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ECOLOGICAL STUDY OF ALGAL FLORA OF WAH GARDEN, DISTRICT ATTOCK, PAKISTAN

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Abstract

The study was conducted near bridge up to Wah Garden from 1st June 2000 to 31st May 2001. Algal samples were collected by phytoplankton net, pipettes, handpicking, etc. and water samples by Nansen bottles for the study of physico-chemical properties. Algae were preserved in 4 % formaline solution and found to contain 172 species belonging to 79 genera of 10 phyla: Cyanophyta (47 species & 17 genera, 27.32 %), Volvocophyta (53 species & 25 genera, 30.81 %), Chlorophyta (7 species & 5 genera, 4.06 %), Bacillariophyta (39 species & 18 genera. 22.7 %), Chrysophyta (2 species & 2 genera, 1.16 %) Xanthophyta (3 species & 3 genera, 1.74 %), Vaucheriophyta (1 species & 1 genus, 0.58 %), Euglenophyta (13 species & 3 genera, 7.56 %), Charophyta (2 species & 1 genus, 1.16 %), Rhodophyta (5 species & 4 genera, 2.9 %). The water samples were analysed for 36 physico-chemical parameters. Water was found to be rich in primary productivity as well as fish production. The ratio of D.O. was high throughout the year and water was alkaline.

Introduction

Water bodies with a large population of algae present a major problem to the water purification department of many inland cities which depend upon surface supplies as their source of water. Such water when used in the purification process of public supplies has obnoxious taste and odour which cannot be completely removed by known treatments. The heavy population of algae also causes filter matting and clogging which is another problem of equal importance. Therefore, qualitative and quantitative determinations of algal flora are essential for measuring the aquatic productivity, as algae are chief source of food for aquatic animals. They are also good indicator for pollution (Patric & Reimer, 1966). From this point of view the area of Wah Garden was selected for the study of algal growth and changes occurring in the surrounding water.

Wah garden is located 12 km west of Taxila on G.T. Road and about 50 km away from Islamabad. Once a major campsite of Mughal rulers, these gardens were developed with magnificent trees and water channels. Tapering cypress trees line the canals through which cool waters once flowed between elegant romanic pavilions and cascading into large reflecting basins. The gardens are being restored to their original beauty. They are located at an altitude of 727 meters above sea level (latitude 33° 50', longitude 72° 47').

Materials and Methods

Planktonic species were collected monthly from June, 2000 to May, 2001 between 11 a.m. to 3 p.m. with the help of phytoplankton net of 5-10 μm mesh. Filamentous algae were picked up with the help of forcep, diatoms were collected with tooth brush from the different zones (Nulla) of Wah Garden such as mixed reactors, too old branches, basins, pools, dead zones at the back of tree groynes, stones etc. Water samples were taken using water sampler (Nansen bottle) for studying physico-chemical features using standard methods (APHA, 1985). Algal samples were preserved in 4 % formalin solution (Mason, 1967), species composition was determined by utremohal method (Lund, 1958). Species determination and counts were made using inverted light microscope (BH-2 Olympus, Japan 10x 20^x & 40^x). They were identified with the help of suitable literature (Tilden, 1910; Husted, 1930; Majeed, 1935; Smith, 1950; Desikachary, 1959; Prescott, 1962; Siddiqi & Faridi, 1964; Patrick, 1966; Philpose, 1967; Tiffany & Britton, 1971; Vinyard, 1979; Akiyama & Yamagishi, 1981; Shameel, 2001).

Results and Discussion

A total number of 172 species belonging to 79 genera of 10 phyla, could be identified (Table 1). They have been arranged according to the recently proposed classification (Shameel, 2001). The details, of the various phyla are: Cyanophyta (47 species belonging to 17 genera, 27.32 %), Volvocophyta (53 species belonging to 25 genera, 30.81 %), Chlorophyta (7 species belonging to 5 genera, 4.06 %), Bacillariophyta (39 species belonging to 18 genera, 22.7 %), Chrysophyta (2 species belonging to 2 genera, 1.16 %) Xanthophyta (3 species belonging to 3 genera, 1.74 %), Vaucheriophyta (1 species belonging to 1 genus, 0.58 %), Euglenophyta (13 species belonging to 3 genera, 7.56 %), Charophyta (2 species belonging to 1 genus, 1.16 %), Rhodophyta (5 species belonging to 4 genera, 2.9 %).

