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Seasonal fluctuations in the physio-chemical analysis of water from Maharashtra, India's Khadkpurna reservoir

Nagmote SR[1]* , Gaikwad PR[1] and Nikam MT[2]
1Department of Zoology, Late B. S. Arts, Prof. N. G. Science & A. G. Commerce College, Sakharkherda, Tq. Shindkhed Raja, Dist.Buldhana, Maharashtra, India.
2Head Department of Zoology, Shri Shivaji Science and Arts College, Chikhli, Dist. Buldhana, Maharashtra, India.
*Corresponding author: Mr. S. R. Nagmote,
Email: 1. sr.nagmote@gmail.com | 2 prgaikwad10@gmail.com |3 meenanikam66@gmail.com

Abstract:
To find seasonal variations in the water quality, the physical and chemical characteristics of the Khadakpurna river, which is near Chikhali, were assessed. Physicochemical properties like color, pH, turbidity, total dissolved solids, conductivity, and temperature were the main focus of the investigation. Chemical properties like dissolved oxygen, free carbon dioxide, alkalinity, CO3 (carbonate phenolphthalein alkalinity), HCO3 (bicarbonate or methyl orange alkalinity), hardness (calcium, magnesium), chloride, salinity, phosphate, and nitrate were investigated in order to determine the relationship between temperature and hardness.
Keywords: Khadakpurna, Chemical properties, physicochemical, fluctuations, relationship

1. Introduction:

Khadakpurna Dam, located in Buldhana district, Maharashtra, is one of the region's three major reservoirs. Positioned at Latitude 20° 4′ 10.79″ N, Longitude 76° 10′ 4.73″ E, and at an altitude of 445 meters, it has a storage capacity of 160.66 million cubic meters. The dam plays a crucial role in water conservation and management, with its catchment area receiving about 276 mm of rainfall annually, ensuring steady water replenishment. Originating from the Gautala forest, the reservoir supports ecological balance and diverse water-based activities. The physico-chemical properties of water—temperature, pH, dissolved oxygen (DO), and nutrient availability—directly regulate phytoplankton production, which forms the base of the aquatic food chain and influences nutrient exchange between water and sediment. For fisheries and aquatic biodiversity, parameters like pH, DO, CO_2, alkalinity, and essential minerals determine fish growth, survival, and reproduction. However, pollutants such as ammonia, nitrates, and fluctuating DO levels degrade water quality, posing significant environmental challenges.

2. Methodology:

The physico-chemical parameters of water were analyzed following standard methods prescribed by APHA [2] using a Systronics digital portable water analysis kit equipped with a DO meter, pH meter, and CST meter. Key parameters assessed included turbidity, temperature, and conductivity, which influence water clarity and overall quality. Dissolved oxygen (DO) and carbon dioxide (CO_2) were measured to evaluate aquatic respiration and ecosystem balance. Alkalinity (carbonate and bicarbonate), total hardness (calcium, magnesium), chloride, and salinity were analyzed to determine water mineral composition. Additionally, phosphate and

nitrate levels were assessed to understand nutrient enrichment, which impacts plankton growth and aquatic biodiversity.

3. Results and Discussion:

Water samples were systematically collected from six designated sites (S1, S2, S3, S4, S5, and S6) located in different directions of the Khadakpurna reservoir to ensure comprehensive water quality assessment. Sampling was conducted seasonally over a one-year period from January 2022 to December 2022 to capture seasonal variations in water parameters. Each site was strategically chosen based on factors like water inflow, depth, and human activity impact. The collected samples were analyzed for physicochemical parameters to evaluate their influence on plankton diversity and fish yield in the reservoir.

Physical parameters:

The water color of Khadakpurna Reservoir was assessed using the "Visual Comparison Method" prescribed by APHA [2]. Seasonal variations were observed, with a yellowish-green hue during the monsoon (June–September) due to increased organic matter, sediment influx, and dissolved nutrients from runoff. Post-monsoon (September–December), a rise in phytoplankton and zooplankton populations turned the water light green. During winter and summer, water appeared green to dark green, aligning with findings by Singh et al. [4]. These color shifts indicate ecological changes, nutrient dynamics, and biological productivity, directly impacting fish yield and overall aquatic health.

