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Environmental Impact of Cage Culture on Poondi Reservoir, Tamil Nadu

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ABSTRACT

The present investigation was carried out in Poondi reservoir, Tamil Nadu, for a period of 8 months from September, 2014 to April, 2015 where the cage culture has been already initiated by the state fisheries department. The water and sediment samples were collected from the reservoir at point and non- point sources of the cage culture units and were analyzed for their physico-chemical parameters. The total microbial load, *E. coli* and feacal streptococci population were also assessed from the reservoir. During the study period, pH, sulphate, nitrate and BOD values were found within the permissible range for drinking water quality. The alkalinity values were found optimum in the reservoir water. The sediment characteristics such as pH, electrical conductivity, total organic carbon and available phosphorus values were also found to be within the standard limit. The optimum water and sediment quality characteristics and the absence of *E. coli* and feacal streptococci observed in the cage culture unit clearly showed that the small cage farming in the reservoir does not have major environmental impacts on the water and sediment quality.

Key words: Cage culture, water quality, sediment quality, microbial load, environmental impact.

INTRODUCTION

Cage culture is commonly practiced worldwide in both freshwater and marine environments, including open ocean, estuaries, lakes, ponds and reservoirs[1,2]. Cage cultured fish are entirely dependent on formulated diets[3]. Relatively small portion of the organic matter and inorganic nutrients in feed applied to cages is transformed to fish biomass. It is estimated that for every ton of fish production in cage culture, 132.5 kg of nitrogen and 25.0 kg of phosphorus are released into the environment[4]. This nutrient availability is usually as a result of wastes of cage culture, consisting of uneaten food and faecal and urinary products, which are released directly into the environment. This could result in environmental problems such as eutrophication, alterations in fish growth and changes in benthos. The ability of the environment to assimilate or decompose the nutrients varies greatly according to local conditions of depth, hydrography, water exchange and sediment type. The intensive system may be harmful to the water quality, given limitations in the capacity to neutralize the metabolites, CO_2 and ammonia released by the fish as well as the excess of fish rations[5]. Furthermore for tilapia cage culture it was reported that 81 -90 % of carbon is lost from the cages to the surrounding environment[6]. For a reservoir where there is not much exchange of water, accumulation of these wastes potentially results in water quality deterioration such as eutrophication and anoxic water as reported in lake Cirata in Indonesia[7].

Several studies have reported that nitrogen and phosphorous released from fish cage can affect chemical parameters of sediment[8,9,10]. Extensive studies on the ecological aspects and fisheries of certain reservoirs in Tamilnadu such as Mettur, Bhavanisagar, Sathanur, Aliyar and Thirmoorthy have already been made by several workers[11, 12, 13, 14]. However, the environmental impact of cage culture is often ignored and rarely subjected to study. There are no reports directly on the environmental impact of cage culture on the water quality of reservoirs of Tamilnadu.