Physical and chemical parameters show the effect of temperature (Table 2). High air temperature (13-38° C) changes the climate, directly affecting glacier, snow, water form and water surface temperature (17-26°C). High temperature of water surface helps in dissolving the organic and inorganic matter and temperature often controls the horizontal distribution of many algae. The photosynthetic rate of phytoplankton has been found to increase with increase of temperature. The pH (7.8-8.5) shows that the water is alkaline, pH increase is due to high concentration of dissolved organic and inorganic matter, temperature and algal species, etc. The T.D.S. (200-300 ppm) showing the concentration of total dissolved solids of water is quite productive for aquatic life. The T.S.S. (0.5-4 mg/L) shows the ratio of total suspended solids in water, high T.S.S. value shows that high concentration of non-living particulates originating from catchment, derived silts, clay, mud, organic matter, etc. are present in the water. This high value is due to rain and flood, so flood episodes are the major disturbances in water affecting composition and biomass of phytoplankton.

The high turbidity (0.8-1.5) value shows that water is too much turbid. High concentration of abiogenic turbidity (whether disturbance or not), water colum mixing as such or in combination within organic turbidity cause concomitant changes in the light field over time. Consequently, vertical mixing and suspended solids significantly affect phytoplankton photosynthesis and productivity in aquatic environment. Conductivity (40-62 M $ohmsx^{10}$) shows the current ions for production means water is enough for productivity. Salinity (0.5-3 ppt) and orthophosphate (0.08-0.4 μg/L) were low. The result shows that low salinity, orthophosphate, low temperature provide chances for the presence of species of the phylum Chrysophyta. High humidity (46-68 %) value shows that fungi, bacteria, cyanophytes, aerial algae etc. could be present as humidity directly affects light and temperature. Light transparency was 1-4 feet. At one feet the water was too much turbid which affected the light limit, thus decreasing algal/phytoplankton photosynthesis and therefore restricted biomass development.

Table 1. Qualitative and quantitative study of algae of Wah Garden w.e.f. June 2000 to May 2001.

	Range		
	Min.	Max.	Mean±S.D.
Kingdom: MONERA			
Phylum: Cyanophyta			
Class: Chroocophyceae			
Order: Chroococcales			
Family: Chroococcaceae			
1. *Aphanocapsa montana* Cramer	8	10	9±1
2. *A. virescens* (Hass.) Raben.	6	10	8±2
3. *Aphanothece castagnei* (Breb.) Raben.	8	12	10±2
4. *A. nidulans* Richter	5	9	7±2
5. *A. saxicola* Nägeli	3	5	4±1
6. *Chroococcus bituminosus* (Bory) Hansgirg	4	6	5±1
7. *C. endophyticus* Copeland	6	8	7±1
8. *C. giganteus* W. West	3	5	4±1
9. *C. lithophilus* Erceg.	1	3	2±1
10. *C. minutus* var. *thermalis* Copeland	2	4	3±1
11. *C. turgidus* (Kuetz.) Naeg.	6	8	7±1
12. *Gloeocapsa gelatinosa* (Carm.) Kuetz.	3	5	4±1
13. *G. lithophila* (Ehr.) Hollerb.	2	6	4±2
14. *G. compacta* Kuetz.	8	10	9±1
15. *G. nigrescens* Naeg.	4	6	5±1
16. *Gloeothece confluens* Naeg.	8	12	10±2
17. *Gomphosphaeria aponina* var. *delicatula* Virieux.	3	5	4±1
18. *G. aponina* var. *cordiformis* Elenk.	4	6	5±1
19. *G. lacustris* Chod.	6	8	7±1
20. *Merismopedia glucum* (Ehr.) Naegeli	8	10	9±1
21. *M. convoluta* Breb.	10	12	11±1
22. *Microcystis aeruginosa* Kuetz.	10	16	13±3
23. *M. flos-aquae* (Wittrock) Kirchner.	8	12	10±2
24. *Pseudoholopedia convoluta* (Breb.) Elekin.	6	8	7±1
25. *Synechococcus aquatilis* Sauv.	1	3	2±1
Class: Nostocophyceae			
Order: Nostocales			
Family: Oscillatoriaceae			
26. *Lyngbya bornettii* Zukal	4	6	5±1
27. *L. confervoides* Agardh	2	4	3±1
28. *L. martensiana* Meneghini	6	10	8±2
29. *Oscillatoria agardhii* Gomont	2	4	3±1
30. *O. curvceps* Agardh	6	10	8±2

Table 1. (Cont'd.)

