Studies on water quality assessment and seasonal changes in physico-chemical parameters of Urmodi dam reservoir from Satara district, Maharashtra, India

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Abstract:
Water is an essential natural resource and most important environmental factor in the ecosystem. Human needs water reservoirs for all their need for life and survival. In addition to our need, water also plays versatile role in functioning of the biosphere. It forms the aquatic ecosystem which is the largest ecosystem on the earth planet. Water quality is a direct reflection of the essence and wellbeing of aquatic ecosystems. The abundance of phytoplankton, species composition, stability, productivity and physiological state of aquatic organisms are affected by water quality. Water quality in aquatic environments relies on physical, chemical and biological factors. There is a change in water quality with seasonal changes in temperature, precipitation, crop residues, and anthropogenic activities. The conservation of healthy aquatic environments depends mainly on physico-chemical properties of water and monitoring of water quality is a top priority in environmental protection policy. Urmodi dam reservoir provides the water for domestic use and also for irrigation to its adjoining villages and river basin area. The present work was undertaken to assess the water quality in terms of nutrient status assessment and seasonal changes in physico-chemical analysis of water from Urmodi dam reservoir.

Keywords:
Water quality, seasonal changes, aquatic ecosystem, Urmodi dam, etc.

1. Introduction

Water is most significant and valuable natural resource on earth. About three fourth of earth surface has been covered by water. About 97% water is present as marine and 3% as fresh water. The 3% fresh water is further categorized as 68.7% trapped in glaciers and polar ice caps, 30.1 % groundwater and 1.2 % surface water in the form of lakes, rivers and other reservoirs. Out of all water on earth planet about 0.01% is present as surface fresh water reserve which is directly available for the living organisms on the earth. The aquatic ecosystem forms the largest ecosystem in the biosphere. It forms the habitat for immense varieties of species. Reservoirs of fresh water are generally divided into lentic and lotic water bodies.

Lentic water bodies like lakes, ponds, swamps, marshes, and dam reservoir have recently gained significance in developing countries for drinking, irrigation, fish and aquaculture, recreational purposes, hydropower generation, etc. However, water sources are used for the disposal of domestic waste, agricultural and industrial sewage, and therefore water becomes gradually unfit for mankind, eutrophication, and loss of biodiversity in aquatic environments. Human-induced eutrophication is due to the addition of waste water, fertilizers into natural water, and this is the very rapid method of washing nutrient-rich soil into lakes and rivers, whereas natural eutrophication is a slow process. The method of direct assessment of status of ecosystem is the determination of physico-chemical parameters of same water body (Vandysh, 2004). The distribution of plants and animals in aquatic environments is highly influenced by minor variations in these physical and chemical characteristics of water (Verma *et al*., 2012).

India has a distinctive and varied physical, geographical and meteorological characteristics with its strategic location and is rich in inland water supplies that exist as both lotic and lentic systems. Being the Western Ghats, Satara district of Maharashtra state has various geomorphological characteristics. The hilly region is the source of important rivers, such as Krishna, Koyana, Urmodi, Venna, etc. The studies on physico-chemical analysis for determining the water quality were conducted extensively in different regions of India (Ganapathi, 1960; Muniyellappa, 2018; Premsudha et al., 2022; Santhi et al., 2023; Rajeshwari and Padmaja 2024; Gopal, 2025). In Maharashtra, several workers studied physico-chemical analysis of water (Nandan and Aher, 2005; Gore and Pingle, 2007; Prabhakar et al., 2008; Pradhan and Shaikh, 2011; Patil et al., 2012). There are some reports on studies of water quality of reservoirs from Satara district. Pawar and Sonawane (2011) studied physico-chemical parameters of Kas reservoir, Kanher dam and Mahadare reservoir in relation to the diversity of phytoplanktons therin. Lubal *et al*. (2012) determined the physico-chemical aspects of the Mhaswad water reservoir. Pawar and Sonawane (2012) measured the water quality profile of the Kas reservoir.

The water from Urmodi dam is used for drinking and irrigation. Studies on physico-chemical analysis of water from Urmodi dam water is essential to assure the safe drinking, sustainable irrigation, healthy aquatic life, and effective resource management while also documenting seasonal and anthropogenic changes. Urmodi dam water is a source for drinking and domestic supply to Satara and nearby villages. By studying physico-chemical analysis, we can check drinking water standards. The water from dam is also used for irrigation in large parts of Satara district. The parameters like EC, TDS, nitrate, etc. contributes to salinity and directly affect soil fertility and crop yield. Hence, the regular monitoring helps to prevent soil salinization and reduced productivity. The detection of organic contamination in early stage helps to prevent health hazards. The monthly and seasonal physico-chemical analysis helps in ecological and environmental monitoring, as the seasonal variations affect fish survival, biodiversity, and water self-purification capacity. The analysis of water helps to provides baseline reference data for long-term environmental monitoring and is helpful for policymakers and irrigation engineers to make sustainable water management plans.

The previous researchers have studied physico-chemical analysis of water from Urmodi river originating from the Urmodi dam reservoir. Shah (2012) performed water quality assessment of bore wells from Satara with respect to total hardness and *E. coli* contamination. Suryawanshi et al (2016) studied the quality of drinking and irrigation water from sixteen villages in Urmodi River basin, Satara district, Maharashtra (India). Gaikwad et al (2018) studied physico-chemical parameters of water from Urmodi river from the different sampling stations of the river in order to assess level of contamination. Dhekale et al (2019) investigated the level of contaminants of surface water, groundwater and sediment analysis of selected rivers of Krishna River located in Mahuli and Urmodi river located in Nagthane, Satara district. However, the data on water quality assessment studies from Urmodi dam reservoir are not available till date. Hence, the extensive research work where water sampling was performed monthly for a period of two years to study the physico-chemical parameters of water from Urmodi dam reservoir and to study the seasonal changes in physico-chemical parameters.

