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Seasonal Influence on Qualitative and Quantitative Water Quality Characteristics of Tisgaon Dam, Aurangabad District, India

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Abstract: Water is one of the most vital components of the earth and covers three-quarters of the earth's surface. A vast region of water on land is saltwater, and solely a small quantity is determined as freshwater. Water is the most quintessential ingredient for dwelling things. Life on earth is in no way feasible, barring water. Water is one of the essential factors of the human environment. The high-quality water is decided with the aid of its physico-chemical factors. Monitoring the physico-chemical parameters of a water physique is imperative for each lengthy and brief period analysis. Estimation of the physicochemical residences of water is beneficial in figuring out the have impact of air pollution on water quality. The water is influenced by way of herbal and synthetic effects, such as the neighborhood climate, irrigation practices, and geology. This study addresses the physic-chemical properties, seasonal fluctuations, correlation coefficients, cluster analysis, and water quality assessment of the Tisgaon Dam in Aurangabad, Maharashtra, India, which were analyzed from January to December 2011. The results showed that conditions of this dam have shown fluctuations of the physico-chemical parameters in different seasons. The quality of the dam's water and the correlation coefficient shows a positive and negative relationship, as well as a significant positive relationship and the negative relationship of these parameters is correlated with the different seasons. The physico-chemical analysis found that dam water is free from pollution and ecologically balanced. Cluster analysis is used to classify variables based on their similarity level.

Keywords: Seasonal variations, Correlation coefficient, Qualitative, Quantitative, Hierarchical cluster analysis, Tisgaon dam

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Introduction

Water is a vital resource for the survival of all living organisms on Earth. It supports a wide variety of aquatic life, from microscopic plankton to large aquatic plants and animals. Natural surface waters, such as rivers and streams, are exposed to various pollutants, including organic and inorganic substances. The quality of freshwater is often assessed through its physico-chemical properties, which are closely linked to the metabolism and overall health of aquatic organisms (Desmukh and Ambore, 2006). Dams serve as important wetlands near human settlements, acting as semi-natural ecosystems that provide standing water. These ecosystems offer numerous benefits, including freshwater supply, regulation of ambient temperature, aquifer recharge, habitat for diverse flora and fauna, and aesthetic value. However, rapid population growth and surrounding development have placed significant stress on freshwater bodies. Overuse, accumulation of waste, and nutrient loading contribute to declining water quality. Water pollution arises from multiple sources, including increasing population, industrial effluents, excessive use of fertilizers in agriculture, and other human activities. Contaminated water is a major cause of waterborne diseases in humans, which can occur through bathing, washing, drinking, or using polluted water for food preparation. Regular monitoring of water quality is therefore essential to prevent health hazards and reduce economic losses caused by water-related diseases. Water pollution remains a critical issue in many developing countries. The primary objective of this study was to assess the water quality of the basin with respect to its physico-chemical properties and evaluate the impact of various anthropogenic and natural factors on the aquatic ecosystem (Manjare *et al*., 2010).

The quantity and quality of water are two closely related aspects. Water quality refers to its physical, chemical, and biological characteristics (Diersing, 2009). A healthy water system is one in which the water quality supports a rich and diverse community of living organisms. The physical and chemical properties of water, along with its biodiversity, are the two main factors needed to maintain a healthy water system. Water contains different amounts of dissolved and suspended substances, and because of this, its physical, chemical, and biological properties vary. The water is influenced by herbal and anthropogenic effects, such as the neighborhood climate, irrigation practices, geology, etc. Estimating the physic-chemical homes of water is beneficial to decide the results of air pollution on water exceptional (Ramachandra *et al*., 2002).Water is a renewable resource, but careless use and poor management of water systems cause serious problems in water availability and quality. Water can become polluted by chemicals or microorganisms and may not be safe for drinking or other uses. In our country, a large amount of water is polluted, and many diseases and infant deaths are caused by water pollution. Water quality is usually judged by its physical and chemical properties. Household and industrial waste released into natural water bodies reduces water quality and leads to eutrophication. The different primary sources of water air pollution are mass baths, landfills, city and rural waste, agricultural runoff, and reliable waste disposal (Tiwana, 1992).

