Assessment of the water quality of religious lentic water bodies of a coastal village in Puri district (Odisha, India) using selective physico-chemical parameters

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ABSTRACT

Water quality is controlled by several factors i.e. climate, rainfall, composition of the materials of the water body, hydrologic fluctuations, topography etc. Interaction of these factors play critical role in spatial and temporal variation in water quality. The variability of the parameters is linked to various biological, physical and chemical processes taking place in the water bodies. Several parameters affect the usability of the water. In the current study water quality is assessed on the basis of various physico-chemical parameters like pH, dissolved oxygen, salinity, conductivity, total dissolved solids, phosphorous, total phytoplankton count, and total zooplankton count etc. We have studied three water bodies located near temples and have tried to find out whether the wastes of these temples are affecting the water quality of these water bodies or not.

***Index Terms* – Water bodies, Temple, Water quality, Physico-chemical parameters, Usability .**

1. INTRODUCTION

Aquatic ecosystems are being polluted, as a consequence of several developmental activities which can cause serious problems for the biota **(Khallaf et al., 2010).**For the sustainability of living organisms, water is of vital concern. Loss of fluids through normal physiological activities is replenished by water.Contamination of fresh water bodies is a threat to public water supplies and to the aquatic ecosystems by damaging the aquatic life with a wide range of pollutants **(Canli et al., 1998).** The heavy metals released from domestic and industrial wastes, agricultural activities, physical and chemical weathering of rocks, soil erosions, sewage disposal and atmospheric deposition etc are contaminating natural aquatic systems extensively **(Alloway and Ayres, 1993).** There are some metals which are non- biodegradable and their presence in the food chain is hazardous for human beings or animals if they get accumulated in different organs through a number of pathways **(Korai et al., 2008).**
Clean Water Act (CWA) of 2004 defines water quality as "the characteristics of water which define its use in terms of physical, chemical, biological, bacteriological or radiological characteristics by which the acceptability of water is evaluated."

Measurement of water quality provides important information about the reliability of a water body. The most widely used method is the measurement of its physical, chemical and bacteriological constituents. Water quality monitoring results are used as basis for policy or management decisions concerning a water body and its uses.

Monitoring water quality is crucial because these water bodies contain large number of aquatic organisms. So, in the present study an attempt have been made to study the water quality of three religiously important water bodies, and to find out whether their water quality is suitable for its aquatic life and the aquatic food web.

2. MATERIALS AND METHODS

2.1. STUDY AREA

The current study was carried out in the coastal village Arisandha (20.010445, 85.991379), in Nimapada block of Puri district, Odisha. There are a number of temples in this village. Some temples are having big ponds attached to them. The wastes of these temples are disposed in these ponds. Although these ponds are being washed time to time by the village temple committee, but definitely their physico-chemical properties are being affected. In this study we have tried to monitor the water quality of these ponds to analyse whether these water bodies are reliable for aquatic ecosystems or not.

2.2. COLLECTION OF WATER SAMPLE

The current study is to check a few physical and chemical parameters of the water to determine the present status of water quality of the sampling water bodies. Water samples were collected for sampling from the three ponds located near three temples. For the collection of water samples, plastic bottles of one liter capacity were used. Water samples were collected without disturbing the substratum to avoid the loose sediments in sample. Samples were collected carefully from the surface (usually 1-2 cm). Sufficient volume of sample was transferred into the sample container. Bottles containing samples were labelled as sample 1, 2, and 3. Then the samples were transported to the laboratory as earlier as possible.

2.3. PHYSICO-CHEMICAL PARAMETERS STUDIED

The different physicochemical parameters studied are

1. pH
2. Dissolved Oxygen (DO)
3. Conductivity
4. Total dissolved solids (TDS)

5. Salinity
6. Phosphorous

pH was measured by Digital pH meter and DO (Dissolved Oxygen), conductivity, TDS (Total Dissolved Solid), salinity, phosphorous were measured by Systronics Water Analyser 371.

2.4. BIOLOGICAL PARAMETERS STUDIED

The total phytoplankton and total zooplankton count of the three water bodies were determined by using Sedgwick Rafter cell (SR cell).

