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STUDIES ON MICROALGAL DIVERSITY, ARSENIC (As) CONCENTRATION AND PHYSIOCHEMICAL PARAMETERS IN DIFFERENT WATER HABITATS FROM WEST BENGAL, INDIA

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Abstract:-The present investigation has been carried out to study the algal diversity, arsenic concentration and to analyze the physiochemical parameters in different water resources of West Bengal, India. Several microalgal spp. found in sampling sites were microscopically identified and recorded. The microalgal species were compared with respect to the arsenic concentration. Twenty nine (29) samples from pond, river and ground water including three (3) soil samples were analyzed for arsenic concentration. In twenty two (22) water samples some of the physical parameters were analyzed by using YSI multiparameter instrument. In ten (10) Water samples all the physiochemical parameters were analyzed. Among the twenty nine (29) water samples analyzed the arsenic concentration was ranged from 0.05 ppm to 3.0 ppm and the highest concentration 3 ppm was observed in Baruipur, Chinsurah, Alipur and Dhaksineswar. In this issue an immediate remediation for arsenic pollution has to be implemented, otherwise it may lead to serious health effects on human beings if it is mixed up with the potable drinking water.

Keywords: Arsenic, West Bengal, Arsenic water pollution, Physiochemical parameters, Ground Water, River, algal diversity.

INTRODUCTION :-

West Bengal is one of the states in India and extremely rich in natural water resources. World Health Organization (WHO) states that “Arsenic poisoning is the largest mass poisoning in the history of humanity”. Nearly eight districts of West Bengal (Maldah, Murshidabad, Nadia, North parganas 24, South parganas 24, Bardaman, Howrah and Hoogly) are affected by arsenic water contamination, the concentration was ranges from 0.28 to 3.2 mg/L. Consumption of arsenic at the 50 µg/L level is estimated to cause mortality due to lung, kidney, or bladder cancer in 1 out of every 1,000 or 10,000 people (Mandal et al., 1996). Most of them in West Bengal (India) are suffered by skin diseases, many of them even died by the dreaded disease “cancer”, caused due to the poisoning of their bodies by the deadly “Arsenic” through consumption of naturally arsenic contaminated ground water.

Arsenic is a naturally occurring poisonous chemical element present in water, air, rocks and soil. The main ores of arsenic are arsenopyrite, arpiment, realgar and arsenopalledenite. The main anthropogenic sources for arsenic pollution are industrial waste, phosphate, fertilizers, coal, oil, cement, mine tailing, smelting, ore processing, metal extraction and purification, chemicals, glasses, leather processing, textiles, alkali, petroleum refineries, acid mines, alloys, pigments, insecticides, herbicides and catalysts (Debkumar et al., 2004, Dipankar et al., 1996). As water passes through and over geologic formations it can dissolve arsenic. The river Ganga from himalyas passes through West Bengal and reaches sea. High content of arsenic from river waters are deposited on the surface of the soil, and through irrigation arsenic contaminates the ground water. The result is arsenic can be present in some water resources. Ingesting drinking water containing arsenic can cause adverse health effects. Most notably, arsenic is known carcinogen, and long term ingestion may increase the risk of cancer. Public water supplies must comply with the EPA standard of 10 ppb. 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).

The literature shows that the major incidents of arsenic related diseases caused by drinking arsenic contaminated water were in Taiwan (Lu, 1990), Antofagasta (Borgono and Grebier, 1971), Mexico (Cebrian et al., 1983) and Argentina

(Astolfi et al., 1981). Ground water in a large part of the West Bengal contains arsenic above the WHO maximum permissible limit of 0.05 mg/L has been found in different places. A large number of people in West Bengal are compelled to drink water with arsenic concentration above the permissible limit. However the present study is carried out to study about the algal diversity in the arsenic polluted areas and to monitor the arsenic concentration and physiochemical parameters in water samples because the drinking water quality is an emerging issue of concern.

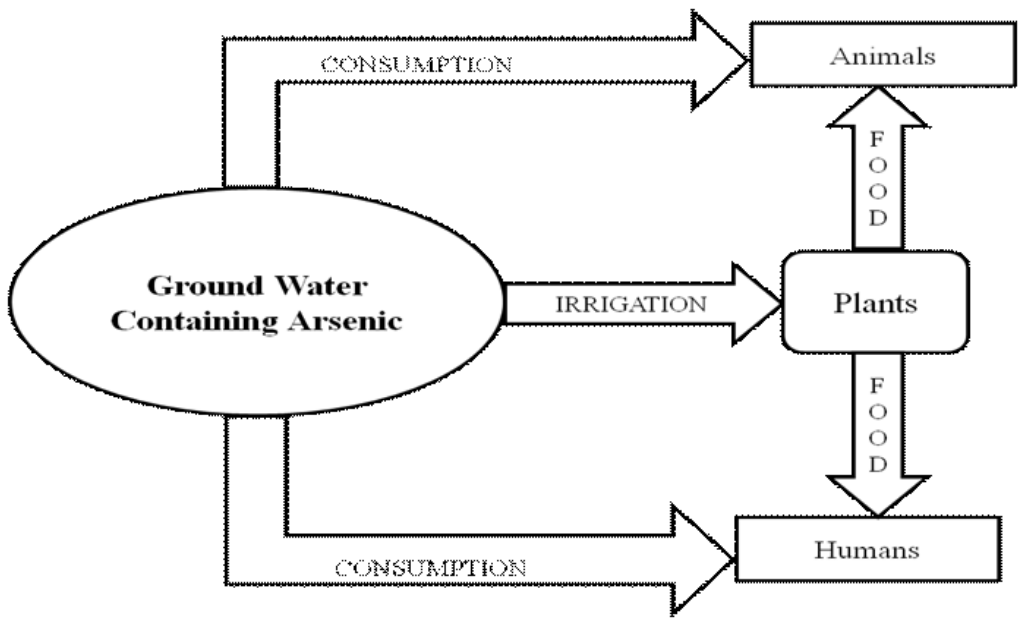


Figure 1 : Arsenic transformation through food chain.

Arsenic in drinking water could not be detected by taste, sight or smell. The only way to know the concentration of arsenic in water is through sampling and laboratory testing. The people are requested to test arsenic concentration in drinking water on a regular basis.

MATERIALS AND METHODS:

Sample Collection:

Totally twenty nine (29) water samples were collected from river, pond and ground waters of 4 districts (Hooghly, Howrah, Kolkata and South 24 Parganas) of West Bengal, India. Ground water samples were taken from tube wells. Microalgal samples also were collected in collection tubes from the water sampling sites. The samples were collected at the month of January, 2014. Random sampling method was carried out throughout the study. From each of the sample sites 2 Litters of Water samples were collected in water canes by filtration through mesh net.