	Range		
	Min.	**Max.**	**Mean±S.D.**
31. *O. formosa* Bory	4	6	5±1
32. *O. iwanoffiana* (Nyg.) Geitler	4	6	5±1
33. *O. limosa* Agardh	6	10	8±2
34. *O. minnestensis* Tilden	6	8	7±1
35. *O. tenuis* Agardh	3	5	4±1
36. *O. princeps* Vaucher	1	3	2±1
37. *Phormidium faveolarum* (Mont.) Gom.	2	4	3±1
38. *P. subfuscum* (Ag.) Kuetz.	2	4	3±1
39. *P. tenue* (Menegh.) Gom.	6	8	7±1
40. *P. uncinatum* (Agardh) Gomont	8	12	10±2
Family: Nostocaceae			
41. *Anabaina aequalis* Borge	1	3	2±1
42. *A. inaequalis* (Kuetz.) Born. et Flah.	6	8	7±1
43. *A. variabilis* Kuetz.	7	9	8±1
44. *Nostoc commune* Vaucher	3	5	4±1
45. *N. muscorum* Ag.	1	3	2±1
Family: Rivulariaceae			
46. *Calothrix parietana* (Naeg.) Thuret	1	3	2±1
47. *Rivularia natans* (Hedw.) Welw.	1	1	1±00
Kingdom: PROTISTA			
Phylum: Volvocophyta			
Class: Volvocophyceae			
Order: Chlorococcales			
Family: Oocystaceae			
1. *Ankistrodesmus falcatus* var. *stipitatus* (Chod.) Lemm.			
2. *Kircheneriella lunaris* (Kirch.) Moebius	2	4	3±1
3. *K. subsolitoria* West	1	3	2±1
4. *Nephrocytium agardhianum* Naegeli	2	6	4±2
5. *Oocystis borgei* Snow	8	12	10±2
6. *O. crassa* Wittrock	1	3	2±1
7. *O. parva* West & West	3	5	4±1
8. *Tetraedron asymmetricum* Prescott	4	6	5±1
9. *Trochiscia hirta* West	2	4	3±1
Family: Chlorococcaceae			
10. *Chlorococcum humicola* (Naeg.) Rab.	10	14	12±2
Family: Coelastraceae			
11. *Coelastrum cambricum* Archer	2	2	2±0
12. *C. microporum* Naegeli	1	1	1±0
13. *C. sphaericum* Naegeli	1	3	2±1

Table 1. (Cont'd.)

	Range		
	Min.	**Max.**	**Mean±S.D.**
Family: Dictyosphaeriaceae			
14. *Dictyosphaerium ehrenbergianum* Naegeli	3	5	4±1
15. *D. pulchellum* var. *ovatum* Wood	2	4	3±1
Family: Hydrodictyaceae			
16. *Pediastrum boryanum* (Turp.) Men.	1	3	2±1
17. *P. duplex* Meyen	2	4	3±1
18. *P. duplex* var. *clathratum* (A. Braun) Lagerheim	1	3	2±1
19. *P. intergrum* Naegeli	1	1	1±00
20. *P. tetras* (Ehr.) Ralfs.	3	5	4±1
Family: Scenedesmaceae			
21. *Crucigenia tetrapedia* (Kirch.) West & West	2	2	2±0
22. *Scenedesmus arcuatus* Lemm.	1	3	2±1
23. *S. acutiformis* Schroeder	2	4	3±1
24. *S. bijuga* (Turp.) Lager	8	10	9±1
25. *S. quadricauda* (Turp.) de Breb.	3	5	4±1
26. *S. tibiscensis* Uberk.	4	6	5±1
Order: Chlorellales			
Family: Chlorellaceae			
27. *Chlorella pyrenoidosa* Korsa	2	4	3±1
28. *C. ellipsoidea* Gerneck	1	3	2±1
29. *C. vulgaris* Beyerinck	4	6	5±1
Order: Tetrasporales			
Family: Palmellaceae			
30. *Palmella mucosa* Kuetz.	18	22	20±2
Family: Cocomaxaceae			
31. *Elakatothrix viridis* (Snow) Printz	2	4	3±1
32. *E. gelatinosa* Wille	1	3	2±1
Family: Tetrasporaceae			
33. *Tetrospora lubrica* (Roth.) Agardh	16	20	18±2
34. *T. lacustris* Lemm.	8	12	10±2
Order: Volvocales			
Family: Chlamydomonadaceae			
35. *Chlamydomonas pseudopertyi* Pascher	6	8	7±1
Family: Volvocaceae			
36. *Eudorina elegans* Ehr.	1	3	2±1
37. *Gonium quadratum* Pringsheim	2	2	2±0
38. *Pandorina morum* Prins.	1	3	2±1
39. *Pleodorina illinoisensis* Kofoid	2	2	2±0
Class: Desmidiophyceae			