Studying different water parameters is very important to understand the activities of living organisms in aquatic ecosystems. These parameters affect water and sediment conditions and influence the growth and distribution of plants and animals. Therefore, it is necessary to study important water parameters while doing ecological research in aquatic ecosystems. Regular studies help to show whether changes in the ecosystem are good or harmful. In India, many hydrobiological studies have been carried out on traditional water bodies such as temple tanks and village ponds (Naga and Shashikant, 2002; Hiware and Ugale, 2003; Ingole *et al.*, 2009; Shinde *et al*., 2010).

The primary objective of this study was to assess the water quality of the basin with respect to its physico-chemical properties and evaluate the impact of various anthropogenic and natural factors on the aquatic ecosystem (Manjare *et al*., 2010).

Materials and Methods

Water samples were taken for physico-chemical analysis from the Tisgaon Dam, Aurangabad, India (geographic coordination Longitude 75^0 - 15' - 45'' and Latitude. 19^0 - 52 ' – 30''). The samples were collected early in the morning between 8:00 and

Table 1: Seasonal variations in Physico-chemical parameters of Tisgaon dam, (M.S) India (During January - December 2012)

Parameter	Range	Summer	Monsoon	Winter	Average
Atmospheric temperature (0ºC)	20-35	34.60±1.19	26.27±1.05	21.20±1.46	27.35±6.76
DO (mg/l)	6-8	6.85±0.23	5.35±0.62	7.75±0.12	6.65±1.21
BOD (mg/l)	3-6.3	3.44±0.35	6.1±1.01	4.89±1.08	4.81±1.33
COD (mg/l)	7-16	8.40±0.87	15.23±2.30	13.12±1.65	12.25±3.49
Sulphate (mg/l)	9.1-18.5	17.80±1.38	15.70±2.18	12.12±2.03	15.20±2.87
Chloride (mg/l)	18-30.3	29.3±1.34	26.07±2.01	19.75±0.90	25.04±4.85
Nitrate (mg/l)	0.5-1.5	0.6±0.12	1.40±0.50	0.9±0.25	0.96±0.40
Phosphate (mg/l)	0.1-0.6	0.20±0.11	0.59±0.09	0.42±0.20	0.40±0.19

Table 2: Values of correlation coefficient among Physico-Chemical parameters, of Tisgaon dam, (M.S) India (During January - December 2012)

Parameters	A.T.	DO	BOD	COD	Sulphate	Chloride	Nitrate	Phosphate
A.T	1	-0.23	-0.65*	-0.77*	0.95**	0.94**	-0.49	-0.67*
DO		1	-0.57	-0.43	-0.50	-0.53	-0.72*	-0.55
BOD			1	0.98**	-0.41	-0.38	0.98**	0.99**
COD				1	-0.55	-0.52	0.93**	0.98**
Sulphate					1	0.99**	-0.22	-0.43
Chloride						1	-0.19	-0.40
Nitrate							1	0.97**
Phosphate								1

**significant at $p < 0.01$, *significant at $p < 0.05$

11:00 during the first week of each month from January to December 2012. Samples were collected in Acid-washed plastic five-liter containers at a depth of 5 to 10 cm below the water's surface. Separate samples were collected to dissolve oxygen in 250 ml bottles, and the dissolved oxygen was fixed in the field by adding an alkaline solution of iodide azide immediately after collection. The samples were directly analyzed in the laboratory. The physic-chemical properties of the dam water, such as Atmospheric Temperature, COD, BOD, Suphate, Chloride, Nitrate, and Phosphate were determined in summer, monsoon, and winter using the standard methods (Trivedi and Goel 1984; APHA, 2005).

Results and Discussion

The physico-chemical parameters data during various seasons and correlation coefficient data of Tisgaon dam, Aurangabad, India are presented in Tables 1 and 2.

Physico-chemical Characteristic

Atmosphere Temperature

Temperature is a measure of the heat content of a substance and significantly influences the physical and chemical properties of water, as well as the growth, metabolism, and biological activities of aquatic organisms. While pure water temperature may have limited impact due to the thermal tolerance of aquatic life, in polluted waters, temperature can strongly affect dissolved oxygen (DO) levels and biochemical oxygen demand (BOD). Seasonal variations, geographic location, sampling time, and the temperature of incoming wastewater are key factors that determine fluctuations in river water temperature.