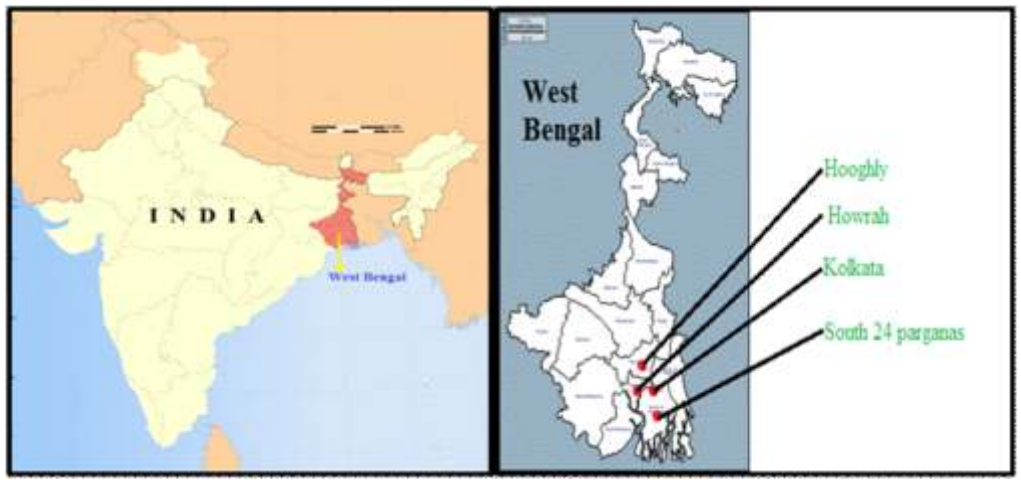


Figure 2 : Map of India and West Bengal highlighting the sampling sites.

Isolation of Microalgal Species:

The algal samples collected from sampling sites are isolated by quadrant streaking in Bold basal medium (BBM) agar plates. The petriplates were incubated at 25°C, 16:8 hour dark and light period. The single colonies are sub cultured in a fresh BBM agar plates and incubated in optimum conditions for growth. Purified cultures are stored at 4°C for further studies.

Morphological Identification of Microalgae:

Isolated microalgal species has been photographed by using "OLYMPUS CH20i" microscope with attached "SONY" camera. The microalgal species are morphologically identified with the reference of monographs.

Physiochemical Analysis of Water Samples:

Physiological parameters such as temperature, conductivity, specific conductivity, resistivity, total dissolved solids, salinity, dissolved oxygen, pH and oxidation reduction potential were analyzed in twenty two (22) water samples by YSI-Multiparameter. In ten (10) water samples physiochemical water parameters such as appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, pH alkalinity as $CaCo_3$,total alkalinity, total hardness, Calcium, Magnesium, Sodium, Potassium, Iron, Manganese, free Ammonia, Nitrite, Nitrate, Chloride, Fluoride, Sulphate, Phosphate and Tidy's test were analyzed by Tamil Nadu Water supply and Drainage Board (TWAD Board), Chennai- 600 005.

Analysis of Arsenic Concentration:

All the 29 water samples were analyzed for arsenic concentration by colour comparison method (semi quantitative). Arsenic concentrations of water samples were analyzed by commercially available field portable Arsenic test kit (Rakiro Biotech Systems Pvt. Ltd. - AE: 408). Arsenic ppm was analyzed by the comparison of the tested paper with colour chart provided in the kit.

Figure 3: Arsenic detection kit used for determination of arsenic concentration in the collected water samples.

RESULTS:

Sample Collection:

The microalgal samples and water samples are collected from 29 different places of Howrah, Hooghly, Kolkata and South 24 Parganas, West Bengal, India.

The following figure showing the sampling sites of West Bengal, India.

Figure 4: Place and Source of Water and Soil Sample collection spots in West Bengal, India. 01. Akma (river), 02. Uluberia (river 1), 03. Uluberia (river 2), 04. Uluberia (ground water), 05. Jay Nagar (pond soil), 06. Uluberia (pond 1), 07. Baruipur (pond 2), 08. Chinsurah (river), 09. Baruipur (pond soil), 10. Chinsurah (ground water), 11. Baruipur (pond 1), 12. Baruipur (land soil), 13. Achipur (river), 14. Uluberia (pond 2), 15. Uluberia (ground water).

Figure 5: Place and Source of Water and Soil Sample collection spots in West Bengal, India. 16. Baruipur (ground water), 17. Uluberia (soil), 18. Sonarpur (pond), 19. Dhaksineswar (river 1), 20. Dhaksineswar (river 2), 21. Jay Nagar (pond), 22. Sonarpur (ground water), 23. Howrah (river), 24. Chinsurah (river soil), 25. Jay Nagar (soil), Alipur (ground water), 26. Sonarpur (soil), 27. Alipur (ground water), 28. Jay Nagar (ground water), 29. Uluberia (river soil).

Isolation and Identification of Microalgal Species:

The microalgal samples were isolated and microscopically identified. The following figures are showing the microalgal species found in the collection sites.

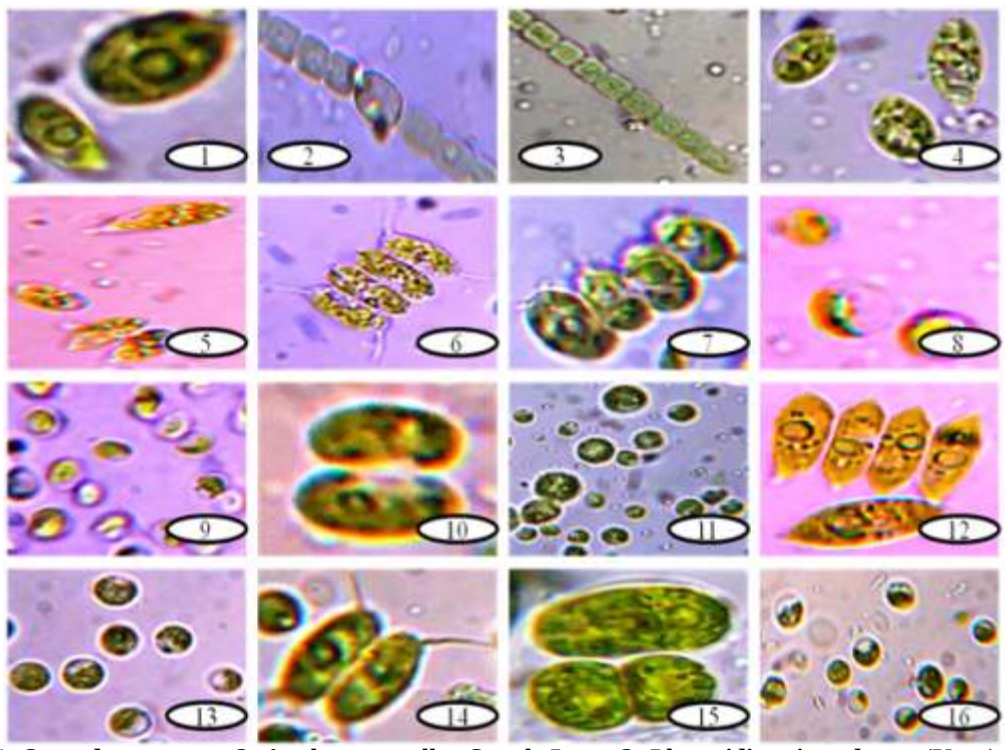


PLATE 1: 1. *Scenedesmus* spp., 2. *Anabaena azollae Strasb*. Loae, 3. *Phormidium inundatum* (Kutz), 4. *Scenedesmus bijugatus var*. graevenitzii (Bernard) comb. Nov, 5. *Scenedesmus deserticola* L.A.Lewis and V.R.Fle. ex E. Heg., C.Bock and Kr, 6. *Scenedesmus quadricauda Var*. parvus G. M. Smith, 7. *Scenedesmus subspicatus* Chodat, 8. *Chlorella vulgaris* Beyerinck, 9. *Chlorella vulgaris Beyerinck*, 10. *Scenedesmus abundans* (Kirchner) Chodat, 11. *Chlorella vulgaris Beyerinck*, 12. *Scenedesmus dimorphus* (Turpin) Kuetzing, 13. *Chlorella vulgaris Beyerinck*, 14. *Scenedesmus armatus* (Chodat) G. M. Smith, 15. *Scenedesmus* spp., 16. *Chlorella vulgaris* Beyerinck.