Temperature:

Water temperature in the reservoir exhibited seasonal fluctuations during 2022, with monthly means ranging from 18.50 ± 1.22°C to 29.83 ± 0.75°C. Data from all six sampling sites showed minimal overall variation, with the highest averages recorded at S5 (25.08 ± 3.26°C) and S6, and the lowest at S2 (24.08 ± 3.06°C). Statistical analysis revealed t-values between 0.277 and 2.121 and f-values around 0.929, indicating slight differences among sites. Temperature, a critical indicator of water quality, affects aquatic organisms, chemical solutes, and dissolved oxygen and CO_2 levels. The highest temperatures occurred in May and June, while the lowest were noted in November and December. These trends align with previous studies (Kamble et al., 2009; Pandey et al., 2012; Tayade, 2012; Kumbhar et al., 2009; Bade et al., 2009; Patel and Puttiah, 2011). Temperature correlated positively with pH, turbidity, TDS, conductivity, carbonate, and hardness, and negatively with dissolved oxygen, CO_2, bicarbonate, and calcium hardness.

pH:

In aquatic ecosystems, pH indicates water's alkalinity or acidity. In 2022, pH ranged from 7.18 ± 0.27 to 8.30 ± 0.32, with higher values in April and June and lower values in November and December. Significant differences were noted in April, May, and especially June ($t = 4.406$), indicating seasonal variation. Among six sites, the first year's mean pH varied from 7.72 ± 0.455 at S2 to 7.48 ± 0.34 at S6, with similar trends in the second year. Overall, the reservoir maintained an alkaline pH, influencing biological productivity and habitat diversity. These patterns align with findings by Nagmote et al. (2023), Shinde et al. (2011), and others.

Turbidity:

Turbidity of water was found 6.15 ± 0.8180 to 9.28 ± 0.5999 NTU in January to December 2022. Maximum turbidity observed in the month of June and all over the monsoon and minimum in December in the year. During the year highest was observed on sampling site S5 it was 8.15333± 1.07 and 'f' test value form years on same site was 0.799636, lowest was on S4 it ware 7.330833 ± 1.355 and 'f' test was 0.4496 in years. By taking the 'f' test from years by all sites was 0.7829, difference between all sampling sites. 't' value shows the highest significant differences i.e. 3.520 and lowest was 0.115 NTU in September month due fluctuation in turbidity in the year. Clay, organic matter, planktons slit and other microscopic organisms are increases turbidity of water. Turbidity was found different i.e. maximum turbidity found in month of February, due to human activity and decrease in water level reported by (**Manjare and *et al*., 2010).**

Total Dissolved Solids:

Total dissolved solids (TDS) measure the dissolved particles in water, including nitrates, calcium, magnesium, sodium, potassium, iron, carbonates, and bicarbonate. In 2022, TDS averaged 392.18 ± 25.69 mg/L, peaking in June and July and reaching a minimum in April. The t-values ranged from 0.222 to 1.960. Among sampling sites, S5 had the highest TDS (294.95 ± 47.81 mg/L, f-value = 0.7247) and S4 the lowest (274.52 ± 59.60 mg/L, f-value = 0.1428). Overall, the f-value across six sites was 0.3304, indicating no significant differences. Agricultural runoff increases fertilizers, organic matter, and salts, raising TDS levels, as noted by Makode (2012).

Conductivity:

Overall, conductivity is a water quality parameter. In 2022, conductivity ranged from 260.33 ± 33.35 mho/cm to 386.83 ± 24.58 mho/cm. It was lowest in December and peaked in July, likely due to heavy organic load during the monsoon, as indicated by t-values (0.140–3.094). Among the six sampling sites, S2 and S4 recorded the highest mean (339.75 ± 50.60 mho/cm) while S6 was lowest (319.86 ± 55.34 mho/cm). f-test values varied, with S6 at 0.94993 and S1 at 0.06852. While some report higher winter conductivity (Koshy and Nayar, 2000; Karadkhede, 2008; Tayade, 2012), Sing et al. (2012) noted lower values.

Chemical Parameters

Dissolved oxygen (DO)

In 2022, dissolved oxygen (DO) levels ranged from 3.88 ± 0.56 to 6.75 ± 0.46 mg/L. The highest DO was recorded at site S3 (5.94 ± 1.27 mg/L, f-test = 0.395) and the lowest at site S6 (4.18 ± 1.05 mg/L), with an overall f-test of 0.375 across sites. DO peaked during December–January and was lowest in September–October, consistent with Khan et al. (2012). As a vital parameter for aquatic life and fish culture, DO is typically lower in summer (Rani et al., 2004; Medudhula et al., 2012; Prabhahar et al., 2012). T-test values ranged from 0.039 to 1.904, showing no significant differences. Osama (2022) also reported similar findings in river water studies.