2.5. CHEMICALS USED

1. KCl
2. NaCl
3. Vanadate Molybdate reagent
4. Distilled water
5. Lugol's iodine solution
6. Formalin

2.6. PROCEDURES

2.6.1. Measurement of Dissolved Oxygen

This is measured by Systronics Water Analyser 371. First the calibration of the instrument was done by using 7.5 gm KCl solution. For the results, 30ml of water sample was taken in the tube. And readings of the water samples were taken against the calibrated or standard solution.

2.6.2. Measurement of Salinity

This is measured by Systronics Water Analyser 371. First the calibration of the instrument was done by using 10ppt NaCl solution. For the results, 30ml of water sample was taken in the tube. And readings of the water samples were taken against the calibrated or standard solution.

2.6.3. Measurement of Conductivity

This is measured by Systronics Water Analyser 371. First the calibration of the instrument was done by using 0.01N KCl solution. For the results, 30ml of water sample was taken in the tube. And readings of the water samples were taken against the calibrated or standard solution.

2.6.4. Measurement of Phosphorous

This is measured by colorimeter of Systronics Water Analyser 371. For preparing 50ml of sample solution 35ml of water sample was taken in a conical flask. And to it 10ml of Vanadate Molybdate reagent and 5ml of distilled water were added and mixed then kept it for 10 minutes. For the results, 10ml of sample solution was taken in a tube. And readings of the water samples were taken by using blue filter with spectral range 380-480nm.

2.6.5. Measurement of pH

This is measured by Digital pH meter. First water sample was taken in a beaker. Then Digital pH meter was dipped and readings of the water sample were taken.

2.6.6. Measurement of Total Dissolved Solid

This is measured by Systronics Water Analyser 371. First the calibration of the instrument was done by using 0.01N KCl solution. For the results, 30ml of water sample was taken in the tube. And readings of the water samples were taken against the calibrated or standard solution.

2.6.7. Counting of Total Phytoplankton

Water sample was taken and to it Lugol's solution was added in the ratio of 10ml/1litre of sample and mixed. From this, 2ml of solution was taken in SR cell. Then this SR cell was kept under microscope and phytoplanktons were counted.

The total phytoplankton count was done by using the following formula:

Total phytoplankton count = $C \times 1000 / L \times D \times W \times S$

Where, C = Number of organism counted

L= Length of each strip (SR cell length in mm)

D=Depth of a strip (SR cell depth in mm)

W=Width of a strip (Whipplegrid image width in mm)

S=Number of strip counted

The counting was done by Olympus O/C, 10x Compound microscope.

2.6.8. Counting of Total Zooplankton

Water sample was taken and to it 4% Formalin solution was added in the ratio of 40ml/1litre of sample and mixed. From this, 2ml of solution was taken in SR cell. Then this SR cell was kept under microscope and zooplanktons were counted.

The total zooplankton count was done by using the following formula:

Total zooplankton count = $C \times 1000 / L \times D \times W \times S$

Where, C = Number of organism counted

L= Length of each strip (SR cell length in mm)

D=Depth of a strip (SR cell depth in mm)

W=Width of a strip (Whipplegrid image width in mm)

S=Number of strip counted

The counting was done by Olympus O/C, 10x Compound microscope.

2.7. STATISTICAL ANALYSIS

Results obtained were expressed as mean ± S.D. (Standard Deviation). Graphs were drawn using Microsoft Excel.

3. RESULTS

TABLE 1 Values of physico-chemical and biological characteristics of three water bodies studied

Physiochemical and biological characteristics studied	SAMPLE-1	SAMPLE-2	SAMPLE-3
pH	5±0.5	5.7± 0.6	6.1±0.8
Dissolved oxygen (in ppm)	6.8±0.2	8.7±0.2	7.8±0.2
Salinity (in ppt)	0.43±0.01	0.38±0.01	0.37±0.01
Conductivity (in µS)	470±2	491±2.5	586±3.5
Total dissolved solids (in ppm)	236±1.2	247±1.5	296±1.8
Phosphorous (mg/L)	0.053±0.001	0.008±0.001	0.018±0.001
Total phytoplankton count (numbers/ml)	97.22±2.6	138±8.9	92.59±7.5
Total zooplankton count (numbers/ml)	171.29±5.5	74.07±6.5	50.92±5.9

ppm: parts per million
ppt: parts per thousand
µS: micro Siemens
mg/L: milligram per litre
Numbers/ml: numbers per millilitre

