tubewells are arsenic contaminated above 10µg/L while 7,911 (26.7%) above 50µg/L and 1337 (4.5%) above 300µg/L. It is also observed that arsenic contamination in Jalangi block is out of total 1917 samples analyzed 1,491 (77.8%) exceeded the WHO limit (10µg/L) and 38 (2.0%) samples were found to be contaminated above 1000µg/L of arsenic. Maximum concentration 3003µg/L was found in two water samples one from each of Nawda and Raghunathganj I blocks.

It is recognized that at least 140 million people in 50 countries have been drinking water containing arsenic at levels above the WHO provisional guideline value of 10 µg/L. In 2010, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) re-evaluated the effects of arsenic on human health, taking new data into account. JECFA concluded that for certain regions of the world where concentrations of inorganic arsenic in drinking-water exceed 50–100 µg/L, there is some evidence of adverse effects. 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 most important action which is needed in affected communities is the prevention of further exposure to arsenic by provision of a safe water supply by implementing a ecofriendly and low cost method to treat arsenic contaminated water bodies. Unfortunately, until now there is no

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method is invented at affordable cost for the village people to purify and drink the arsenic contaminated water.

There is a much cheaper and eco friendly way to remove arsenic from water by using microalgae. Algae are generally microscopic organisms and the uses of microalgae in wastewater treatment were initiated after 1950's. Microalgae are unicellular organisms, some of these form colonies and reach size visible to naked eye as minute green particles. The organisms are finely dispersed througout the water and may cause considerable turbity showing the maximum algal bloom. Microalgae may undergo different processes to reduce the arsenic toxicity from inorganic arsenic, including cell surface binding, arsenite [*As* (III)] oxidation, arsenate [*As* (V)] reduction, methylation, transformation into arseno sugars or arsenolipids, chelation of *As* (III) with glutathione and phytochelatins, as well as excretion from cells. Several genes and enzymes involved in arsenic transformations have been identified and characterized (Yin *et* al., 2012). Qin *et* al., 2009 has characterized the methyltransferases genes involved and offer a molecular explanation for how these algae tolerate arsenic in their environment.

Hence, the current research have been done to analyze arsenic concentrations in water samples, vegetables, edible leafs, grains and soil samples and to morphologically identify and record the microalgal species diversity found in the arsenic contaminated sampling sites. The research work was also aimed to study and records the health effects and details of arsenicosis affected patients from Murshidabad district.

MATERIALS AND METHODS

Murshidabad district is a district of West Bengal, in eastern India. Murshidabad district lies between the latitudes of 24.1759° N and longitudes of 88.2802° E. The river Ganga forms its northern and eastern boundaries and separates it from Bangladesh. The river Bhagirathi flows across the district and divides it into two equal parts. The area and population of the district is 5,324 km2 and 7,102,430 respectively. There are 26 blocks in this district.

The sample collection was made at various places of Murshidabad district in the month of August 2016 (monsoon / raining season). Five litters of water samples were collected in acid washed, sterile containers from 13 different places in Murshidabad district of West Bengal, India and immediately physio-chemical water parameters were recorded by field portable water analyzing YSI-Instrument. Five (5) Grams of soil samples from Huda Herampur and Bilchatra and Hundred (100) grams of different variety of edible samples from various places of Mursidabad district, West Bengal were collected in sterile polythene cover for arsenic analysis. Microalgal samples were also collected in sterile collection tubes by filtration through mesh net from the water sampling sites and photographed using OLYMPUS CH20i microscope attached with SONY digital still camera (DSC-W320). The microalgal samples were morphologically identified using standard monographs and available literatures reviews. The microalgal samples were then stored at 4°C for isolation and further studies. Arsenic concentration in all the collected water, soil and edible samples were analyzed by FI-HG-method by using Atomic Absorption Spectroscopy (AAS). Test method 3114-B-APHA 22nd Edn. 2012 is followed in water samples and test method EPA 3050B-1996 (Rev-2) / EPA 7061A-1992 (Rev-1) is followed for soil and edible samples to determine arsenic concentration.