MATERIALS AND METHODS

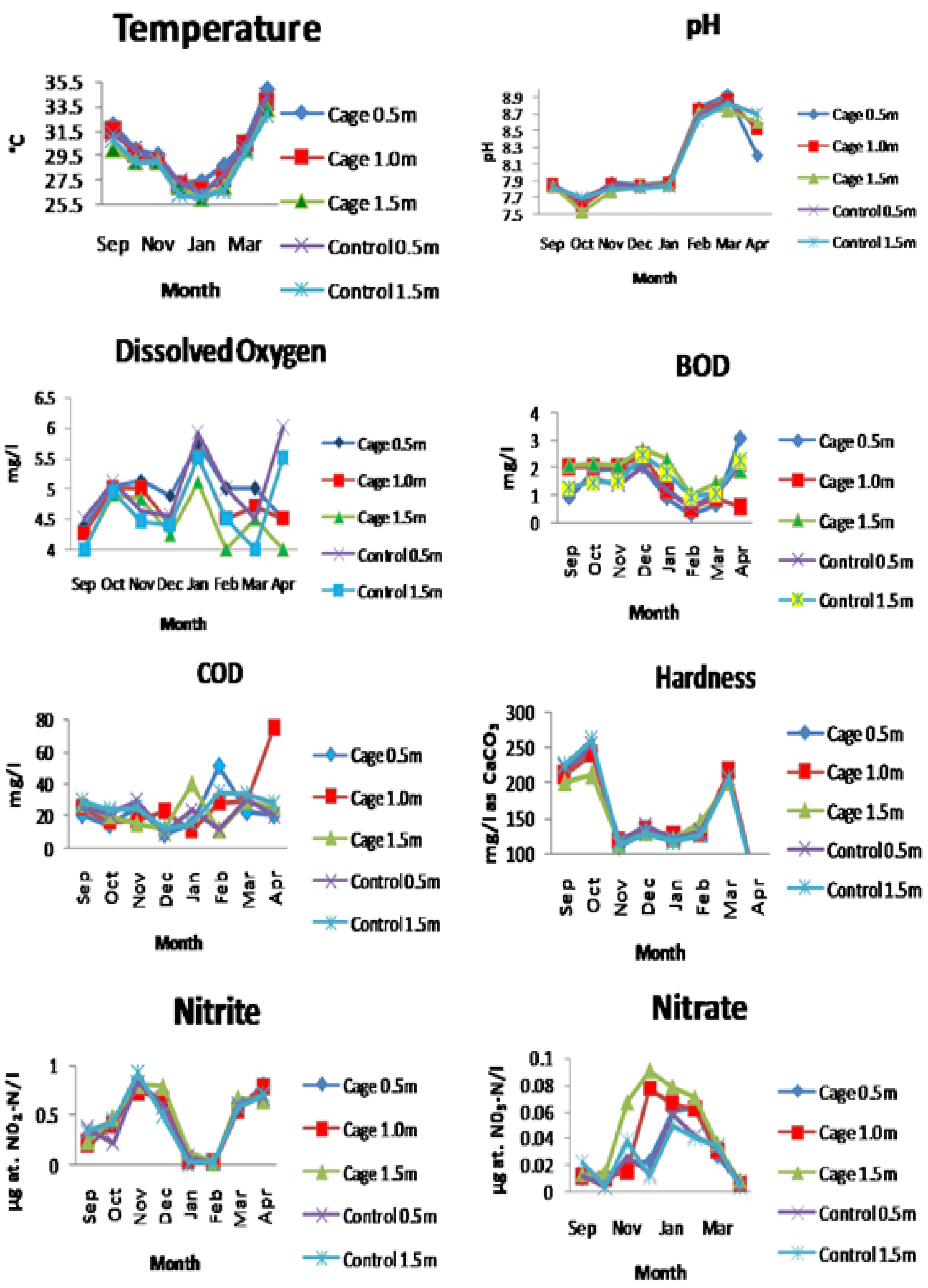
The present investigation was carried out at Poondi Reservoir. The water and sediment samples were collected once in a fortnight from cage site (point source) at 0.5 m, 1.0 m and 1.5 m depth and control site (non- point source) at 0.5 m and 1.5 m depth. The water samples were collected in clean plastic containers without any air bubbles and labeled in the field. The sediment samples were collected with the help of snapper and brought to the laboratory in the polythene bags. The sediment samples were oven dried at 60°C for 24 h and ground well and subjected for analysis. Water quality parameters such as dissolved oxygen, temperature, pH, salinity, alkalinity, hardness, total suspended solids, total dissolved solids, ammonia-N, nitrate-N, nitrite-N, phosphate-P, BOD, COD and sulphate were analyzed as per the procedures of APHA (1995). The sedimentary organic carbon was analyzed by chromic acid oxidization method[15]. The sedimentary total nitrogen was estimated by K-Jeldahl method. The total *E. coli* and feacal streptococci population were analysed once in a month from the reservoir.

RESULTS AND DISCUSSION

Water quality parameters are of much importance in fish culture system for the good growth of fishes, especially in the case of cage culture system under controlled condition. The dissolved oxygen content of the reservoir water was found optimum in both at cage site (4.00 to 5.73 mg/l) and control sites (4.00 to 6.00 mg/l) (Figure 1). Water temperature plays an important role in creating layers of different densities in water column during thermal stratification which results in the uneven distribution of nutrients and dissolved gases[16, 17]. The water temperature of the reservoir ranged from 26 to 34.9°C at cage sites and the maximum temperature was observed during summer months. The temperature ranged from 24.5 to 30.2°C in Odathurai reservoir of Erode district, Tamil Nadu[18]. The pH values ranged from 7.53 to 8.94 at the cage site with an average value of 8.13. The observed values were within the desirable limit from 6.5 to 8.5 as recommend by Bureau of Indian standards[19]. The total alkalinity may be used as the tool for the measurement of productivity. In the present study the alkalinity ranged between 14 and 160 mg/l. There was no significant difference in the alkalinity values observed at cage site with respect to their control sites in the reservoir. The higher alkalinity values in summer season may be due to photosynthetic rate[20]. The alkalinity values of Indian reservoirs ranged between 40 and 240 mg/l[21]. In the present study, the minimum hardness value of 49.04 mg/l as $CaCO_3$ was found at the control site at 1.5 m depth and the maximum hardness value of 260.26 mg/l as $CaCO_3$ was observed at control site, indicating higher concentration of calcium and magnesium in the lake water. However, the hardness values were below the desirable limit of 300 mg/l as $CaCO_3$ as recommended by BIS (Bureau of Indian Standards)[19]. The reservoir water could be grouped under moderately hard category.