2. Materials and Methods

2.1 Study area

Urmodi Dam, 16.6 km from Satara City, is situated on the Urmodi river near Parali Village (Fig. 1 and Table 1). The dam water is released into the Yeralwadi dam that supplies water in Maharashtra to the draught-heat Khatav tehsil. The selected water body is permanent and water is present throughout the year.

Figure 1. Urmodi dam

Table 1. Morphometric features of Urmodi dam

Sr. No.	Parameter	Value
1	Tehsil	Satara
2	District	Satara
3	Name of river	Urmodi
4	Lattitude	17°40'17'' N
5	Longitude	73°52'20'' E
6	Capacity (TMC)	9.964
7	Length of reservoir (Metre)	1860
8	Height of lake/dam (Metre)	50.1
9	Catchment area (Square KM)	116.86
10	Designed storage (million Metre^3=mM^3)	282.14
11	Power generation (Mega Watt)	3
12	Command area (Hectar)	51734
13	Elevation above sea level (Metre)	600
14	Average annual rainfall in mm.	1132.1

(Source: Maharashtra Krishna Khore Vikas Mahamandal, Public Works Department, Satara -415001)

2.2 Methods of sampling and physico-chemical analysis of water

The surface water samples were collected from the study area for a span of two years at regular monthly intervals in acid washed plastic cans with a capacity of two litres at a depth of one foot. Samples were collected between 8-9 am. Surface water samples were subjected to various physico-chemical analyses by following methods given in APHA (1998), Moore (1939), Goetz *et al.* (1950) and Trivedy and Goel (1986). The temperature of the air and water in each water body was determined using a sensitive mercury thermometer (Merck) with an accuracy of 0.1°C. Using digital pH metres, the pH of the water samples was determined on the spot. Free CO_2 from water sample was by titrimetric method. Total alkalinity was determined by titrimetric method. Turbidity was determined by Nephelometric method. Total hardness (TH) was determined by EDTA method. Nitrate content of water samples was estimated by spectrophotometric method by using stock nitrate solution (PDA method). Phosphate content was determined by stannous chloride method. Silica content was estimated by Molybdo-silicate method.

Dissolved oxygen (D.O.) was determined by Azide modification of Winkler's Method. Total dissolved solids (TDS) content of water samples were estimated by gravimetric method. Electrical conductivity (EC) was estimated using calibrated EC meter. The data obtained after the physico-chemical analysis was represented monthly and season wise.

2.3 Determination of water quality index

Water quality index were calculated by using methodology from website www.water research.net

2.4 Statistical Analysis

The data obtained after physico-chemical analysis was subjected for determination of average and standard deviation. Pearson's R correlations matrix was determined by using statistical software MINITAB 14.

3. Results and Discussion

3.1 Physico-chemical analysis of water and seasonal variations

The results of physico-chemical analysis of water performed in every month for a period of two years is represented as the range and average of physico-chemical parameters (Table 2). The data of seasonal variations in the values of water analysis are depicted in Table 3. The results of monthly variation in value of each physico-chemical parameter are represented in the Figure 2 to 14 as the average of two months from the 2 year sampling data.

Table 2. Physico-chemical analysis of water of Urmodi dam

Sr. No.	Parameters	Year-1		Year-2	
		Range	Average	Range	Average
1	Air Temperature (ºC)	18-38	26.83±5.89	27-36	30.46±2.79
2	Water Temperature (ºC)	21-34	26.05±3.35	26-32	28.46±1.92
3	pH	8.1-8.6	8.37±0.14	7.3-9.6	8.19±0.58
4	Free CO_2 (mg/L)	0-30.8	17.5±8.82	13.2-57.2	38.72±18.95
5	Total alkalinity (mg/L)	21-29.4	24.03±3.08	25-31	27.17±1.99
6	Turbidity (NTU)	0.6-4.6	1.82±1.69	0.1-1.8	0.76±0.48
7	Total hardness (mg/L)	49-69	56.33±5.48	49-69	56.5±5.66
8	Nitrates (mg/L)	0.048-2.13	0.72±0.60	0.04-2.91	0.95±0.82
9	phosphate (mg/L)	0-0.45	0.19±0.21	0-1.57	0.14±0.45
10	Silica (mg/L)	5.7-12	8.10±1.96	3.58-13.46	8.49±3.22
11	D.O. (mg/L)	4.0-13.2	8.03±2.76	6.2-9.2	7.43±0.98
12	TDS (mg/L)	19.2-57.6	45.33±13.22	38.4-51.2	44.8±4.73
13	EC (mhos/cm)	0.03-0.09	0.07±0.02	0.06-0.08	0.07±0.01

Table 3. Seasonal variations in physico-chemical parameters

Sr. No.	Parameters	Seasons		
		Winter (Oct. Nov. Dec., Jan.)	**Summer (Feb March, Apr. May)**	**Rainy (June, July, Aug. Sep.)**
1.	Air Temperature (oC)	29.5±5.04	28.56±5.46	27.88±4.61
2.	Water Temperature (oC)	27.31±1.62	27.13±4.52	27.33±2.31
3.	pH	8.05±0.32	8.41±0.11	8.38±0.62
4.	Free CO2 (mg/L)	36.6±21.85	21.34±15.03	26.39±22.04
5.	Total alkalinity (mg/L)	25±2.62	25.5±4.11	26.3±2.20
6.	Turbidity (NTU)	0.71±0.16	1.15±0.32	2±2.17
7.	Total hardness (mg/L)	29.25±8.03	54±3.38	26±2.39
8.	Nitrates (mg/L)	1.15±0.70	0.21±0.29	1.15±0.89
9.	Phosphate (mg/L)	0.07±0.13	0.41±0.51	0.02±0.01
10.	Silica(mg/L)	7.81±1.47	9.07±2.97	8.01±5.43
11.	D.O.(mg/L)	6.3±1.51	7.61±1.20	9.26±2.24
12.	TDS (mg/L)	44.8±7.65	49.6±4.53	40.8±13.66
13.	EC (mhos/cm)	0.07±0.01	0.08±0.01	0.06±0.02