RESULTS AND DISCUSSION

Five litters of water samples from thirteen (13) different places and 100 grams of different

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variety of edible samples from Mursidabad district, West Bengal were collected. Five (5) grams of soil samples from Huda Herampur and Bilchatra were collected and arsenic concentrations were determined in all the collected samples. Microalgal samples from thirteen (13) different places from Mursidabad district, West Bengal were collected, photographed and morphologically identified. The results obtained from the study are as follows.

Figure 1.Sampling sites of various places of Murshidabad district, West Bengal collected on August 2016 (monsoon / raining season)

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Note: 01. Islampur - 1, 02. Islampur - 2, 03 a-d. Jalangi - 1, 04 a-c. Jalangi - 2, 05 a-e. Domkal, 06. Huda Herampur, 07. Bilchatra, 08. Herampur, 09. Suparigola, 10 a&b. Behrampur.

People suffer from arsenic-stricken diseases because of their ignorance and lack of awareness regarding arsenic pollution and its impact on Human Health (Rezaul Hoque, 2013). However regular monitoring of the drinking water quality is an emerging issue of concern. Arsenic concentration in soil sample collected from Huda Herampur and Bilchatra was found to be 1.51 (mg/kg) and 1.95 (mg/kg) respectively. Maximum arsenic concentration (0.54 mg/kg) in edible samples was found in Potato collected from islampur. Minimum arsenic concentration (<0.05 mg/kg) was found in Parangikai, Ladies Finger, Paithangai, Brinjal, Beetroot, Mullu Kai, Thanneer Puga Keerai, Black Gram, Wheat, Toor Dhal and Groundnut samples collected from Islampur, Murshidabad district. The samples of Bitter Gourd (0.31 mg/kg), Turkey Berry (0.14 mg/kg) and Rice (0.21 mg/kg) were also had significant amount of arsenic concentration. Low doses of arsenic, consumed over ears, can ultimately cause death (Argos *et al*., 2010).

Figure 2.Vegetables, Edible Leafs, Grains and Soil Samples which are collected on August 2016 (monsoon / raining season) from various places of Murshidabad district

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Note: 01. Wheat, 02. Rice, 03. Black Gram, 4. Chickpea, 5. Toor Dhal, 6. Groundnut, 7. Spinach, 8. Taro, 9.Yardlong Beans, 10. Ridge Gourd, 11 & 12. Bitter Gourd, 13. Green Chilli, 14. Mullu Kai, 15. Brinjal, 16. Ladies Finger, 17. Onion, 18. Potato, 19. Beetroot, 20. Soil.

Millions of people affected by arsenic poisoning in West Bengal, almost half of the state is under the toxicity of this heavy metal arsenic. According to a latest report, in West Bengal alone there are 1.04 crore persons are affected by arsenic contamination (The Hindu, 19th March, 2017).

Table 1.Arsenic concentrations of soil and edible samples collected on August 2016 (monsoon / raining season) from various places of Murshidabad district, West Bengal

S. No.	Place of Collection	Type of Sample	Concentration of Arsenic (mg/kg)
1.	Huda Herampur	Soil	1.51
2.	Bilchatra	Soil	1.95
3.	Islampur	Onion	0.09
4.	Islampur	Parangikai	BDL (DL:0.05)
5.	Islampur	Ladies Finger	BDL (DL:0.05)
6.	Islampur	Paithangai	BDL (DL:0.05)
7.	Islampur	Brinjal	BDL (DL:0.05)
8.	Islampur	Beetroot	BDL (DL:0.05)
9.	Islampur	Koku Keerai	0.05
10.	Islampur	Mullu Kai	BDL (DL:0.05)
11.	Islampur	Bitter Gourd	0.31
12.	Islampur	Potato	0.54
13.	Islampur	Thanneer Puga Keerai	BDL (DL:0.05)
14.	Islampur	Black Gram	BDL (DL:0.05)
15.	Islampur	Wheat	BDL (DL:0.05)
16.	Islampur	Toor Dhal	BDL (DL:0.05)
17.	Islampur	Turkey Berry	0.14
18.	Islampur	Groundnut	BDL (DL:0.05)
19.	Islampur	Rice	0.21