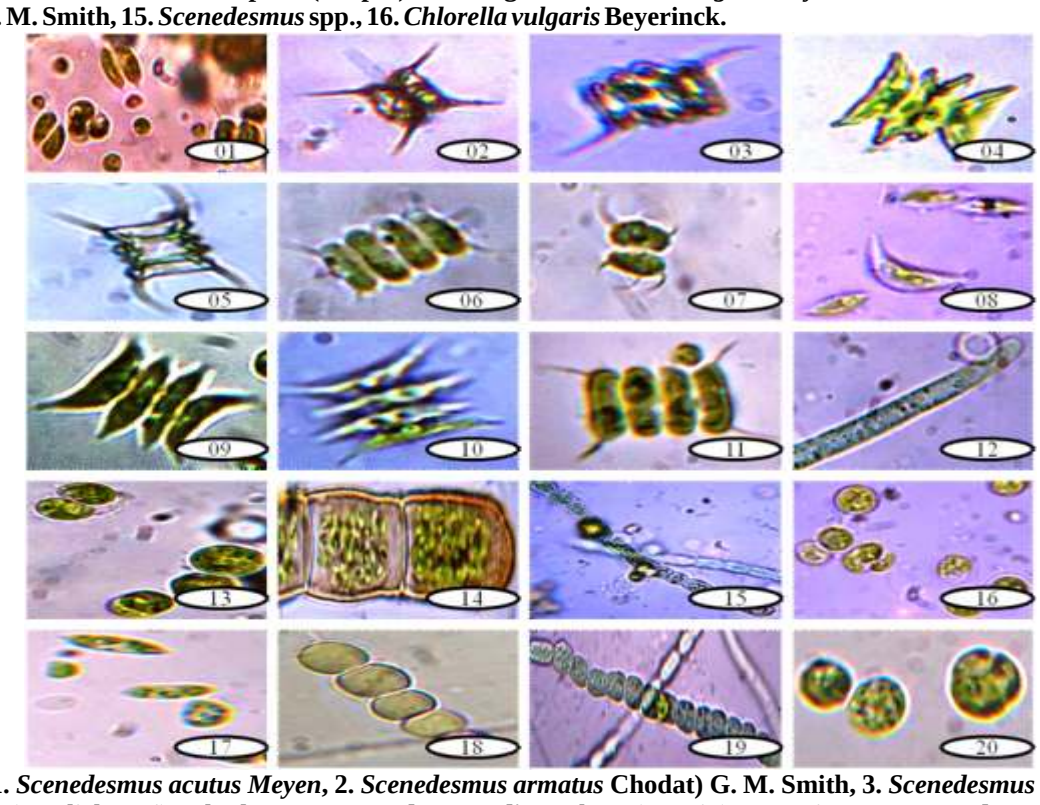


PLATE 2: 1. *Scenedesmus acutus Meyen*, 2. *Scenedesmus armatus* Chodat) G. M. Smith, 3. *Scenedesmus armatus* Var. bicaudatus (Guglielmetti) Chodat., 4. *Scenedesmus dimorphus* (Turpin) Kuetzing, 5. *Scenedesmus perforates* Lemmermann, 6. *Desmodesmus spinosus* (Chodat) Hegewald, 7. *Scenedesmus abundans* (Kirchner) Chodat, 8. *Scenedesmus deserticola* L.A.Lewis and V.R.Fle. ex E.Heg., C.Bock and Kr., 9. *Scenedesmus dimorphus* (Turpin)

Kuetzing, 10. *Scenedesmus dimorphus* (Turpin) Kuetzing, 11. *Scenedesmus armatus* (Chodat) G. M. Smith, 12. *Oscillatoria vizagapatensis Rao*, C.B, 13. *Scenedesmus* spp., 14. *Lyngbya cryptovaginata Schkorbatow*, 15. Cylindrospermum muscicola Kuetz., 16. Chlorella vulgaris Beyerinck, 17. Scenedesmus deserticola L.A. Lewis and V.R.Fle. ex E.Heg., C.Bock and Kr., 18. *Anabaena constricta Geitler*., 19. *Anabaena oryzae Fritsch*, 20. *Chlorococcum humicola* (Naeg) Rabenhorst.