3.1. SAMPLE 1 (TABLE 1)

In sample 1, the pH of water was found to be 5±0.5. The Dissolved Oxygen and Total Dissolved Solid in this sample were 6.8±0.2ppm and 236±1.2ppm, respectively. Salinity was 0.43±0.01ppt. Conductivity of this pond was 470±2µS. The phosphorous level was 0.053±0.001mg/L. Total phytoplankton and zooplankton count were found to be 97.22±2.6 Numbers/ml and 171.29±5.5 Numbers/ml, respectively.

3.2. SAMPLE 2 (TABLE 1)

In sample 2, the pH of water was found to be 5.7±0.6. The Dissolved Oxygen and Total Dissolved Solid in this sample were 8.7±0.2ppm and 247±1.5ppm, respectively. Salinity was 0.38±0.01ppt. Conductivity of this pond was 491±2.5µS. The phosphorous level was 0.008±0.001mg/L. Total phytoplankton and zooplankton count were found to be 138±8.9 Numbers/ml and 74.07±6.5 Numbers/ml, respectively.

3.3. SAMPLE 3 (TABLE 1)

In sample 3, the pH of water was found to be 6.1±0.8. The Dissolved Oxygen and Total Dissolved Solid in this sample were 7.8±0.2ppm and 296±1.8ppm, respectively. Salinity was 0.37±0.01ppt. Conductivity of this pond was 586±3.5µS. The phosphorous level was 0.018±0.001mg/L. Total phytoplankton and zooplankton count were found to be 92.59±7.5 Numbers/ml and 50.92±5.9 Numbers/ml, respectively.

3.4. COMPARATIVE ANALYSIS

pH of sample 3 was highest of 6.1 among the three. Sample 1had the lowest pH of 5 (Figure 1).

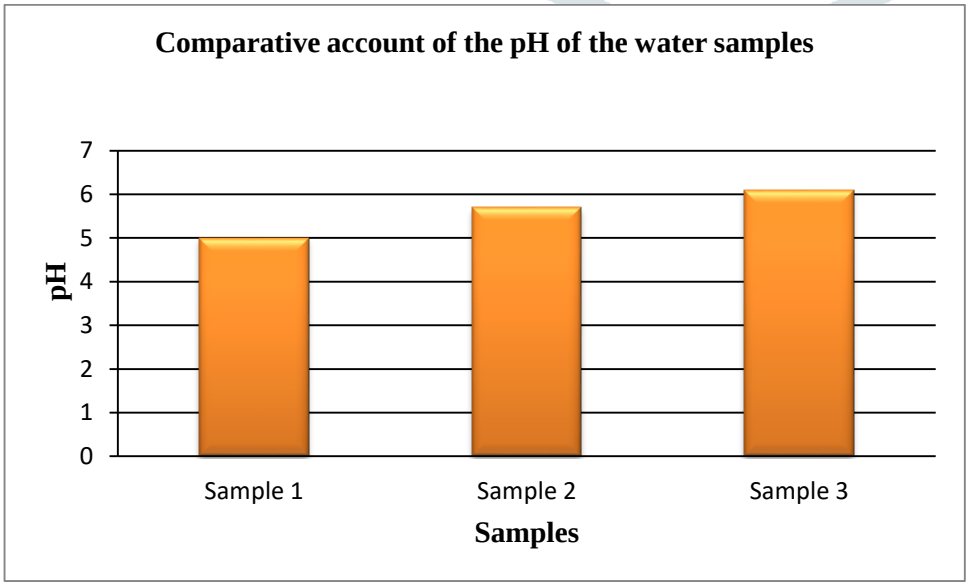

Fig.1 Comparative account of the pH of three water samples

Dissolved Oxygen of sample 2 was highest of 8.7ppm among the three. Sample 1 had the lowest Dissolved Oxygen of 6.8ppm (Figure 2).