Table 1. (Cont'd.)

	Range		
	Min.	**Max.**	**Mean±S.D.**
Order: Desmidiales			
Family: Desmidiaceae			
40. *Closterium dianae* Ehr.	2	4	3±1
41. *Cl. moniliferum* (Bory) Ehr.	1	1	1±00
42. *Cl. ehrenbergii* Menegh	2	2	2±0
43. *Cl. Pusillum* var. *minus* Allorge	1	3	2±1
44. *Cosmarium constrictun* Delponte	6	8	7±1
45. *C. baergesenii* Gronbl.	2	2	2±0
46. *C. circulare* Reinsch	3	5	4±1
47. *C. punctulatum* Breb.	4	6	5±1
48. *C. tetrachondrum* Lundell.	2	4	3±1
49. *C. subtumidum* var. *rotundum* Hirano	6	8	7±1
50. *C. supergranatum* f. *minor*	3	5	4±1
51. *C. undulatum* Corda	2	2	2±0
52. *Penium simplex* N. sp.	8	12	10±2
53. *Pleurotaenium ehrenbergii* Breb.	4	6	5±1
Kingdom: PROTOCTISTA			
Phylum: Chlorophyta			
Class: Siphonocladophyceae			
Order: Cladophorales			
Family: Cladophoraceae			
54. *Cladophora glomerata* (L.) Kuetz.	3	5	4±1
Class: Ulvophyceae			
Order: Ulotrichales			
Family: Ulotrichaceae			
55. *Koliella Helvetica* (Kol.) Hindok	1	3	2±1
56. *Ulothrix aequalis* Kuetz.	2	4	3±1
Class: Zygnemophyceae			
Order: Oedogoniales			
Family: Oedogoniaceae			
57. *Oedogonium olevaceum* Ehr.	4	6	5±1
58. *O. angustissimum* West & West	2	4	3±1
Order: Zygnemales			
Family: Zygnemaceae			
59. *Spirogyra aequinoctialis* West	6	10	8±2
60. *S. crossa* Kuetz.	8	12	10±2
Phylum: Bacillariophyta			
Class: Bacillariophyceae			
Order: Biddulphiales			

Table 1. (Cont'd.)

