

BIOASSAY STUDIES OF *Chlorella vulgaris* IN RELATION TO VANI VIHAR LAKE

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Abstract

The finding based on water quality and nutrient status of Vani Vihar Lake, a shallow artificial water body in Bhubaneswar, India. Mainly focuses on the physico-chemical parameters of water and sediment as well as the algal bioassay method to assess the lake's water quality. The study was conducted over a period of four months (March to June 2024) and aimed to identify the sources of pollution, monitor water and sediment quality, carry out biological assessment using phytoplankton, and study the impact of various reaches of the lake on water quality. The lake is found to be in a progressively eutrophicated state, with higher values of pH, conductivity, chloride, calcium, phosphate, and nitrate-nitrogen in the outlet water and sediment compared to the inlet. The algal bioassay using *Chlorella vulgaris* showed that the lake water does not contain any toxic chemicals affecting the growth of the algae. The growth of *Chlorella vulgaris* was highest in raw lake water and reduced with maximum dilution of the medium. The nutrient status of the lake is influenced by various sources, including domestic sewage, agricultural runoff, and washing, bathing, and recreation activities. The presence of high nutrient concentrations, particularly phosphorus and nitrogen, contributes to the lake's eutrophication. The study highlights the importance of preserving fresh water bodies as natural nutrient traps and nutrient sinks, as they play a crucial role in removing nitrogen and phosphorus from polluted waters. The findings of this study provide valuable insights into the water quality and nutrient status of Vani Vihar Lake, which can be used to formulate a proper management plan for the lake. The results emphasize the need for effective pollution control measures and the preservation of fresh water bodies to maintain their ecological balance and support sustainable development.

Keywords: Ecological, Phytoplankton, Bioassay, sewage.

1. Introduction

Water is the most important natural renewable resource on which all of our life activities depend. Principally most of the water on this planet is stored in oceans and ice caps, which is difficult to be recovered for our diverse needs. So, most of our demand is fulfilled only by rainwater, which get deposited in the surface and ground. But strictly speaking it does not exist in pure form for any appreciable length of time in nature. It is easily contaminated as a result of multitude reasons namely urban growth, increased industrialized activities farming and the over use of fertilizers and other chemicals due to agricultural production.

1.1 Genesis of water pollution

Untreated water from urban settlement and industrial activities and run off from agricultural land carrying chemicals are primarily responsible for deterioration of water quality and contamination of lake, rivers and ground water bodies. This is brought about by transformation of natural biological processes as a result of human activity.

The increased nutrients like phosphorus and nitrogen can upgrade water quality when it enters streams, reservoirs and lakes by promoting algal blooms and nuisance aquatic plant growth. Land runoff is an important source of nutrients to surface waters particularly in agricultural regions (Vites, 1971). The same also applies to other chemical elements (Carbon, Sulphur, metals etc.).

In addition to this the composition of chemical fluxes in the environment is under constant reflecting the increased input from human activity.

1.2 Deterioration of water quality

Fresh water and ground water pollution is a growing concern in many areas, further limiting access of safe water. Poor water quality leads not only to water related diseases but also reduces agricultural production, which means that more foodstuffs and agricultural products must be imported. Poor water quality also limits economic development options, such as water-intensive industries and tourism, a situation that is potentially disastrous in developing countries.

To encounter this problem many countries have established to enforce effluent water standards and rehabilitated water treatment facilities. Besides these, other responses include purification and decontamination of fresh water systems and public awareness campaigns. Although only recently implemented, these responses have been locally successful in improving access to drinking water and raising awareness (Adedipe et al., 2000).

1.3 Natural fresh water systems as nutrient traps

Fresh water bodies playing the role of integrating different processes going on in the water shades are more susceptible to chemical changes when compared with many other natural systems. As a result, we face increasing water pollution, growing salinity of water and such specific but spread processes like eutrophication and acidification.

In recent years many authors have suggested that fresh water bodies are excellent nutrient traps and are as a result valuable because they are acting as natural treatment plants removing nitrogen and phosphorus from polluted waters passing through them (Wharton, 1970). If fresh water bodies are indeed significantly nutrient traps then every effort should be made to preserve them in order to lessen the degradation of receiving bodies of water caused by urban and agricultural runoff.

1.4 Interaction or nutrient turnover between water and sediment

Pollutants discharged into the aquatic system are mostly adsorbed on the suspended particles, which finally accumulate in the sediments. The distribution of these pollutants between the sediment and water provides important information about type and nature of water sediment interactions. This is considered as important in studying the biogeochemical cycling of the pollutants.

The pollution transports in fresh water systems are often controlled by sediment water interaction (Barbanti *et al.*, 1992). Therefore, collection and analysis of water and sediment as an important aspect in

many environmental monitoring programmes for identification of contaminants. (Bufflap and Allen, 1995).

Sedimentation of particles in a fresh water system result in the over-lying water being trapped and deposited in the sediment. The sediments thus serve as a valuable sink for a large number of pollutants (Sigg et al., 1987). Depending on the physiochemical environment the contaminants trapped in the sediment can reach out to the overlying water and therefore, such processes have to be taken into account in water management planning and in various sediment clean-up programs (song and Muller, 1999). The pollutants in sediment and in overlying water not only affect aquatic life but also human being living near it.

1.5 Use of micro algae in water quality assessment

Use of micro algae is particularly attractive, because of their photosynthetic resulting in the conversion of solar and energy into useful biomass immobilizing nitrogen and phosphorus that are responsible for eutrophication.

Sewage water is considered as the main pollutant of water and it is necessary to evaluate and reduce their biological toxicity before they are disposed of.

Assessment of any biological problem such as water pollution requires selection of suitable system that may be used both at the field and laboratory level to elucidate the interplay of numerous interlocking complex factors. Indigenous aquatic communities including algae often becomes subjected to the catastrophic consequences of domestic sewage, agricultural runoff, heavy metals, radio nuclides etc., requires more time and cost effective which tempered physiologists to use algae in studying various aspects of the water pollution problems.

Several attempts have been made to understand the relationship between nutrients loading rate and phytoplankton standing crop under natural conditions (Schindeler, 1975; Aizaki *et al.*, 1986) Hedge and Bharati (1984) have recorded good growth of certain algae in lake water under eutrophication. Various workers like Trivedy (1986), Dash (1992) and Verma and Mohanty (1994) have used algae either for assessing the degree of pollution for eutrophication study of different water bodies.

A great deal of work has been done on using algae as bioindicator of pollution (Mohanty, 1983; Reddy and Venkateswarulu, 1986; Tripathy, 1989). However, in recent years the algal bioassay has gained importance as a reliable and quick method for determining the level of pollution of a water body (Nylom and Lynby, 1988; Mohapatra and Mohanty, 1992). Prior to use in bioassay technique, animals like fish and invertebrates (*Daphnia*) were used for water quality studies (Hall *et al.*, 1978). However, the use of algae for example *Chlorella vulgaris* and *Scenedesmus bijuga* (Tiwary, 1983), *Selenastrum capricornutum* (Miller *et al.*, 1978) and the Cyanobacterium *Nostoc punctiforme* (Hosetti and Patil, 1986) to remove nutrients from water bodies and in toxicity testing prove to be advantageous.

This method is very useful for assessing the nutrient status of water bodies to distinguish between available and non-available forms of nutrients and to detect the trends of certain micronutrients such as vitamins, other essential micronutrients, etc. (Jeeji Bai and Sasi, 1983).

The selection of test organism (algae) in bioassay study is never universal and according to workers like Payne (1975), Jeeji Bai and Sasi (1993) and Mohapatra (1991) prefer some indigenous phytoplankton of different groups for the same while Schanz *et al.*, (1979), on the other hand advocate the use of algae belonging to the same class.

The nutrient status of algae is governed by ions like nitrates and phosphates. It is a fact that nitrate and phosphorus help extensive growth of phytoplankton. These inorganic nutrients form the basis for the entire food chain through their conversion into inorganic growth factors by microorganisms. So the main objectives of physio-chemical analysis of water are to determine the nutrients status of the medium, which is intimately linked with the occurrence, growth, and development of algae.

1.6 Ecology of Lakes

Lakes are important fresh water ecosystem influencing not only species distribution and biodiversity in general but also human settlements and activities. They provide natural flood control, carbon storage and natural water purification (WRI, 2000).

Human activities including agricultural and settlements have caused serious damage to fresh water ecosystems and contribute to the 50% of the world's freshwater ecosystems during the 20th century (Finlayson et al., 1999). This damage to ecosystems reduces water quality and quantity leading to a reduction in the effective available of water for human use.

There is now a growing emphasis on increasing water use efficiency and increased productivity with the limited resources available (Postel, 1997; Postel, 1999; Gleick, 1998). Throughout the world there are great opportunities to meet human needs with less water by:

Using existing technology,

Changing irrigation technology;

Finding and stopping waterfall lakes;

Changing water use practices (such as irrigating during the day, using potable water for landscape irrigation) and Changing human activities (Shifting to more efficient crops, changing industrial processes away from water bodies).

