EXPERIMENTAL DESIGN

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*
2.0. EXPERIMENTAL DESIGN

2.1. STUDY SITE

One Temple Pond (TP), One Small Community Pond (SCP) and a large Community Pond (LCP) were taken for the present study. The three ponds are situated in the municipality area of Baragarh town, which is north-west 380 km by road from Bhubaneswar, the capital city of Orissa and 1433 km by rail away from New Delhi, the capital of India. It is situated on the bank of JIRA river. It is situated between 21°19'N latitude, 83°36'E longitude and 176.362 mts above sea level.

The Temple Pond is a square area Pond with 32,400 sq.m. in area. As the name indicates this pond is used for some religious occasion of the majority hindu population. During the "Dhanu Yatra", an annual festival celebrated in the Baragarh town since time immemorial, a big boat is decorated and lord Krishna along with his accomplices make watersport in this pond. So the name temple pond and locally called as Monabandha. Also in the bank of this bandha a Mahima temple is situated. All sides of the pond has earthen roads. In some places the rural migrants built some thatched low cost houses for their shelter. The Municipal authorities employs a day watchman to guard the pond against using the pond for bathing & washing. It is a perennial pond. During rainy season water comes to the brink of the embankment. During Summer it goes to low
level. The average summer depth of water is 0.92 mtr. where as the rainy depth of water is around 2.1 mtr. As the surrounding earthen embankment is high enough on all sides no outside water enters the pond. So the surface run-off of the embankment is only draining into the water body. Water is most of the year transparent. A thick vegetation of Macrophyte remain in the water. The list of plant species found in the pond is given in Table 2.1. These are identified as species of Salvania, Jussiae, Scirpus, Ipomoea, Hydrocharis, Limnathemum, Marsilea, Potamogeton, Azolla, Ceratophyllum, Wolfia, Nelumbium & Hydrilla. The Shoreline Vegetation consists of species of Panicum, Paspalum, Oryza, Cyperus & Zoysia. The Pond is mostly used for feet washing & the water is taken by adjoining inhabitants for utensil washing. In the evening when cow heard return from the field, the cattle drink water from it.

The other study pond is a small community pond locally known as Dorā bandha. It is a rectangular type of pond having area 21,000 sq.mt. All the sides of the pond is occupied by low income people with small thatched houses and the houses do not have toilet facility. So the banks of the pond is extensively used for open air latrine. One side of the bank contains huge amount of municipal solid garbage. Surface run-off containing the dried faecal material enter the water body during rainy season. The colour of the water remains always green having no macrophyte. The shoreline
vegetation is only *Ipomea carnea*. The average water depth in summer is 0.85 mtr. and during rain it is 2.4 mtrs. After defecation, people clean the lower part of their body in the pond and thus raw faeces also get mixed up with water.

The third study pond is a large perennial community pond locally known as Khajurikatā bandha. It is also a rectangular pond. One side of the pond's bank is converted into a motorable road. The adjacent sides of the roads are occupied by the inhabitants. A large number of population from dawn to dusk use the pond in various ways. Bathing, washing clothes, washing after defaecation, washing of the cattle, washing of utensils are done by a large number of population. The average water depth during summer was 0.81 mtrs. and during the rainy season water depth was raised almost upto the top of the embankment and during rainy & winter season, the municipal drains overflow over the embankment & the drain water enters the pond. The shore line flora consists of species of plants of *Astracantha*, *Spiranthes*, *Heliotropium*, *Spilanthes* & *Eclipta*. The macrophyte population consists of *Ipomoea aquatica* and *Digitaria* sp. Khajuri is the local name of date palm. It is seen that the banks of the pond contains some Khajuritrees and near by locality is known as Khajuritikrā.
SKETCH MAP OF BARGARH TOWN
NOT TO SCALE

MAP-2 SHOWS THE AREA OF BARGARH TOWN

REFERENCE:

TP = 1
SCP = 2
LCP = 3

VILLAGE BUNDAM
WARO BRAHMAPURI
RIVER, CANAL, TANK
RAIL
ROAD
Photo-4
SCP in summer

Photo-5
SCP in rainy
Arrow shows piece

Photo-6
SCP in winter
Photo-7
LCP in summer

Photo-8
Arrow shows
LCP in rainy/overflow drain

Photo-9
LCP in winter
2.1.b. History of the Pond

Local residents say Monabandha (temple pond) dora bandha (SCP) and Khajurkata bandha (LCP) were dug before 1955 to irrigate paddy fields during drought conditions in the past. Because of the canal system drawn from Hirakud reservoir after 1957, the water of the pond is not used to irrigate paddy fields. It is also not used for pisciculture.

2.1.c. Morphometry and Bathymetry of the Pond

The morphometry of the three ponds was observed by studying the maps of the ponds available in the local revenue department. Bathymetry of the ponds was done by using long nylon ropes transect across the width of the ponds. A graduated nylon rope with 1/2 mtr marks attached to 5 kg deeper, was used to measure the depth of the ponds.