Exposure to arsenic through consumption of arsenic contaminated food or drinking arsenic contaminated water for prolonged period leads to severe carcinogenicity in humans. The present study revealed the present status of arsenic toxicity, stratigraphic condition of the Mirshidabad district in West Bengal state and the physiobiochemical consequence of chronic exposure of arsenic toxicity on human health.

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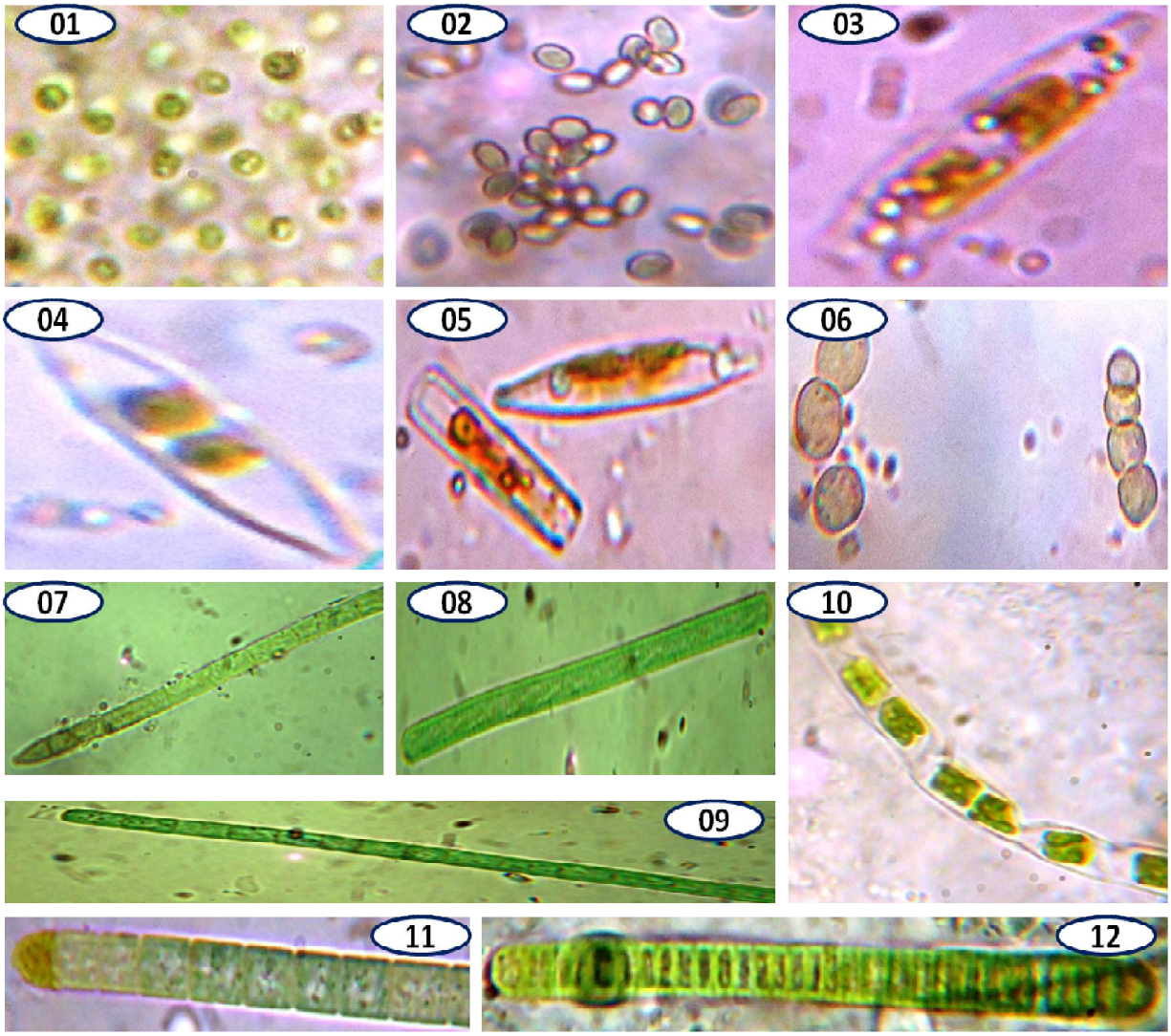