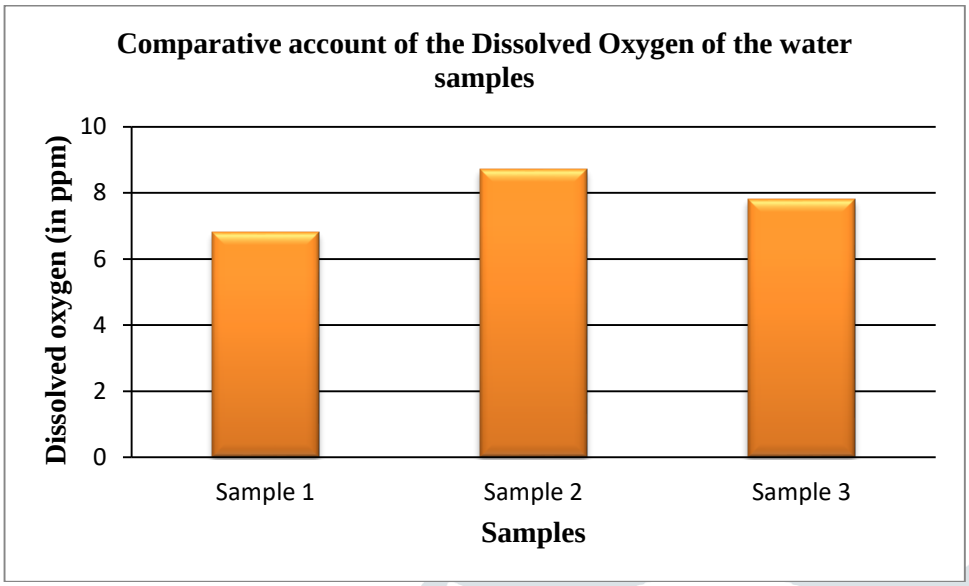

Fig. 2 Comparative account of the Dissolved Oxygen of three water samples

Salinity of sample 1 was highest of 0.43ppt among the three. Sample 3 had the lowest Salinity of 0.37ppt (Figure 3).

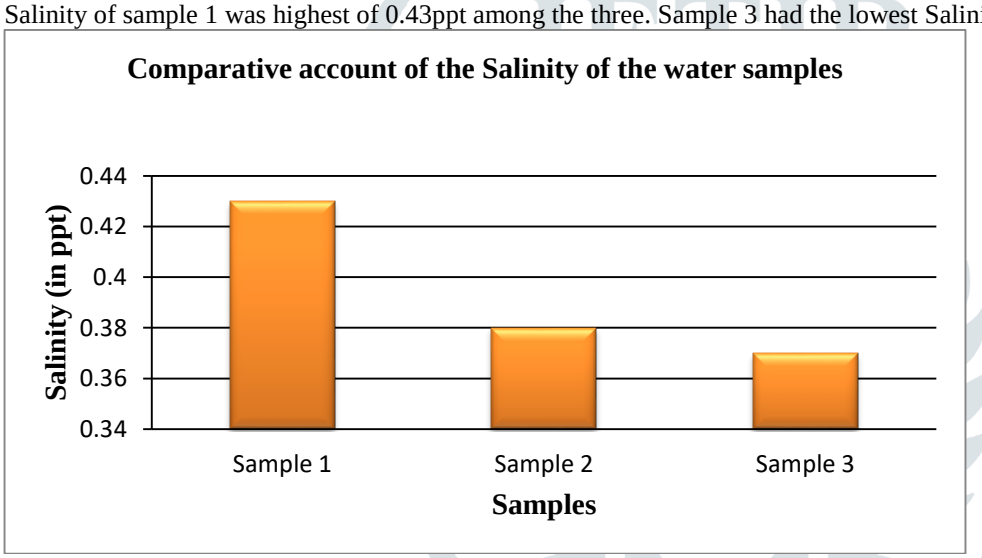

Fig. 3 Comparative account of the Salinity of three water samples

Conductivity of sample 3 was highest of 586µS among the three. Sample 1 had the lowest Conductivity of 470µS (Figure 4).