In recent years, studies on the ecology of lakes (either artificial or natural) gained some importance on account of their uses in potable water supplies, agricultural and industries. In India a number of workers have contributed to this discipline but most of them focused on the physico-chemical aspects and quite a few have discussed both chemical and biological characteristics. In Orissa intensive studies have been carried out by Mohanty (1981), Muni and Mohanty (1985), Muni *et al.*, (1985), Dash (1992), Parida (2000), Verma and Mohanty (1998), Pashi and Mohanty (1996), Mohapatra and Mohanty (1992), Mohapatra *et al.*, (1999), Mohapatra *et al.*, (2000), Swain and Adhikary (1990), Swain et al., (1994) the ecology of fresh water algae giving special significance to species composition in assessing the quality of water and simultaneously during their study.

The present study deals with the nutrient status of Vani Vihar Lake which is a shallow artificial water body in Bhubaneswar. It has high nutrient concentrations coming from various sources including a city draining point and other process of washing, bathing and recreation. An account of the ecology of this shallow artificial lake is available (Mohanty, 1981; Chatterjee, 1985; Muni and Mohanty, 1985, Muni *et al.*, 1985). However, it was felt that the information collected more than a decade ago is insufficient in the light of several development activities undertaken in the lake. In view of the above and in order to formulate a proper management plan, it was felt essential to collect latest information on the water and sediment quality.

1.7 Objectives

The Objectives of the study are,

1. To study the source of pollution,
2. To monitor water and sediment quality through analysis of physical and chemical parameters,
3. To carry out biological assessment by the use of phytoplankton.
4. To study the impact of various reaches of the lake on the quality of water.

2. Material Methods

Water Analysis-

pH by pH meter, Conductivity by Conductivity meter, Chloride by triteric method, Hardness by EDTA titrimetric method, Nitrate- Nitrogen and Phosphorus analysis by

Sediment analysis-

Ph by pH meter, Conductivity by Conductivity meter, Organic carbon by colorimetric method, nitrate-nitrogen by Phenol disulphuric acid method (Jackson 1958), Available Phosphorus by Olsen's method (Olsen *et al.*, 1954).

Culture Analysis-

The test organism-

The green algae *Chlorella* was selected for this experiment.

The culture medium

To grow the test algae in laboratory conditions, Chu No. 10* medium (modified by Safferman and Morris, 1964) with A⁶ trace elements (Gerloff *et al.*, 1950) was used as the culture medium Stock solutions for each of the chemicals were prepared.

The measurement of growth

The growth of the organisms was measured directly by optical density (O.D) of the homogenized cultures. Since *Chlorella vulgaris* formed homogenous suspensions in the culture medium, the growth rates were measured directly by a spekol spectro photometer (Carl Zeis, Zena) at 678nm wavelength against culture medium taking as blank.

Measurement of Chlorophyll-a and b was done by spectrophotometer.

Measurement of carotenoid was done by spectrophotometry method at 460nm.

Measurement of protein was done by Lowery method.

STATISTICAL ANALYSIS

Data collection was made from the inlet, outlet of Sapua river at Hindol. The comparison of the physiochemical parameters of water and sediment was done by t t-test, and their significance level was also tested. The relationship between different physio-chemical parameters of water and sediment have been computed by linear regression analysis. The value of regression coefficient 'r' and its test of significance have also been included in the text, whenever necessary. For all purpose $p < 0.05$ was considered significant. Standard statistical method Gomez and Gomez (1984) and Mishra and Mishra (1999) were followed.

Description of study site-

Vani Vihar lake is an invaluable wetland habitat of great resources vital for ecological and economic development of the region. It is a shallow fresh water body with water spread over 27000 sq. The depth

of water in the lake is only 1.8-1.16m in most parts of the season but reaches during high floods to 3-4 m. The total catchment area in all the streams is 3400 sq.m. The prominent streams supplying to this lake are Naharthali nali, Guali nali, Kashia nali, Bauli nali, Chandaka nali and Barmunda nali. All these are united before Jaydev Vihar and flow into the lake as single stream that passes through extensive areas of crop fields. The only outlet into the river Kuakhai passes through the nicely developed industrial estate. The lake is natural and a permanent one. The water here may be static or flowing at places. Vani Vihar is an attractive wetland ecosystem located by the sides of National High way No. 5. The lake is of considerable importance as a nursery for biota, habitat for a variety of resident and migratory waterfowl. To the people of Bhubaneswar, it is a resource of great economic, cultural, scientific and recreational value, whose loss will be irreparable. Probably this is the reason why such a pond like water body has long since been locally called as a lake in the hillock city of Bhubaneswar.

3.1 Geomorphology of the Lake Area

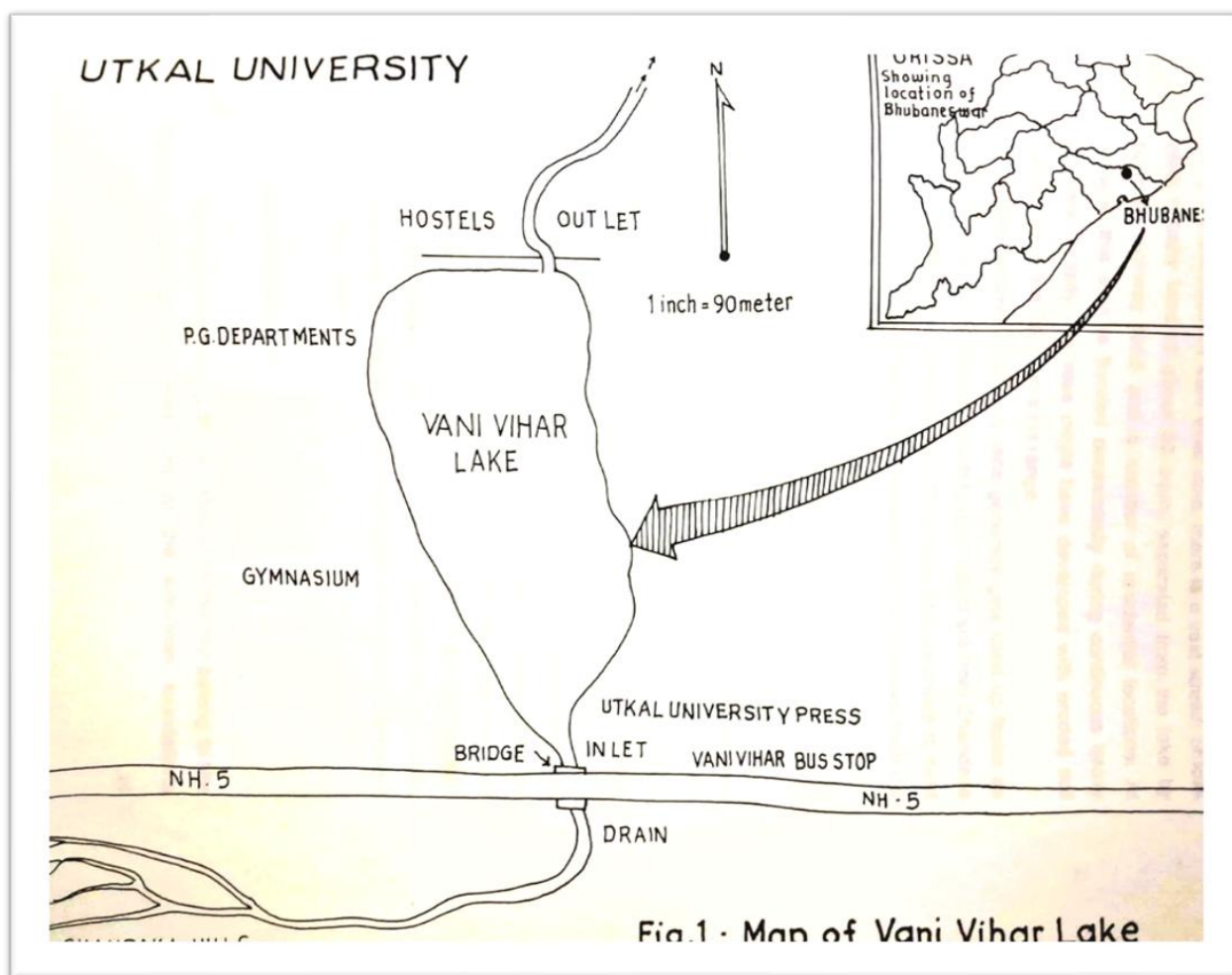
The Vani Vihar Lake (Fig.1) a remarkable depression in this part of the east coast, is essentially a fresh water lake situated at about 65 km inland from the present coastline. It has an area extent of about 27.000sq.m and has a depth of about 2.5 m. at the centre. Evidently the lake has no connection with the sea. To the south of Vani Vihar Lake, there is a vast stretch of lowlying marshy land of about 80 sq. Separated from the lake by National highway NO.5 and a number of residential locations. At present. This area is flooded occasionally during continuous heavy showers. Initially this area might have developed with eroded soil coming down the Chandaka hill range. The patches of marshy land generally get filled up faster as they are fed by small streams which bring in lots of soil from Chandaka hills. Contrary to this condition, the Vani Vihar lake continues to exist through time due, perhaps as a depression situated far away from the hills.