The atmospheric temperature values ranged from 20 to 35 °C. The average atmospheric temperature values were maximum in summer 34.60±1.19 °C and minimum during winter 21.20±1.46 °C and average annual mean 27.35±6.76 °C (Table 1). The atmospheric temperature was positively correlated to Sulphate and Chloride while negatively correlated to BOD, COD, and phosphate (Table 2).

In the present study, the temperature values were maximum in summer and minimum in winter. The low temperature measured in winter can be attributed to a high water level, low exposure to sunlight, low atmospheric temperature, and high temperature in summer can be due to low water level, substantial exposure to water:Sun and a clean environment. Similar results were earlier reported by Sharma *et al*. (2007), Narayana *et al*. (2008) and Jawale and Patil (2009) as these investigators have also recorded minimum temperature in the winter season and maximum in summer.

Dissolved oxygen (*DO*)

Dissolved oxygen (DO) is one of the most critical parameters for maintaining river health, as its depletion directly affects aquatic ecosystems. Low DO levels can disrupt ecological balance and enhance the effects of bioaccumulation and biomagnification. The concentration of dissolved oxygen in water is influenced by various physical, chemical, biological, and microbiological processes. DO is essential for the survival of aquatic organisms and plays a key role in the natural breakdown of pollutants. Adequate dissolved oxygen levels support higher forms of aquatic life and help maintain ecological stability, thereby indicating good water quality.

The dissolved oxygen values ranged from 6 to 8 mg/l. The average Dissolved oxygen values were maximum in winter 7.75±0.12 mg/l and minimum during monsoon (5.35±0.62 mg/l) and average annual mean 6.65±1.21 mg/l (Table 1). Dissolved oxygen was negatively correlated to Nitrate (Table 2).

A high level of dissolved oxygen in winter could increase photosynthesis by phytoplankton and during the post-monsoon to oxygen circulation. A lower value was probably found during the premium zone due to the decomposition of organic substances. Similar results were reported by Chauhan and Sharma (2007) and Ingole *et al*. (2009) who have also observed maximum Dissolved Oxygen during winter and minimum during summer in religious Lake Budha Pushkar, Ajmer, Rajasthan, India.

Biochemical Oxygen Demand (*BOD*)

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen required by aerobic microorganisms to decompose organic matter present in water. It is an important indicator of organic pollution originating from domestic sewage and industrial effluents. The biodegradation of organic substances reduces dissolved oxygen levels in water, thereby increasing BOD. Thus, BOD reflects the oxygen demand exerted by microbial activity during the stabilization and decomposition of organic materials in aquatic systems.

The biochemical oxygen demand values ranged from 3 to 6.3 mg/l. The average biochemical oxygen demand values were maximum in monsoon (6.1±1.01 mg/l) and minimum during summer (3.44±0.35 mg/l) and average annual mean 4.81±1.33 mg/l (Table 1). The biochemical oxygen demand was positively correlated to COD, Nitrate, and Phosphate, while it was negatively correlated to atmospheric temperature as recorded (Table 2).

In the present study, BOD values were highest during the monsoon and lowest during the summer. Higher BOD values in monsoons than in winter and summer may be due to contaminants mixed with rainwater. Similar results were reported by Jayabhaye *et al*. (2008) and Reddy *et al*. (2009).

Chemical Oxygen Demand (*COD*)

Chemical Oxygen Demand (COD) represents the amount of oxygen required to chemically oxidize both biodegradable and non-biodegradable organic substances present in water using a strong oxidizing agent. COD serves as an important indicator of wastewater and industrial pollution and reflects the level of reduced chemical substances in water. It is widely used as an indirect measure of the total organic matter present in water. Therefore, COD is a reliable parameter for assessing organic contamination in surface water bodies.

The chemical oxygen demand values ranged from 7 to 16 mg/l. The average chemical oxygen demand values were maximum in monsoon (15.23±2.30 mg/l) and minimum during summer (8.40±0.87 mg/l) and average annual mean 12.25±3.49 mg/l (Table 1). The chemical oxygen demand was positively correlated to BOD, Nitrate, and Phosphate, while it was negatively correlated to atmospheric temperature (Table 2).