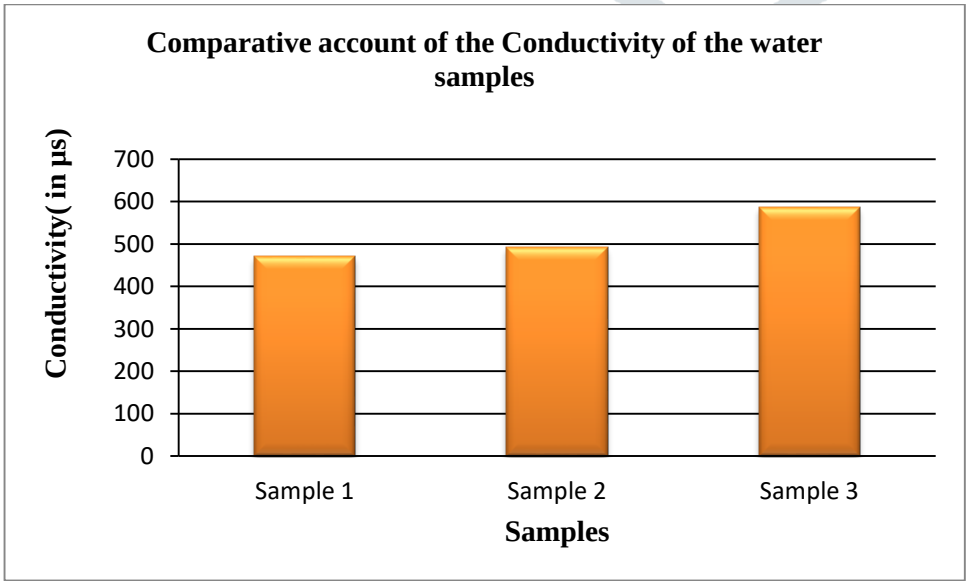

Fig. 4 Comparative account of the Conductivity of three water samples

TDS of sample 3 was highest of 296ppm among the three. Sample 1 had the lowest TDS of 236ppm (Figure 5).

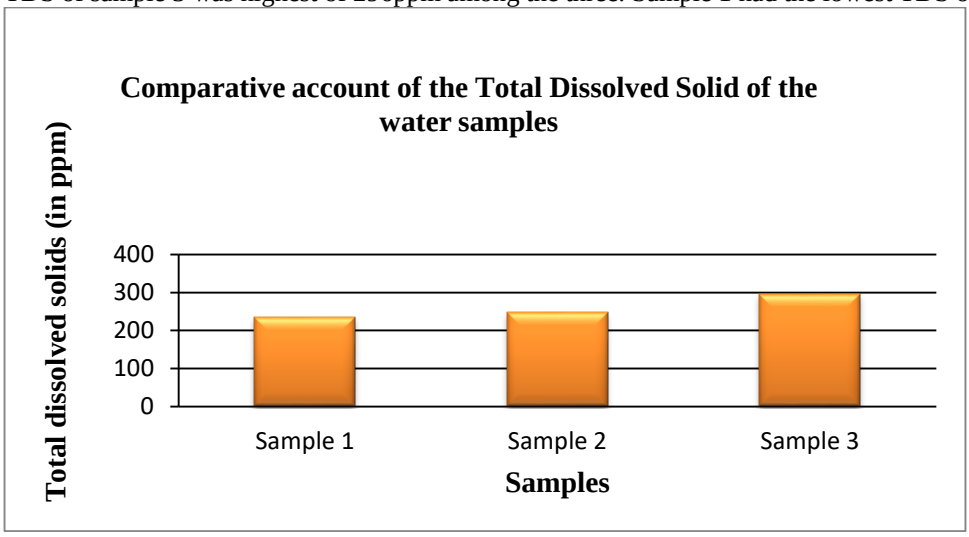

Fig. 5 Comparative account of the Total Dissolved Solid of three water samples

Phosphorous of sample 1 was highest of 0.053mg/L among the three. Sample 2 had the lowest Salinity of 0.008mg/L (Figure 6).