3.2 Hydrochemistry

Vani Vihar Lake is a wet land (fresh water body) lying between the deltas of Kuakhai and Daya rivers, with a water spread of 27,000 sq. m. The mean annual rainfall in the catchment is normally 152.7 mm. The depth of water in the lake is only about 2m. all over the year excepting in rainy season reaching a depth of 3.5 m. in high floods. The normal flood discharge into the lake is estimated at 8,000 cusecs, with a value of 390 for upland catchment and that of 86 for deltaic catchment as per record in the office of chief engineer (irrigation) Gov. of Orissa. The only outlet of the lake passes through the Mancheswar industrial estate into Kuakhai River. It is seen from the records that the maximum water level in the lake exceeded 5 in 16 out of 45 years.

3.3 Geochemistry

The rock making up the foundation of the city belongs to the Eastern Ghats group, which are of the archaean foundations comprising khondolites, charnockites and garnetiferous granite Gondwana, laterite and recent aluminium.



4. Results

In the lentic system such as lakes, the normal physico-chemical and biological make-up is influenced by nutrient enrichment viz. exposure to pollutants of various kinds. In addition, variations also occur depending upon the nature of the land, substratum, volume of water, flow condition, topography etc.

In the present investigation the results of the physico-chemical analysis of water and sediment of Vani Vihar Lake was shown in Table 1 & 2 and the algal bioassay method for the study of water quality was shown. The physico-chemical study was carried out for four months i.e. from March to June and presented in Table 1 & 2. The monthly means with standard deviation were taken into account in regard to each parameter. Bioassay study of water quality was undertaken by the alga *Chlorella vulgaris* (mass), which were grown for 4 days in different combinations of untreated lake water and grown for 4 days in different combinations of untreated lake water and growth medium with distilled water. The results obtained were measured in terms of growth (O. D. at 678nm) of the cultures.

The results were discussed in three different parts as

Water parameters,

Sediment parameters,

And bioassay parameters.

4.1 Water parameters

4.1.1 Hydrogen ion concentration (pH)

It is defined the negative logarithm of hydrogen ion concentration and is used to express the intensity of acidic or alkaline condition of a solution. It is an important factor in water analysis since it enters into the calculation of acidity, alkalinity and processes like coagulation, disinfections and corrosion control. From Table-1, it was revealed that pH of the inlet and outlet water of Vani Vihar Lake remained alkaline throughout the period of study.

The lowest and highest pH values of inlet water were 7.2 ± 0.081 (March and April) and 7.7 ± 0.08 (June) where as for the out let water the corresponding values were 7.1 ± 0.062 (April) and 8.4 ± 0.03 (May), respectively.

The average pH of inlet and outlet water was 7.4 ± 0.021 and 7.575 ± 0.496 , respectively.

4.1.2 Conductivity

The conductivity values of inlet and outlet water varied monthly. The lowest and highest conductivity values of inlet water were $145.00 \pm 9.31 \mu\text{S}$ (March) and $263.8 \pm 9.02 \mu\text{S}$ (June), whereas for the outlet water the simultaneous data were $195.80 \pm 6.03 \mu\text{S}$ (May) and $293.0 \pm 7.18 \mu\text{S}$ (June) Table-1.

The average of inlet and outlet water conductivity values were $212.675 \pm 7.02 \mu\text{S}$ and $236.355 \pm 8.14 \mu\text{S}$, respectively.

The inlet lake water was found to have comparatively less conductivity than out let water.

4.1.3 Chloride

The salts dissolved in water give saline property to that water. It has influence on the alkalinity and conductivity of the water body.

In the present investigation the mean chloride content of inlet water of Vani Vihar Lake was $34.91 \pm 3.33 \text{ mg/l}$ which was slightly higher than outlet water $31.121 \pm 3.25 \text{ mg/l}$.

The minimum and maximum chloride contents of inlet water were $25.56 \pm 2.42 \text{ mg/l}$ (may) and $43.07 \pm 2.32 \text{ mg/l}$ (June) and $36.92 \pm 3.25 \text{ mg/l}$ (March, May), respectively (Table-1)

Table-1: Average monthly data of chemical parameters (water) of Vani Vihar lake

Sl. No.	Parameters/ Months	Inlet				Outlet			
		March	April	May	June	March	April	May	June
1	pH	7.2 ± 0.081	7.2 ± 0.081	7.5 ± 0.078	7.7 ± 0.08	7.3 ± 0.032	7.1 ± 0.062	8.4 ± 0.03	7.5 ± 0.058
2	Conductivity(μs)	145± 9.31	195.00 ± 8.62	246.90 ± 8.01	263.8 ± 9.02	226.3 ± 11.01	230.32 ± 8.12	195.80 ± 6.03	293.0 ± 7.18
3	Chloride (mg/l)	42.126 ± 4.2	43.07 ± 4.30	25.56 ± 2.42	28.87 ± 2.8	36.92 ± 3.25	35.02 ± 2.04	36.92 ± 2.82	24.14 ± 2.32
4	Calcium (mg/l)	16.56 ± 0.088	19.77 ± 0.462	18.16 ± 0.468	14.458 ± 0.466	15.494 ± 0.931	21.90 ± 0.462	17.364 ± 1.222	14.42 ± 0.092
5	Phosphate (mg/l)	0.97 ± 0.021	0.690 ± 0.055	1.536 ± 0.184	1.389 ± 0.084	1.168 ± 0.016	0.763 ± 0.084	1.747 ± 0.016	1.011 ± 0.079
6	Nitrate-nitrogen (mg/l)	1.283 ± 0.052	0.678 ± 0.058	0.367 ± 0.504	0.111 ± 0.010	1.175 ± 0.05	0.168 ± 0.055	0.858 ± 0.069	0.583 ± 0.059

4.1.4 Calcium

The dissolved calcium content is directly proportional to the hardness of water in terms of CaCO₃. The calcium content of inlet water was comparatively less than outlet water.

The maximum and minimum values of dissolved calcium content of inlet water were 19.77 ± 0.462 mg/l (A 0.092 mg/l (April) and 14.458 ± 0.466 mg/l (June) respectively while in case of outlet water the corresponding values were 21.90 ± 0.462 mg/l (April) and 14.42 ± 0.092 mg/l (June), respectively (Table-1) The mean values of calcium content of inlet and outlet water were 17.238 ± 0.092 mg/l and 17.297 ± 0.094 mg/l.

4.1.5 Phosphate

Phosphate is found in water in form of traced oxidized form like H₂PO₄⁻, HPO₄⁻³ etc. Phosphorus is released to the water body through anthropogenic activities like sewage, fertilizer, detergents etc. When the values are exceeding from a standard value then eutrophication arises, which in turn is a major concern for the determination of phosphate in water bodies. In the present investigation it was found that the phosphate content of outlet water of Vani Vihar was higher to inlet water.

The highest and lowest values of phosphate content in inlet water 1.536 ± 0.184 mg/l (May) and 0.690 ± 0.055 mg/l (April) respectively where as for the outlet water the corresponding values were 1.747 ± 0.016 mg/l (May) and 0.763 ± 0.084 mg/l (April), respectively (Table-1).

The mean values of Phosphate of inlet and outlet water were 1.063 ± 0.0335 mg/l and 1.292 ± 0.0357 mg/l.

4.1.6 Nitrate Nitrogen

Nitrate are the end product of organic matter and indicate that organic matter present in water is fully oxidized. It occurs in surface water by leaching from cesspools, waters from chemical fertilizer and agricultural pesticide run off during rainy season. When the values of nitrates exceed much more than standard value then eutrophication arises which in turn is a major concern for the determination of nitrate nitrogen in the water bodies.

In the present investigation it was found that the nitrate- nitrogen in the water bodies.

The maximum and minimum values of nitrate- nitrogen of inlet water were 1.283 ± 0.052 mg/l (March) and 0.0367 ± 0.504 mg/l (May) respectively while for the outlet water the corresponding values were 1.175 ± 0.05 mg/l (March) and 0.168 ± 0.055 mg/l respectively. (Table-1).

4.2 PHYSICO CHEMICAL PARAMETERS OF SEDIMENT

4.2.1 Hydrogen ion concentration (pH)

Sediment pH values of inlet and outlet varied marginally. Inlet sediment pH was slightly acidic as compared to outlet sediment pH value.

The lowest and highest pH values of inlet sediment were 6.7 ± 0.867 (March) and 7.4 ± 0.923 (April), respectively whereas for the outlet sediment the corresponding values were 6.6 ± 0.632 (March) and 7.6 ± 0.931 (April), respectively. (Table-2).

The mean pH of inlet and outlet sediment were 7.025 ± 0.837 and 7.275 ± 0.913 , respectively.

4.2.2 CONDUCTIVITY

The inlet conductivity was higher to outlet conductivity values. The lowest and highest conductivity content of inlet sediment were 127.76 ± 2.62 μ S (April) and 291.69 ± 9.31 μ S (June), respectively whereas for the outlet sediment conductivity the corresponding values were 102.5 ± 1.36 μ S (May) and 280.7 ± 9.26 μ S (March), respectively. (Table-2).