3.1.1 Air temperature
Air temperature has so many profound direct and indirect influences on aquatic ecosystem and these changes in temperature also affect pH, D.O. content and hardness of water (Kumar *et al.*, 2012).The values for air temperature during the study period varied from 18-38ºC (Table 2). Air temperature was found to be highest in winter season followed by summer (Table 3). Statistical analysis showed that atmospheric temperature showed positive correlation with water temperature (Table 4).

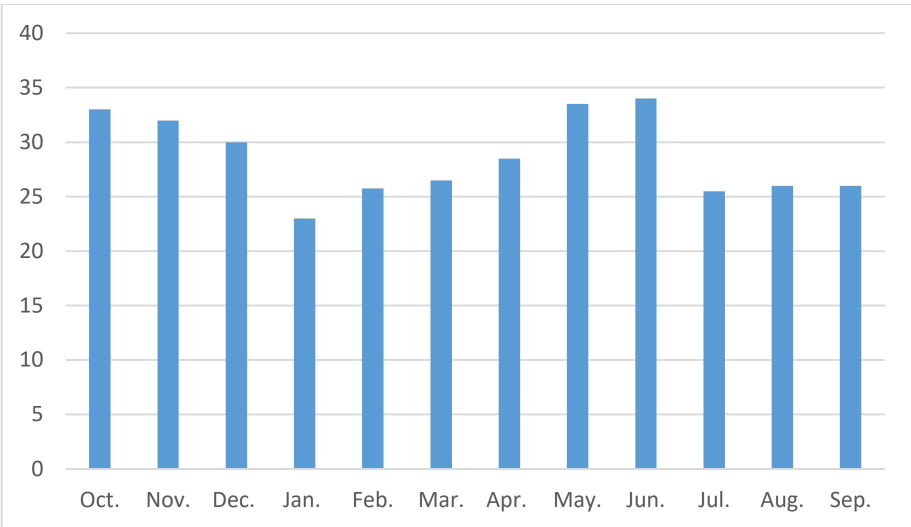

Figure 2. Monthly variations in atmospheric temperature

3.1.2 Water temperature
Water temperature is the important parameter in determining pH, EC, TDS, which affects physical properties of water and the life of organisms living in water body (Bhadija and Vaghela, 2013). Water temperature has been called ʽAbiotic masterʼ factor due to its influence on aquatic organisms (Brett, 1971). The water temperature during the study period varied from 21-34ºC (Table 2). Seasonal fluctuation shown that highest temperature is noted in winter season (Table 3). As seen in statistical analysis (Table 4), water temperature showed a significant positive correlation with atmospheric temperature.

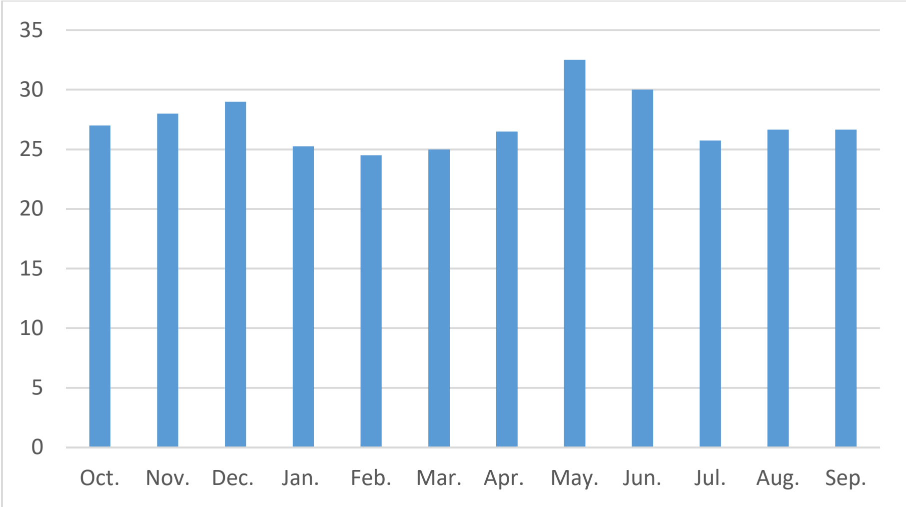

Figure 3. Monthly variations in water temperature

3.1.3 pH

All physico-chemical and biological parameters directly depend on pH. It is the important parameter in assessing water quality of water body (Ghosh *et al.*, 2012). The values of pH during the study period varied from 7.3-9.6 (Table 2). Standard deviation was found to be very low indicating that alkaline water is present. pH value was found to be low in winter season and high pH in summer season (Table 3). Our observations are found to be homologous with Mankar and Bobdey (2015), Singh and Balasingh (2011). Statistical data obtained by statistical analysis (Table 4) showed correlation which denotes positive correlation of pH with TDS, EC, while negative correlation with Free CO_2.