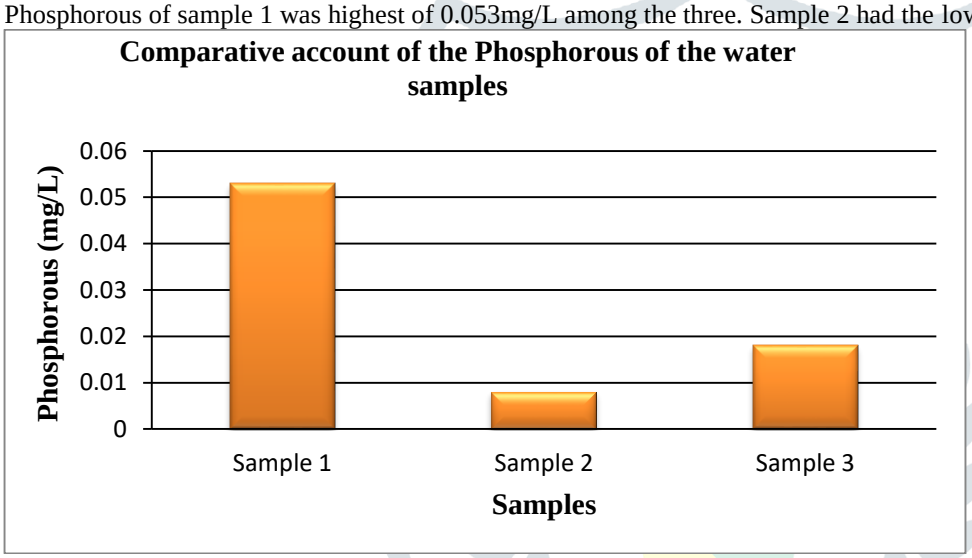

Fig. 6 Comparative account of the Phosphorous of three water samples

Phytoplankton of sample 2 was highest of 138Numbers/ml among the three. Sample 3 had the lowest Phytoplankton of 92.59Numbers/ml (Figure 7).

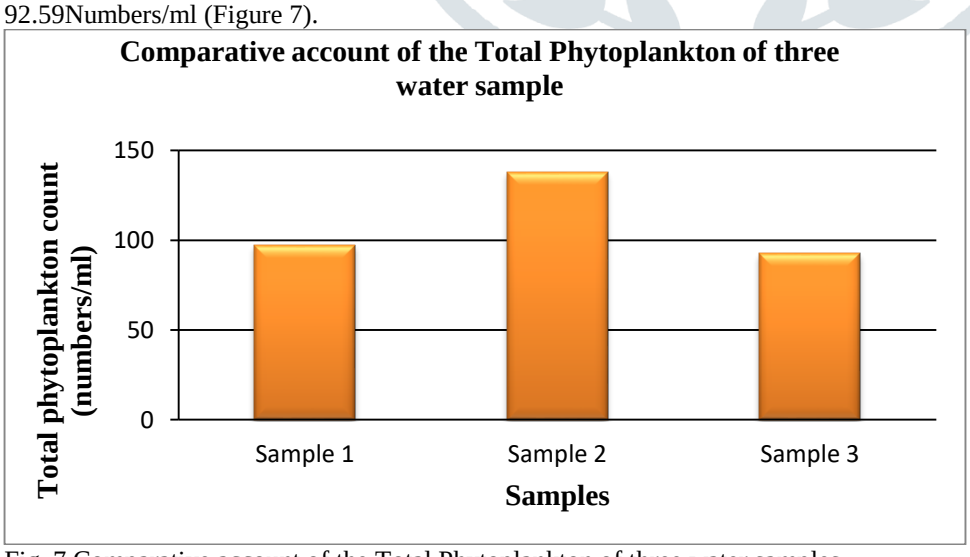

Fig. 7 Comparative account of the Total Phytoplankton of three water samples

Zooplankton of sample 1 was highest of 171.29Numbers/ml among the three. Sample 3 had the lowest Zooplankton of 50.92Numbers/ml (Figure 8).

