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Physico-Chemical Properties, Seasonal Variation, and Water Quality Assessment of Tisgaon Dam, Aurangabad, India

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Abstract: Water is an essential natural resource for all living organisms. Water quality (chemical, physical, and biological properties) is important for human consumption, agriculture, fish farming, domestic service, and industrial use. The present study deals with the physico-chemical properties, seasonal variation, correlation coefficient, cluster analysis, and water quality assessment of Tisgaon dam, Aurangabad, Maharashtra, India analyzed from January - December 2011. The results indicated that the condition of dam in different seasons showed fluctuations in physico-chemical parameters. The water quality of dam and the correlation coefficient shows a highly significant positive and negative relationship; and also a significant positive and negative relationship of these parameters are correlated with the different seasons. Correlation coefficients are used to measure the strength of the association between parameters. Cluster analysis is used to classify variables based on their similarity level.

Keywords: Physico-chemical properties, Seasonal variations, Water quality, Correlation coefficient, Hierarchical cluster analysis, Tisgaon dam

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Introduction

Water is an imperative aspect of human existence and a general solvent that can dissolve many elements from organic and inorganic compounds. With this top-notch property, however, it is nearly impossible to have water in its pure form. Water supposed for human consumption should be free fom living and non-living organisms, toxic elements, and chemical substances. The superiorslide of water leads to a collection of adjustments in the physico-chemical houses of water, which have been the problem (Bernard and Ayeni, 2012).

The water supply for the pond can be the river or the quantity of the rain. A lake should be manageable for managed agriculture. Life in aquatic surroundings is generally decided through its physico-chemical properties and its stability. Various adjustments that organisms make in

water are crucial for their existence. Reservoirs, which are a critical phase of the improvement of civilization, have many points that distinguish them from lakes or rivers. Therefore, it is a one-of-a-kind class of floor reservoirs. The water from the dam is no exception; it is uncovered to infection issues that can affect its health and impact each person and animal's mortality. The dam's flooding has induced a range of disruptions in the ecosystem for some time, ranging from enormous ecological and productivity-related changes and the dam administration regime. Floods tend to purpose hydraulic disturbances that decide the composition of the biotic communities in the canal, the riparian zone, and the floodplain. The water storage in reservoirs leads to physical, chemical, and organic modifications in the saved water. Dams affect the upstream and downstream ecosystems. Floods from dams motive the everlasting destruction of terrestrial ecosystems utilizing tides. All land flora and animals disappear from the submerged place (Siciliano *et al*., 2018).
Understanding the chemistry of water is the groundwork for the appreciation of the multidimensional component of the chemistry of the aquatic environment, which consists of the source, composition, reactions, and transport of water. High-quality water is of integral significance for humanity because it is immediately associated with the well-being of people. It is a rely on records that infection of consuming water has triggered the waterborne illness. Physico-chemical parameters are vital for analyzing the water earlier than it is used for drinking, for domestic, agricultural, industrial purposes. Water has to be interpreted with many physico-chemical parameters. The physico-chemical parameter is essential to have a correct thought of the best of the water. Then we examine the outcomes got with the overall values. Evaluating water quality is vital to shield the herbal ecosystem (Patil *et al*., 2012).

One of the best environmental challenges of this century is maintaining the herbal biological, structural, and purposeful environment of aquatic ecosystems, essentially rivers. This goal requires that we understand the kingdom of these dynamic structures and how they are influenced through certain elements and forces. Today, we can, without difficulty, see that the surroundings incorporate many pollutions due to human activities. The destruction of herbal habitats and environmental pollution can affect the ecological stability of any ecosystem. Among the specific ecosystems of the world, the rivers that drift in areas such as agriculture and enterprise are the most uncovered and affected through human activities. Assessment and classification of ecological fine water via index-based procedures can make contributions to river conservation and management. The dimension of the physico-chemical parameters is typically long, expensive, and relies upon one-of-a-kind instruments. However, the physico-chemical parameters can solely point out the satisfaction of the water at the time of dimension, and these can alternate over time. In India, some hydrobiological work on ancient shallow-water bodies like temple reservoir and village ponds have been done (Sharma *et al.,* 2007; Pejaver and Gurav, 2008; Ingole *et al.*, 2009; Shinde *et al*., 2010).