After studying the length, Width, surface area, depth of the ponds, the volume of the water and mean depth-maximum depth relation etc were calculated according to Welch (1948). Table 2.3 depicts morphometric and bathymatrical features of the study ponds.

2.2. METEOROLOGICAL CONDITION

Orissa, on the eastern sea board of India, enjoys a tropical monsoonic type of climate. Its annual average rainfall is about 200 cm. The variability of rainfall is below 15 percent in the north and north eastern parts of the
state. In the southern and southwestern and western parts of the state, the variability of rainfall increases to 15-20 percent. The South-West monsoon normally sets in between the 5th June to the 10th June in the coastal plain and by 1st July the whole of the state. By 15th October, the south west monsoon withdraws completely from Orissa.

Orissa, on the eastern coast of India, is not directly influenced by the south west monsoon as it moves along Bay of Bengal almost parallel with Orissa's land mass. But the annual cyclone from the Bay of Bengal influences it and brings rain with two seasonal peaks July-August and October-November. During the Winter, north-eastern retreating monsoon brings some rain to northern Orissa but all other parts remain dry.

An analysis of rainfall data reveals that the annual rainfall in the western Orissa varies between 78 to 155 cms. and some areas experience usually low rainfall. Bargarh along with portions of Balangir district (Balangir, Patnagarh and Titlagarh) comes under low rainfall region.

Like the other places of India, Orissa experiences three main seasons. Rainy season extends from mid June to October, autumn-winter extends from November to February and the spring-summer extends from March to mid June. For the first few weeks after onset of monsoon rains, the
atmosphere becomes surcharged with moisture and a sudden change from extreme heat to damp atmospheric condition. The monsoon wind does not blow continuously but at intervals. The whole sky is filled with long trail of cloud (In July 1991). On the average 3.02 hr. of sunshine was experienced per day. At times the rain occurs with thunder storms. After a few weeks this condition passes away and then comes the real period of monsoon. The whole sky is covered with cloud and the sun remains hidden behind the cloud continuously for few days. Heavy and torrential rain falls, (537.9 mm of rainfall was recorded in August 1991 see Table-2.2). The season of retreating monsoon occurs between mid September to December. The severity of the monsoon is less felt towards the end of October (17.3 mm rainfall was recorded in October, 1991 see Table-2.2)

The sky begins to be cleared and the interval of bright sunshine over the region increases (7.23 hr/day in October 1991). The colour of the cloud changes from black to white-grey. The mercury in the barometer begins to rise and the thermometer begins to record in the descending order (79.5% humidity & 33.1° C in October 1991). At times several depressions pass during this period of retreating monsoon. In the month of December, the night sky is clear. The moon shines clearly and the cold of the winter is not severe (average 26.8° C in December 1991). Slight rainfall (15 mm in February 1990), lowest cloud amount in the sky in
february help free radiation. In the evening clouds appear
in the horizon. Dew drops are formed on the blades of green
grass. Morning and evenings present a smoky appearance in
the country side. Barometer records in the ascending order,
While the mercury in the thermometer descends (82% humidity
& 33.3° C temp in February, 1991). Towards the end of
February patches of very big black clouds appear in the
clear blue sky the afternoon and the wind blows from the
east. It brings occasional rain often accompanied by hail
storm.

The hot weather season of spring and summer starts
from march and ends with mid-June. In the early march the
temperature was not very high (31.4° C in March 1991).
Cloud in the sky is not very thick and the barometer and
thermometer record in the reverse order of that of the
winter month. The wind blows from the South. The sky
becomes clear and the Sun is bright (9.92 hr/day sunshine in
April 1991). May was the warmest month of the year and the
temperature was the highest (41.1° C in May 1992). Some
rainfall may occur in May (25.5 mm. in May 1992) and it
usually falls on the afternoon and accompanied by strong
wind, thunders and lightening. Towards mid June the monsoon
sets in and rain again becomes more frequent and almost
continuous. The monsoon rain brings a sudden fall in
temperature and gives relief to the people.
Meteorological data (Table-2.2) confirm that Baragarh is a tropical region and shows three distinct seasons viz. Summer extending from mid March to mid June. Rainy extends from mid June to October and Winter from November to February. The town is situated in the south eastern climatic zone of India.

A distinct variation in meteorological conditions was observed in course of investigation. The mean maximum air temperature of 1990-1992 were respectively 31.4°C, 31.2°C & 33.9°C. The annual rainfall was 779 mm, 1318 mm and 1684 mm in 1990, 1991, & 1992. The maximum rainfall of 261 mm, 538 mm, 713 mm was recorded in July of 1990, July of 1991 and August of 1992 respectively.