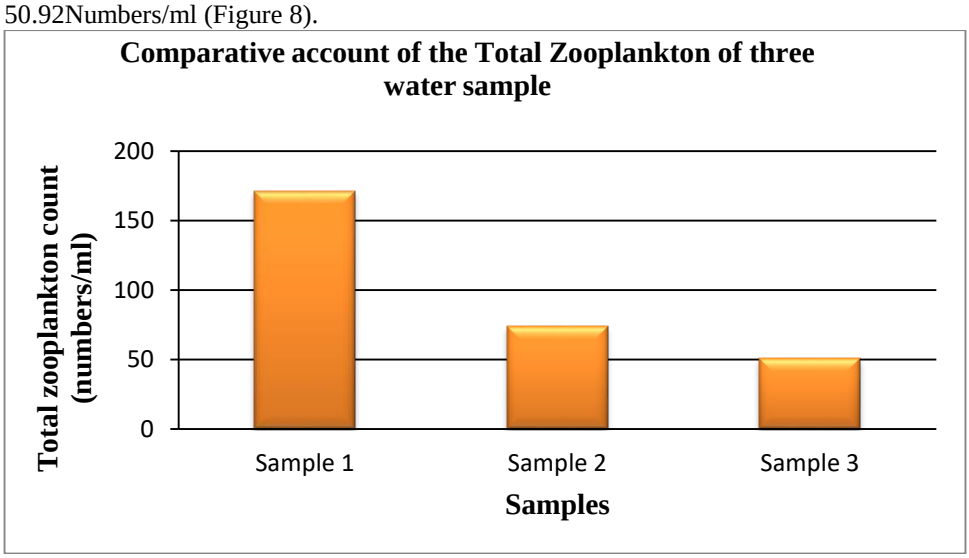

Fig. 8 Comparative account of the Total Zooplankton of three water samples

DISCUSSION

Water analysis was done for three religious lentic water bodies in the village Arisandha, in Puri district of Odisha. These water bodies are very important in terms of their religious value. In all the cases water quality is affected due to higher level of human activities. Studies have been carried out to evaluate the impact of mass bathing and religious activities on similar water bodies **(Vyas *et al.*, 2007; Bhatnagar and Sangwan, 2009; Gupta *et al.*, 2011).** The water bodies studied here are good breeding place for frogs and other aquatic plants and animals. These data will serve as reference point when assessing changes caused by nature or man overtime in the water bodies. Such data will be of high importance for better management and environmental impact assessment for these water bodies.

Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms **(Solis, 1988).** The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones, due to low solubility of oxygen in water and solubility decreases with factors like- increase in temperature; increase in salinity, low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly **(Bhatnagar and Garg, 2000).** DO (Dissolved Oxygen) between 3.0-5.0 ppm is unproductive and for average or good production it should be above 5.0 ppm **(Banerjee, 1967).** It may be incidentally mentioned that very high concentration of DO (Dissolved Oxygen) leading to a state of super saturation sometimes becomes lethal to fish fry during the rearing of spawn in nursery ponds **(Alikunhi *et al.*, 1952).** In the present study DO (Dissolved Oxygen) level of three lentic water bodies are 7.8ppm (sample 3), 6.8ppm (sample 1) and 8.7ppm (sample 2) which are suitable for the aquatic resources.

The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas **(Boyd, 1979).** Fish have an average blood pH of 7.4, a little deviation from this value, generally in between 7.0 to 8.5 is more optimum and conducive to fish life. pH between 7 to 8.5 is ideal for biological productivity , fishes can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0 and death is almost certain at a pH of less than 4.0 or greater than 11.0 **(Ekubo and Abowei, 2011).** In the present study pH level of three lentic water bodies are 6.1(sample 3), 5.0 (sample 1), 5.7 (sample 2) which are not suitable for aquatic organisms particularly fish. This acidic water is also not suitable for domestic purpose.

Salinity is defined as the total concentration of electrically charged ions (cations – Ca^{++}, Mg^{++}, K^{+}, Na^{+} ; anions – CO_3^{-}, HCO_3^{-}, SO_4^{-} , Cl^{-} and other components such as NO_3^{-}, NH_4^{+} and PO_4^{-}). Salinity is a major driving factor that affects the density and growth of aquatic organisms' population **(Jamabo, 2008).** Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in its bloodstream through the movement of salts and water across their gill membranes. Desirable range for common carp is 2 ppt **(Garg and Bhatnagar, 1996),** 10 ppt for *Mugil cephalus* **(Barman *et al.* 2005)** and suggested 25 ppt for *Chanos chanos* **(Garg *et al.* 2003).** In this study salinity of three water bodies are 0.37ppt (sample 3), 0.43ppt (sample 1), and 0.38ppt (sample 2).