The present study deals with the physico-chemical properties, seasonal variation, correlation coefficient, cluster analysis, and water quality assessment of Tisgaon dam, Aurangabad, Maharashtra, India.

Materials and Methods

The water samples for physico-chemical analysis were collected from Tisgaon dam (Aurangabad, Maharashtra, India) (geographical coordination Longitude 75^0 - 15' - 45'' and Latitude. 19^0 - 52' - 30''), in the morning between 8 am and 11 am in the first week of every month from January to December 2011. The water samples were collected in an acid-washed five-liter plastic container from a depth of 5-10 cms below the water surface.

The physico-chemical characteristics of the dam water like water temperature, turbidity, transparency, pH, conductivity, total solids (TS),

total dissolve solids (TDS), total suspended solids (TSS), total hardness and alkalinity were determined in summer, monsoon and winter according to standard methods (Trivedi and Goel, 1984; APHA, 2005).

Results and Discussion

The season-wise physico-chemical parameter data, correlation coefficient, and cluster analysis data of Tisgaon dam, Aurangabad, India have been presented in Tables 1, 2 and Figures. 1-3.

Physico-Chemical Characteristic

Water Temperature

Temperature affects water's physical and chemical properties, aquatic vegetation, organisms, and their biological activities. Temperature is a physical factor that ages the properties of water and is considered an essential factor in controlling plantation fluctuations and the functioning of the aquatic ecosystem. Temperatures determine the degree of dissociation of dissolved salts in water systems and, to some extent, control the rate of oxidation of organic substances. Temperature and hydrogen ion concentration (pH) are vital factors for certain microbial activities. In an aquatic environment, this regulates the methylation of elements such as lead and mercury in the aquatic environment.

The water temperature values ranged from 17 to 32 ºC. The average water temperature values were maximum in summer 29.80±1.12 ºC and minimum during winter 18.28±1.01 ºC and average annual mean 23.74±5.78 ºC (Table 1). The water temperature was positively correlated to Transparency. pH was negatively correlated to Total solids and Total dissolve solids (Table 2).

The water temperature was consistently lower than the atmospheric temperature. 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, little exposure to sunlight, low atmospheric temperature. High temperature in summer may be due to low water level, intense exposure of water to sun. Similarly, minimum temperature in the winter season and maximum in summer has been reported by Sharma *et al*. (2007); Narayana *et al*. (2008) and Jawale and Patil (2009).

Transparency

The transparency of the water is an essential factor that controls the dynamic relationship at various trophic levels. The transparency of natural waters is an indicator of productivity. The extent to which light can penetrate depends on the transparency of the vertical water column. Also, water clarity is inversely proportional to the turbidity generated by the inorganic and organic substances in suspension.

The transparency values ranged from 9 to 25 cm. The average values were maximum in summer 18.78±3.59 cm and minimum during monsoon 09.20±2.66 cm and average annual mean 13.76±4.80 cm (Table 1). Transparency was positively correlated to water temperature, and alkalinity. In contrast, it was negatively correlated to total solids, total dissolved solids, total suspended Solids, and total hardness (Table 2).