	Range		
	Min.	Max.	Mean±S.D.
Family: Coscinodiscaceae			
1. *Cyclotella glomerata* Hustedt	1	3	2±1
2. *C. planctonica* Hustedt	2	4	3±1
3. *Melosira granulata* (Ehr.) Ralfs	3	5	4±1
Order: Bacillariales			
Family: Achnanthaceae			
4. *Achnanthes inflata* Kuetz.	8	10	9±1
5. *Cocconeis placentula* Ehr.	2	2	2±00
Family: Epithemiaceae			
6. *Epithemia argus* Kuetz.	5	7	6±1
7. *E. zebra* (Ehr.) Kuetz.	3	5	4±1
Family: Eunotiaceae			
8. *Eunotia pectinalis* (Kuetz.) Rab.	2	2	2±0
Family: Cymbellaceae			
9. *Amphora delicatissima* Krab.	10	12	11±1
10. *A. ovalis* Kuetz.	10	14	12±2
11. *A. ovalis* var. *gracilis* Meister	8	12	10±2
12. *Cymbella leptoceros* (Ehr.) Grunow	6	8	7±1
13. *C. tumida* (Gregory) Cleve	1	3	2±1
14. *C. turgida* (Gregory) Cleve	3	5	4±1
Family: Gomphonemaceae			
15. *Gomphonema augur* Ehr.	4	6	5±1
16. *G. abbreviatum* Agardh	3	5	4±1
17. *G. olivaceum* var. *calcarea* Cleve	6	8	7±1
18. *G. ghosea* n.l.	8	12	10±2
19. *G. affine* var. *insigne*	5	9	7±2
Family: Naviculaceae			
20. *Gyrosigma scalproides* (Rabh.) Cl.	2	4	3±1
21. *G. kuetzingii* (Grunow) Cleve	2	2	2±0
22. *Navicula radiosa* var. *tenella* Grun.	4	6	5±1
23. *Neidium dubium* (Ehr.) Pfitzer.	1	1	1±0
24. *Pinnularia debesi* Schale	2	2	2±0
25. *P. gibbai* (van Heur.) Bayer	6	8	7±1
26. *Rhopaldia gibba* (Kuetz.) Mueller	7	9	8±1
Family: Fragilariaceae			
27. *Diatoma elongatum* (Lyngb.) Ag.	6	8	7±1
28. *D. heimale* (Roth) Heib.	4	6	5±1
29. *D. vulgare* Bory	8	12	10±2
30. *Synedra accus* Kuetz.	1	3	2±1

Table 1. (Cont'd.)

	Range		
	Min.	**Max.**	**Mean±S.D.**
31. *S. affinis* (Kuetz.) Pascher	2	4	3±1
32. *S. minuscula* Grun.	6	8	7±1
33. *S. ulna* (Nitzsch) Ehr.	8	12	10±2
34. *S. ulna* var. *aequalis* (Kuetz.) Hust.	6	10	8±2
35. *S. ulna* var. *oxyrhynchus* Hust.	7	11	9±2
36. *S. ulna* var. *danica* (Kuetz.) Grunow	4	6	5±1
Family: Nitzschiaceae			
37. *Nitzschia filiformis* (Smith) Hust.	2	2	2±00
38. *N. ignorata* Krabke	1	1	1±0
Family: Surirelliaceae			
39. *Surirella elegans* Ehr.	1	1	1±0
Phylum: Chrysophyta			
Class: Chrysophyceae			
Order: Ochromonadales			
Family: Chrsocapsaceae			
1. *Chrysocapsa planctonica* (West & West) Pas.	2	2	2±0
Family: Dinobryaceae			
2. *Dinobryon sociale* Ehr.	1	1	1±00
Phylum: Xanthophyta			
Class: Xanthophyceae			
Order: Mischococcales			
Family: Chlorobotrydaceae			
1. *Botryococcus brunii* Kuetz.	4	6	5±1
2. *Chlorobotrys regularis* (W. & W.) Bahlin	1	3	2±1
3. *Perone dimorha* Pascher	1	1	1±0
Phylum: Vaucheriophyta			
Class: Vaucheriophyceae			
Order: Vaucheriales			
Family: Vaucheriaceae			
1. *Vaucheria sessilis* (Vauch.) DeCandolle	2	2	2±0
Phylum: Euglenophyta			
Class: Euglenophyceae			
Order: Euglenales			
Family: Euglenaceae			
1. *Euglena cyclopicola* Geik.	2	2	2±00
2. *E. desus* Ehr.	1	3	2±1
3. *E. elongata* Schewiakoff	2	4	3±1
4. *E. intermedia* (Klebs) Schmitz.	1	3	2±1
5. *E. mutabilis* Schmitz	3	5	4±1

Table 1. (Cont'd.)