Free Carbon dioxide:

CO_2 exists in water as free CO_2, carbonate (CO_3^{2-}), or bicarbonate (HCO_3^-) depending on pH and biological conditions. In 2022, CO_2 levels ranged from 0.55 ± 0.8526 mg/L to 2.35 ± 0.8712 mg/L. The highest concentration, 2.008 ± 1.0094 mg/L, was recorded at one site, while the

lowest, 0.467 ± 0.507 mg/L, was observed at S6. Low f-test (0.0604) and t-test values (0.035–1.268) indicate minimal overall variation across six sites. CO_2 peaked during the monsoon and was lowest in March, reflecting seasonal and sampling time influences. CO_2 is essential for phytoplankton and aquatic vegetation metabolism (Sivakumar et al., 2008).

CO3 (Carbonate Phenolphthalein alkalinity):

The alkality to natural waters is mainly imparted by three prominent bases; Carbonate ($C0_3$), bicarbonates ($HC0_3$) and hydroxide (OH), therefore alkality estimated as individual base. According to **Solanki and Pandit (2006)** the alkality changes depends upon the carbonate and bicarbonate and also depend upon release of carbon dioxide.

HCO3 (Bicarbonate or Methyl Orange alkalinity):

During the study period Carbonate was found 24.5 ± 4.5935 mg/L to 63.5 ± 21.2108 mg/L in year of study period and 25.67 ± 7.0048 mg/L 64.67 ± 17.0607 mg/L in 2022. 't' value ranged from 0.105 to 1.627 during study period. By observing the site wise mean of carbonate , highest was observed on sampling site S6 it was 50.42± 22.82, 'f' value was 0.744, lowest was observed on S3 it was 27.17 ± 7.89, 'f' value was 0.200. in year highest was observed on same site that is S6 it was 52.33 ± 25.24. 'f' value was 0.7439, while lowest was on same sit S3 it was 32.33 ± 11.78. the carbonate value from all sampling sites of years was 0.6929. which was not show any significant difference during study period .Carbonate value increases in summer and minimized in monsoon season.

Total Hardness:

Total hardness of water was found 143 ± 13.842 to 322.5 ± 21.4453 mg/L in 2022. The maximum hardness of the reservoir water increases in February month in the year and minimum hardness found in winter season during study period. Calculated 't' value of total hardness ranged from 0.072 to 1.255 annually. Mean total hardness from all sampling sites was observed, during the year of analysis mean total hardness was observed on sampling site S5 it was 251 ± 54.5227, lowest was on S4 it was 213.667 ±49.84. the mean highest and lowest value was observed on same sampling site on both years. Like was 'F' value found 0.3991on the basis of all sampling sites of years, which do not show any significant differences in all six sites.

The total harness was recorded higher in summer, it might be due to decrease in water level and rate of evaporation of water .similar result observed by **(Hujare ,2008; Manjare and *et al.*, 2010).** Total hardness of water increases mainly due to the presence of (Ca^{2+}) and magnesium (Mg^{2+}) ions in every water body which may increases due the human washing clothes, bathing activities in Khadkpurna reservoir.

4.2.4.2 Calcium Hardness:

Calcium is major cation found in water. During year of study period calcium Hardness found 17.8 ± 5.5472 to 45.9 ± 5.8595 mg/L in 2022. The maximum Calcium hardness found in January month and minimum in Monsoon in the year, 't' value ranged from 0.013 to 3.338 during study period. Site wise mean of calcium harness value, During 2022 the highest mean was observed on S5 it was 41.0925 ± 9.11, lowest was on S2 it was 32.1225 ± 10.14, 'f' value was 0.8635. From the all sampling site mean calcium hardness calculated by taking 'F' value was

0.5506 throughout the study periods. The maximum desirable limit of calcium in drinking water is 75mg/l **(W.H.O)**, therefore above recorded value of calcium, it indicate water is use for drinking purpose. Maximum value of calcium in in winter season, controversial result obtained by **Harney and *et al*., (2013)** recorded calcium hardness minimum in winter season. **Ravikumar *et al*., (2005)** reported the maximum calcium hardness in April month in Ayyanakere tank in Harapanahalli town in Davangere district of Karnataka.