In this study, transparency levels were highest in summer and lowest in monsoons. Low monsoon transparency values can be attributed to rainwater flow from the watershed, cloud cover, less incidence of light, and high turbidity due to inert suspended particles. However, the increased transparency values in summer can be attributed to a bright atmosphere and robust light transmission. The northern location, in particular, showed low transparency values since the exclusive addition of wastewater increased the turbidity and negatively influenced the transparency. Similarly, low values of transparency during monsoon compared to summer and winter has been reported earlier by Yeole and Patil (2005), Kadam *et al*. (2007), and Gaur and Mohan (2009).

pH

pH of a solution refers to its activity of hydrogen ions, expressed as the logarithm of the inverse

Table 1: Seasonal variations in Physico-chemical parameters of Tisgaon dam, (M.S) India (During January - December 2011)

Parameter	Range	Summer	Monsoon	Winter	Average
Water temperature (°C)	17-32	29.80±1.12	23.15±1.75	18.28±1.01	23.74±5.78
Transparency (cm)	9-25	18.78±3.59	09.20±2.66	13.30±2.37	13.76±4.80
pH	7.3-8.5	8.27±0.25	8.10±0.02	7.09±0.03	7.82±0.63
Total solids (mg/l)	320-460	350.10±48.60	445.23±18.04	440.83±13.25	412.05±53.69
Total dissolve solids (mg/l)	220-360	287.97±41.80	339.67±17.05	337.01±12.06	321.55±29.11
Total Suspended solids (mg/l)	8.5-12.9	9.30±0.31	12.14±0.87	10.25±1.08	10.56±1.44
Alkalinity (mg/l)	170-220.5	202.25±11.05	178.47±5.45	191.05±8.10	190.59±11.89
Total Hardness (mg/l)	200-400	230.17±23.08	386.25±12.10	312.97±40.05	309.79±78.08

Table 2: Values of correlation coefficient among Physico-Chemical parameters, of Tisgaon dam, (M.S) India (During January - December 2011)

Parameters	W.T.	Trans.	pH	TS	TDS	TSS	Alk.	TH
Water temperature	1	0.64*	0.88**	-0.88**	-0.88**	-0.41	0.54	-0.60
Transparency		1	0.21	-0.92**	-0.92**	-0.96**	0.99**	-0.99**
pH			1	-0.57	-0.57	0.05	0.09	-0.16
Total solids				1	0.99**	0.78*	-0.86**	0.90**
Total dissolve solids					1	0.78*	-0.87**	0.90**
Total Suspended solids						1	-0.98**	0.97**
Alkalinity							1	-0.99**
Total Hardness								1

** $p < 0.01$; * $p < 0.05$

movement of hydrogen ion by a specific temperature. pH is measured on scales from 0 to 14. A pH of 7 is neutral; A pH below 7 is acidic, and a pH above 7 indicates essential saturation or alkalinity. The influence of pH on the chemical and biological properties of liquids makes its determination very important.

In this study the pH values ranged from 7.3 to 8.5. The average values were maximum in summer (8.27±0.25) and minimum during winter (7.09±0.03) and average annual mean 7.82±0.63 (Table 1). The pH was positively correlated to water temperature (Table 2).

In the present study, the pH values were maximum in summer and minimum during monsoons. In the present study, the pH range showed that the water at all lake sampling points was highly alkaline in the summer. High summer pH values can be due to low water levels and low nutrient concentrations in the water. The decrease in pH was due to dilution caused by rainwater during the monsoon. pH of water is important for the biotic communities because most of the plant and animal species can survive in the narrow range of pH from slightly acidic to a slightly alkaline condition (Anitha, 2002; Kadam *et al*., 2007; Narayana *et al*., 2008; Reddy *et al*., 2009).

Total solids, total dissolve solids, and total suspended solids (*TS, TDS and TSS*)

Mean suspended solids are essential parameters that describe the chemical components of water and can be seen as a general edaphic relationship that contributes to productivity in water. The total dissolved solids (TDS) represent the number of inorganic salts of calcium, magnesium, sodium, etc. and a small percentage of the organic substance present in the water. The total suspended solids (TSS) content in water depends on the number of suspended particles, soil, and sludge, which is directly related to the turbidity of the water. The term total solids (TS) refers to the filterable or swellable material that remains as a

residue after evaporation. The total solids are the sum of the total suspended solids and the total dissolved solids. The solids varied in proportion to the temperature and rarely varied inversely with the water level. In water, the total solids, the total suspended solids, and the total dissolved solids mainly consist of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, Ca, Na, K, Mn, organic substances, sediments and other particles that contaminate the water and increase the concentration of the total amount of solid.