The average conductivity of inlet and outlet sediment were 207.462 ± 0.634 μ S and 171.537 ± 0.352 μ S, respectively.

4.2.3 ORGANIC CARBON

The variation of organic content in sediment in the inlet and outlet site of Vani Vihar Lake is shown in Table-2.

The inlet organic carbon content of the sediment was higher to outlet values. The maximum organic carbon content of the sediment was higher to outlet values. The maximum and minimum values of organic carbon of inlet sediment were 4.921 ± 0.054 g/kg (June) and 3.102 ± 0.091 g/kg (April), respectively while for outlet sediment the corresponding values were 4.932 ± 0.036 g/kg (June) and 2.682 ± 0.273 g/kg (April), respectively.

The mean organic carbon content of inlet and outlet sediment of lake were 3.967 ± 0.098 g/kg and 3.680 ± 0.082 g/kg, respectively.

Table-2: Average monthly data of chemical parameters (sediment) of Vani Vihar lake.

Inlet						Outlet			
Sl.No.	Parameters/ months	March	April	May	June	March	April	May	June
1	pH	6.7 ±0.867	7.4 ±0.923	6.8 ±0.812	7.2 ±0.901	6.6 ±0.632	7.5 ±0.925	7.4 ±0.923	7.6 ±0.931
2	Conductivity(μs)	238.5 ±8.002	127.76 ±2.62	171.9 ±3.64	291.69 ±9.31	280.7 ±9.26	186.95±4.03	102.5 ±1.36	116 ±2.03
3	Organic Carbon (g/kg)	3.155 ±0.158	3.102 ±0.091	4.690 ±0.111	4.690 ±0.111	2.944 ±0.241	2.682 ±0.273	4.164 ±0.138	4.932 ±0.036
4	Phosphate (mg/kg)	8.4 ±1.2	21.667 ±0.115	2.267 ±0.643	2.267 ±0.643	11.2 ±0.917	29.067 ±0.306	20.1 ±0.819	18.8 ±0.529
5	Nitrate- nitrogen (mg/kg)	1.487 ±0.042	1.563 ±0.025	0.667 ±0.147	0.667 ±0.147	1.243 ±0.059	1.947 ±0.035	0.337 ±0.064	0.453 ±0.191

4.2.4 PHOSPHATE

The data on phosphate content of sediment in the inlet and outlet site of Vani Vihar Lake is shown in table-2. The phosphate content of outlet sediment was comparatively higher than the inlet content.

The maximum and minimum values phosphate of inlet sediment were 21.667 ± 0.015 mg/kg (April) and 1.5 ± 0.1 mg/kg (June), respectively whereas for outlet sediment the simultaneous values were 29.067 ± 0.306 mg/kg (April and 11.2 ± 0.917 mg/kg (March), respectively.

The mean phosphate content of inlet and outlet sediment of lake were 8.458 ± 1.231 (mg/kg) and 19.792 ± 0.613 (mg/kg), respectively.

4.2.5 NITRATE-NITROGEN

The nitrate nitrogen value of outlet sediment was comparatively less than that of inlet sediment.

The maximum and minimum values of nitrate-nitrogen of inlet sediment were 1.563 ± 0.025 mg/kg (April) and 0.067 ± 0.147 mg/kg (May), respectively whereas for outlet sediment the corresponding values were 0.667 ± 0.147 mg/kg (April) and 0.453 ± 0.191 mg/kg (June), respectively.

The mean nitrate- nitrogen content of inlet and outlet sediment of lake were 0.998 ± 0.082 mg/kg and 0.995 ± 0.191 mg/kg, respectively.

The mean nitrate-nitrogen content of inlet and outlet sediment of lake were 0.998 ± 0.082 mg/kg and 0.995 ± 0.071 mg/kg, respectively.

4.3 BIOASSAY STUDIES

For the bioassay study, the required time taken for the observation of different chemical parameter analysis of the algae was four days from the day of incubation. It is observed that the algae grow maximum up to four days.

4.3.1 GROWTH MEASUREMENT OF ALGAE

Chlorella vulgaris showed an increase in growth with increase in the days of incubation. It responds highest growth in raw lake water without any dilution (100%), which was gradually decreased on dilution with distilled water as 1 > 3:1 > 1:1 > 1:3.

The initial culture growth showed minimum growth as 0.029 ± 0.001 O. D, whereas after four days it showed highest growth as 0.180 ± 0.010 O. D. In 3:1, 1:1 and 1:3, combination of lake water and distilled water it showed the minimum and maximum growth values in terms of O. D as 0.030 ± 0.001 , 0.030 ± 0.002 , 0.029 ± 0.003 and 0.142 ± 0.010 , 0.138 ± 0.008 , 0.115 ± 0.005 respectively.

The growth in strength of the medium also showed the respective highest and lowest growth in control (100%) and 1:10 strength of the medium.

The highest growth in controlled medium in four days was 0.183 ± 0.006 O. D and lowest was in initial inoculated day as 0.029 ± 0.001 O. D.

The least growth in 1:10 strength of medium changed to highest value in four days as 0.065 ± 0.009 O. D. while lowest value in initial stage was 0.028 ± 0.003 O. D.,

The respective highest and lowest values of growth depending upon the strength of medium as controlled, 1:2, 1:4, 1:8 and 1:10 in terms of O. D. were 0.183 ± 0.006 , 0.157 ± 0.015 , 0.142 ± 0.003 , 0.072 ± 0.008 , 0.065 ± 0.009 (after four days) and 0.029 ± 0.001 , 0.028 ± 0.002 , 0.030 ± 0.001 , 0.028 ± 0.003 , 0.028 ± 0.003 , respectively.

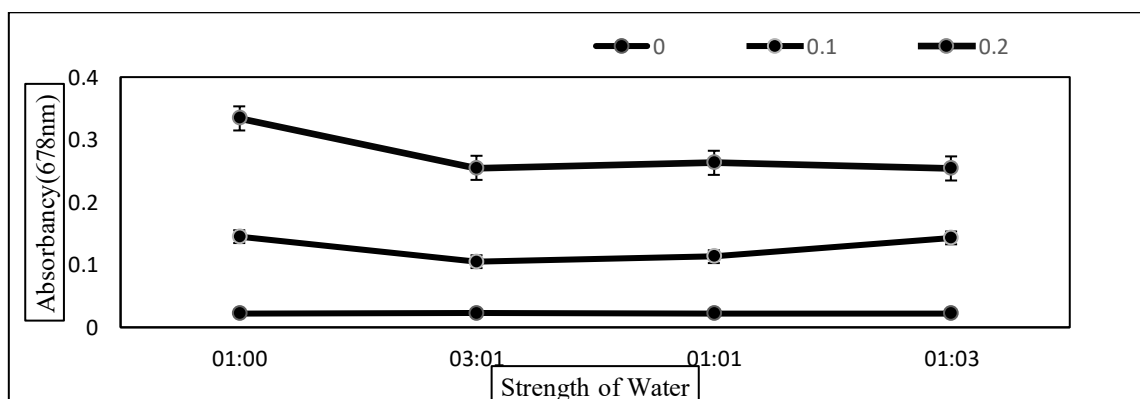


Fig.2: Growth of *Chlorella vulgaris* at different combination of lake water and distilled water.

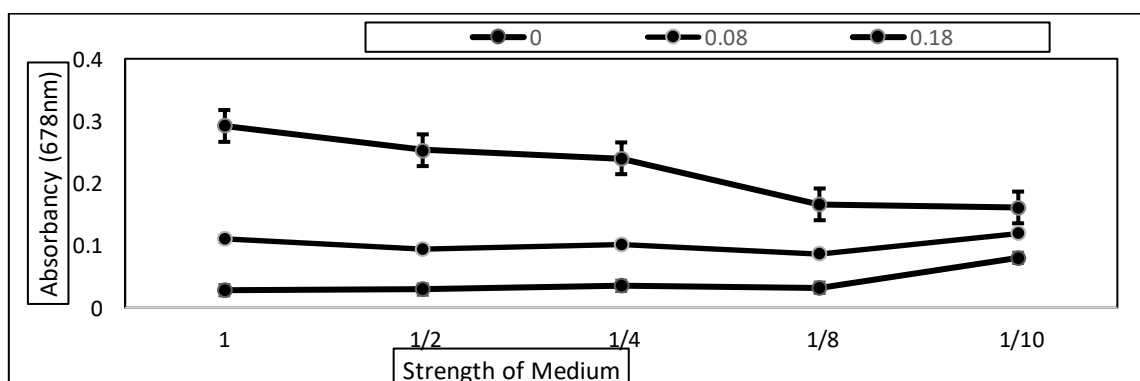


Fig.3: Growth of *Chlorella vulgaris* at different combinations of nutrient medium and distilled water.

4.3 CELL NUMBER

The absorbency of cell growth was the direct effect of increase or decrease in cell number.

The raw lake water and the diluted lake water with distilled water showed a positive increase in cell number with increase of days from initial to four days.