Figure 3.Microalgal species observed at various places of arsenic contaminated sites of Murshidabad district, West Bengal, India on August 2016 (monsoon / raining season)

Note: 01. *Chlorella vulgaris*, 02. *Chlorella vulgaris*, 03. *Nitzschia amphibian*, 04. *Navicula rostellata*, 05. *Pinnularia viridiformis*, 06. *Nostoc commune*, 07. *Lyngbya major*, 08. *Oscillatoria chlorine*, 09. *Oscillatoria* curviceps, 10. *Ulothrix variabilis*, 11. *Oscillatoria pseudogeminata*, 12. *Oscillatoria princeps*.

Oscillatoria and *Chlorella* species were found to be more dominant microalgal species found at arsenic contaminated sites of Murshidabad district, West Bengal, India during the month of August 2016 (monsoon / raining season). The dominant microalgal species found at natural arsenic contaminated sites could be a potent microalgal species and can be used to reduce the arsenic concentrations in the drinking water habitats.

The Physio-Chemical parameters of the water samples were analyzed and results were compared. The maximum and minimum temperature observed in collected water sample was found at Islampur-1 (29.33°C) and Herampur-2S (27.44 °C) respectively.

Tabel 2 (end of the paper)

Maximum and minimum Conductivity was found at Islampur-2 (1.342) and Islampur-1 (0.22) respectively. Maximum and minimum Conductivity in Milli Siemens was found at Islampur-2 (1.441) and Islampur-1 (0.239)

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respectively. Maximum and minimum resistivity was found at Islampur-1 (4191.8) and Islampur-2 (695.261) respectively. Maximum and minimum TDS was found at Islampur-2 (0.871) and Islampur-1 (0.143) respectively. Maximum and minimum salinity was found at Islampur-2 (0.66) and Islampur-1 (0.1) respectively. Maximum and minimum dissolved oxygen percentage was found at Domkal (27.2) and Herampur-1Q (-2.1) respectively. Maximum and minimum dissolved oxygen in milligrams was found at Domkal (2.05) and Bilchatra-2 (-0.17) respectively. Maximum dissolved oxygen in charge (99.2) was found at Islampur-2, Jalangi-1&2, Domkal, Huda Herampur-1, Bilchatra -2 and Bilchatra-3 and minimum (92.1) was found at Islampur-1. Maximum and minimum pH was found at Jalangi-2 (6.89) and Islampur-2 (6.5) respectively. Maximum and minimum pH in milli volts was found at Islampur-2 (-9.7) and Jalangi-2 (-33.7) respectively. Maximum and minimum oxidation reduction potential (ORP) was found at Herampur-1Q (-121.6) and Islampur-2 (-148.1) respectively.

Table 3.Arsenic concentrations of water samples collected from various places of Murshidabad district, West Bengal, India

Sl. No.	Place of Collection	Source of Water Sample	Concentration of Arsenic (mg/l)
1.	Islampur-1	River	BDL (DL:0.001)
2.	Islampur-2	Tube Well	0.007
3.	Jalangi-1	River	0.003
4.	Jalangi-2	Tube Well	BDL (DL:0.001)
5.	Domkal	Tube Well	BDL (DL:0.001)
6.	Huda Herampur-1	Tube Well	BDL (DL:0.001)
7.	Huda Herampur-2	Tube Well	0.004
8.	Bilchatra-1	Tube Well	0.003
9.	Suparigola	Tube Well	BDL (DL:0.001)
10.	Bilchatra -2	Tube Well	BDL (DL:0.001)
11.	Bilchatra- 3	Tube Well	BDL (DL:0.001)
12.	Herampur- 1Q	Tube Well	BDL (DL:0.001)
13.	Herampur- 2S	Tube Well	0.002