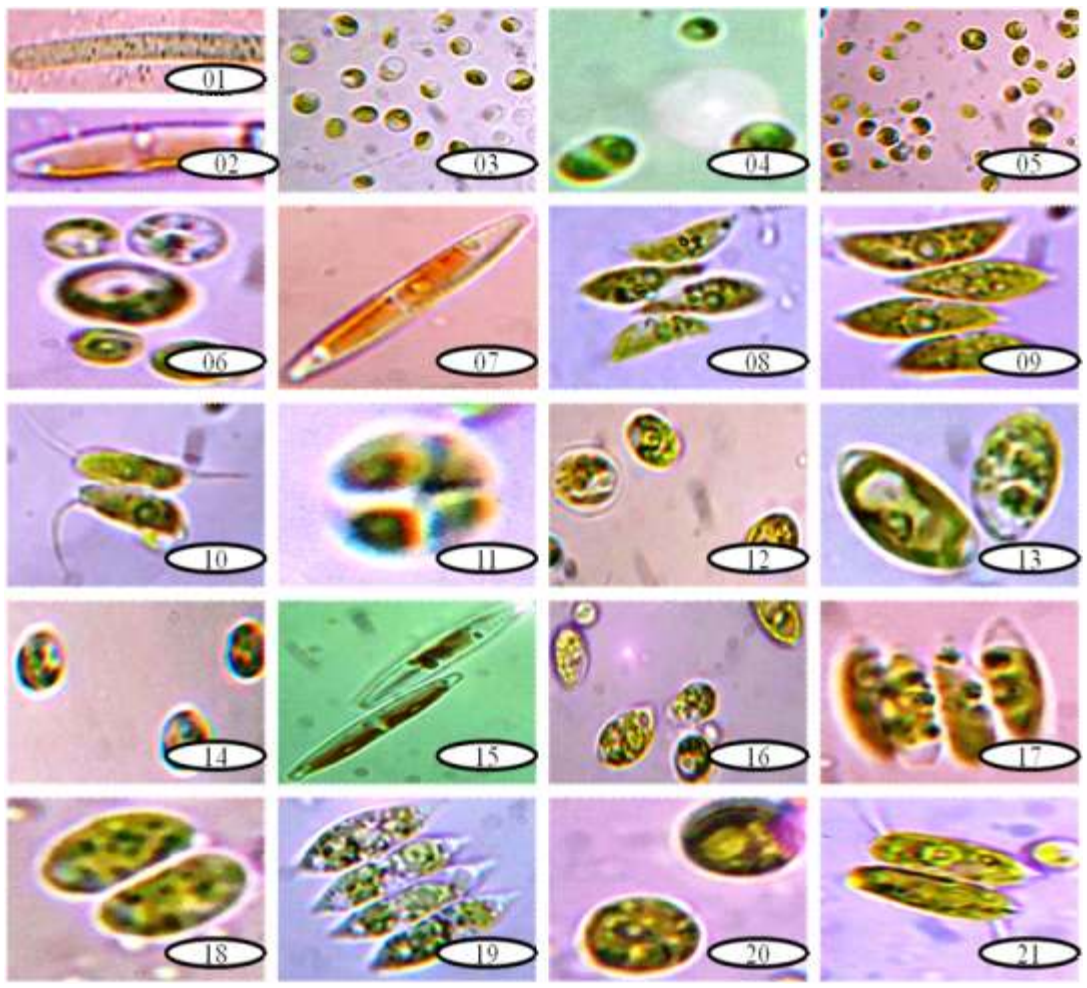


PLATE 3: 1. *Oscillatoria vizagapatensis Rao*, C.B, 2. *Synedra ulna Var*. amphirhynchus, 3. *Chlorella vulgaris Beyerinck*, 4. *Dictyosphaerium pulchellum* Wood, 5. *Chlorella vulgaris Beyerinck*, 6. *Chlorella vulgaris Beyerinck*, 7. *Nitzschia obtuse* W. Smith, 8. *Scenedesmus acuminatus* (Lagerheim) Chodat, 9. *Scenedesmus acutus Meyen*, 10. *Scenedesmus armatus* (Chodat) G. M. Smith, 11. *Crucigenia tetrapedia* (Kirchner) W. West and GS. West, 12. *Oocystis rhomboidea* Fott, 13. Scenedesmus bijugatus var. graevenitzii (Bernard) comb. Nov, 14. Chlorella vulgaris Beyerinck, 15. Nitzschia obuse W. Smith, 16. *Euglena pascheri Swir*, 17. *Scenedesmus arcuatus Var.* capitatus G. M. Smith, 18. *Scenedesmus* spp., 19. *Scenedesmus arcuatus* Var. capitatus G. M. Smith, 20. *Botryococcus braunii Kuetzing*, 21. *Scenedesmus armatus* Var. bicaudatus (Guglielmetti) Chodat.

YSI Physiochemical Multiparameter Analysis Instrument:

Among the twenty two (22) water samples were collected from different places of West Bengal were analyzed by YSI multiparameter, the following parameters were obtained. Average temperature was 27.92° C, the maximum conductivity was Sonarpur (1.925 milli-Siemens/cm) and minimum was found in Achipur river water (0.028 ms/cm), maximum specific conductivity was found in Sonarpur (2.029 ms/cm) and minimum was found in Achipur (0.028ms/cm), maximum resistivity was found in Baruipur pond-1 (4248.74 Ω/cm) and minimum was found in Sonarpur pond (492.31 Ω/cm), Maximum TDS was found in Sonarpur pond (1.252 g/l) and minimum was found in Achipur river (0.015 g/l), maximum salinity was found in Sonarpur pond (0.97 ppt) and minimum was found in Achipur (0 ppt), maximum dissolved oxygen percentage was found in Uluberia tap water (143.1 %) and minimum was found in Sonarpur pond (8.6 %), maximum dissolved oxygen was found in Uluberia tap water (11.23 mg/l) and minimum was found in Sonarpur pond (0.66 mg/l), maximum dissolved oxygen (ch) was

found in Baruipur and Uluberia tap water (22.6 ch) and minimum was found in Akma (8.4 ch), maximum pH was found in Dhaksineswar, Baruipur and Jay Nagar (7.23) and minimum was found in Baruipur, Alipur and Sonarpur (7.13), maximum pH in milli Volts (mV) was found in Alipur (12) and minimum was found in Jay Nagar (5.7) and maximum oxidation reduction potential (ORP) was found in Sonarpur(-14.6) and minimum was found in Dhaksineswar (-117 mV).

The following table shows the results obtained from YSI physiochemical multiparameter analysis of twenty two (22) water samples collected from different places of West Bengal.

Table 1 : Comparison of YSI physiochemical multiparameter instrument analysis results of water samples collected from West Bengal. (Highest and lowest values are marked as red).

place	Source	Temp.	Cond.	Cond.(mS	Resis.	TDS	Salinity	DO(%)	DO(mg/L	DO(ch)	pH	pH (mV)	ORP (mV
Uluberia	River	27.8	0.466	0.493	2032.77	0.305	0.23	101.9	8	17.5	7.16	10.4	-51.6
Jaynagar	Pond	27.73	0.545	0.574	1742.74	0.355	0.26	47.7	3.74	14.5	7.14	11.3	-26.6
Baruipur	Pond (2)	27.65	0.736	0.773	1294.41	0.478	0.36	64.1	5.04	16.5	**7.13**	11.6	-23.8
Akma	River	27.57	1.014	1.064	939.55	0.66	0.5	20.4	1.58	**8.4**	7.14	11	-15.1
Howrah	River	27.52	0.579	0.607	1647.44	0.376	0.28	68.6	5.4	15.5	7.17	9.2	-50.3
Chinsurah	River	27.47	0.436	0.456	2192.42	0.283	0.21	83.8	6.61	16.5	7.2	7.5	-51.9
Alipur	Tap	**27.41**	0.977	1.022	977.62	0.637	0.48	30.3	2.39	11.4	**7.13**	**12**	47.2
Howrah	Ground	27.8	0.455	0.479	2087.35	0.296	0.22	98.2	7.71	17.5	7.22	6.8	-56.8
Sonarpur	Ground	27.77	1.309	1.379	725.43	0.852	0.65	18.3	1.42	11.4	7.14	11.5	**-14.6**
Sonarpur	Pond	27.85	**1.925**	**2.029**	**492.31**	**1.252**	**0.97**	**8.6**	**0.66**	10.4	**7.13**	11.7	-34
Dhaksines	River	27.74	0.471	0.496	2017.22	0.306	0.22	13.6	1.07	10.4	7.18	8.7	**-117**
Dhaksines	River (Sh	27.68	0.217	0.223	4000.08	0.143	0.1	99.3	7.82	18.6	7.22	6.6	-58.5
Achipur	River	27.64	**0.028**	**0.028**	1245.81	**0.015**	**0**	100.4	667	16.5	7.22	7.4	-51.6
Dhaksines	River (2)	27.73	0.46	0.484	2065.54	0.299	0.22	41.6	3.28	12.4	**7.23**	6.1	-43.6
Chinsurah	Ground	27.64	0.322	0.338	2951.67	0.21	0.15	75.8	5.97	15.5	7.18	9.1	-49.8
Uluberia	River (2)	27.53	0.234	0.246	4065.48	0.153	0.11	104	8.24	19.6	7.22	6.7	-43.4
Baruipur	Tap	**27.92**	0.238	0.251	3981.81	0.155	0.11	132.1	10.36	**22.6**	**7.23**	6.1	-42.9
Dhaksines	River (3)	27.9	0.242	0.255	3921.1	0.157	0.11	82.7	6.48	18.6	**7.23**	5.8	-38.8
Akma	Ground	27.71	0.432	0.454	2203.66	0.28	0.21	68.7	5.4	14.5	7.21	7.1	-19.4
Baruipur	Pond (1)	27.79	0.223	0.235	**4248.74**	0.145	0.1	57.2	4.49	16.5	7.2	8	-56.6
Uluberia	Tap	27.84	0.233	0.246	4058.17	0.152	0.11	**143.1**	**11.23**	**22.6**	7.22	6.5	-42.9
Jaynagar	Ground	27.87	0.55	0.581	1722.22	0.358	0.26	71.8	5.63	15.5	**7.23**	**5.7**	-38.7