	Range		
	Min.	Max.	Mean±S.D.
6. *E. proxima* Dangeard	6	8	7±1
7. *E. viridis* Kuetz.	8	10	9±1
8. *E. pascheri* Swirenko	1	1	1±00
9. *Phacus caudatus* (Hulb.)	1	1	1±00
10. *P. caudatus* var. *ovalis*	1	3	2±1
11. *P. orbicularis* Huebner	2	2	2±00
12. *P. suecicus* Lemm.	1	1	1±00
13. *Trachelomonas volvocina* Ehr.	2	2	2±00
Phylum: Charophyta			
Class: Charophyceae			
Order: Charales			
Family: Characeae			
1. *Chara fibrosa* Ag.	1	3	2±1
2. *C. vulgare* L.	2	6	4±2
Phylum: Rhodophyta			
Class: Nemaliophyceae			
Order: Batrachospermales			
Family: Batrachospermaceae			
1. *Batrachospermum moniliforme* Roth	10	14	12±2
Family: Audouinellaceae			
2. *Audouinella chalybea* Bory	3	5	4±1
3. *A. ermanii* (Roth) Duby.	4	6	5±1
Order: Compsopogonales			
Family: Compsopogonaceae			
4. *Compsopogon coeruleus* (Babis) Mont.	2	12	10±2
Class: Bangiophyceae			
Order: Porphyridiales			
Family: Cyanidiaceae			
5. *Cyanidium caldarium* (Tilden) Geitler	2	2	2±0

Dissolved oxygen (8.2-9.4 mg/L) was in sufficient quantity of D.O. for production of aquatic life like fish, fauna etc. but this high concentration of D.O. was due to low temperature and slowly running water. Carbon dioxide CO_2 (80-100 ppm) was in sufficient quantity for the growth of phytoplankton/algal species as increase in CO_2 causes increased algal species. Blue green algae were found in colonies like *Nostoc*, *Anabaina*, *Oscillatoria*, *Phormidium* etc. and green algae making mats like *Cladophora*, *Spirogyra*, *Chara* etc. as well as layer of *Cosmarium*. Higher value of CO_2 shows availability of carbonaceous rocks. High nitrate (0.3-2.3 μg/L) value in summer season increased chlorophyll-a distribution and alternate high value in cold/winter season low chlorophyll-a were observed which means that both nitrate and temperature play significant role in chlorophyll distribution. Phosphate (0.1-0.9 μg/L) plays significant role to control the algal growth. Total hardness (1200-1500 ppm) concentration shows that sufficient quantity of blue green algae was available in this water. Increase in Calcium hardness (900-1100 ppm) increases the production of green algae. Increase in the concentration of magnesium hardness (300-400 ppm) results in the production of colonies of Cyanophyta. Higher wave (4-10 inch) reading was due to fast flow of water.

Table 2. Physico-chemical properties of Wah Garden, District Attock.

S. No.	Parameters	Unit	Range		Mean±S.D.	
			Min.	Max.	Min.	Max.
1.	Soil temperature	°C	11-13	24-26	12 ± 1	25 ± 1
2.	Air temperature	°C	13-15	36-38	14 ± 1	37 ± 1
3.	Water surface temperature	°C	17-19	24-26	18 ± 1	25 ± 1
4.	Water bottom temperature	°C	17-19	24-26	18 ± 1	25 ± 1
5.	pH		7.8-8	8.3-8.5	7.9 ± 0.1	8.4 ± 0.1
6.	Turbidity	NTU	0.8-0.8	1.5-1.5	0.8 ± 0.0	1.5 ± 0.0
7.	T.D.S.	ppm	200-200	300-300	200 ± 0.0	300 ± 0.0
8.	T.S.S.	mg/L	0.5-0.7	2-4	0.6 ± 0.1	3 ± 1
9.	Conductivity	ohmsX^{10}	40-44	60-62	42 ± 2	61 ± 1
10.	Salinity	ppt	0.5-0.9	1-3	0.7 ± 0.2	2 ± 1
11.	Humidity	%	46-50	66-68	48 ± 2	67 ± 1
12.	Light transparency	feet	1-1	3-5	1 ± 0.0	4 ± 1
13.	Dissolved oxygen	mg/L	8.2-8.4	9.2-9.4	8.3 ± 0.1	9.3 ± 0.1
14.	Saturation	%	65.3-67.5	71.5-74.5	66.4 ± 1.1	73 ± 1.5
15.	CO_2	ppm	80-84	90-100	82 ± 2	95 ± 5
16.	Ammonia Nitrogen	ppm	0.01-0.03	0.04-0.06	0.02 ± 0.01	0.05 ± 0.01
17.	Density	g/v	1.004-1.006	1.005-1.009	1.005 ± 0.001	1.007 ± 0.002
18.	Nitrate	μg/L	0.3-0.5	2.1-2.3	0.4 ± 0.1	2.2 ± 0.1
19.	Phosphate	μg/L	0.1-0.3	0.7-0.9	0.2 ± 0.1	0.8 ± 0.1
20.	Orthophosphate	μg/L	0.08-0.1	0.2-0.4	0.09 ± 0.01	0.3 ± 0.1
21.	Total Hardness	ppm	1200-1200	1500-1500	1200 ± 0.0	1500 ± 0.0
22.	Ca^{++} Hardness	ppm	900-900	1100-1100	900 ± 0.0	1100 ± 0.0
23.	Mg Hardness	ppm	300-300	400-400	300 ± 0.0	400 ± 0.0
24.	$CaCl_2$ Hardness	ppm	999-999	1221-1221	999 ± 0.0	1221 ± 0.0
25.	$Mg Cl_2$	ppm	285-285	380-380	285 ± 0.0	380 ± 0.0
26.	Grain Per Gallon	Gpg	52.2-52.2	87-87	52.2 ± 0.0	87 ± 0.0
27.	Refractiv index		1.334-1.334	1.334-1.334	1.334 ± 0.0	1.334 ± 0.0
28.	Wave	CM	4-6	6-10	5 ± 1	8 ± 2
29.	Taste		Tasteless			
30.	Water colour		Grey		Green	
31.	Odour		Vegetation smell		Odourless	
32.	Day		Cloudy		Clear	
33.	Weather		Fogy		Dry Clear	
34.	Water		Slow running			
35.	Soil		Muddy		Rocky	
36.	Zone		Subtropical			