As dilution factor showed a negative correlation with increase number of cells.

The constant cell number 1×10^6 cells/ml in each strength of lake water i.e. control, 3:1, 1:1 and 1:3 showed the highest number of cells in four days as 6.448×10^6 cells/ml in each strength of lake water i.e. control, 3:1, 1:1, and 1:3 showed the highest number of cells in four days as 6.448×10^6 cells/ml, 4.893×10^6 , 5.126×10^6 cells/ml, 4.095×10^6 cells/ml, respectively.

The similar tendency was shown in strength of medium also. As the strength of medium was decreased, the number of cells was also decreased simultaneously, but it was increased with increase of days of incubation.

The highest number of cells with respect to the nutrient medium strength as control, 1:2, 1:4, 1:8 and 1:10 were 6.173×10^6 cells/ml, 5.457×10^6 cells/ml, 4.577×10^6 cells/ml, 2.833×10^6 cells/ml, and 3.097×10^6 cells/ml respectively, with constant initial number of cells as 1×10^6 cells/ml in each strength medium.

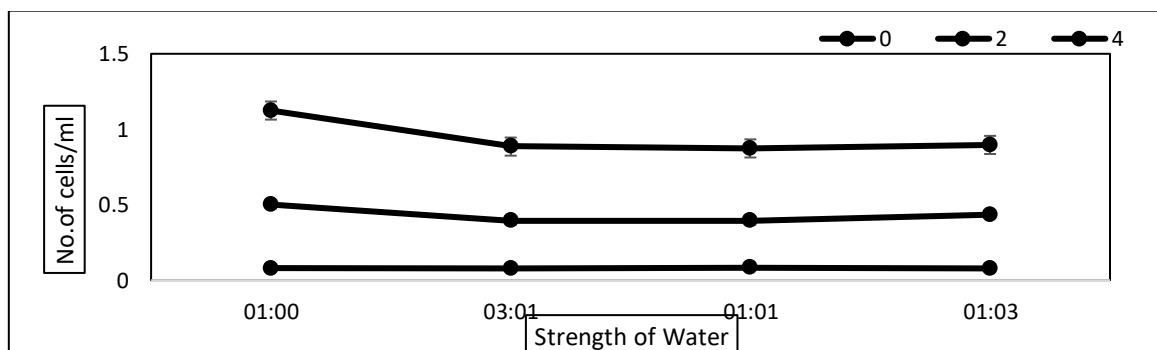


Fig.4: Biomass/ml of *Chlorella vulgaris* in different combinations of lake water and distilled water

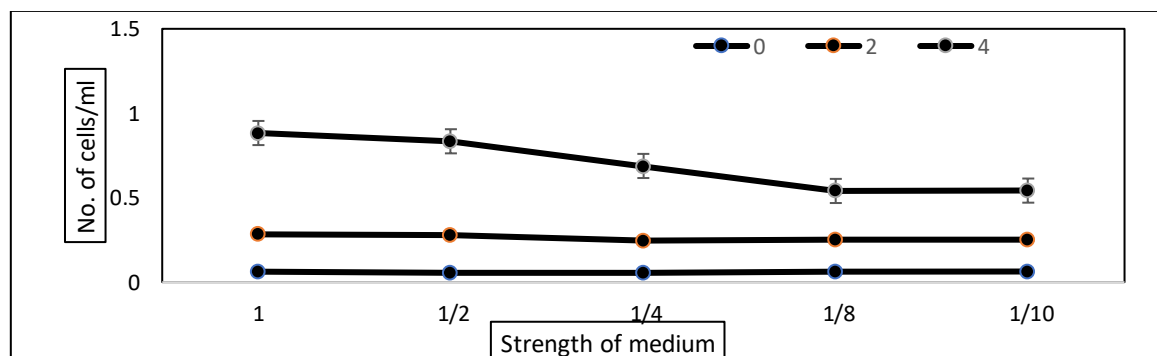


Fig.5: Biomass/ml of *Chlorella vulgaris* in different combinations of nutrient medium and distilled water.

4.3.3 CHLOROPHYLL-a ($\mu\text{g/ml}$)

Chlorophyll-a was proportionate with rate of growth in all combination studied.

The average value of Chl-a content was decreased as dilution of the water was increased from its normal strength.

In raw lake water the growth rate was found highest in four days of (100%) control as compared to initial growth condition. Similarly, the effect was corresponding in case of Chlorophyll-a.

The highest and lowest values of Chlorophyll-a content with respect to the strength of raw lake water as control (100%), 3:1, 1:1 and 1:3 were $3.677 \pm 0.342 \mu\text{g/ml}$, $2.707 \pm 0.075 \mu\text{g/ml}$, $2.843 \pm 0.113 \mu\text{g/ml}$, $1.953 \pm 0.281 \mu\text{g/ml}$ and $0.687 \pm 0.071 \mu\text{g/ml}$, $0.660 \pm 0.280 \mu\text{g/ml}$, $0.723 \pm 0.075 \mu\text{g/ml}$ and $0.650 \pm 0.267 \mu\text{g/ml}$, respectively.

In case of medium as nutrient of culture growth, the dilution of medium was inversely proportional to the chlorophyll-a of the culture.

The highest and lowest chlorophyll-a content in four days were $5.070 \pm 0.219 \mu\text{g/ml}$, $3.843 \pm 0.1012 \mu\text{g/ml}$, $1.230 \pm 0.233 \mu\text{g/ml}$, $0.723 \pm 0.100 \mu\text{g/ml}$, $0.567 \pm 0.142 \mu\text{g/ml}$, $0.647 \pm 0.067 \mu\text{g/ml}$ respectively on the fourth day and first day in the different nutrient medium strengths such as control (100%), 1 :2, 1:4, 1:8, and 1:10.

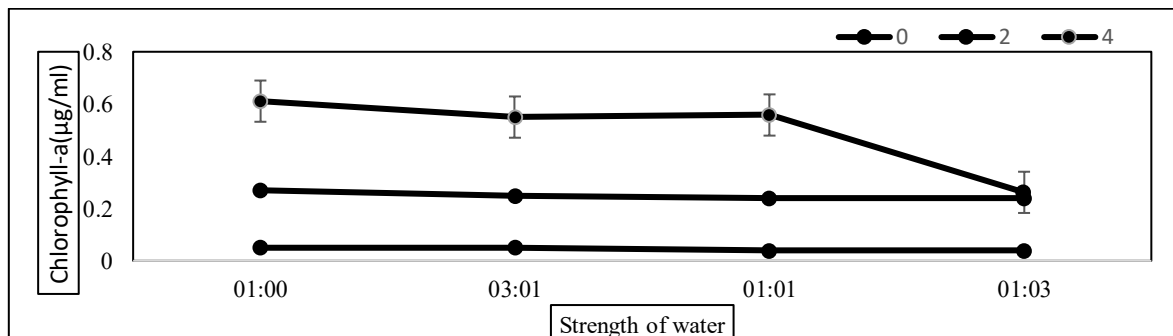


Fig.6: Chlorophyll-a content of *Chlorella vulgaris* at different combinations of lake water and distilled water.

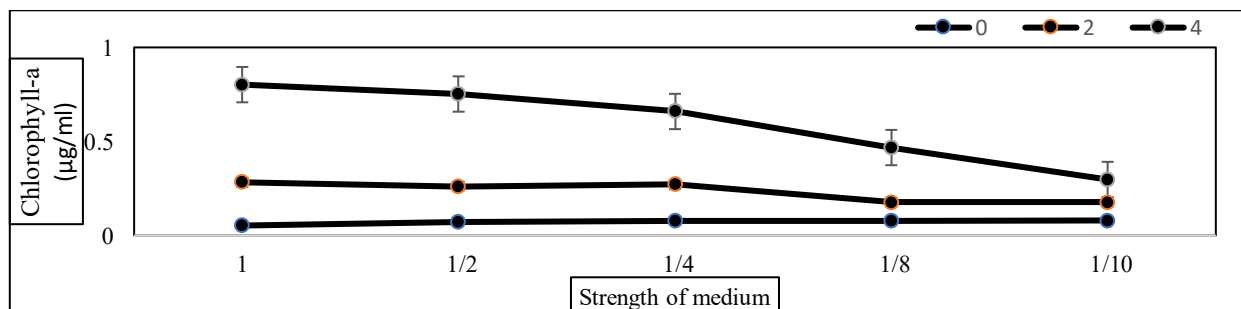


Fig.7: Chlorophyll-a of *Chlorella vulgaris* in different combinations of nutrient medium and distilled water.

CHLOROPHYLL-b ($\mu\text{g/ml}$)

Chlorophyll-b is much closely related to chlorophyll-a. its value was found significantly less than chlorophyll-a and it showed the same trend as the latter.