The total solids values ranged from 320 to 460 mg/l. The average total solids values were maximum in monsoon 445.23±18.04 mg/l and minimum during summer 350.10±48.60 mg/ and average annual mean 412.05±53.69 mg/l. The total dissolved solids values ranged from 220 to 360 mg/l. The average total dissolved solids values were maximum in monsoon 339.67±17.05 mg/l and minimum during summer 287.97±41.80 mglL and average annual mean 321.55±29.11 mg/l. The total suspended solids values ranged from 8.5 to 12.9 mg/l. The average total suspended solids values were maximum in monsoon 12.14±0.87 mg/l and minimum during summer 9.30±0.31 mg/l and average annual mean 10.56±1.44 mg/l (Table 1).

The total solids were positively correlated to total dissolved solids, total suspended solids, and total hardness while it is negatively correlated with water temperature, transparency, and alkalinity. The total dissolved solids were positively related to total solids, total suspended solids, and total hardness while negatively correlated with water temperature, transparency, and alkalinity. Total suspended solids were positively correlated with total solids, total dissolve solids, and total hardness, while it was negatively correlated with transparency and alkalinity (Table 2).

In the present investigation, the TS, TDS, and TSS values were maximum during monsoon and minimum during summer. High values of total suspended solids during monsoon may be due to siltation, deterioration, heavy precipitation, and mixing runoff rainwater, which carried mud, sand mixed in the dam water.Similar results have been reported by Jawale and Patil (2009). Salve and Hiware (2006) performed seasonal analysis and recorded low total dissolved solids in winter season while the maximum value was in monsoon due to the addition of solids from surface runoff in Wanparakalpa reservoir, Nagapur near Parali Vaijanath Dist. Beed, Maharashtra, India.

Alkalinity

The alkalinity of most natural waters is a function of bicarbonate and carbonates. Its salts hydrolyze in solution and produce hydroxyl ions. It is also used as a measure of productivity. Alkalinity values provide information on using appropriate doses of chemicals in waste and water treatment processes, particularly in coagulation and operational control of anaerobic digestion. The alkalinity of water is a measure of its ability to neutralize acids. The alkalinity of natural water is based on the salt of carbonates, bicarbonates, borates, silicates, and phosphates, and free hydroxyl ions. However, the leading position of alkalinity in natural water is caused by carbonate and bicarbonate with high pH values.

The alkalinity values ranged from 170 to 220.5 mg/l. The average alkalinity values were maximum in summer 202.25±11.05 mg/l and minimum during monsoon 178.47±5.45 mg/l and average annual mean 190.59±11.89 mg/l (Table 1). Alkalinity was positively correlated with transparency while it was negatively correlated with total dissolve solids, total suspended solids, and total hardness as recorded (Table 2).

In the present study, alkalinity values were highest in the summer and lowest during the monsoons. It can be attributed to an increase in the rate of organic decomposition, which releases CO_2, which reacts with water to form HCO_3, thus increasing general alkalinity in the summer. The increase in alkalinity in summer and winter was due to the concentration of nutrients in the water. The decrease is due to dilution caused by rainwater during the monsoon.Similarly, there is

higher values of total alkalinity with high bicarbonate contents in the dam. The findings of the present is supported by the observations made by Brion (1973) and Wetzel (1983), that the dams are highly productive from the viewpoint of alkalinity of its water.

Total hardness

Water hardness is an important consideration when determining the suitability of water for domestic and industrial use. The hardness is caused by polyvalent metal cations and certain anions present in the water with the formation of scales. The chief cations responsible for hardness are divalent calcium, magnesium, strontium, iron, and manganese. The hardness of water depends on dissolved solids and pH. The hardness measures the total concentration of divalent metal cations such as calcium, magnesium, and strontium. The hardness of the water is mainly due to the salts of Ca^{++} and Mg^{++}, mainly carbonates, and sulfates.