Sulphate concentration in the reservoir ranged from 0.0011 to 1.2340 mg/l. The level of sulphate was higher in cage site when it compared to control site in the reservoir, however, these values were found within the permissible range for drinking water quality[19]. The sulphate content of Ramsagar reservoir ranged from 1.50 to 8.87 mg/l[22]. The values of BOD provide information regarding quality of water and helps in deciding the suitability of water for consumption. The range of BOD and COD values was 0.3 to 3.05 mg/l and 8.0 to 75.0 mg/l respectively. Similarly BOD value was reported in Ramsagar reservoir, India[22]. The maximum BOD value was noticed in cage site at 1.0 m, which indicates the higher organic load.

Ammonia is the prime source of nitrogenous waste from excretion of fish and decomposition of plant, uneaten feed is converted to ammonia by bacteria. Due to exhaustive aquaculture activities, the primary source of ammonia is fish feeds[23]. The higher ammonia concentration of 1.1800 µg.at.NH_3-N/l was observed at 1.5m depth in the cage site. Nitrite concentration of Nova Avanhandava reservoir ranged from 2.69 to 3.49 µg/l[24]. The maximum and minimum nitrite value of 0.9285 µg.at.NO_2-N/l and 0.0080 µg.at.NO_2-N/l were noticed in the control site at 1.5 m depth. Nitrate values ranged from 0.0035 to 0.0912 µg.at.NO_3-N/l in the cage and control site.


Temperature
°C
35.5
33.5
31.5
29.5
27.5
25.5
Sep Nov Jan Mar
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
pH
pH
8.9
8.7
8.5
8.3
8.1
7.9
7.7
7.5
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
Dissolved Oxygen
mg/l
6.5
6
5.5
5
4.5
4
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
BOD
mg/l
4
3
2
1
0
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
COD
mg/l
80
60
40
20
0
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
Hardness
mg/l as CaCO3
300
250
200
150
100
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
Nitrite
µg at. NO2-N/l
1
0.5
0
Sep Oct Nov Dec Jan Feb Mar Apr
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m
Nitrate
µg at. NO3-N/l
0.1
0.08
0.06
0.04
0.02
0
Sep Nov Jan Mar
Month
Cage 0.5m
Cage 1.0m
Cage 1.5m
Control 0.5m
Control 1.5m