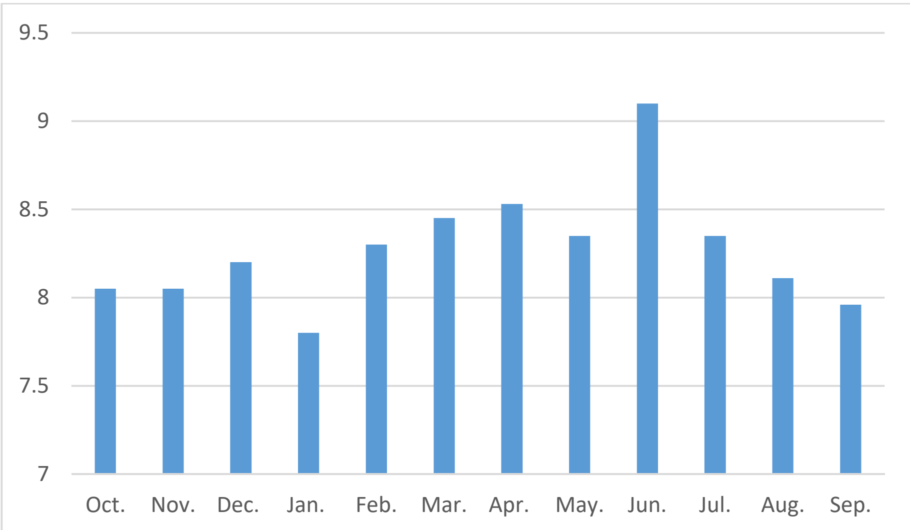

Figure 4. Monthly variations in pH

3.1.4 Free Carbon dioxide (Free CO_2)

Free CO_2 is one of the chemical parameter of immense importance which is essential for the autotrophs to prepare their food. Free carbon dioxide concentration values were ranged from 0-57.2 mg/L (Table 2). High value of average Free CO_2 was found in winter season followed by rainy and summer seasons (Table 3). Our observations resembled with Manjare *et al.*, 2010; he recorded maximum free CO_2 during winter due to decomposition of organic matter. Statistical data obtained exhibits a significant positive correlation of free CO_2 with atmospheric temperature (Table 4).

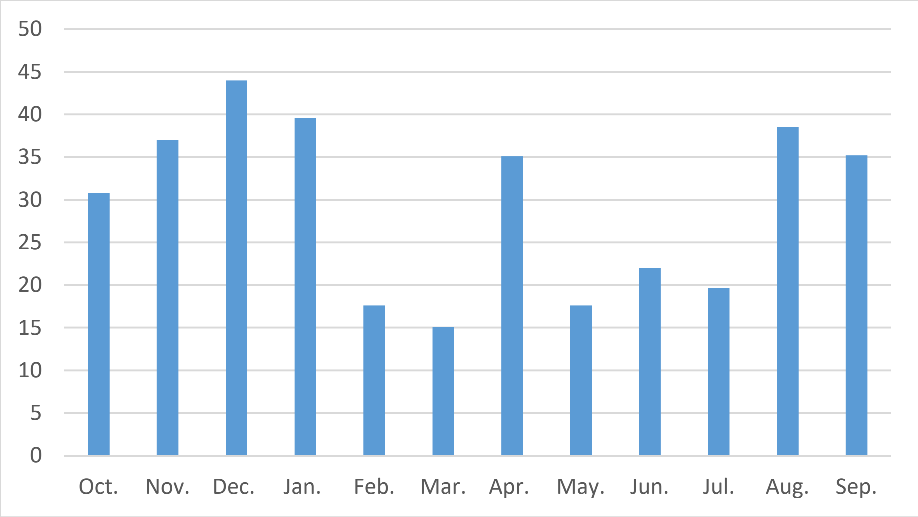

Figure 5. Monthly variations in Free CO_2

3.1.5 Total alkalinity

Total alkalinity is an important parameter that indicates buffering capacity of water (Koshy and Nayar, 2000). Total alkalinity of any water body determines the nature of the water body; higher alkalinity value indicates eutrophic nature of water body (Kaur *et al*., 1996). The value alkalinity of water ranged between 21-31 mg/L (Table 2). Average TA values were found to be high in rainy season followed by summer and winter (Table 3). Our observations found to be homologous with those of Muniyellappa (2018). Significant correlation observed (Table 4), Total alkalinity showed positive correlation with turbidity whereas negative correlation with.

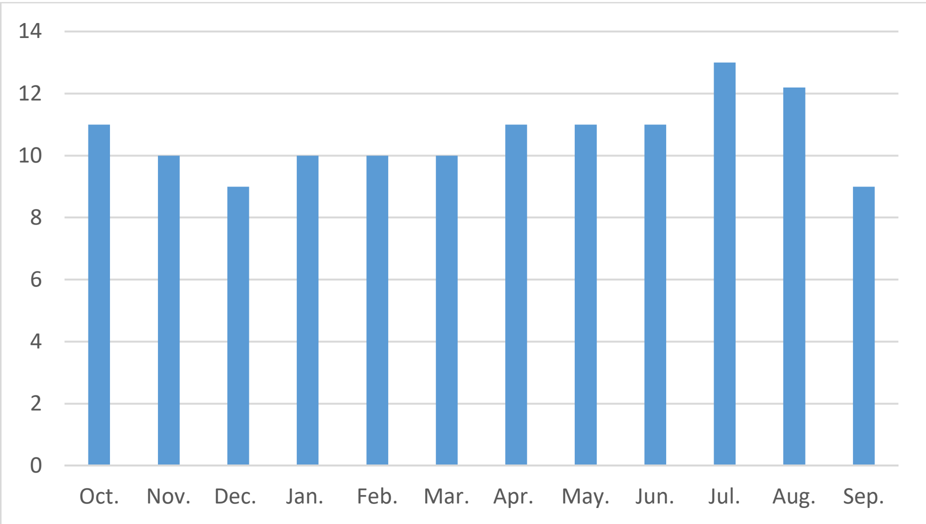

Figure 6. Monthly variations in Total alkalinity

3.16 Turbidity

Turbidity of water is due to the presence of colloidal suspended matter such as clay, slit organic matter plankton and other microscopic organisms (Muniyellappa, 2018). The value of turbidity during the study period varied from 0.1-4.6 mg/L (Table 2). The high value of TA was observed in rainy season followed by summer and winter season (Table 3). Observations made in present study are found to be similar with those made by Manjare *et al.*, 2010; Raj and Sevarkodiyone, 2018. Table 4 showed positive correlation of turbidity with DO whereas turbidity showed negative correlation with TDS and EC.