Physiochemical Analysis of Water Samples Collected From West Bengal:

Among the ten (10) water samples analyzed Jay Nagar pond water has highest turbidity in NT units 19.4 and Akma river water has lowest turbidity in NT units 2.4, Sonarpur pond water has highest total dissolved solids (TDS) 1202 mg/l and Chinsurah river water has lowest TDS 316 mg/l, Sonarpur pond water has highest electrical conductivity 1717 micromol/l and Chinsurah river water has lowest electrical conductivity 451 micromol/l, Uluberia river water has highest pH 7.53 and Howrah ground water sample has lowest pH 6.84, pH alkalinity as $CaCo_3$ is not found in all water samples, Sonarpur pond water has highest total alkalinity as $CaCo_3$ 460mg/l and Jay Nagar pond water has lowest total alkalinity as $CaCo_3$ 152mg/l, Sonarpur pond water has highest total hardness as $CaCo_3$ 490mg/l and Jay Nagar pond water has lowest total hardness as $CaCo_3$ 132 mg/l, Sonarpur pond water has highest Calcium as Ca 120 mg/l and Jay Nagar pond water has lowest Calcium as Ca 39 mg/l, Sonarpur pond water has highest Magnesium as Mg 46 mg/l and Joy Nagar pond water has lowest Magnesium as Mg 8 mg/l, Sonarpur pond water has highest Sodium as Na 148 mg/l and Chinsurah river water has lowest Sodium as Na 25 mg/l, Sonarpur pond water has highest Potassium as K 11 mg/l and Howrah river water has lowest Potassium as K 2 mg/l, Jay Nagar pond water has highest Iron as Fe 0.57 mg/l and Akma river water has lowest Iron as Fe 0.20 mg/l, Manganese is not found all the water samples, Jay Nagar pond water has highest free Ammonia as NH_3 2.15mg/l and Akma river water has lowest free Ammonia as NH_3 0.31mg/l, Sonarpur pond water has highest Nitrite as NO_2 1.12mg/l and Chinsurah river water and Baruipur pond water has lowest Nitrite as NO_2 0.02mg/l, Akma river water has highest Nitrate as NO_3 39mg/l and Uluberia ground water has lowest Nitrate as NO_3 4mg/l, Sonarpur pond water has highest Chloride as Cl 230mg/l and Chinsurah river water has lowest Chloride as Cl 23 mg/l, Uluberia ground water has highest Fluoride as F 0.36 mg/l and Uluberia river water has lowest Fluoride as F 0.12 mg/l, Sonarpur pond water has highest Sulphate as SO_4 25mg/l and Howrah ground water has lowest Sulphate as SO_4 3mg/l, Akma river water has highest Phosphate as PO_4 0.22mg/l and Uluberia river water has no Phosphate concentration, and Jay Nagar pond water has highest O_2 (Tidys test for 4 hours) 2.4mg/l and Chinsurah river water has lowest

O_2 (Tidys test for 4 hours) 1.2 mg/l.

Physiochemical parameter analysis results of water samples are listed in following table.

Table 2 : Comparison of Physiochemical parameters of water samples collected from West Bengal, India. (Highest and lowest values are marked as red).

I. physical examination :	Uluberia river Water	Akma river Water	Howrah river Water	Chinsurah river Water	Sonarpur pond Water	Joy Nagar pond Water	Baruipur pond Water	Dhaksine-swar river Water	Uluberia Ground water	Howrah Ground Water
Appearance	Turbid	Clear	Turbid	Clear	Turbid	Turbid	Turbid	Clear	Clear	Clear
Colour (pt.co-scale)	Colourless	Colourless	Colourless	Colourless	Black	Colourless	Colourless	Colourless	Colourless	Colourless
Odour	None	None	None	None	None	None	None	None	None	None
Turbidity NT units	6.3	2.4	6.3	3.4	7.3	19.4	14.8	13.2	6.4	13.4
TDS mg/L	326	683	379	316	1202	334	449	378	616	519
Electrical conductivity micro mho/L	466	976	542	451	1717	477	642	540	880	741
II. Chemical examination:										
pH	7.53	7.35	7.14	7.23	7.29	6.98	7.14	7.18	6.94	6.84
pH. alkalinity as CaCo3mg/L	0	0	0	0	0	0	0	0	0	0
Total alkalinity. as CaCo3mg/L	172	340	176	168	460	152	184	184	288	280
Total hardness as CaCo3mg/L	166	308	184	164	490	132	188	188	240	218
Calcium as Ca mg/L	45	83	49	45	120	39	52	53	62	58
Magnesium as Mg mg/L	13	24	15	12	46	8	14	13	20	18
Sodium as Na mg/L	27	74	35	25	148	47	54	29	74	61
Potassium as K mg/L	3	4	2	3	11	5	6	2	6	4
Iron as Fe mg/L	0.4	0.2	0.47	0.36	0.35	0.57	0.55	0.46	0.31	0.39
Manganese mg/L	0	0	0	0	0	0	0	0	0	0
Free ammonia as NH3mg/L	0.59	0.31	0.63	0.39	1.41	2.15	1.23	1.17	0.83	0.72
Nitrite as NO2 mg/L	0.06	0.97	0.03	0.02	1.2	0.09	0.02	0.05	1.19	0.29
Nitrate as NO3mg/L	5	39	5	5	10	17	29	8	4	9
Chloride as Cl mg/L	28	72	58	23	230	50	70	49	90	62
Fluride as F mg/L	0.12	0.18	0.26	0.26	0.19	0.26	0.21	0.31	0.36	0.21
Sulphate as SO4 mg/L	9	10	6	6	25	6	6	5	6	3
Phosphate as PO4mh/L	0	0.22	0.01	0.01	0.19	0.01	0.02	0.02	0.02	0.17
Tidys test 4 hrs. as O2mg/L	1.5	1.4	1.3	1.2	2	2.4	1.5	1.3	1.7	1.4

Arsenic Analysis in Water and Soil Samples Collected From West Bengal:

The following figures showing the colour comparison between the results obtained from arsenic test and standard arsenic colour chart.