The temperature varied from highest in May and lowest in January. In tropics, the temperature is directly proportional to the solar intensity falling on the surface. The solar radiation energy affects the abiotic and biotic components of inland waters because, it brings about an alteration in Photosynthetic activities. Solar radiation may be limiting ecological factors in water bodies and affect the vertical distribution of plants and animals via Oxygen and trophic condition (Szumiec 1975, and Mokiejvskij 1962). The cloudy sky of the monsoon brings about a change in spectral composition of radiation, reacting water surface and altering the rate of
Photosynthesis. The high temperature of the Summer and monsoon months results in an increase in rate of decomposition of organic matter by microbial population on the bottom which affects the chemistry of water by removing \( \text{O}_2 \) and adding \( \text{CO}_2 \) and other substances.

The climatological particulars are given in Table 2.2. Rainfall in Baragarh ranged from nil (December of 1990 & 1992) to highest in July. Due to rain a huge amount of organic and inorganic substances washed away from soil to waterbodies and change its Chemistry (Hutchinson, 1957).

The velocity of wind ranged from 8.3 km/hr in July to 2.6 km/hr in December. The values of wind velocity observed during October - March was lower than those of April - September. Wind is an important factor influencing the aquatic environment by creating water circulation and mixing of water and suspended solids. In addition, wind plays an important part in gas exchange between air and water. Water evaporation increasing with wind velocity is an important element in the balance of heat, water and inorganic compounds of water body (Szumiec, 1983). According to Munawar (1970) the percentage of \( \text{O}_2 \) and \( \text{CO}_2 \), free ammonia and total sulphides in water vary inversely with wind speed.
2.3. FIELD STUDY

a. Water Sampling for Physico chemical parameter

Surface water samples from five location (one location on each side and one from the central region of the pond, (below 5 cm to surface) were collected in triplicate in plastic container during morning hours in 2nd week of every month from the three ponds separately and analysed in the laboratory of panchayat college, Baragarh. The water samples were fixed for Oxygen analysis in the study site and brought to the laboratory for analysis. On each pond sites which were not used by bathers were chosen for sampling.

b. Water sampling for planktons

One litre water sample in polythene bottles in 10 such bottles were collected from the surface zone (below 5 cm to surface) from five sampling locations of every pond. Lugol's solution was added to it in a 1:100 ratio (Vollenweider 1969) and the samples were kept for 24 hours in dark. After sedimentation of phytoplankton, the supernatent liquid was siphoned off and the remaining sample was centrifused. The zooplanktons were collected from the surface water from each pond. Fifty litres of surface water was passed through a cone shaped plankton net No.25 bolting silk (mesh size 0.03-0.04 mm). The concentrate was collected by a vial tied in the lower end of the cone.
The water collection for planktons were done between 9 and 10 am usually in the first week of the month. The zooplankton sample was preserved in 4% formalin.

Methods of study of other biotic parameters like bacteria, macrophyte, macroinvertebrate population etc. are described in sections - 2.7.3, 2.7.4, 2.7.5 of this chapter.

2.4. LABORATORY METHOD

Analysis of total alkalinity, total hardness, dissolved Oxygen, pH, Chloride, Sodium, Potassium, Magnesium, Calcium, Turbidity, total solids, total dissolved solids, Nitrate, Phosphate, Sulfate, Water temperature, BOD, COD and seasonal total Coliform, seasonal total faecal coliform & seasonal mud samples were analysed as per the methods given in Golterman et al (1978) and APHA (1985). Out of the 19 physico-chemical parameters studied, 13 parameters were used for the calculation of water quality Index (Deininger & Maciuunas, 1971; Harkins, 1974; Tiwari and Ali, 1988)

2.4.1. PHYSICO-CHEMICAL PARAMETER

i. Temperature

It was measured with the help of an ordinary mercury thermometer (±0.1°C)
ii. **Turbidity**

It is measured according to methods prescribed by \( \text{(APHA1985)} \). It was measured by a Nephelometer and expressed as NTU (Nephelometric turbidity Unit). Standard solution was prepared by using hydrazine sulphate and Hexamethylene tetramine and the instrument was set. It was operated according to its manual.

iii. **Hydrogen-ion-concentration**

The \( pH \) was measured with the help of a digital \( pH \) meter.

iv. **Total Alkalinity**

The total alkalinity was obtained by titrating against Sulphuric acid solution using phenolphthalein and methyl orange indicator. \( \text{(Trivedy & Goel 1984)} \)

v. **Chloride**

The Chloride was measured by titrating against silver nitrate solution using potassium Chromate as indicator.

vi. **Hardness**

Hardness was measured by titration against EDTA using Erichrome black T indicator.
vii. Calcium

It was determined using NaoH, EDTA titrant and murexide indicator.

viii Magnesium

The content of Magnesium was determined by subtracting the value of calcium from the Total Hardness.

ix. Dissolved Oxygen

The dissolved Oxygen was measured by less modified winkler's method (winkler, 1888). The samples were collected from each experimental stations and immediately fixed with manganous sulphate and alkali potassium Iodide. The resultant brown coloured precipitate was dissolved by 2 ml of concentrated Sulphuric Acid. Then treated sample was titrated against standard solution of sodium thiosulphate solution using starch as an indicator.

x. Biochemical Oxygen Demand (BOD)