In case of raw water, the highest and lowest value of chlorophyll-b content with respect to the strength as control (100%), 3:1, 1:1, and 1:3 were $1.650 \pm 0.187 \mu\text{g/ml}$, $1.130 \pm 0.053 \mu\text{g/ml}$, $1.147 \pm 0.055 \mu\text{g/ml}$, $0.787 \pm 0.093 \mu\text{g/ml}$ and $0.317 \pm 0.093 \mu\text{g/ml}$ and $0.317 \pm 0.035 \mu\text{g/ml}$, $0.330 \pm 0.087 \mu\text{g/ml}$, $0.357 \pm 0.061 \mu\text{g/ml}$, $0.297 \pm 0.107 \mu\text{g/ml}$ respectively .

The highest and lowest chlorophyll-b were $1.993 \pm 0.040 \mu\text{g/ml}$, $1.590 \pm 0.066 \mu\text{g/ml}$, $1.390 \pm 0.166 \mu\text{g/ml}$, $0.473 \pm 0.060 \mu\text{g/ml}$, $0.420 \pm 0.147 \mu\text{g/ml}$ and $0.283 \pm 0.075 \mu\text{g/ml}$, $0.253 \pm 0.047 \mu\text{g/ml}$, $0.320 \pm 0.065 \mu\text{g/ml}$, $0.223 \pm 0.085 \mu\text{g/ml}$, $0.283 \pm 0.040 \mu\text{g/ml}$, respectively, on the fourth day and first day in the different nutrient medium strength such as control (100%), 1:2, 1:4, 1:8, 1:10.

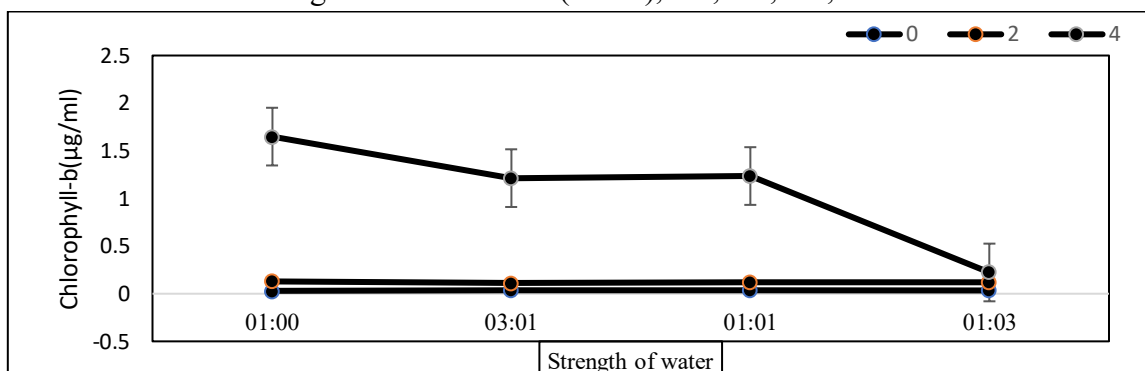


Fig.8: Chlorophyll-b content of *Chlorella vulgaris* in different combinations of lake water and distilled water.

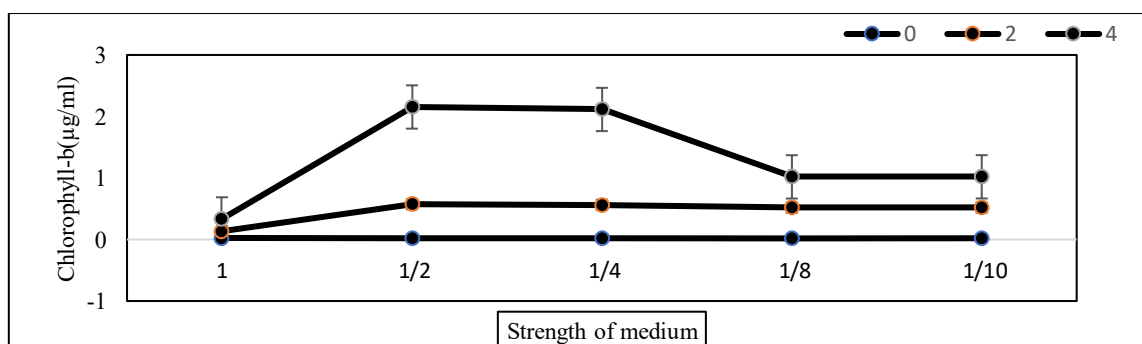


Fig.9: Chlorophyll-b content of *Chlorella vulgaris* in different combinations of nutrient medium and distilled water.

4.3.6 PROTEIN ($\mu\text{g/ml}$)

Protein content of the cell was proportionate with growth of the cultured cell.

Protein content showed the same trend with the negative and positive response of growth of cells depending on the dilution factor of the medium as linear nutrient for the culture and with increase of days of incubation from the initial inoculation day onwards.

The medium as lake water for the culture growth, the highest and lowest protein content of the cells with respect to strength conditions of nutrient as control (100%), 3:1, 1:1, and 1:3 was $118.533 \pm 5.718 \mu\text{g/ml}$, $86.367 \pm 0.202 \mu\text{g/ml}$, $89.067 \pm 2.417 \mu\text{g/ml}$, $24.500 \pm 2.787 \mu\text{g/ml}$, $23.600 \pm 3.551 \mu\text{g/ml}$, respectively.

In nutrient medium the highest and lowest protein content of the cells were $157 \pm 4.670 \mu\text{g/ml}$, $123.967 \pm 12.536 \mu\text{g/ml}$, $105.067 \pm 6.080 \mu\text{g/ml}$, $53.333 \pm 4.934 \mu\text{g/ml}$, $55.700 \pm 3.118 \mu\text{g/ml}$ and $21.567 \pm 1.286 \mu\text{g/ml}$, $23.400 \pm 3.804 \mu\text{g/ml}$, $24.067 \pm 2.303 \mu\text{g/ml}$, $18.600 \pm 3.969 \mu\text{g/ml}$, $20.967 \pm 2.802 \mu\text{g/ml}$, respectively, on the fourth day and first day in the different nutrient medium strength such as control 100%, 1:2, 1:4, 1:8 and 1:10.

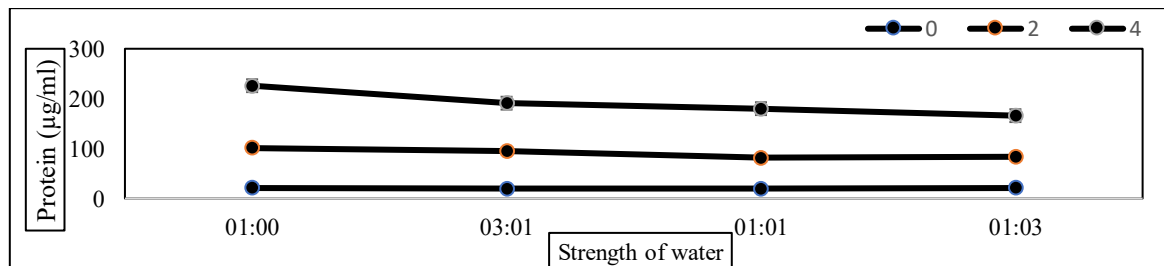


Fig.10: Protein content of *Chlorella vulgaris* in different combinations of lake water and distilled water.

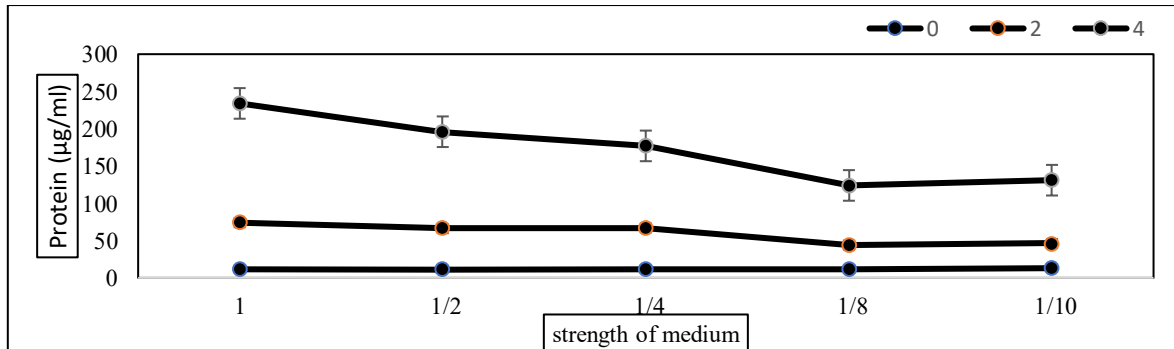


Fig.11: Protein content of *Chlorella vulgaris* in different combinations of nutrient medium and distilled water.

4.3.6 CAROTENOID (µg/ml)

Carotenoid was direct effect on growth condition of cells.

Carotenoid content decreased as dilution of the medium was increased but it showed direct effect with linear increase of days.

The medium as lake water for the growth of culture, the highest and lowest carotenoid content of the cells with respect to strength conditions of nutrient as (100%) lake water, 3:1, 1:1, and 1:3 were 2.200 ± 0.182 µg/ml, 1.803 ± 0.162 µg/ml, 1.690 ± 0.060 µg/ml, 1.110 ± 0.187 µg/ml and 0.417 ± 0.035 µg/ml, 0.497 ± 0.112 µg/ml, 0.437 ± 0.059 µg/ml, 0.373 ± 0.068 µg/ml, respectively .