In the present study, the COD values were highest during the monsoon and lowest in summer. The maximum COD values during the monsoon can be due to the mixing of runoffs, which carry sludge, dead, and rotting biomass. On the other hand, the minimal COD in summer was probably due to the deposition of organic matter. Similar results were reported by Ingole *et al*. (2009).

Sulphate

Sulfate is a naturally occurring constituent of drinking water. Health concerns related to sulfate arise when present at high concentrations, as consumption of sulfate-rich water has been associated with gastrointestinal effects, particularly diarrhea. Sulfate concentrations exceeding 250 mg/l impart a bitter or medicinal taste to water, reducing its palatability and suitability for drinking. The sulfate content of natural waters is an important factor in determining their appropriateness for public and industrial water supply. Prolonged exposure to elevated sulfate levels may also lead to adverse health effects in humans.

The Sulphate values were ranged from 9.1 to 18.5 mg/l. The average Sulphate values were maximum in summer (17.80±1.38 mg/l) and minimum during winter (12.12±2.03 mg/l) and average annual mean 15.20±2.87 mg/l (Table 1). The Sulphate was positively correlated to atmospheric temperature (Table 2).

In the present study, sulfate levels were highest during the monsoon and lowest during the winter. The maximum concentration of sulfate during monsoons may be due to dilution and sulphate use by aquatic plants. However, the low concentration of sulfate found in winter could be due to biodegradation and low water levels. Similar results have been reported by Shanthi *et al*. (2006), Telkhade *et al*. (2008) and Reddy *et al*. (2009) who have also observed high value in monsoon.

Chlorides

Chloride occurs naturally in all types of water and is present in most freshwater systems primarily as sodium and calcium salts. It is an essential element for the physiological functions of plants and animals. However, elevated chloride concentrations are often considered indicators of contamination from organic wastes of domestic, municipal, or industrial origin. High chloride levels in water samples may result from the discharge of chloride-rich wastewater from sewer systems and municipal effluents. Excessive chloride concentrations can impart a salty taste to water and beverages, reducing their suitability for drinking.

The chloride values ranged from 18 to 30.3 mg/l. The average chloride values were maximum in summer (29.3±1.34 mg/l) and minimum during winter (19.75±0.90 mg/l) and average annual mean 25.04±4.85 mg/l (Table 1). The chlorides were positively correlated to atmospheric temperature (Table 2).

In the foregoing study, chloride levels were highest in summer and lowest in winter. It can be concluded that there is no defined pattern of chloride fluctuation; a lower value in winter could be attributed to the dilution effect and the renewal of the water after summer stagnation and could also be due to a high sedimentation rate under relatively stable environmental conditions. The maximum value in summer could be due to a higher chloride concentration due to evaporation. Similar results have been reported by Nirmal *et al*. (2005), Chauhan and Sharma (2007), Narayana *et al*. (2008) and Reddy *et al*. (2009) as these investigators have also recorded maximum value of Chloride in May while minimum recorded in August.

Nitrate

Nitrate enters freshwater systems mainly through sewage discharge, industrial effluents, and agricultural runoff. The concentration and loading rate of nitrate are strongly influenced by land-use practices within the surrounding catchment area. In the present study, lower nitrate concentrations were recorded during the monsoon season, while higher values were observed during the summer season. Elevated nitrate levels may result from the influx of nitrogen-rich runoff and increased wastewater discharge. High nitrate and nitrogen concentrations, particularly during the rainy season, promote algal bloom formation (Anderson *et al*., 1998).

The Nitrate values ranged from 0.5 to 1.5 mg/l. The average Nitrate values were maximum in monsoon (1.40±0.50 mg/l) and minimum during summer (0.6±0.12 mg/l) and average annual mean 0.96±0.40 mg/l (Table 1). The Nitrate was positively correlated to BOD, COD, and Phosphate, while it was negatively correlated to DO (Table 2).

In the present study, nitrate levels were highest during the monsoon and lowest during the summer season. Nitrate levels in surface waters often show large seasonal fluctuations, with higher concentrations during the monsoon months than in the summer and winter months. During the summer months, the reduction of nitrates could be due to the absorption of algae and other biochemical mechanisms. A higher level of nitrates during the monsoon could be due to surface runoff and domestic wastewater, particularly to wash. The observations of present study derives support from studies of Gorham, (1961) and Rajashekar *et al*. (2007) who have also recorded similar findings.