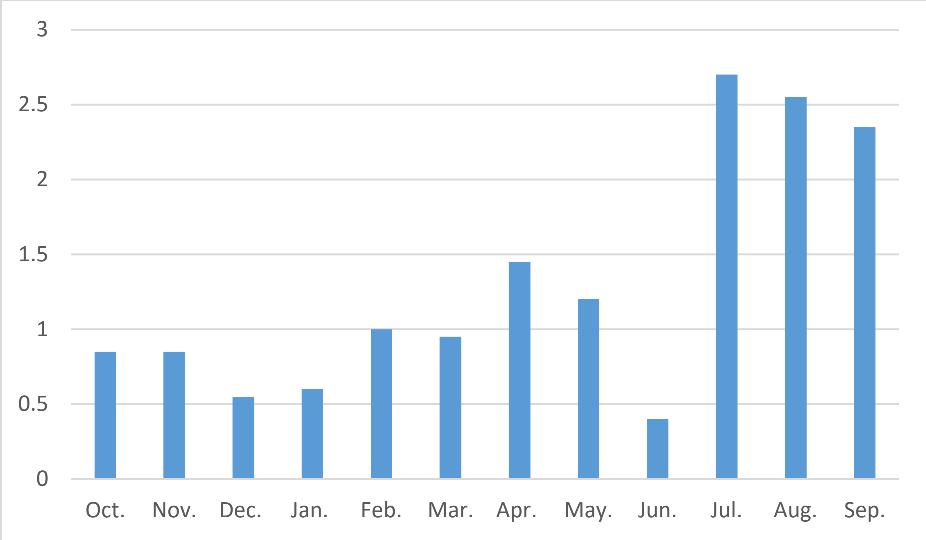

Figure 7. Monthly variations in Turbidity

3.1.7 Total hardness

The hardness of water is due to the calcium and magnesium compounds present in water. The value of total hardness during the study period varied from 49-69 mg/L (Table 2). In the present investigation Urmodi dam showed soft water (23-75 mg/L). The high value of TA was observed in summer season and low in rainy season (Table 3). According to BIS (2012) standards for the drinking water, Total hardness values are within the range of permisible range (600 mg/L).

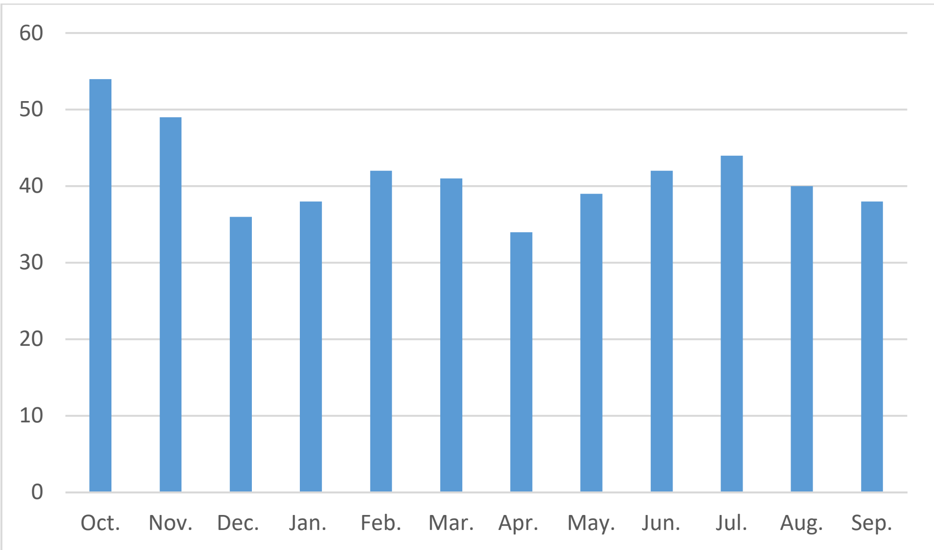

Figure 8. Monthly variations in Total hardness

3.1.8 Nitrate

Nitrate is the highly oxidized form of nitrogen compounds and is important factor for occurrence and abundance of phytoplanktons. The values of nitrate fluctuated from 0.04-2.91 mg/L (Table 2). The nitrate during the present study was found to be high in rainy and winter season (Table 3). Our results are in well agreement with those of Muniyellappa (2018) who recorded maximum value of nitrate during rainy season due to the influx of rain water from catchment areas. Statistical analysis showed (Table 4) positive correlation of Nitrate with Silica whereas Nitrate showed negative correlation with TA and EC.