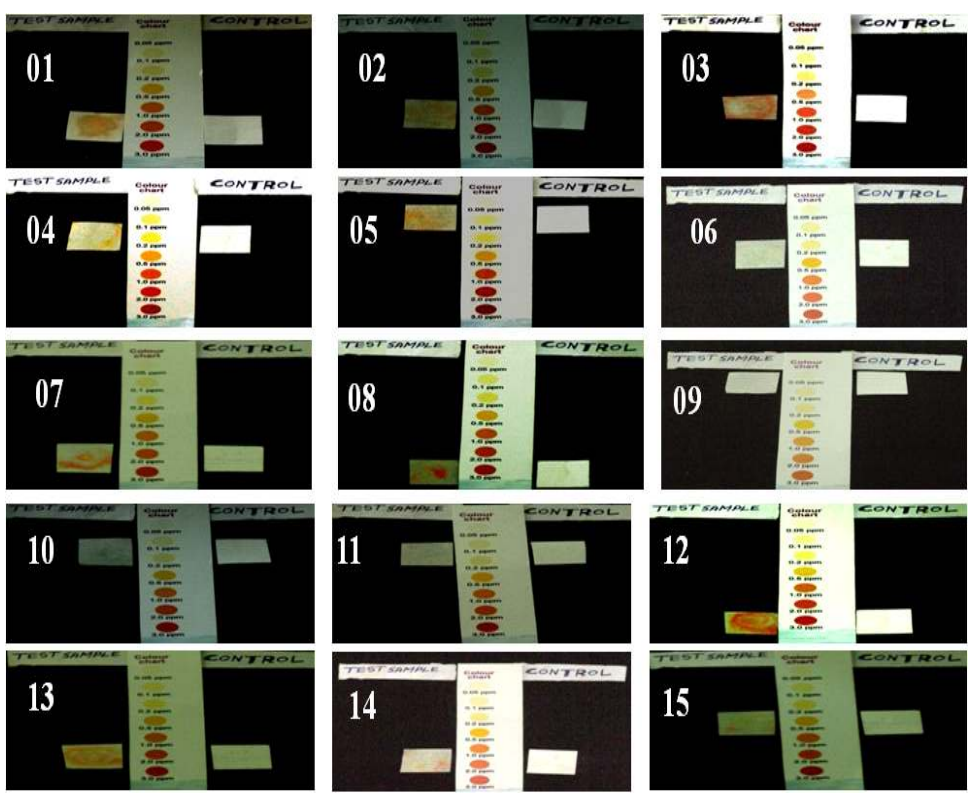
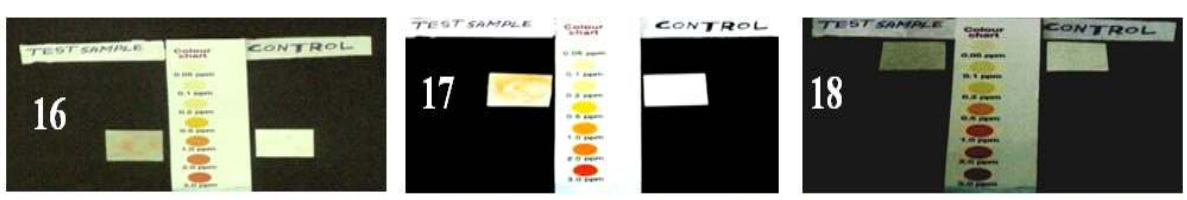


Figure 6: Comparison of arsenic concentration with standard arsenic colour chart (Place and Source of collection) :- 1. Uluberia (River Water), 02. Uluberia (Pond Water), 03. Achipur (River Water), 04. Uluberia (Ground Water), 05. Howrah (Ground Water), 06. Uluberia (land Soil), 07. Uluberia (River Soil), 08. Alipur (Ground Water), 09. Howrah (River Water), 10. Chinsurah (Ground Water), 11. Akma (River Water), 12. Chinsurah (River Water), 13. Sonarpur (Pond Water), 14. Jaynagar (Pond Soil), 15. Baruipur (Pond



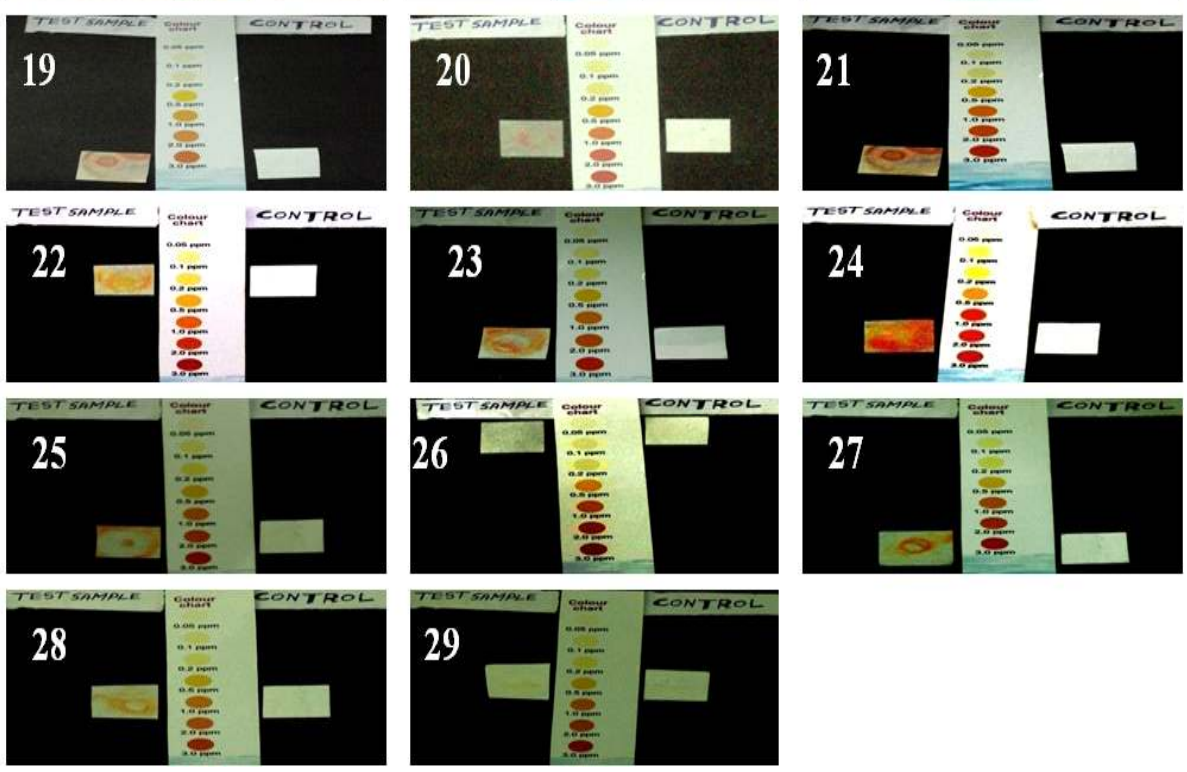


Figure 7: Comparison of arsenic concentration with standard arsenic colour chart (Place and Source of collection) :- 16. Baruipur (Soil-1), 17. Sonarpur (Soil), 18. Jay Nagar(Pond Water), 19. Baruipur (Pond Water), 20. Baruipur (Soil 2), 21. Baruipur (Pond Water 2), 22. Sonarpur (Ground Water), 23. Baruipur (Ground Water), 24. Jay Nagar (Ground Water), 25. Dhaksineswar (River Water), 26. Dhaksineswar (River Water 2), 27. Dhaksineswar (River Shallow Water), 28. Uluberia (Pond Water 2), 29. Chinsurah (River Soil).