Conductivity is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water **(Ogbeibu and Victor, 1995).** Conductivity can be used as indicator of primary production (chemical richness) and thus fish production. Conductivity of water depends on its ionic concentration (Ca_2^{+}, Mg_2^{+}, HCO_3^{-}, CO_3^{-}, NO_3^{-} and PO_4^{-}), temperature and on variations of dissolved solids. Distilled water has a conductivity of about 1 µ mhos/cm and natural waters have conductivity of 20-1500 µ mhos/cm **(Abowei, 2010).** Conductivity of freshwater varies between 50 to 1500 µs/cm **(Boyd, 1979),** but in some polluted waters it may reach 10,000 µs/cm and seawater has conductivity around 35,000 µs/cm and above. It has been recommended that for pond fish culture the desirable range is 100-2,000 mS/cm and acceptable range 30-5,000 mS/cm **(Stone and Thomforde, 2004).** In my present study conductivity of three water bodies are 586 µS (sample 3), 470µS (sample 1), and 491µS (sample 2).

Electrical Conductivity is also the measure of the water quality parameter "Total Dissolved Solids" (TDS) or salinity. At about 0.3 S/m is the point at which the health of some crops and fresh water aquatic organisms will to be affected by the salinity. In the current study TDS (Total Dissolved Solids) level of the three water bodies are 296ppm (sample 3), 236ppm (sample 1), and 247ppm (sample 2).

Almost all of the phosphorus (P) present in water is in the form of phosphate (PO_4) and in the surface water mainly present as bound to living or dead particulate matter and in the soil is found as insoluble $Ca_3(P0_4)_2$ and adsorbed phosphates on colloids except under highly acid conditions. It is an essential plant nutrient as it is often in limited supply and stimulates plant (algae) growth and its role for increasing the aquatic productivity is well recognized. Soil phosphorus (unit- mg of P_2O_5 per 100gm of soil) level below 3 might be considered indicative of poor production, between 3 and 6 of average production and ponds having available phosphorus above 6 are productive **(Banerjee, 1967).** The phosphate level of 0.06 mgL^{-1} is suitable for fish culture **(Stone and Thomforde 2004).** It has been suggested that 0.05-0.07 ppm is optimum and productive; 1.0 ppm is good for plankton/shrimp production **(Bhatnagar *et al.* 2004).** In my present study Phosphorus of three water bodies are 0.018mg/l (sample 3), 0.053mg/l (sample 1), and 0.0085mg/l (sample 2).

Those aquatic pelagic organisms, which are carried about by the movement of the water rather than their own ability to swim are called planktons. The plant components are called as phytoplankton and animal components as zooplanktons and they serve as fish food organisms for enumeration they are collected using plankton net. As plankton is at the base of the food web, there is a close relationship between plankton abundance and fish production **(Smith and Swingle, 1938).** The optimum plankton population has been suggested to be approximately 3000-4500 per litre, in fish culture ponds **(Bhatnagar and Singh 2010).** In the present study phytoplankton of three water bodies are 92.59no./ml (sample 3), 97.22no./ml (sample 1), 138no./ml (sample 2). And zooplanktons of three water bodies are 50.92no./ml (sample 3), 171.29no./ml (sample 1), and 74.07no./ml (sample 2).

CONCLUSION

Because of over population, rapid urbanization, industrialization, and modern agricultural and man-made activities, the quality of water bodies are deteriorating **(Bhadja and Vaghela, 2013).** In the present study it was found that most of the physico-chemical parameters analysed were beyond the standard permissible limits. In sample 3 and 1 the threat to the productivity was found mostly due to cultural eutrophication. Though religious activities cannot be stopped but the people can be made aware of the situation. As the interaction of both the physical and chemical properties of water play a significant role in the composition, distribution and abundance of aquatic organism, this study will help in the effective utilization and sustainable exploitation of the large aquatic resource that abound in the these three water bodies studied.

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