Phosphate

Anthropogenic inputs of phosphorus significantly influence river water quality. Phosphate primarily originates from domestic wastewater discharges and agricultural runoff. It is a key nutrient responsible for eutrophication, which promotes excessive algal growth. Phosphate is generally present in low concentrations in natural waters due to rapid uptake by aquatic plants; therefore, elevated phosphate levels indicate contamination and contribute to eutrophic conditions.

The Phosphate values ranged from 0.1 to 0.6 mg/l. The average Phosphate values were maximum in monsoon (0.59±0.09 mg/l) and minimum during summer (0.20±0.11 mg/l) and average annual mean 0.40±0.19 mg/l (Table 1). The Phosphate was positively correlated to BOD, COD, and Nitrate while it was negatively correlated to atmospheric temperature (Table 2).

In this study, chloride levels were highest during monsoons and lowest in summer. The maximum values during the monsoon can be due to washing activities; there is an inflow of detergent into the water body and a smaller amount of water and during the summer season to the relatively low phosphate content, which is due to the abundance of phytoplankton.Similar results have been reported by Chary (2003) and Rao (2004).

Cluster Analysis

Cluster analysis was employed to classify physico-chemical variables based on their degree of similarity. Hierarchical cluster analysis (HCA) is an important multivariate statistical technique used to identify homogeneity and to visualize relationships among measured variables through dendrograms. Dendrograms were constructed using the linkage method, which groups variables based on rescaled distance measures. The primary objective of this analysis was to group water

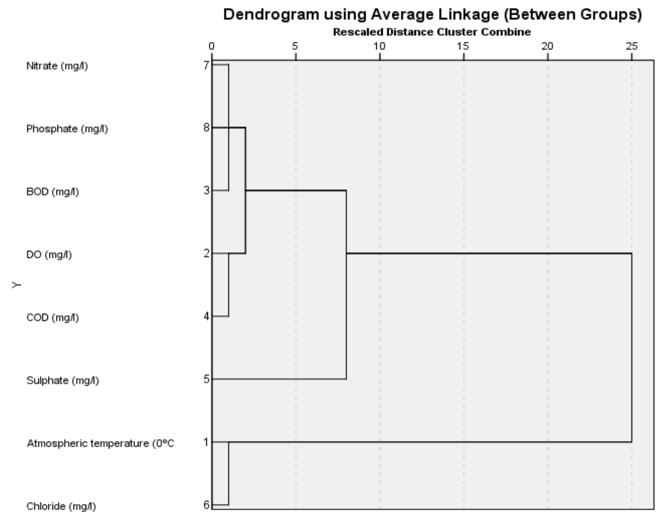

Fig. 1: Dendrogram showing the clustering of various physicochemical parameters in the summer season of Tisgaon dam, (M.S) India (During January - December 2012).

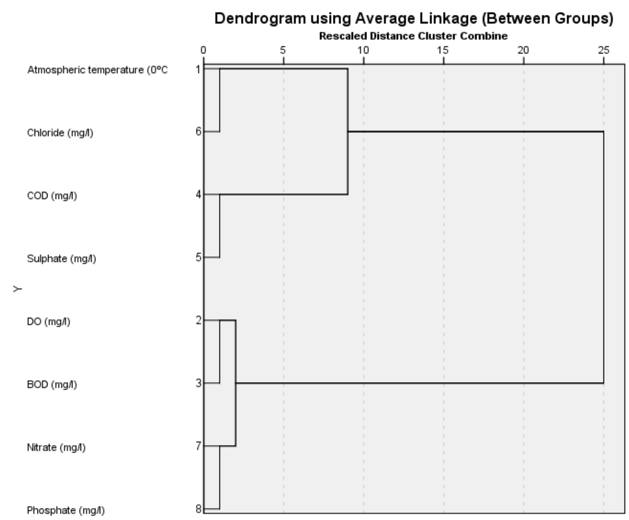

Fig. 2: Dendrogram showing the clustering of various physicochemical parameters in the monsoon season of Tisgaon dam, (M.S) India (During January - December 2012).

quality parameters according to their mutual associations (Shrestha and Kazama, 2007).