The biochemical Oxygen Demand was calculated from the difference of dissolved Oxygen initially present at the time of collection of the sample and after five days of incubation at 20°C. The Oxygen contents of samples were analysed by winkler's Method (APHA.1985).
xi. Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand was measured using potassium dichromate as oxidant in the presence of Sulphuric Acid. The excess dichromate remaining after oxidation was titrated against standard ferrous Ammonium sulphate solution using ferroin indicator (APHA 1985)

xii. Total Dissolved Solids

The total suspended solids were analyzed by filtering about 500 ml of sample through filter paper (whatman No.42) and the filterate was taken in a evaporating dish. It was evaporated on a hot water bath. When the whole water was evaporated. The weight of the evaporating dish after cooling it in a desicator was taken. The difference of weight of the dish is the dissolved solid in 500 ml. of water. The calculation was made to make it mg/l. (Trivedy & Goel 1984)

xiii. Total solids

The total solids were calculated by taking 500 ml of water in a evaporating dish. Before hand the weight of the evaporating dish was taken. 500 ml water was taken in the dish and evaporated in a water bath. Then the dish was cooled in a desicator and weight is taken. The difference of
weight gives the total solid in 500 ml. of water. Then calculation was made to make it mg/l.

xiv. Sodium and Potassium
The flame photometer was used to know the concentration of sodium and potassium. The instrument was set zero by using distilled water. Then known concentrations were used to plot a standard graph by using 589 nm filter for Sodium and 769 nm filter for potassium. Then the filtered samples were fed and reading was noted. The exact concentrations were deduced from the standard graph.

xv. In Organic Phosphorus
Coloured and colloidal impurities containing water was treated with activated charcoal and then it was filtered. 25 ml of sample in a flash was taken and 1 ml of Ammonium molybdate solution and 3 drops of (0.12ml) of stannous chloride solution was added. The blue colour, which was developed was kept for 10 minutes and it’s absorbance on spectrophotometer was recorded on 690 nm using distilled water as blank with the same amount of chemicals. A standard curve was prepared between absorbances and concentrations of standard phosphorus solutions. Then the phosphorus of the
sample water was deduced by comparing the absorbance with the standard curve. This is expressed as PO₄-P mg/l. (Trivedy & Goel 1984)

xvi. Nitrate

25 ml sample was taken in a conical flask. To remove the interference of Chloride an equivalent amount of silver sulphate solution (1 mg/l of Cl⁻ = 1 ml Ag₂SO₄ solution) was added. It was slightly heated and the precipitate of AgCl was filtered. The filtrate was evaporated in a Porcelain basin to dryness on a hot water bath. 0.5 ml Phenoldisulphonic Acid was added to the residue and the latter was dissolved with a glass spatula. Then 5 ml of distilled water and 1.5 ml of Potassium hydroxide solution was added and stirred for thorough mixing. The supernatant yellow colour was taken and its absorbance was recorded using 410 nm filter in a spectrophotometer against a distilled water blank. Standard nitrate solution in similar manner was processed and standard graph was plotted between absorbance and concentration of various standard solution. Then the value of the sample was deduced by comparing it with standard graph expressed as NO₃⁻ N in mg/l. (Trivedy & Goel-1984).
xvii. Sulphate

50 ml fiterate sample was taken in an Erlenmeyer flask. 10 ml of Nacl Hcl solution, 10 ml of glycerolethanol solution and 0.15g of barium chloride was added to the sample flask. A magnetic stirrer was used to stir the sample for an hour. Then it’s absorbance was noted against a distilled water blank at 420 nm using spectrophotometer. The standard solutions of different strength in similar way was used to record the absorbance and a standard graph was plotted. The sample sulphate concentration was deduced by comparing with standard curve. The result was expressed as mg/l (Trivedy & Goel 1984)

2.5. WATER QUALITY INDEX

Out of 19 physico-chemical parameter studied, 13 parameters have been selected to calculate water quality index. These parameters are (i) $pH$ (2) Total Alkalinity (3) Total Hardness (4) Dissolve Oxygen (5) Biological Oxygen Demand (6) Chloride (7) Sodium (8) Potassium (9) Calcium (10) Magnesium (11) Turbidity (12) Total solids (13) Chemical Oxygen Demand.

QUALITY RATING & WEIGHTAGE

In the formulation of water quality index, the importance of various parameters, depends on the intended
use of water. Here water quality parameters are studied from the point of view of suitability for human consumption. The standards (permissible values of various pollutants) for the drinking water, recommended by the Indian Council of Medical Research (ICMR) are given. When the ICMR standards are not available, the standards of United states Public Health Service (USPHS), World Health Organisation (WHO) have been quoted.

To calculate the water quality index (WQI) first the parameter subindex (QiWi) corresponding the ith parameter was calculated. These are given by the product of the quality rating Qi and the unit weight Wi of the ith parameter.