The Arsenic concentration was analyzed in all the samples collected from different places of West Bengal, India. The arsenic concentration was ranged from 0.05 to 3.0. The maximum concentration of arsenic (3 ppm) was found in Baruipur (pond water 1, 2), Chinsurah (river water), Alipur (ground water) and Dhaksineswar (river water).

Table 3 : Comparison of microalgal spp. present in the sample collection sites and arsenic concentrations analyzed from various places of West Bengal. (Highest and lowest values are marked as red).

Sl. No.	Sample Collection Area	Source and Type of Sample	Arsenic (As) Concentration (PPM)	Microalgae present in the sampling sites
1.	-	Deionized Water	0.00	-
2.	Howrah	River Water	**0.05**	1.) *Scenedesmus armatus* Var. bicaudatus Guglielmetti Chodat. 2.) *Botryococcus braunii* Kuetzing. 3.) *Scenedesmus* spp.
3.	Jay Nagar	Pond Water	**0.05**	1.) *Scenedesmus deserticola* L. A. Lewis & V. R. Fle ex E. Heg., C. Bock & Kr. 2.) *Chlorella vulgaris* Beyerinck. 3.) *Scenedesmus abundans* (Kirchner) Chodat. 4.) *Scenedesmus* Spp. 5.) *Oscillatoria vizagapatensis* Rao, C.B. 6.) *Lyngbya cryptovaginata* Schkorbatow. 7.) *Cylindrospermum muscicola* Kuetz.
4.	Dhakshineswar	River Water	**0.05**	*1.) Chlorella vulgaris* Beyerinck. 2.) *Scenedesmus* spp.
5.	Akma	River Water	0.1	1.) *Chlorella vulgaris* Beyerinck. 2.) *Nitzschia obtuse* W. Smith. 3.) *Euglena pascheri* Swir. 4.) *Scenedesmus bijugatus* Var. graevenitzii (Bernard) Comb. nov. 5.) *Scenedesmus deserticola* L. A. Lewis & V. R. Fle. Ex E. Heg., C. Bock & Kr. 6.) *Scenedesmus subspicatus* Chodat.
6.	Baruipur	Pond Water	**3.0**	1.) *Chlorella vulgaris* Beyerinck.
7.	Chinsurah	Ground Water	0.2	_
8.	Uluberia	River Water	2.0	1.) *Scenedesmus dimorphus* (Turpin) Kuetzing.
9.	Uluberia	Pond Water(1)	1.0	1.) *Scenedesmus deserticola* L. A. Lewis & V. R. Fle. ex E. Heg., C. Bock. & Kr. 2.) *Scenedesmus dimorphus* (Turpin) Kuetzing. 3.) *Anabaena azollae* Strasb. Loae. 4.) *Phormidium inundatum* (Kutz)
10.	Baruipur	Ground Water	2.0	_
11.	Achipur	River Water	1.0	1.) *Scenedesmus dimorphus* (Turpin) Kuetzing.
12.	Sonarpur	Ground Water	0.2	_
13.	Chinsurah	River Water	**3.0**	1.) *Scenedesmus acutus* Meyan. 2.) *Scenedesmus arcuatus* Var. capitatus G. M. Smith.
14.	Alipur	Ground Water	**3.0**	1.) *Chlorella vulgaris* Beyerinck.
15.	Uluberia	Ground Water	0.2	_
16.	Jay Nagar	Ground Water	2.0	_
17.	Sonarpur	Pond Water	0.2	1.) *Chlorella vulgaris* Beyerinck. 2.) *Crucigenia tetrapedia* (Kirchner) W. West and G. S. West. 3.) *Oocystis rhomboidea* Fott. 4.) *Scenedesmus bijugatus*Var. Graevenitzii (Bernard) Comb. nov. 5.) *Synedra ulna* Var. amphirhynchus.
18.	Baruipur	Pond Water(2)	**3.0**	1.) *Dictyosphaerium pulchellum* Wood.
19.	Dhaksineswar	River Shallow Water	**3.0**	_
20.	Dhaksineswar	River Water	2.0	1.) *Chlorella vulgaris* Beyerinck.
21.	Uluberia	Pond Water (2)	1.0	1.) *Anabaena constricta* Geitler. 2.) *Anabaena oryzae* Fritsch. 3.) *Chlorococcum humicola* (Naeg) Rabenhorst. 4.) *Oscillatoria vizagapatensis* Rao, C.B.
22.	Howrah	Ground Water	0.1	_
23.	Baruipur	Soil	1.0	-
24.	Uluberia	Soil	0.2	-
25.	Baruipur	Soil(2)	2.0	-
26.	Jay Nagar	Pond Soil	2.0	1.) *Scenedesmus acutus* Meyan. 2.) *Scenedesmus armatus* (Chodat) G.M.Smith. 3.) *Scenedesmus armatus*Var. bicaudatus (Guglielmetti) Chodat. 4.) Scenedesmus dimorphus (Turpin) Kuetzing. 5.) *Scenedesmus perforates* Lemmermann.
27.	Chinsurah	River Soil	0.5	1.) Scenedesmus dimorphus (Turpin) Kuetzing. 2.) *Scenedesmus armatus* (Chodat) G.M.Smith.
28.	Sonarpur	Soil	2.0	-
29.	Baruipur	Pond Soil	0.5	1.) *Chlorella vulgaris* Beyerinck.
30.	Uluberia	River Soil	2.0	1.) *Desmodesmus spinosus* (Chodat) Hegewald. 2.) *Scenedesmus abundans* (Kirchner) Chodat.