Taste, odour, and colour of the water of Wah Garden showed that it was tasteless and odourless, but sometimes it gave vegetation smell due to thick aquatic vegetation and reduced water level in winter and in spring season. Colour in winter season was gray but in summer and in monsoon season it was colourless, mixed with sand, mud, etc. The water is rich in algal species due to which fish species like *Oriochromis mosambicus, Catla catla* Ham. (local name: Thaila or Thaili), *Tortor* (local name: Mahasheer), *Lobeo gonius* (local name: Cirreah), *L. dyocheilus, L. rohita* Ham. (local name: Rahu or Dumbro) etc. were commonly found.

The species of blue green algae were dominant in summer and in monsoon season while those of green algae in winter season. The species of Bacillariophyta were dominant in autumn and in spring season, the species of Charophyta were common throughout the year while those of Euglenophyta in mid of winter and beginning of spring. The species of Rhodophyta were prevalent by the end of autumn up to the beginning of spring season. This phylum includes 5 species at a time in this locality otherwise it is represented by one species on one side/locality and other species in the other side for example species of *Batrachospermium* are available here and even collected from Kuzakhella on 23.10.1998 near Mangora side. During spring *i.e.* in the months of October and November only this genus is represented. Second genus *Comsopogon* occurs here in the month of March in Katass mixed with aquatic vegetation like *Potomogeton pectinalis, P. crispus, Hydrilla vallisnaria, Cyprus, Phragmites, Typha latifolia* etc.

Particular attention was not given to any factor which seemed to deviate from normal immediately preceding an algal/plankton rise. In the examination and interpretation of these fluctuations the very important factor, rainfall must also be considered. This affects the physico-chemical results and the algal count by dilution, and may affect plankton multiplication by substituting soft water for hard water, as is usually found in their natural environment. It was noted that when a large amount of rainfall occurred, the algal count made a sharp decline which was a simple dilution factor. During the summer and fall when small amount of rainfall occurred there was a marked increase in the algal count which was probably due to flushing of heavily populated algal pools in the stream and on the watershed in order to determine the amount of flushing that occurred each year.

Conclusion

1. The algal/plankton peaks were fairly constant from year to year in their periodicity and were usually the major peaks of the season. The green algae reached their maxima during winter season.
2. The high algal/plankton peaks were accompanied by an increase in dissolved oxygen and pH.
3. The pH seemed to be governed by the amount of free carbon dioxide *i.e.* the greater the carbon dioxide content of the water the lower the pH.
4. The nitrite and nitrate contents of the water decreased algal/plankton pulses represented by a mixed flora, thus indicating their significance for multiplication of most algal organisms.
5. The heaviest algal/plankton population was always down streams from the point of sewage pollution and the location of the algae/plankton peak seemed to be governed by the rate of water flow.

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