The overall water quality index was then calculated by aggregating these parameter subindex linearly and divide it with summation value of Wi. Thus we may write

$$ WQI = \left( \sum_{i=1}^{N} Q_i W_i \right) / \left( \sum_{i=1}^{N} W_i \right) $$

2.6. POND BOTTOM SOIL ANALYSIS METHOD

Five samples from five different spots (at four corners and one in the centre of the pond) were collected seasonally from the ponds with the help of ekman grab sampler. The sampling was done usually on 2nd week of
April, 2nd week of August and 2nd week of December between 10 and 13.00 hrs. The soil samples were thoroughly mixed. The samples were then air dried and powdered with mortar and pestle and passed through a nylon mesh (size 1.00mm). The processed soil was used for chemical analysis. The following parameters of the soil were studied by following standard methods.

**pH**

The soil for analysis (20 g.) was taken in a beaker. A small amount of distilled water was added to the soil in the beaker without stirring it. After some time it was stirred with the help of a glass rod and extra water up to 100 ml. was added to make a uniform paste of the soil (1 soil : 5 water). There after the pH of the unfiltered soil suspension was determined using the Electronic pH meter.

**ORGANIC CARBON (%)**

It was estimated by walkley & Black (1934) method. The dried 10 g. soil sample was taken. Then 10 ml of 1 N K₂Cr₂O₇ solution and 20 ml conc H₂SO₄ were added to the soil sample. The H₂SO₄ was previously mixed with silver sulphate (1.25%). The soil, acid & Dichromate mixture was diluted then with 200 ml of distilled water and 10 ml of phosphoric Acid. The value was determined using 0.4N ferrous Ammonium Sulphate (FAS) as titrant and 1ml of diphenylamine as indicator.
The percentage of organic carbon was calculated as

\[
\text{Organic Carbon} = \frac{V_1 - V_2}{W} \times 0.003 \times 100
\]

Where \(V_1\) = Volume of FAS used in blank titration

\(V_2\) = Volume of FAS used in sample

\(W\) = Weight of Soil in grams

**Total kjeldahl - Nitrogen**

Nitrogen was determined according to standard methods (APHA 1980). Conc \(H_2SO_4\), digestion catalyst (CuSO4+Hgo+Selenium powder + \(Na_2SO_4\)), 40% \(NaOH\), 0.1 N Hcl titrant and indicator (4% Boric acid + 0.5% bromocresol green + 1% methyl red) were used. Result was calculated using the formula

\[
\% N = \frac{(a-b) \times N \text{ of Hcl} \times 1.4 \times V}{U \times \frac{W}{V} \times S}
\]

Where \(a\) = ml of Hcl used with sample

\(b\) = ml of Hcl used with blank

\(V\) = ml of total digest

\(U\) = ml of digest distilled

\(S\) = Wt of the soil taken

**AVAILABLE PHOSPHATE**

1 g. powdered soil was taken and 200 ml of 0.002 N \(H_2SO_4\) was added to it. The suspension was shook for half an hour and filtered (Through what man No. 50) to get a clearer solution. 50 ml of the clear solution was taken. 2 ml ammonium molybdate and 5 drops of \(SnCl_2\) solution was added
to develop blue colour. Optical density was measured at 690 nm on a spectrophotometer (spectronic - 20). With the help of standard curve exact concentration of available phosphate was calculated (Trivedy & Goel 1984).

\[
\text{mg P/l soil solution} \quad \% \text{ available } P = \frac{\text{mg P/l soil solution}}{50}
\]

2.7. BIOTIC ANALYSIS

Biotic parameters can be used as indicator of pollution. The basic interest in pollution is owing to its effects on living organisms. Hence, the impact assessment of pollution is basically a biological problem. The chemical data measure the concentration of pollutants but the degree of ecosystem imbalance is measured by biological information. The biomonitoring includes here MPN count of Total coliform and ecotaxonomical methods. The ecotaxonomical method include single indicator species and changes in community structure. The presence or absence of organisms indicate the type & load of pollution. Some organisms in water are sensitive to pollution while others are tolerant. The sensitive organism, hence, disappear and their place is taken up by the tolerant species in a polluted water. This type of approach is first used by Kolkwitz & Marsson (1908) and later by Liebman (1962)

The algae, which are unattached, dispersed individually or as colonies in the water are designated as phytoplankton.
The phytoplankton are the natural inhabitants of the water bodies. This is the reason that several algal species have been considered as indicators of water quality (Palmer 1969, James and Evison 1979, Raina et al 1982)

2.7.1. PHYTOPLANKTON

A microtransect method as described by Lackey (1938) cited in IBP handbook no.2, edited by Vollenweider (1969) was used to count the Phytoplankton. A microtransect is the area seen through the microscope when the slide is moved so that a path is seen from one side of a square coverglass to the other. A drop of water was put under the cover glass and the drop was measured previously. Then the transect represents a known volume of water & represent a known fraction of the area of covers glass and the no. of organisms in the transect was counted and per ml organisms was calculated. The collected 4% formalin - preserved plankton bottles were agitated and a standardised medical dropper was used to drop, the material vertically on a clean slide. Area of the transect and the coverglass was measured by micrometer. Volume of a drop is measured and counting done under a compound microscope.