In nutrient medium, the highest and lowest carotenoid content of the cells with respect to strength conditions as control (100%), 1:2, 1:4, 1:8, and 1:10 were 2.867 ± 0.080 µg/ml, 2.327 ± 0.165 µg/ml, 1.903 ± 0.180 µg/ml, 0.740 ± 0.072 µg/ml, 0.717 ± 0.130 µg/ml and 0.407 ± 0.015 µg/ml, 0.387 ± 0.031 µg/ml, 0.377 ± 0.042 µg/ml, 0.373 ± 0.015 µg/ml, 0.370 ± 0.040 µg/ml, respectively, on the fourth day and first day in the different nutrient medium strengths such as control (100%), 1:2, 1:4, 1:8 and 1:10.

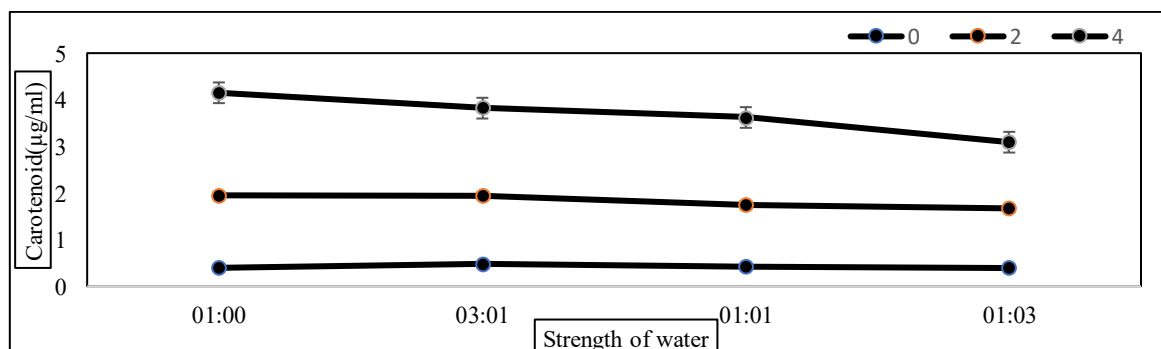


Fig.12: Carotenoid content of *Chlorella vulgaris* in different combinations of lake water and distilled water.

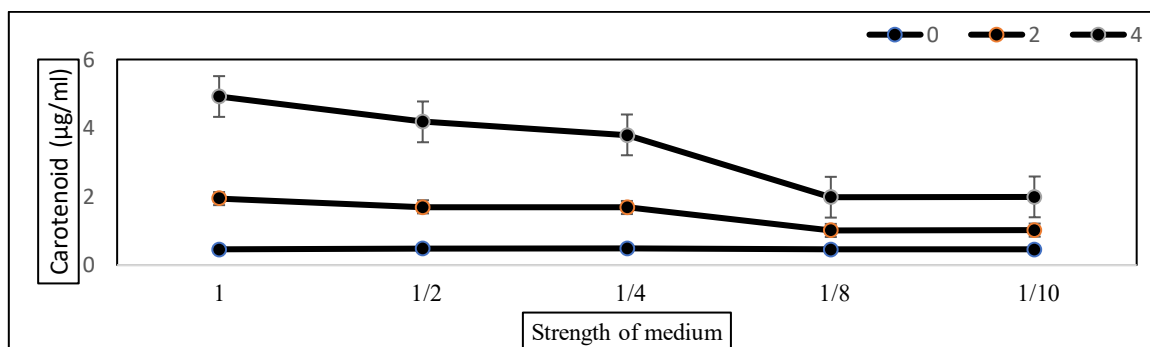


Fig.12: Carotenoid content of *Chlorella vulgaris* in different combinations of nutrient medium and distilled water.

5. DISCUSSION

The assessment of water quality of Vani Vihar Lake is based on the studies of its physico-chemical variables and biological parameters. In the present investigation, the physico-chemical parameter of water and sediment of Vani Vihar Lake has been studied and the data were collected over a period of four months i. e from March, 2024 to June, 2024. The study supports that the water body is greatly influenced by asset of independent physical factors, surface run off and catchment area. The local influence and location also play a crucial role in the variation of the water quality of the lake.

The monthly means along with the “t” values of inlet and outlet water and sediment of Vani Vihar Lake has been given in Table-3 and 4. The linear correlation coefficients between some physico-chemical parameters of inlet and outlet water and sediment are also presented.

5.1 WATER

Hydrogen ion concentration or pH is thought to be an important factor in maintaining the bicarbonate system of fresh waters. It is controlled to a greater extent by the interaction of the hydrogen ions resulting from the dissociation of carbonic acid and hydroxyl ions arising from the hydrolysis of bicarbonates Clymo (1964) and Wetzel (1975). Saha (1984) was of the opinion that high pH of a water body indicated its nutrient rich water, which seems to be true for Vani Vihar Lake (Table-1). Higher of pH have been found in the present study due to increasing photosynthesis and precipitation of magnesium salts (Atkins and Harris, 1924).

Dissolved solids in ionic state show conductance because the concentration of alkalis and alkaline earth compounds of bicarbonate, carbonate, sulphate and chlorides usually constitute ionic sphere in the water body and add the salinity to the water (Wetzel, 1975). It has been considered as an important measure in the determination of lake types. Olsen (1950) and Vollenweider and Frei (1953) classified the lakes to be meso-oligotrophic when the conductivity is < 200mmhos. The Vani Vihar Lake with conductivity values falling almost in this range fits in this in this category and is in the process of being converted into mesotrophic lake.

Chloride concentration in the water is an indicator of the pollution and thus is very important factor in determining the water quality. The higher value of chlorides observed in Vani Vihar Lake is due to regular addition of organic waste from domestic sewage. National Environmental Engineering Institute (NEERI,

1979) proposed high chloride concentration as an indicator of pollution caused by organic matters particularly that of human and animal excretions. Besides this similar type of results have been observed in different water bodies by Rao (1955), Cole (1979) and others.

Calcium has an important role in the aquatic ecosystem and is implemented in several ways to affect growth and development of the normal metabolism of flora and fauna. It also forms an important role in the aquatic ecosystem and is implemented in several ways to affect growth and development of the normal metabolism of flora and fauna. It also forms an important indicator for classification of domestic pollution in water bodies (Unni, 1983). Moyle (1946) viewed waters to be hard if their calcium concentration exceeds 400mg/l. Further higher concentration of the calcium in the lake water is considered as an indicator for eutrophic status, Parida (2000) stated that calcium content of various lakes of Bhubaneswar varies from 8.19 mg/l to 42.50mg/l. In the present investigation the calcium content of inlet and outlet water of Vani Vihar Lake varies from 14.46 mg/l to 19.77 mg/l and 14.42 mg/l to 21.90mg/l, respectively. The higher value of calcium content both in the inlet and outlet water during summer (in the month of April) may be due to the sewage contamination of the water body as represented by Tripathy and Pandey (1989).

Nitrate represent the stable and oxidized form of element nitrogen and is brought to the lake water after heavy rains, irrigation, discharge of municipal sewage water etc. Fresh water normally possesses 0.2 mg/l nitrates (Bowen, 1966). In the present investigation the nitrate- nitrogen content of Vani Vihar Lake water both in the inlet and outlet sites is much higher than that of the normal values as reported by Bowen (1966), the high nitrate nitrogen content in Vani Vihar Lake is due to entry of municipal sewage water into it, which carrying huge mass of organic nutrients.

The content of excess amounts of phosphorus and nitrogen leading to lake eutrophication is well accepted by all. This idea holds that there is a relationship between a lake's trophic state and the nutrients entering the lakes. Thus, the phenomenon of nutrient loading arises and phosphorus acts as the primary limiting nutrient in lake and pond ecosystems (Schindler, 1977).

A certain number of phosphates and other nutrients are required for the sustenance of aquatic life. The domestic and agricultural wastes contribute to phosphate content of water; otherwise, they occur in lower amounts in fresh water bodies.

Golterman (1973), Somashekar (1981) and Verma (1991) observed increase in phosphate following increase in nitrate nitrogen content. When these two parameters are correlated with one another positive correlation appears among them, out of these two correlations the correlation at the outlet site is statistically significant, while at the inlet site the correlation is statistically in significant. Significant positive correlation appears between these two parameters at the outlet site of Vani Vihar Lake supports their findings.

TEST OF SIGNIFICANCE BETWEEN INLET AND OUTLET WATER CHEMICAL PARAMETERS (t-test).

The comparison of mean differences along with t- values of both inlet and outlet water chemical parameters are given in table-3.

From the tabulated data of t – values between the chemical parameters of water both at the inlet and outlet sites of the Vani Vihar lake are found insignificant, Absence of remarkable differences between the chemical parameters of water both at the inlet and outlet sites of Vani Vihar Lake is due to minimum

distance i.e. 400 meters between two sites. Besides this the other probable reasons are less water spread area of the lake among the study sites due to lake area development by the project water.