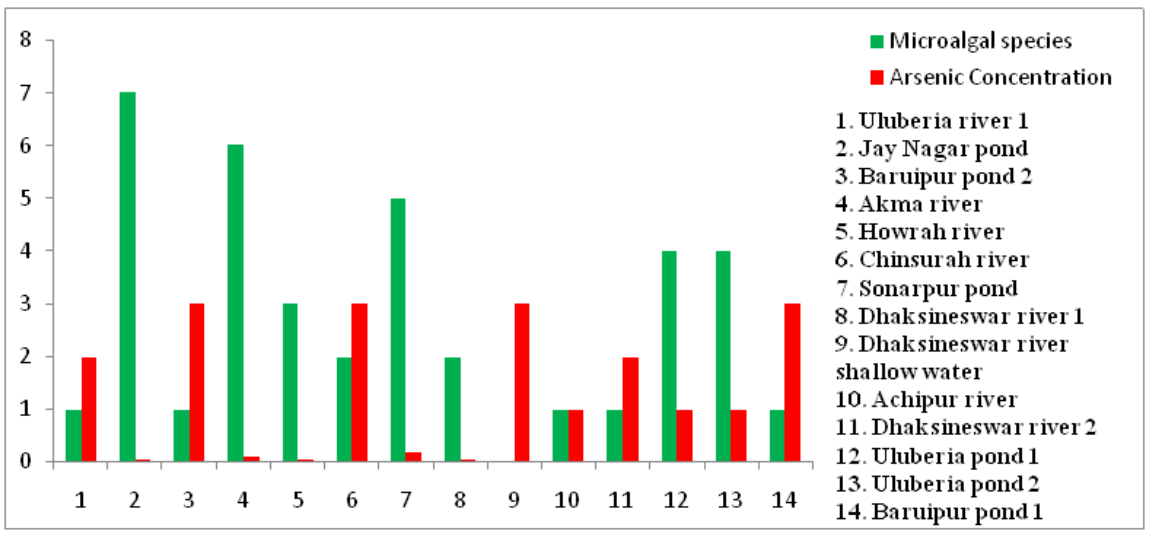


Figure 8: Arsenic concentration versus microalgal spp. present in the sampling sites.

DISCUSSION:

According to the World Health Organization (WHO), arsenic has been responsible for the largest mass poisoning of a population in history (Smith, Lingas, and Rahman, 2000). Pollution by arsenic occurs naturally through the dissolution of minerals and ores, and concentrations in groundwater in some areas are elevated as a result of erosion from local rocks (McArthur et al., 2001). West Bengal has extremely rich natural water resources. Most of the people in West Bengal are drinking arsenic contaminated water above the permissible limit (0.01 mg/L). Continuous drinking from arsenic-laced wells can cause various health disorders including birth complications and cancer (Waalkes et al, 2007; Li et al., 2008; Tokar et al., 2011). Prolonged exposure to inorganic arsenic can lead to hallucinations, agitation, emotional lability, memory loss, gangrene and skin as well as internal (lungs, bladder and kidneys) cancer (ATSDR, 2005). There is evidence that chronic arsenic exposure causes adverse pregnancy outcomes in terms of spontaneous abortion, still birth and pre-term birth rates (Ahmad et al., 2001; Ehrenstein et al., 2006). Smith et al., 2006, found significant increases in mortality from lung cancer and bronchiectasis in persons with probable exposure to high concentrations of arsenic in drinking water in early childhood. For various reasons, arsenic exposure is a public health concern for children and infants as well. Low doses of arsenic, consumed over ears, can ultimately cause death (Argos et al., 2010). 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. This study attempt was made to study about microalgal diversity, arsenic concentration and other parameters in water samples in West Bengal. In all the water samples collected physiochemical parameters were analyzed. Uluberia ground water has highest Fluoride as F 0.36 mg/l and Uluberia river water had lowest Fluoride as F 0.12 mg/l. Arsenic concentration was ranged from 0.05 to 3.0 ppm. Baruipur (pond water 1, 2), Chinsurah (river water), Alipur (ground water) and Dhaksineswar (river water) had highest arsenic concentration 3 ppm. In Baruipur all the samples tested from pond water, ground water and soil samples arsenic concentration was ranged from 0.5 to 3 ppm. There are some correlations between arsenic concentrations and physiochemical parameters that is when nitrite concentration increases the arsenic concentration decreases and wise versa, when sodium concentration increases the microalgal spp. increases and wise versa. All the water resources in West Bengal are found to be having enough water parameters and well being for the growth of microalgal spp. and there is no other correlations found between arsenic concentrations and physiochemical parameters.

There should be a remediation has to be implemented for arsenic pollution, otherwise it may leads to serious health effects to the human beings if mixed up with potable drinking water. In many villages, unsafe tube wells are often near a safe well (van Geen et al., 2005). In this arsenic water contamination issue a new technology with low cost is needed to treat arsenic in drinking water samples. Several attempts were made to treat arsenic by using algae. Isolates from four genera of freshwater green algae were capable of methylating sodium arsenite in lake water and Bold's basal medium (Baker et al., 2011). Ghassemzadeh et al., 2007 reported that a macroalgae Chara vulgaris could significantly remove arsenic from polluted water. Microalgae (phytoplankton) are key contributors to arsenic cycling in the marine environment primarily as a food source for higher organisms (Sanders et al., 1989; Edmonds et al., 1997). The formation of arsenoribosides has subsequently been detected in the diatom Chaetoceros concavicornis (Edmonds et al., 1997) and freshwater algae Chlorella vulgaris (Murray et al., 2003), Chlorella sp. (Levy et al., 2005) and Monoraphidium arcuatum (Levy et al., 2005). In further this study will try to treat arsenic in drinking water with low cost by using microalgae isolated from the native environment.

In this study the microalgal strains were isolated and morphologically identified from different native environments. At higher arsenic concentrations (2-3 ppm), some of the microalgae were found to be grown such as Chlorella vulgaris Beyerinck, Scenedesmus dimorphus (Turpin) Kuetzing, Scenedesmus acutus Meyan, Scenedesmus arcuatus Var. capitatus G. M. Smith, Dictyosphaerium pulchellum Wood, Scenedesmus armatus (Chodat) G.M.Smith, Scenedesmus armatusVar. bicaudatus (Guglielmetti) Chodat, Scenedesmus perforates Lemmermann, Desmodesmus spinosus (Chodat) Hegewald and Scenedesmus abundans (Kirchner) Chodat. At lower arsenic concentrations (0.05 - 0.5 ppm) most microalgal spp. were found to be grown such as Scenedesmus armatus Var. bicaudatus Gugliemetti Chodat, Botryococcus braunii Kuetzing, Scenedesmus spp., Scenedesmus deserticola L. A. Lewis & V. R. Fle ex E. Heg., C. Bock & Kr, Chlorella vulgaris Beyerinck, Scenedesmus abundans (Kirchner) Chodat, Oscillatoria vizagapatensis Rao, C.B, Lyngbya cryptovaginata Schkorbatow, Cylindrospermum muscicola Kuetz, Euglena pascheri Swir, Scenedesmus subspicatus Chodat, Nitzschia obtuse W. Smith, Crucigenia tetrapedia (Kirchner) W. et G. S. West, Oocystis rhomboidea Fott, Scenedesmus bijugatusVar. Graevenitzii (Bernard) Comb. nov, Synedra ulna Var. amphirhynchus and Scenedesmus dimorphus (Turpin) Kuetzing. This indicates that microalgal diversity increased in lower arsenic concentrations and decreased in higher arsenic concentrations. Scenedesmus spp. and Chlorella vulgaris are found to be grown in both the higher and lower arsenic concentrations. These microalgal species could accumulate arsenic in their bodies and reduce the arsenic concentrations as well. If so the gene which is specific for arsenic detoxification can be identified and cloned. Then by the use of gentic engineering techniques the gene could transformed to efficient organisms so that higher arsenic concentrations can be bioaccumilated. By using filteration and separation techniques the bioaccumilated arsenic can be removed from the water and arsenic free water can be obtained.

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