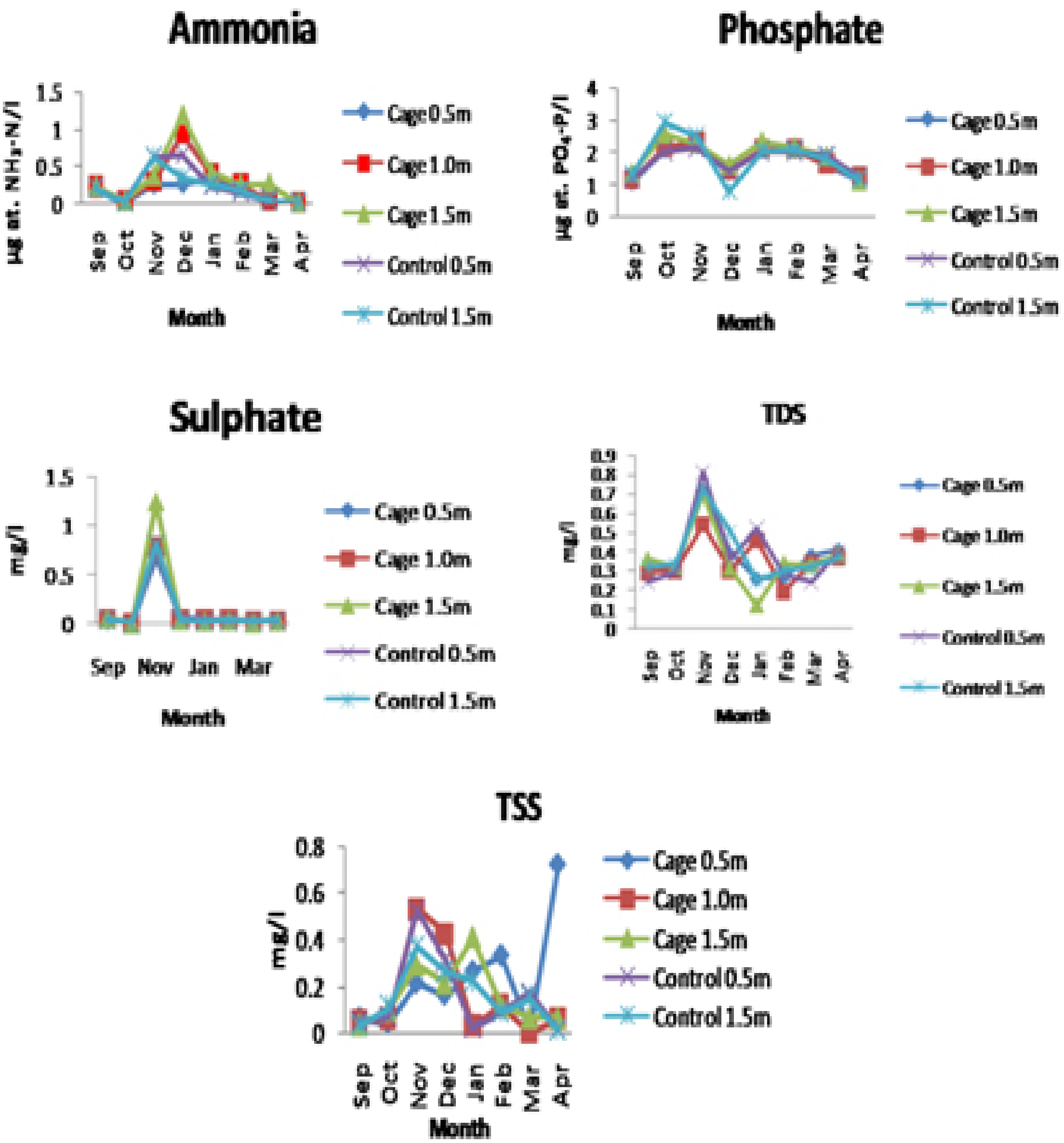


Fig. 1: Monthly variations in water quality parameters

Similar nitrate level was determined in the Ramsagar reservoir, which was ranging from 0.011 to 0.033 mg/l[22]. The organic nitrogen fractions such as ammonia –N and nitrate –N values found slightly maximum at cage site than the control site in the present study.

Phosphorus is considered as an important element limiting algal growth. Reservoir with phosphorous concentration between 30 and 100 µg/l are categorized under Eu – polytrophic. In the present study, phosphate concentration ranged from 0.7798 to 2.9173 µg.at. PO_4-P/l. The availability of phosphate is of a very low order and rarely exceeds 0.1 mg/l in Indian reservoirs, except for a shorter period during the monsoon[22]. The one way ANOVA performed with water quality parameters showed no significant difference between cage and control sites in Poondi reservoir ($P< 0.05$).

Sediment quality

The sediment quality characteristics such as pH, electrical conductivity, total organic carbon and available phosphorus were analyzed both at cage and control sites of all the four reservoirs. Reservoirs with soil pH ranging from 6.5 to 7.5 (circum neutral pH) are categorized as medium productive ones. Reservoirs with alkaline soil having a pH exceeding 7.5 are considered highly productive and this category includes Poondi reservoir. There is no significant difference in the pH of cage and control sites. The electrical conductivity of the reservoirs ranged from 2.81 to 55.99 mS/cm in the cage site.

It is estimated that more than 70% of organic matter entering into the sediment of the reservoir comes from autochthonous sources and the macrophytes are the major source of organic matter. The total organic carbon of the sediment samples of these reservoirs ranged from 0.47 to 3.33 % and the maximum was found at cage site. Unlike carbon, phosphorous cycle is long and it takes many years for recycling. The available sediment phosphorus ranged from 5.9754 to 29.8524 mg/100g and the