The hardness values ranged from 200 to 400 mg/l. The average hardness values were maximum in monsoon 386.25±12.10 mg/l and minimum during summer 230.17±23.08 mg/l and average annual mean was 309.79±78.08 mg/l (Table 1). Hardness was positively correlated with total dissolve solids, and total suspended solids while it was negatively correlated with transparency and alkalinity (Table 2).

The maximum hardness during the monsoon and the minimum during the summer season were recorded in this study. The maximum value of the total hardness measured during the monsoon could be due to the washing out of stones in the river catchment area. The hardness is mainly due to calcium and magnesium, the principal cation in natural waters. The primary source is the washing out of rocks in the ponds. Its concentration limits water consumption, while it is an essential part of the exoskeleton of arthropods and conch shells (Piska, 2000). Similar results have been reported by Pawar and Pulley (2005) who have studied on Pethwadaj Dam, Nanded, Maharashtra, India; and recorded maximum values during monsoon while minimum during winter. Salve and Hiware (2006) reported that the total hardness was higher in winter, moderate in monsoon, and lower in summer.

Cluster Analysis

Cluster analysis is used to classify variables based on their degree of similarity. Hierarchical cluster analysis is another critical statistical tool to organize homogeneity and visualize the association between variables measured using the dendrogram. Dendrograms are constructed using the method of connecting stations and are designed for combinations of resized distance groups. The main objective of this technique was to gather the parameters based on the associations between them (Shrestha and Kazama, 2007). The results showed that the cluster analysis technique was proper to allow a reliable classification of the physicochemical parameters present in the dam, which provides valuable information. The result is illustrated in the dendrogram, which shows the groups and their proximity. Cluster analysis is carried out, considering eight physico-chemical parameters in seasonal fluctuations (summer, monsoon, and winter) (Figures 1-3).

In the summer season they form two distinct clusters in which the first cluster have pH, total suspended solids, transparency and water temperature which executed close association with each other and second cluster have alkalinity, total hardness, total solids, and total dissolve solids which executed close association with each other (Fig. 1). In the monsoon season they form two distinct clusters in which the first cluster they have transparency, pH, total suspended solids, and water temperature which executed close association with each other and in second cluster they have alkalinity, total dissolve solids, total hardness, and total solids which executed close association with each other (Fig. 2). In the winter season they form two distinct clusters-- in the first cluster they have transparency, total suspended solids, pH, and water temperature which executed

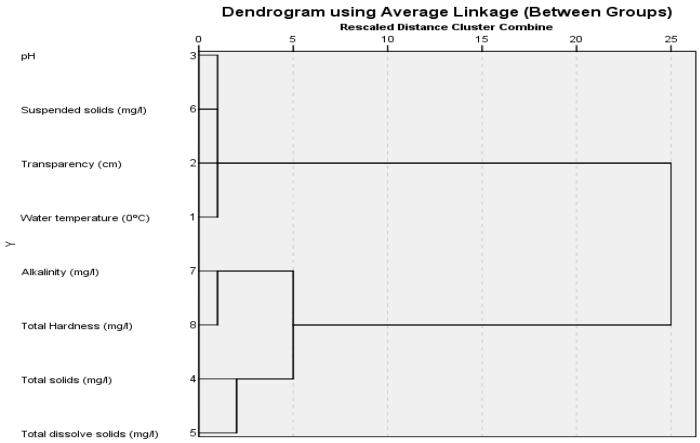

Fig. 1: Dendrogram showing the clustering of various physicochemical parameters in the summer season of Tisgaon dam, (M.S) India (During January - December 2011).