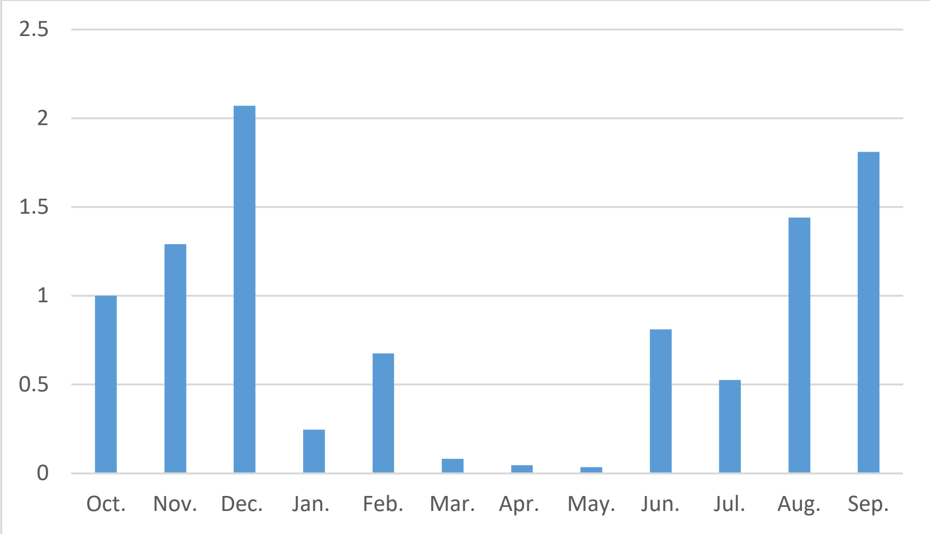

Figure 9. Monthly variations in Nitrate

3.1.9 Phosphate

Phosphate is considered as one of the important nutrient which is limiting factor for growth of phytoplanktons (Bachmann and Jones, 1974). Phosphate is a key nutrient in growth of microscopic algae therefore responsible for productivity of water body. Average range of phosphate was 0.0-1.57 mg/L (Table 2). The phosphate in Urmodi dam water was found to be high in summer and low in rainy season (Table 3).

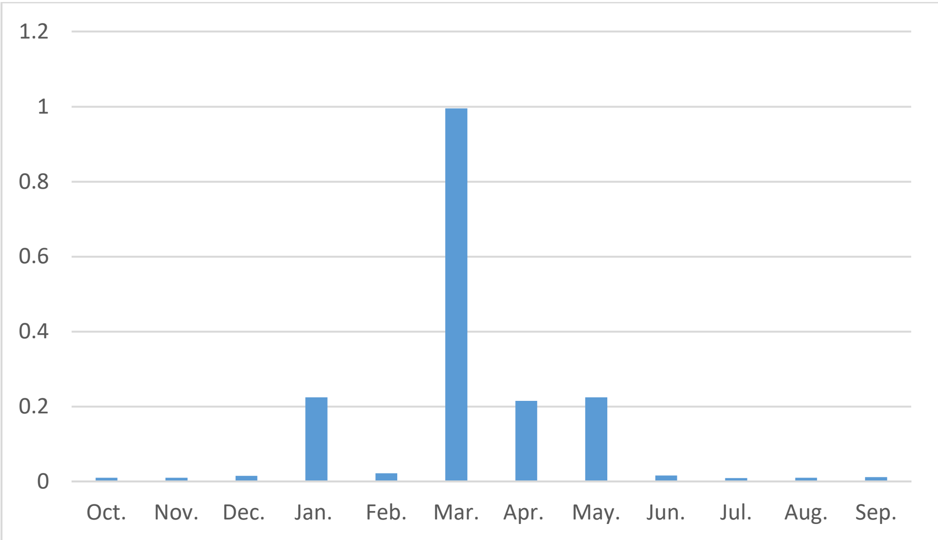

Figure 10. Monthly variations in Phosphate

3.1.10 Silica

The chemical weathering and mechanical erosion lead to formation of silicates in aquatic system. The monthly variation in silica at Urmodi dam is fluctuated from 3.58 mg/L to 13.46 mg/L (Table 2). Summer season showed high silica in water and low silica content in water was observed in winter season (Table 3). Table 4 showed positive correlation of silica with nitrates while Silica showed negative correlation with TDS and EC.

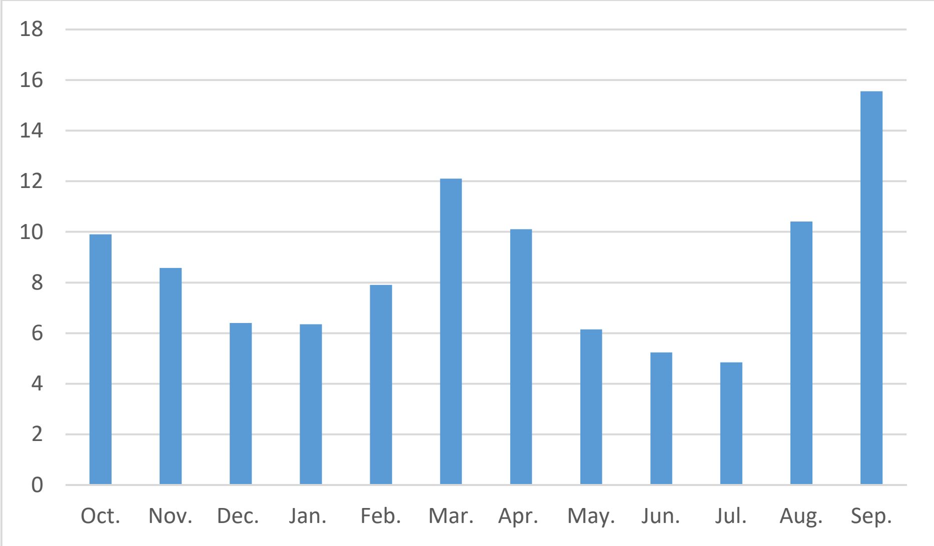

Figure 11. Monthly variations in Silica

3.1.11 Dissolved oxygen (D.O.)

Dissolved oxygen provides much information about water quality. It is released in the process of photosynthesis by phytoplanktons, algae and hydrophytes. The estimates in dissolved oxygen values at Urmodi dam were fluctuated between 4-13.2 mg/L (Table 2). Rainy season showed high value of D.O. in water (Table 3). Dissolved oxygen levels were decreased during summer season and low D.O. was observed in winter season. Koshy and Nayar (2000), Chennakrishanan *et al.* (2008) also recorded maximum dissolved oxygen during rainy season due to the rain water. Dissolved oxygen showed significant inverse relationship with water temperature. Positive correlation of dissolved oxygen was observed with turbidity (Table 4).