Identification of Phytoplankton was done on the basis of their external appearance, colour, morphological characteristics, size, cellular structure and pigments. These were identified by drawing a neat cameralucida
diagram. Its dimension were noted by using a micrometer. In the colonial form, the number of individuals in the colony was noted. Each colony was counted as a unit. The specimens from Chlorophyceae, Cyanobacteria (blue green algae) and Bacillariophyceae were identified. For identification of Phytoplanktons, the keys & monographs were used (Ward & Whipple 1959, Fritsch 1945; Desikachary 1959; Philipose 1967; Iyenger and Desikachary 1981; Randhawa 1959; Gonzalves 1982;)

Calculation of Planktons were done by the following formula

\[
\text{Total number/drop} = \frac{\text{Area of the Coverglass}}{\text{Area of one transect}} \times \frac{\text{Individual counts recorded}}{\text{per transect}}
\]

\[
\text{Organism/L.} = \frac{a \times v}{2} \text{ unit/L.}
\]

\(a = \text{Organism / ml}\)

\(v = \text{Volume of concentrate in ml}\)

\(L = \text{Water filtered in litre}\)

Organism/l. can be known by multiplying organism/drop with the no. of drops that makes one ml. then one litre was calculated.
2.7.2. ZOOPLANKTON

The Zooplankton constitute an important component of secondary production in aquatic system and play a key role in the energy allocation at different trophic levels. The Zooplanktons were considered comprising four groups. These are Rotifera, Cladocera, Copepoda & Ostracoda.

There are many reports on the Zooplankton in fish ponds from foreign countries (Hall et al 1970; Pace, 1984). Zooplankton periodicity from Indian water bodies are also available (Michael, 1968; Jana 1973; Das 1980; Mallik & Bose 1988).

Zooplankton from the surface were collected at different sampling spot from all over the ponds regularly in all the months of the year. The methods for collection, preservation and identification of Zooplankton were identical as those of Phytoplankton. Identification of Zooplankton was made by using standard monograph & literature (Ward & Whipple, 1959; Pennak, 1978; Tonapi, 1980; Sehgal, 1983).

Counting of Zooplankton was made by a Sedgwick - Rafter cell. The sedgwick - Rafter cell has a built in rectangular chamber 50 x 20x 1mm (length x Breadth & depth). The area enclosed is 1000 sqmm with a capacity of 1 ml. Thus 1 ml of plakton concentrate was poured in to sedgwick Rafter. The
coverslip was placed over the rectangular groove carefully avoiding air bubbles. It was then allowed some time for settling the plankton. Then counting was done under a microscope. Usually 5 replicates are studied from the plankton. Calculation was made by the following

\[
\text{No. Of. planktons/L.} = \frac{a \times v}{L}
\]

- \(a\) = Zooplankton per ml.
- \(v\) = Volume of concentrate in ml.
- \(L\) = Water filtered in litre.

2.7.3. MPN OF TOTAL COLIFORM & FAECAL COLIFORM

The multiple tube fermentation technique was used to know the MPN of Total Coliform & Faecal Coliform. It is the most probable number of the Bacteria. It was done seasonally. The number of Bacteria was calculated on the basis of positive and negative combinations of the tubes using MPN table.

2.7.4. MACROPHYTIC VEGETATION

Random sampling was done with the help of a 1mt.x1mt. floating type square from 10 different regions of the pond seasonally. During sampling, plants which fell within the quadrat were taken into account. No sampling was done in the areas previously disturbed. The plants were collected by hand. After collection, plants were washed to remove shell, epiphytes, Gastropods and insects present over the
leaves of the macrophytes and then sorted in to different species and counted. Then it was weighed. The samples were kept in the hot air oven for 24 hours in 105°C to know the dryweight. The following calculation were made.

\[
\text{Frequency} = \frac{\text{No. of quadrats in which the species occurred}}{\text{Total no. of quadrats studied}} \times 100
\]

\[
\text{Density} = \frac{\text{No. of individuals}}{\text{metre}^2}
\]

2.7.5. MACRO INVERTEBRATE

The benthic macro-invertebrates were collected by Ekman grab sampler seasonally. Five benthic samples were randomly taken (one sample from each side and one sample from the centre of the pond). Insects were captured with the help of an insect collecting net made up of nylon cloth (2mm mesh size). Five replicates were randomly collected each season & their average was taken in to consideration. Macrofauna attached with various parts of various macrophyte were collected by picking up the macrophytes. The specimens were fixed in 10% formalin (Trivedy & Goel 1984). There after these were identified & counted.