5.2 SEDIMENT

Comparatively higher values of hydrogen ion concentration were observed during June and lower during March both in the inlet and outlet sites of Vani Vihar Lake. It might be due to the increased rate of decomposition in the bottom organic matter and the ultimate conversion of released carbon dioxide into carbonic acids (Saha, 1981).

Phosphates are present in the bottom soli both in organic and inorganic forms. The availability of these depends upon pH and the concentration of decaying organic matter. Lower value of available phosphate recorded in the month of June is due to the fact that during oxygen deficiency in lake water, the phosphate is released into the water from the sediment (Einsele, 1936).

Saha (1981) observed increase in sediment pH following increase in phosphate content. A significant positive correlation between these two parameters both at the inlet and outlet sites of Vani Vihar Lake supports his findings.

Table-3: Comparison of the chemical parameters of water at inlet and outlet sites of Vani Vihar Lake.

Parameters	Means Values		t- values
	Inlet	Outlet	
pH	7.4	7.575	1.08
Conductivity	212.675	236.355	1.347
Chloride	34.908	31.121	0.406
Calcium	17.238	17.297	0.055
Phosphate	1.063	1.292	1.301
Nitrate-nitrogen	0.61	0.779	0.315

Increase in nitrate nitrogen content of sediment in April perhaps due to addition of nitrogenous compound by washing of rain water through catchment areas and surrounding fields. Besides this addition of dead part of the free-floating aquatic macrophytes in the sediment and their decomposition just after the winter season may also be responsible for increase in nitrate- nitrogen content of sediment.

Saha (1981) stated that mode of fluctuation in nitrate- nitrogen content is more or less in accordance with that of phosphate. A significant positive co-relation between these two parameters at the inlet site of Vani Vihar Lake supports his findings. But similar observation was noticed at the outlet site of Vani Vihar Lake, which was however statistically insignificant.

Organic carbon loading, in deposited sediment of lakes received much attention in environmental monitoring and management programmes owing to their strong bearing of physical, chemical and biological processes operating in these environments. Organic carbon reaches the lake sediment is not only related to the characteristics of the catchment area but also related to the productivity of the system (Pearson and Seki, 1970).

The high content of organic carbon both in the inlet and outlet sites of Vani Vihar Lake in the present investigation may be due to flocculation followed by the faster settling of organic carbon rich suspended particulates (Padmalal, 1992) as well as the increased productivity of the lake system (Nair *et al.*, 1975). In addition to this a substantial amount of organic carbon can also reach the lake through sewage sludges as well.

Saha (1981) stated that almost an inverse correlation is established between the hydrogen ion concentration and organic carbon content. In the present study correlation was observed between the two parameters both at the inlet and outlet sites of Vani Vihar lake, but the correlation was statistically insignificant.

Test of significance between inlet and outlet sediment chemical parameters (t-test),

The comparison of mean differences along with t- values of both inlet and outlet sediment chemical parameters have been given at 99% or 99.9% level of significance indicated by * and ** marks, respectively (Table-4).

The t- values in respect of pH and phosphate were found significant between the inlet and outlet sediment at 99.9 % and 99% respectively, while the other chemical parameters of sediment did not show any remarkable significance among the study sites.

5.3 BIOASSAY

The present study based on algal bioassay provides important information on biological availability of nutrients to the test organisms and moreover, it is possible to assess and predict the tolerance capability of the test organism against the higher unfavourable condition Payne (1975) has reported the differential responses of green and blue-green algae in bioassay studies and Schanz *et al.*, (1979) have studied the role of micro algae in nutritional status of fresh water bodies. Keeping all these under consideration, one indigenous phytoplanktonic alga has been used to study the nutritional status and to assess water quality of the lake. The test organism is selected on the basis of its frequency in occurrence and distribution pattern in the water body.

Table-4: Comparison of the chemical parameters of sediment at inlet and outlet sites of Vani Vihar Lake.

Parameters	Means Values		t- values
	Inlet	Outlet	
pH	7.025	7.275	4.032**
Conductivity	207.462	171.537	1.125
Organic Carbon	3.967	3.68	1.857
Phosphate	8.458	19.792	3.661*
Nitrate nitrogen	0.998	0.995	0.424

During the study period, the culture of the alga *Chlorella vulgaris* did not show inhibition of growth in laboratory condition at any combinations of nutrient media, distilled water and lake water used or severe pollution level of the waters (Gour, 1981). However, the remarkable highest growth of the culture at 100% control (Nutrient medium) is almost equivalent with that of the total raw (lake) water medium after 4 days i. e. 0.183 ± 0.006 and 0.180 ± 0.010 . It shows that the nutrient loading condition of lake is favourable for

growth of *Chlorella vulgaris* which is a bio-indicator rich in protein, vitamin and mineral nutrient, promoter of cell reproduction, controller of cholesterol deposition, positive influencer of haemoglobin increasement. It is also the catalyst in the processes of breaking down the secondary product like hydrocarbon and metallic toxins such as DDT, PCB, Mercury, Cadmium, lead and also controller of immune system. The latest growth of *Chlorella vulgaris* at 1:3 (lake water: distilled water) is 0.065 ± 0.009 , after four days of study. Studies indicate that, the growth condition of the species reduces on dilution may be due to shortage of limiting factors and absence of certain micro and macro nutrients that support luxuriant growth of alga (Jeeji Bai and Sasi, 1983; Nyholm and Lyngby, 1988; Harrison *et al.*, 1990).

The better growth of alga may be due to the presence of sufficient amount of dissolved organic matter of favourable ratio of monovalent/ divalent cations in a particular combination (Jeeji Bai and Sasi, 1983), When the light intensity both in vivo (lake ecosystem) and in the laboratory is favourable for the *Chlorella vulgaris*, the growth is high.

The amount of pigment synthesis (chlorophyll-a and chlorophyll-b) and production of secondary metabolites (protein) were always found proportionate with growth.

Thus, from the present experiment, it can be concluded that,

- i) The micro algae play a crucial role in water quality assessment and the algal growth can be stimulated when nutrient medium is enriched.
- ii) The eutrophicated water bodies can be recovered by extending the invitro technique with limited nutrient enrichment to natural conditions.
- iii) In management point of view, dilution of waters of lake, ponds and tanks as and when necessary, will be beneficial not only at present but in long term perspectives (Tam and Wong, 1989; Mohapatra, 1992). This will save the water bodies in the long run and is well applicable to freshwater lakes.

6. SUMMARY

While the lake development operations are on, the water area of the Vani Vihar lake has been squeezed and during this period the present study has been undertaken starting from March, 2024 to June 2026. In order to have a glimpse on the lake water quality the water as well as sediment was studied in respect of parameters such as pH, conductivity, calcium, chloride, nitrate-nitrogen, phosphorus and organic carbon, on the other hand to recon the efficiency of lake water in providing nutrition for the growth of algae and to investigate the toxic effects of pollution, if at all, on the phytoplankton and other forms of algae growing in the lake water, the algal bioassay are also made.

Water quality

The water is always found alkaline with an average pH of 7.45 while the conductivity ranged from 176.4 μ S to 236.3 μ S, chloride content variation was quite substantial being up to 43-47 mg/l. The calcium, phosphate and nitrate- nitrogen in their maximum concentration had values such as 17 mg/l, 1.7 mg/l and 1.2 mg/l. The sediment analysis indicated that the ranges of pH were 7-7.2, conductivity 102-280 μ S, organic carbon 2.6-4.9 g/kg, phosphate 1.5-21.6 mg/kg and nitrate-nitrogen in their maximum concentration had values such as 17 mg/l, 1.7mg/l and 1.2 mg/l. The sediment analysis indicated that the ranges of pH were 7-7.2, conductivity 102-280 μ S, organic carbon 2.6-4.9 g/kg. phosphate 1.5-21.6 and nitrate-nitrogen 0.06-1.5 mg/kg. All these parameters reveal that the lake is in progressively eutrophicated state and phosphate provides a suitable substratum for growth of phytoplankton and other forms of algae.

ALGAL BIOASSAY of the phytoplankton's available in Vani Vihar Lake water, because of certain good reasons *Chlorella vulgaris* was selected, for an algal bioassay test in the laboratory. Several combinations taking nutrient medium, lake water and distilled water were made allowing the algae to grow in each of these combinations for at least a four-day period. Parameters like growth, biomass (cell number), chlorophyll-a, chlorophyll-b, protein and carotenoid were studied in order to know, if the algae is benefited in the lake water or up structured with the presence of some toxic chemicals. It was always found that though all these parameters increase in the nutrient media since it is the best substratum for maximum/ optimal growth. Similarly drastic growth reduction was observed with maximum dilution of the medium. On the other hand, *Chlorella vulgaris* grows quite well and reaches it's peak in raw lake water while growth is substantially reduced when the alga is grown in a medium with maximum dilution. This indicates the lake water does not contain any toxic chemicals so as to affect the growth of *Chlorella* sp. In raw lake water can be comparable to that in nutrient medium inside the culture room. In fact, in the latter case the growth is almost equal in the former being 0.180 and 0.183 respectively.

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Conflict of interest- The author declares that there is no conflict of interest.

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