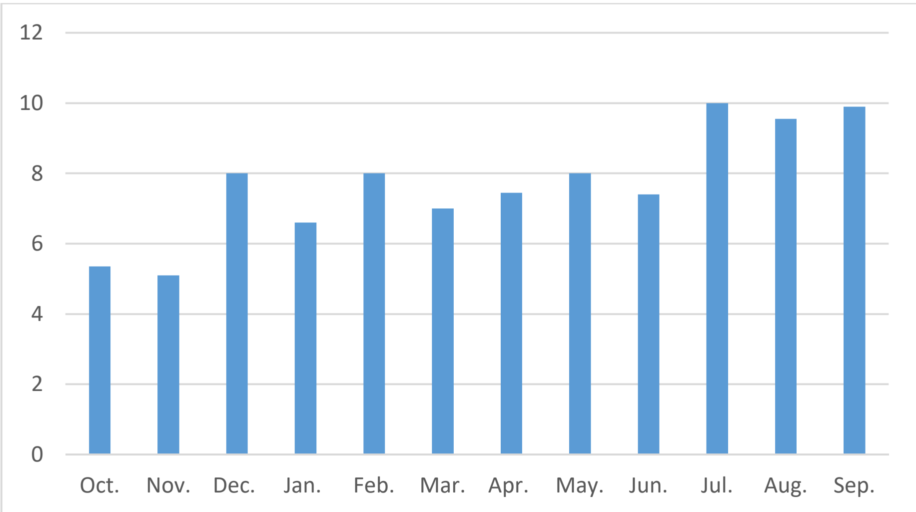

Figure 12. Monthly variations in Dissolved oxygen

3.1.12 Total dissolved solids (TDS)

The natural fresh water body contains total dissolved solids which are in the form of carbonates, bicarbonates, magnesium, nitrate, sulphate, phosphate, etc. The level of TDS at Urmodi water body fluctuated from 19.2-57.6 mg/L (Table 2). Summer season showed high value of TDS and rainy season showed low TDS value (Table 3). Devi and Benarjee (2024) also recorded maximum TDS during summer season. Table 4 showed positive correlation of TDS with pH, while TDS showed negative correlation with Silica. According to BIS (2012) standards for the drinking water, TDS values were within the range of permissible range (2000 mg/L).

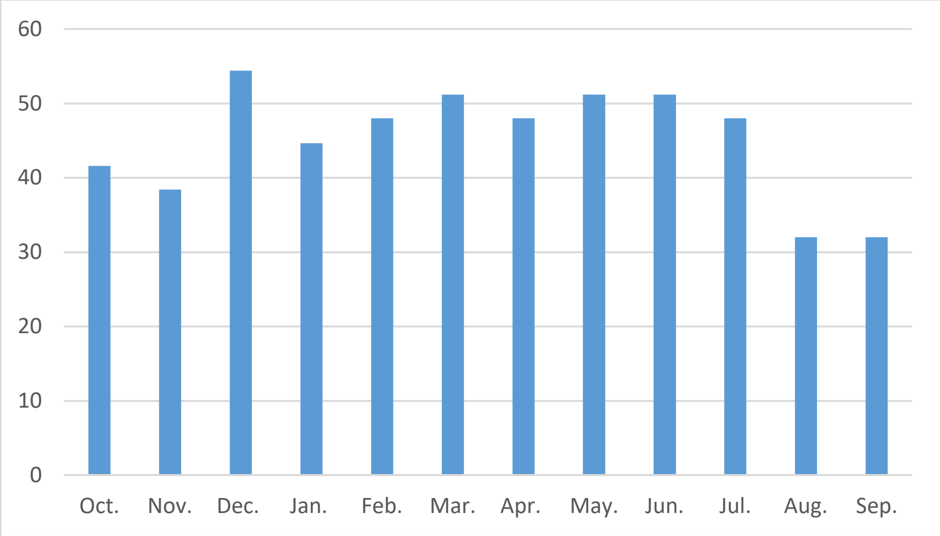

Figure 13. Monthly variations in Total dissolved solids

3.1.13 Electrical conductivity (EC)

Electrical conductivity is the ability of aqueous solution to pass electric current through it. It is an indicative of the salt concentration. The range of EC in Urmodi dam water fluctuated from 0.03-0.09 mhos/cm (Table 2). Summer season showed high value of EC and rainy season showed low value of EC (Table 3). Correlation of EC with various parameters is depicted in Table 4 depicted positive correlation of EC with pH whereas EC showed negative correlation with turbidity, nitrates, Silica.