4.2.4.3 Magnesium Hardness:

Magnesium Hardness was calculated from removing calcium hardness from total hardness. The magnesium hardness found in this reservoir was 25.03 ± 3.0655 to 67.75 ± 5.3850 mg/L in 2022. Mean Magnesium hardness from the 2022, highest value was observed on sampling site S1 it was 51.95 ± 12.97, 'f' value was 0.4928, lowest was on S4 it was 43.355 ± 11.47, over all 'f' value from all sampling site was 0.4867. 't' value calculated ranged from 0.047 to 1.495. Which not show much more significant differences during study period. Maximum hardness of magnesium was found in the month of February and minimum in winter season of both the year of study period. Similar result found by **(Patil 2014)** about magnesium. 'F' value of Magnesium hardness which show significant difference in value of all six sites of the reservoir water in 2022 do not show significance difference. The permissible limit of magnesium of drinking water is 50mg/l **(W.H.O)** but our result about magnesium was above 66mg/l, so it may hazarders for drinking purpose.

4.2.5 Chloride:

The chloride value of Khadkpurna reservoir was ranged from 62.09 ± 6.1056 mg/l to 138.93 ± 24.8423 mg/l in 2022**.** The second year highest mean was observed on S6 it was 116.5467 ± 28.90, 'f' value was 0.390, lowest was on S3 it was 82.92 ± 25.046, 'f' value was 0.68015. The 't' value ranged from 0.234 to 2.326 in annual recording of chloride which did not show much more fluctuation during study period. The chloride value was higher in summer and minimum during winter season in the year of study period. Similar result obtained by **Shinde *et al*., (2011)**, according to them Higher level of chlorides in natural water is indication of pollution and domestic sewage. Likewise in Morna reservoir there may be certain anthropogenic activities increases chloride concentration in water. The result obtained by **Pulugandi (2014)** that chlorides was minimum at winter and shows maximum in monsoon season. When compared Six sites 'F' value obtained as 0.0949, which also not show any changes throughout the year.

4.2.6. Salinity

The salinity value ranges from 112.10 ± 11.0206 mg/l to 250.80 ± 44.8403 mg/l in 2022. The 't' value ranged from 0.098 to 1.759 in annual salinity value recorded. During year of analysis the highest was observed on the sampling site S6 value was 210.3967 ± 52.166, 'f' values from the same sampling from both year it was 0.390442, lowest was observed on S3 it was 149.7066 ± 45.20876, 'f' observed value was 0.68015. 'f' value from all sampling sites of both the years was 0.0949. During the study periods water salinity highest recorded in the month of March and lowest was in the month of February in years.

4.2.7 Phosphate:

As the Khadkpurna reservoir is totally surrounded from all sides by field area and totally water in reservoir is used for irrigation purpose, therefore it also necessary to study the phosphate level in water.

The phosphate level during the year of study was found 0.22 ± 0.0539 to 1.96 ± 0.6276 mg/l in 2022**.** The phosphate 'f' value from the year was 9E-52. The phosphate value was not much more significant from all sampling site during years. The 't' value calculated was ranged from 0.196 to 3.145 during study periods. It shows 0.05 level of significance difference in month of October and December due changed phosphate level in water during the year. The phosphate level was higher in Monsoon season and lower in summer and winter season. Similar result obtained by (**Manjare, 2010 and Makode, 2012)** that the maximum value of phosphate recoded in August and minimum in October i.e.in winter season. Due to surface water runoff, agriculture run off, washer man activities increases inorganic phosphate in water in rainy season therefore phosphate level increases in monsoon season. It not show very significant difference in total four sites in study period of 2022 i.e. calculated 'F' value was 0.06 in 2022.

4.2.8 Nitrate:

Nitrates is highly oxidized form of nitrogen, in natural water due to runoff fertilizers, decayed vegetable and domestic waste are increases the amount of nitrogen in water.

Nitrate value ranged from 1.83 ± 0.2733 to 3.86 ± 0.7806 mg/l in year 2022**.** In 2022 the highest value recorded from the sampling site S1 it was 3.063 ± 0.9447, 'f' value was 0.6593. The 't' value ranged from 0.205 to 2.388 which did not show any significance difference during study period of year. The nitrates value was higher in monsoon season and recorded lower in late winter and summer season. All Six sites in years of study period shows comparative 'f' values 0.5042 , which not fluctuate in years. The controversial result obtained by **(Dabhade 2006)** that is high values of nitrates observed in winter season and gradually increased in summer season. Nitrates is act as nutrient for growth of plants, excess amount of nitrogen helps for rapid growth of algae and other plants in water.

Nitrates is found very small amount in nature because ongoing process of growth and decaying. Most stable form of nitrogen is nitrates which enhances the growth of plankton density and primary production, (**Parida *et al.*, 1999, Thorat *et al.*, 2020).**

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