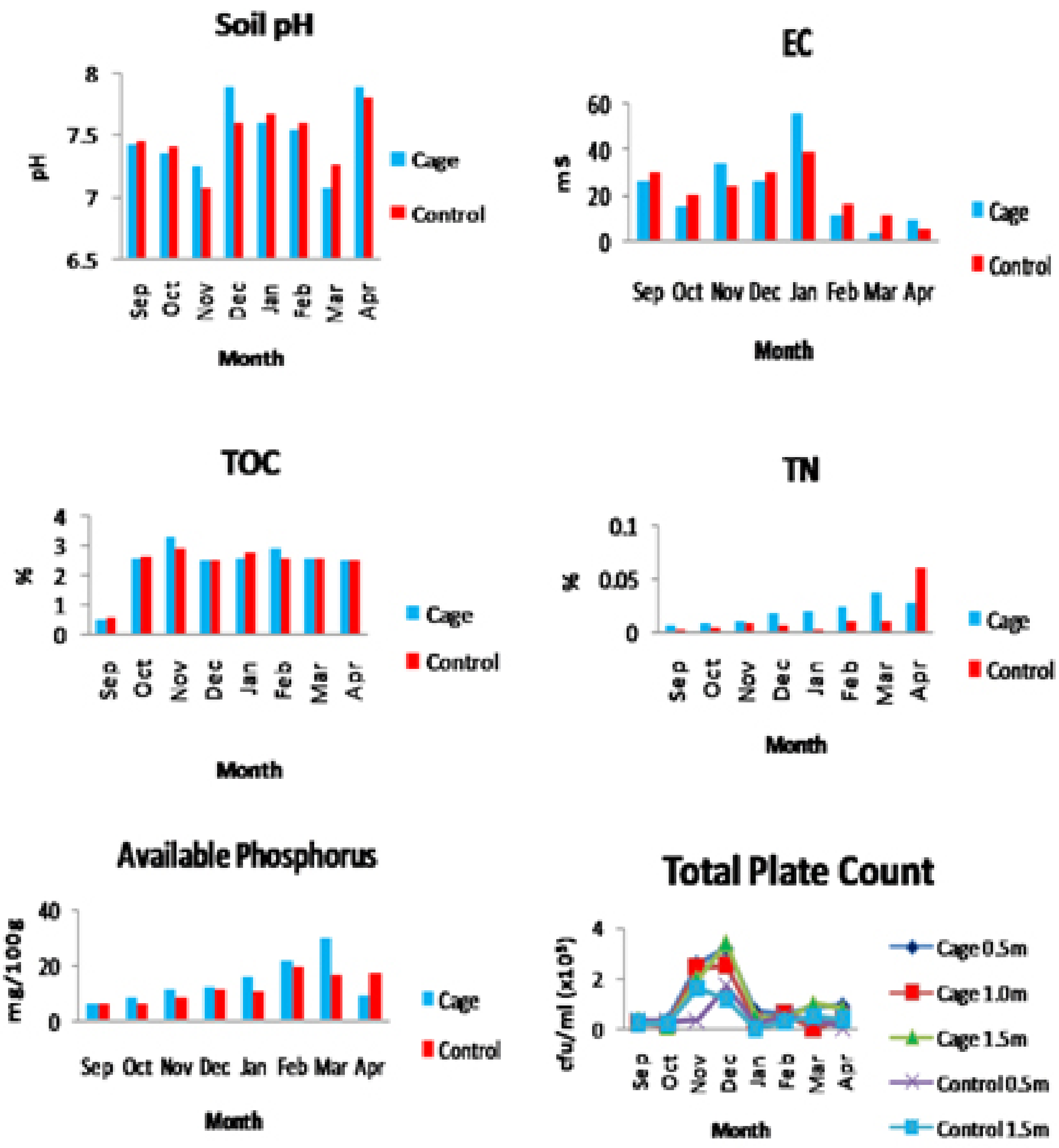


Fig. 2: Monthly variations in sediment characteristics and microbial quality

maximum was observed at cage site. This study clearly reveals that the sediment characteristics were within the desirable limits. The ANOVA results revealed that, pH, electrical conductivity, total organic carbon and available phosphorus of the sediment samples were not statistically significant.

Microbial assessment

The reservoir water is being used for drinking purpose, it is essential to enumerate the microbial load of each reservoir due to cage culture farming. Environment rich in organic matter favour the proliferation of microorganism[25]. The microbial load (TPC) was maximum (3.4 x 10^5 cfu /ml) in the cage site at 1.5m depth, and minimum (0.01x 10^5 cfu/ml) in the cage site at 1.0 depth and also in the control site at 1.5m depth (Figure 2). *E. coli* and feacal streptococci count were nil throughout the study period, which shows the suitability of water for human consumption.

The overall increase in the nutrient levels like ammonia, nitrite, nitrate and phosphate values were found higher at control site than the cage sites. It is clear that only the mass input of exogenous nutrients may cause negative effect on water quality. The cage culture activity with the minimum number of cages (12 numbers) for short term duration does not have noticeable impact over the water quality at cage sites, but the long term effects are need to be monitored for the sustainability of cage farming. The physico – chemical parameters of all the four reservoir waters were within the desirable limit as recommended by the Bureau of Indian Standards, 105000 [19] for fish culture, irrigation and drinking water. The optimum physico chemical properties of water and sediment in the reservoirs couples with absence of *E. coli* clearly indicates that the small cage farming units do not have major environmental impact on the water and sediment quality of the reservoirs.

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