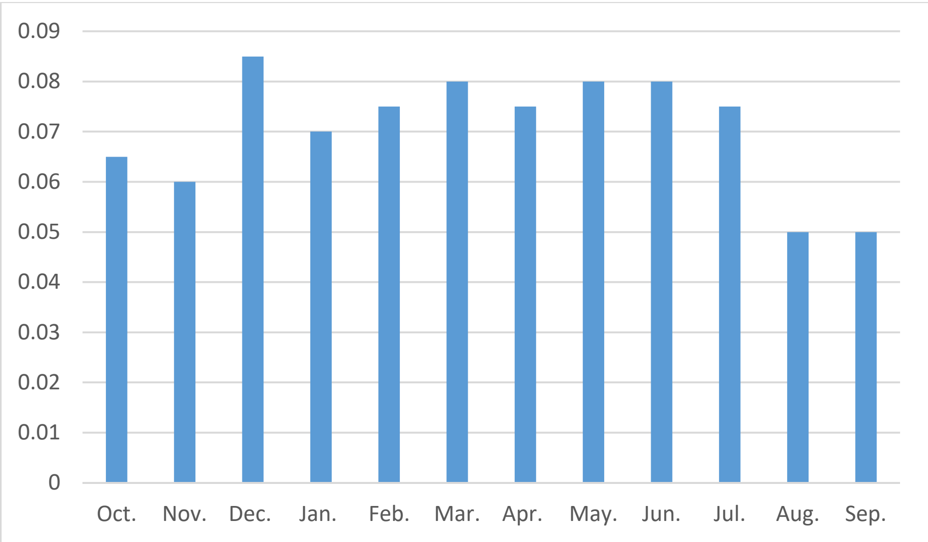

Figure 14. Monthly variations in Electrical conductivity

3.2 Water quality index

The water quality index of Urmodi dam water was determined as 76.5 indicating good quality of water. According to Akkaraboyina and Raju (2012), the higher water quality index values showed that the water was very clear and free of any impurities and that the biotic communities were protected by water in good condition.

3.3 Statistical analysis

The parameters like temperature, pH, alkalinity, DO, nitrogen, silicate, phosphate etc plays significant role in ecology. The statistical data for the correlation coefficient between each of 13 water variables have presented in Table 6. The correlation coefficient value (r-value) found as no correlation (0), Perfect negative correlation (-ve values), low correlation (up to 0.3), moderate correlation (up to 0.5) or perfect positive (1) correlation. Statistical analysis showed significant correlation between physico-chemical parameters (Table 4), Positive correlation was showed by TDS with pH, EC with pH, water temperature with atmospheric temperature, turbidity with TA, silica with nitrate, Negative correlation was showed by Free CO_2 with pH, nitrate with TA, TDS and turbidity, EC and turbidity, EC with nitrate, TDS with Silica, EC with Silica.

Table 4. Correlation between physico-chemical parameters

	pH	Atm.Temp (^{0}C)	Water Temp(^{0}C)	Free CO2(mg/L)	Total alkalinity (mg/L)	Turbidity(NTU)	Total hardness (mg/L)	Nitrates(mg/L)	phosphate (mg/L)	Silica(mg/L)	D.O.(mg/L)	TDS(mg/L)	EC(ms/cm^2)
pH	1												
Atm.Temp (^{0}C)	0.479	1											
Water Temp(^{0}C)	0.343	0.796	1										
Free CO2(mg/L)	-0.525	-0.115	-0.017	1									
Total alkalinity (mg/L)	0.265	0.009	-0.008	-0.305	1								
Turbidity(NTU)	-0.227	-0.446	-0.237	-0.009	0.517	1							
Total hardness (mg/L)	-0.092	0.389	-0.058	-0.184	0.232	-0.118	1						
Nitrates(mg/L)	-0.343	-0.142	0.025	0.385	-0.507	0.339	-0.172	1					
phosphate (mg/L)	0.156	-0.199	-0.312	-0.454	-0.171	-0.146	-0.057	-0.21	1				
Silica(mg/L)	-0.331	-0.245	-0.334	0.167	-0.37	0.337	-0.048	0.605	0.34	1			
D.O.(mg/L)	0.018	-0.453	-0.064	-0.112	0.308	0.788	-0.486	0.412	-0.148	0.099	1		
TDS(mg/L)	0.544	0.25	0.239	-0.434	-0.046	-0.553	-0.233	-0.523	0.277	-0.618	-0.163	1	
EC(ms/cm^2)	0.544	0.25	0.239	-0.434	-0.046	-0.553	-0.233	-0.523	0.277	-0.618	-0.163	1	1

Legend: Colored values from table indicate significance at the 0.05 level (2-tailed).

4. Conclusion

Urmodi dam reservoir is an important aquatic ecosystem. It is main source of water for drinking and agriculture to adjoining and basin areas. Further, it is a tourist point due to sunset viewpoint, scenic beauty and nature and is very near to other tourist places. To know the quality of water, several physico-chemical parameters were tested monthly for the period of 2 years. The water quality of Urmodi dam reservoir was found to be good as revealed by the WQI value. The data obtained revealed seasonal variations in the values of physico-chemical parameters of water from this water reservoir. In summer season, higher values of pH, Phosphorus, Total hardness, Silica, Total dissolved solids and Electrical conductivity as compared to winter and monsoon also indicates increased influx of organic material in reservoir. In post-monsoon season (i.e. winter), there was high values of Free CO_2 and nitrates as compared to previous monsoon indicates increased influx of organic matter in reservoir. In monsoon season, high values of Total alkalinity, Turbidity, Nitrates and Dissolved oxygen were observed. So, it is evident that mostly in summer and to moderate extent in winter there is enrichment of nutrients in this water reservoir. There is need to differentiate between the causes for the influx of nutrients in the reservoir whether it is a natural seasonal change or it is due to anthropogenic activities, to take appropriate measures to control these influxes and there is need to design and follow strictly the policies for dam conservation.

5. References

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