2.8 INDICES

2.8.1. DOMINANCE DIVERSITY AND EVENNESS INDICES

These indices were calculated using twelve month field data for each site.
DOMINANCE

The dominance value of each phytoplankton and Zooplankton species in each site was calculated using simpson (1949) index

\[ D = \sum \left( \frac{n_i}{N} \right)^2 \]

Where \( n_i \) = importance value for each species

\( N \) = Total of importance value

\( D \) = Dominance index

DIVERSITY

The diversity index was calculated using Shannon and Weaver (1963)

\[ H = - \sum \left( \frac{n_i}{N} \right) \log_e \left( \frac{n_i}{N} \right) \]

Where \( n_i \) = importance value for each component

\( N \) = Total of importance value of all components

\( H \) = Diversity index

EVENNESS

The evenness index was calculated using Pielou (1966), equation

\[ J = \frac{H}{H \text{ max}} \]

Where \( H \) = Shannon and weaver diversity index

\( H \text{ max} = \log_e S \)

\( S \) = No. of species
2.8.2. CO-EFFICIENT OF SIMILARITY

This is calculated using index of Sorenson (1948)

\[ QS = \frac{2J}{a+b} \]

Where:
- \( a \) = The total number of species in habitat 'a'
- \( b \) = The total number of species in habitat 'b'
- \( J \) = The number of species common to both habitats

2.8.3. SIMILARITY INDEX

This is calculated using formula of Bray & Curtis, (1957), and Morisita (1959).

\[ B = \frac{\sum |X_{ij} - X_{ik}|}{\sum |X_{ij} + X_{ik}|} \]

\[ 1-B = \text{Measure of similarity} \]

\[ C_H = \text{Morisita’s Index of similarity} \]

\[ C_H = \frac{2 \sum X_{ij} X_{ik}}{\left( \sum X_{ij}^2/N_j^2 \right) + \left( \sum X_{ik}^2/N_k^2 \right) N_j N_k} \]

Where:
- \( X_{ij} \) is the abundance (Nos/Litre) of \( i^{th} \) species in community 'J'
- \( X_{ik} \) is the abundance (Nos/Litre) of that species in community 'K'
- \( N_j \) Total number of all individuals in community 'J'
- \( N_k \) Total number of all individuals in community 'K'

2.8.4. NYGAARD (1949) TROPHIC STATE INDICES

Nygaard’s myxophycean, Chlorophycean, diatom, Euglenophycean and compound indices were calculated. Details are given in Chapter - 4.

2.8.5. PALMER (1969) ALGAL SPECIES INDEX

Palmer cumulative score of 20 was taken as indication of organic pollution and score of 15 - 19 were taken as probable evidence of high organic pollution. Details are given in Chapter - 4.
## TABLE-2.1 SALIENT FEATURES OF THE STUDY
### PONDS OF BARGARHTOWN

<table>
<thead>
<tr>
<th>Name of the Pond</th>
<th>Area of the Pond</th>
<th>Features</th>
<th>Vegetation Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temple Pond (TP)</strong></td>
<td>32,400 sqm</td>
<td>Used for Utencil Cleaning, Feet Washing</td>
<td><strong>Shoreline-</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Panicum repa</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Paspalum dis-</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>tichum</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Oryza rufipogon</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Cyperus liria</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Zozasia natrella</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Cyperus sp.</em>,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Ipomoea reptans</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Hvdrocharis asiatic</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Limnathemum indicum</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Zozasia natrella</em></td>
</tr>
</tbody>
</table>

| **Small Community Pond (SCP)** | 21,000 sqm | In one side of the Bank | *Ipomoea carnea* |
|                                |            | municipal solid garbage was dumped. Banks are extensively used for open air latrine Extensive human use (bathing and washing) | |