The results demonstrated that cluster analysis effectively classified the physico-chemical parameters, providing reliable and meaningful insights into their interrelationships. The dendrograms clearly illustrated the formation of distinct clusters and the relative proximity among the parameters. Hierarchical cluster analysis was performed on eight physico-chemical parameters across different seasons, namely summer, monsoon, and winter, as shown in Figures 1–3.

During the summer season, two distinct clusters were observed. The first cluster consisted of nitrate, phosphate, biochemical oxygen demand (BOD), and dissolved oxygen (DO), indicating strong interrelationships among these parameters. The second cluster included chemical oxygen demand (COD), sulphate, atmospheric temperature, and chloride, which were closely associated with one another (Fig. 1).

Similarly, during the monsoon season, the parameters were grouped into two major clusters. The first cluster comprised atmospheric (room)

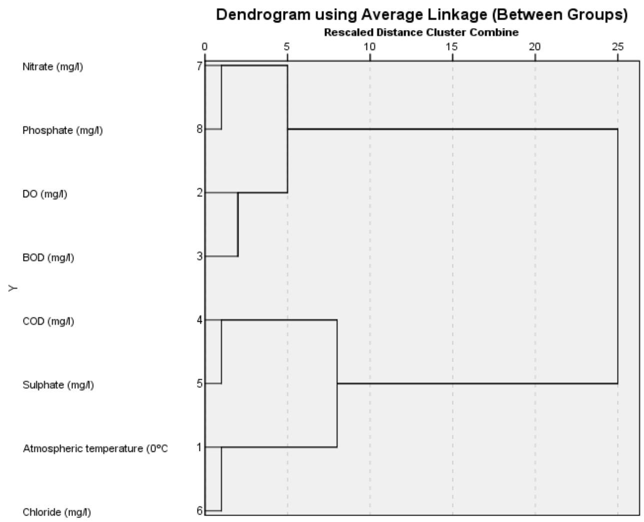

Fig. 3: Dendrogram showing the clustering of various physicochemical parameters in the winter seasonof Tisgaon dam, (M.S) India (During January - December 2012).

temperature, chloride, COD, and sulphate, while the second cluster consisted of DO, BOD, nitrate, and phosphate, reflecting their close association during this season (Fig. 2).

In the winter season, two distinct clusters were also formed. The first cluster included nitrate, phosphate, DO, and BOD, showing strong similarity among these parameters. The second cluster comprised COD, sulphate, atmospheric temperature, and chloride, which exhibited close interrelationships (Fig. 3).

Overall, the cluster analysis revealed consistent seasonal patterns and strong associations among nutrient-related and organic pollution-related parameters, highlighting its usefulness in interpreting seasonal variations and water quality dynamics of the study area.

Conclusion

The present study provides a comprehensive assessment of the physico-chemical characteristics and overall water quality of Tisgaon Dam, Aurangabad District (M.S.), India. The analysis revealed distinct seasonal variations during summer, monsoon, and winter in key parameters such as atmospheric temperature, biochemical oxygen demand (BOD), chemical oxygen demand (COD), sulphate, chloride, nitrate, and phosphate. These seasonal fluctuations reflect natural hydrological and climatic influences on the dam ecosystem.

The observed water quality parameters were found to be within the permissible limits prescribed by the Indian Standards Institution (ISI) and the World Health Organization (WHO), indicating good water quality. The nutrient-rich nature of the dam water supports its suitability for irrigation and fish culture. The absence of industrial activities in the surrounding area suggests that industrial pollution does not contribute to water quality deterioration, while anthropogenic activities remain the primary potential source of pollution. Correlation analysis demonstrated significant positive and negative relationships among various physico-chemical parameters, indicating their interdependence. Cluster analysis further classified the parameters based on their degree of similarity, effectively grouping them according to their associations and shared influences. Overall, the physico-chemical analysis confirms that the water of Tisgaon Dam is unpolluted, ecologically balanced, and suitable for domestic, agricultural, irrigation, and fisheries purposes. However, disturbances in biological and ecological systems may adversely affect humans, aquatic organisms, and wildlife. Therefore, continuous monitoring and effective management practices are essential to maintain water quality and to ensure favorable conditions for fish survival, growth, and reproduction in Tisgaon Dam.

Ethical Statement

No animal or microbes have been used or sacrificed for this study, hence Ethical Approval not required.

Author Contributions

Author has read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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