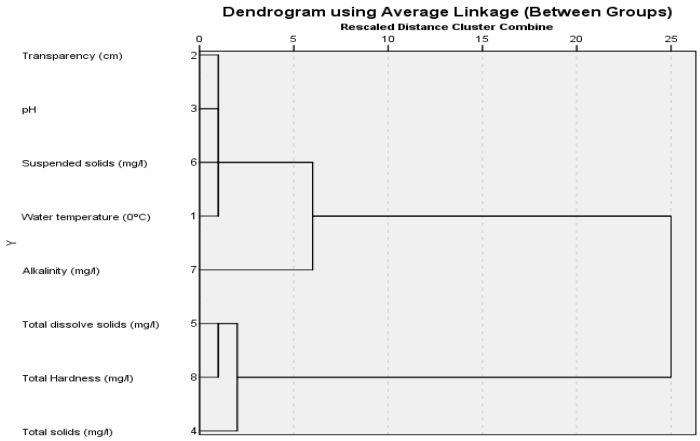

Fig. 2: Dendrogram showing the clustering of various physicochemical parameters in the monsoon season of Tisgaon dam, (M.S) India (During January - December 2011).

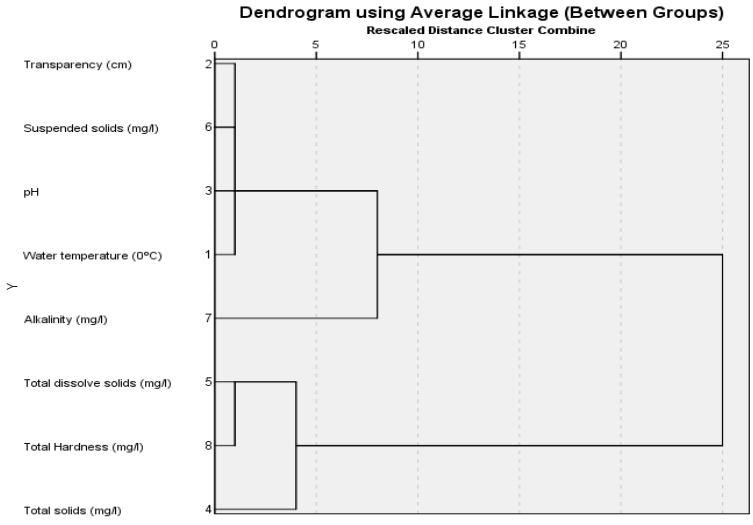

Fig. 3: Dendrogram showing the clustering of various physicochemical parameters in the winter season of Tisgaon dam, (M.S) India (During January - December 2011).

close association with each other and in second cluster they have alkalinity, total dissolve solids, total hardness, and total solids which executed close association with each other (Fig. 3).

Conclusion

The present study showed physico-chemical characteristics and water quality in Tisgaon dam, Aurangabad (M.S), India. The summer, monsoon, and winter seasons show different seasonal fluctuations in water temperature, pH, total solids (TS), total dissolve solids (TDS), total suspended solids (TSS), total hardness and alkalinity. The water of the present dam is helpful for irrigation as well as fish culture. The water parameters indicate that the dam is rich in nutrients. The current investigation observed that water quality parameters are within the permissible limit specified by the ISI and WHO. The disturbance in the biological and ecological system may affect humans, animals, fishes, birds, and aquatic life. Human made activities are the primary source of water pollution. There is no industrial pollution in this area. This study deals with the social and other essential aspects like drinking, domestic, agricultural, irrigation and fishing, etc. The physico-chemical analysis found that dam water is free from pollution and ecologically balanced. The present study performs the significant positive and significant negative correlation present in physico-chemical parameters. We can conclude that all the parameters are more or less correlated with each other. Correlation coefficients are used to measure the strength of the association between parameters. The cluster analysis method is used to classify parameters based on their degree of similarity, and this technique was to gather the parameters based on the associations between them. There should be continuous monitoring of pollution levels and maintain the favorable conditions essential for fish survival, growth, and reproduction in Tisgaon dam Aurangabad (M.S), India.

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 author declares no conflicts of interest.

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