<p>| <strong>Large Community Pond (LCP)</strong> | 25,200 sqm | Banks are used for open air latrine Pond receives municipal drain discharge (except during Summer) | <strong>Astracantha Longifolia Ipomoea aquatica</strong> |
|                                |            |                                  | <strong>Spiranthes indica</strong> <strong>Digitaria sp.</strong> |
|                                |            |                                  | <strong>Eclipta prostrata</strong> |
|                                |            |                                  | <strong>Heliotropium indicum</strong> |
|                                |            |                                  | <strong>Spilanthes acmella</strong> |</p>
<table>
<thead>
<tr>
<th>Month</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
<th>Year 10</th>
<th>Year 11</th>
<th>Year 12</th>
<th>Mean</th>
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<td>27.9</td>
<td>31.47</td>
<td>35.41</td>
<td>33.83</td>
<td>29.8</td>
<td>32.3</td>
<td>32.3</td>
<td>31.01</td>
<td>29.7</td>
<td>27.76</td>
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<td>Air</td>
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<td>35.01</td>
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<td>x</td>
<td>32.2</td>
<td>31.02</td>
<td>33.52</td>
<td>3.11</td>
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<td>41.1</td>
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<td>33.1</td>
<td>30.9</td>
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<td>29.2</td>
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<td>48.19</td>
<td>50.53</td>
<td>60.45</td>
<td>67.06</td>
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<td>84.77</td>
<td>79.43</td>
<td>73.7</td>
<td>88.73</td>
<td>83.51</td>
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<td>At</td>
<td>59.25</td>
<td>82.00</td>
<td>61.55</td>
<td>x</td>
<td>x</td>
<td>84.4</td>
<td>91.11</td>
<td>84.77</td>
<td>79.5</td>
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<td>5:30 P.M.</td>
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<td>91.33</td>
<td>82.66</td>
<td>63.8</td>
<td>59.25</td>
<td>70.1</td>
<td>85</td>
<td>88.1</td>
<td>80.6</td>
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<td>67</td>
<td>43.9</td>
<td>73.8</td>
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<td>Rain</td>
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<td>15</td>
<td>42.6</td>
<td>00</td>
<td>27.2</td>
<td>59.8</td>
<td>261.1</td>
<td>145.6</td>
<td>119.6</td>
<td>77.6</td>
<td>30.8</td>
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<td>27.1</td>
<td>13.3</td>
<td>4.2</td>
<td>115.3</td>
<td>537.9</td>
<td>406.7</td>
<td>124.1</td>
<td>17.3</td>
<td>18.5</td>
<td>15.6</td>
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</tr>
<tr>
<td>mm</td>
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<td>4.2</td>
<td>00</td>
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<td>713.5</td>
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<td>7</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>26</td>
<td>22</td>
<td>7</td>
<td>8</td>
<td>4</td>
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<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Sun</td>
<td>9.96</td>
<td>9.11</td>
<td>8.26</td>
<td>9.92</td>
<td>7.52</td>
<td>3.99</td>
<td>2.11</td>
<td>5.38</td>
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<td>7.61</td>
<td>8.84</td>
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<tr>
<td>shine hr/</td>
<td>8.28</td>
<td>10.15</td>
<td>8.12</td>
<td>9.9</td>
<td>9.85</td>
<td>5.98</td>
<td>3.02</td>
<td>2.27</td>
<td>4.47</td>
<td>7.23</td>
<td>6.81</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>day</td>
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<td>9.31</td>
<td>6.49</td>
<td>9.44</td>
<td>8.42</td>
<td>6.06</td>
<td>3.22</td>
<td>3.27</td>
<td>6.46</td>
<td>7.41</td>
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<tr>
<td>Mean</td>
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<td>3.7</td>
<td>4.3</td>
<td>5.3</td>
<td>6.7</td>
<td>8.0</td>
<td>8.3</td>
<td>7.44</td>
<td>5.5</td>
<td>3.8</td>
<td>3.1</td>
<td>2.6</td>
<td></td>
</tr>
</tbody>
</table>

1990 & 1992 data of Air Temperature, Humidity, Rainfall, Rainy days are from Sambalpur station
1991 Rainfall data collected from Hirakud Research Station.
Sunshine data is from Jharsuguda Station.
Data are supplied by India Meteorological Department, Bhubaneswar.

Mean wind speed data of Sambalpur station collected from Climatological tables of observatories in India
(1931-1960) published by India Meteorological Dept.

x - Data are not available
1 = January, ... 12 = December
Table 2.3 - MORPHOMETRIC FEATURES OF STUDY PONDS IN BARGARH.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T.P.</th>
<th>SCP</th>
<th>LCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum length (mt.)</td>
<td>180</td>
<td>150</td>
<td>210</td>
</tr>
<tr>
<td>Maximum width (mt.)</td>
<td>180</td>
<td>140</td>
<td>120</td>
</tr>
<tr>
<td>Maximum surface area (Sq. mt.)</td>
<td>32400</td>
<td>21000</td>
<td>25200</td>
</tr>
<tr>
<td>Maximum shoreline length in Summer</td>
<td>138</td>
<td>80</td>
<td>170</td>
</tr>
<tr>
<td>Maximum width in Summer</td>
<td>129</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>Maximum length in Rainy</td>
<td>172</td>
<td>141</td>
<td>201</td>
</tr>
<tr>
<td>Maximum width in Rainy</td>
<td>165</td>
<td>133</td>
<td>114</td>
</tr>
<tr>
<td>Maximum length in Winter</td>
<td>167</td>
<td>131</td>
<td>192</td>
</tr>
<tr>
<td>Maximum width in Winter</td>
<td>162</td>
<td>127</td>
<td>108</td>
</tr>
<tr>
<td>Depth of the pond (m)</td>
<td>4.6</td>
<td>5.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Average depth of water in Summer (m)</td>
<td>0.92</td>
<td>0.85</td>
<td>0.81</td>
</tr>
<tr>
<td>Average depth of water in Rainy (m)</td>
<td>2.1</td>
<td>2.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Average depth of water in Winter (m)</td>
<td>1.6</td>
<td>1.8</td>
<td>1.99</td>
</tr>
<tr>
<td>Maximum volume of water in Summer (Cu.m)</td>
<td>16377.8</td>
<td>4896</td>
<td>9501.3</td>
</tr>
<tr>
<td>Maximum volume of water in Rainy (Cu.m)</td>
<td>59598</td>
<td>45007.2</td>
<td>66450.6</td>
</tr>
<tr>
<td>Maximum volume of water in Winter (Cu.m)</td>
<td>43286.4</td>
<td>29946.6</td>
<td>39398.4</td>
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</table>