CONCLUSIONS

The affected people do not have alternative sources of safe drinking water since the arsenic removal plant is not installed in every village of the Murshidabad district, West Bengal and also the very poor people cannot afford to spend money in their daily life for purification of arsenic contaminated drinking water. Still in the most of the villages of Murshidabad district the people are drinking contaminated water owing to non recognition of arsenic contamination as a problem requiring urgent action. The arsenic concentration detected in environmental samples of Murshidabad district is more than the permissible limits and the problems faced by the arsenicosis affected people in Murshidabad district is very serious issue. Therefore the development of arsenic removal technology is essential in severely arsenic affected region in West Bengal and it should be costless technology for the society. Detoxification or removal of arsenic by using microalgae could be the best, eco friendly and costless technology.

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Figure 4.Some of the Arsenicosis affected patients identified with arsenical skin lesions from Murshidabad District and the local Persons who have helped to get the information regarding arsenic affected people

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10. Table 2.Comparison of water parameters analyzed from water samples collected at sample collection 04 from different places of West Bengal, by YSI-Multiparameter water analyzing instrument (Lowest and highest values are highlighted with colors red and green respectively)

Place	Water Source	Temp. (°C)	Cond. (mS/cm^{c})	Cond. (mS/cm)	Resis. (Ω/cm)	TDS (g/l)	Salinity (ppt)	DO (%)	DO (mg/l)	DO (ch)	pH	pH (mV)	ORP (mV)
Islampur-1	River	**29.33**	**0.22**	**0.239**	**4191.8**	**0.143**	**0.1**	20	1.74	**92.1**	6.63	-17.9	-146.6
Islampur-2	Tube Well	29.03	**1.342**	**1.441**	**695.261**	**0.871**	**0.66**	5.6	0.43	**99.2**	**6.5**	**-9.7**	**-148.1**
Jalangi-1	River	28.38	0.232	0.247	4048.2	0.151	0.11	8.3	0.64	**99.2**	6.8	-28.1	-142.2
Jalangi-2	Tube Well	28.08	0.35	0.371	2698.42	0.228	0.17	9.5	0.75	**99.2**	**6.89**	**-33.7**	-132.3
Domkal	Tube Well	28.21	0.685	0.742	1382	0.441	0.33	**27.2**	**2.05**	**99.2**	6.73	-23.8	-145.1
Huda Herampur-1	Tube Well	28.05	0.571	0.606	1650.59	0.373	0.27	10.4	0.81	**99.2**	6.8	-28	-147.1
Huda Herampur-2	Tube Well	27.91	0.595	0.628	1592.75	0.387	0.29	5.1	0.4	98.2	6.81	-28.3	-144.8
Bilchatra-1	Tube Well	27.67	0.937	0.985	1016.9	0.609	0.46	-1.8	-0.12	98.2	6.75	-24.6	-134.9
Suparigola	Tube Well	27.73	1.029	1.085	921.072	0.672	0.51	2.6	0.2	98.2	6.73	-23.6	-136.1
Bilchatra-2	Tube Well	27.78	0.826	0.87	1149.12	0.537	0.4	-2	**-0.17**	**99.2**	6.73	-22.3	-144.2
Bilchatra-3	Tube Well	27.49	0.913	0.956	1046.35	0.593	0.45	2.7	0.21	**99.2**	6.77	-26.1	-145.1
Herampur-1Q	Tube Well	27.67	1.053	1.106	904.312	0.684	0.52	**-2.1**	-0.15	**99.2**	6.75	-24.8	**-121.6**
Herampur-2S	Tube Well	**27.44**	0.622	0.65	1537.54	0.404	0.3	12.7	1	**99.2**	6.8	-28.1	-135.6

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