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COMPARATIVE ANALYSIS OF SEASONAL PHYSICO-CHEMICAL CHARACTERISTICS OF MAMA LAKE, NAWARGAON LAKE AND SHINGADA LAKE NEAR WANI TALUKA OF YAVATMAL DISTRICT, MAHARASHTRA INDIA

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ABSTRACT: The study was designed to determine the physicochemical characteristics of Mama, Nawargaon and Singada lakes near Wani Taluka of Yewatmal District in Maharashtra. Water samples were collected on monthly basis from 5 sampling stations of each lake between October 2020 and September-2021. Physiochemical parameters such as temperature, pH, total dissolved solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, Alkalinity, hardness, chloride, fluoride, nitrite, nitrate and sulphate were determined using standard analytical procedure. It is evident from the results that there is significant variation in physical properties of water from selected lakes. Temperature, pH and TDS of Nawargaon lake is higher than Mama and Singada lake. In addition to this, there is significant variation in chemical properties such as DO, BOD, Hardness, Chloride, Nitrate and Sulphate. Nawargaon and Singada lake show higher level of nitrate and sulphate levels. It also observed that level of chemical parameters of selected lakes rise to the maximum during monsoon season and summer season as compare to winter season. It is also evident that lakes such as Singada and Nawargaon are in the close proximity of locality or supplied by tributaries running through populated areas which shows effect on water quality of these lakes.

Key words: - Lake, Physico-chemical characteristics, Seasonal Variation

INTRODUCTION :

Water is an astonishing element. It is unique because it can be naturally found as a solid, liquid, or gas. There are four major sources of surface water. These are rivers, lakes, ponds, and tanks. Two types of water are available on the earth, i.e., saltwater and freshwater. Salt water is 97% of all water and is found mostly in our oceans and seas. Fresh water is found in glaciers, lakes, reservoirs, ponds, rivers, streams, wetlands, and even under the ground which is known as groundwater. Freshwater sources are disappearing at an alarming rate, despite its importance to the life as a drinking water source, irrigation source (sustaining the crops), a food source (fish and aquaculture), and powering source (hydroelectric projects), etc. (WWF)

Water as a natural resource is important for all living organisms, whether unicellular or multicellular, since it is required for various domestic purposes, such as drinking, bathing, washing, recreation, aquaculture irrigation, power generation, and industries (Krishna and Hemant Kumar, 2017). Water is considered as the elixir of life and is used in the greatest quantity throughout the world. The major sources of the water are rivers, ponds, lakes, and tanks. Subsequently, good quality water is on-demand therefore throughout the world the dams are constructed along with the Lakes, which are the most important water resource

today. But unfortunately, the dams are being polluted by indiscriminate disposal of sewage, industrial wastes, and human activities. The dams are always the victims of the negative impacts of urbanization. Most water bodies become contaminated due to the mixing of untreated solid and liquid waste from domestic and industrial sources. Large towns in India are situated near the dams, their runoff and those from agricultural lands find their way to the river and add in dam water, which unfit for human use. Nowadays due to the increased human population and synthetic conditions, the water quality is deteriorating everywhere (Jayabhaye et al., 2008).

The quality of surface water which depends on the equilibrium between the physical, chemical, and biological characteristics of the surrounding environment is constantly changing in response to daily, seasonal, and climatic condition. Variability in physicochemical parameters is responsible for the distribution of organisms in different freshwater habitat according to their adaptation, which allow them to survive in a specific habitat (Jeffries and Mills, 1990). Since water is of necessity to man, animals and plants, it is of greater importance to assess its quality so as to proffer guidelines for its sustainable usage or make corrective steps to ensure its quality (Adedeji et al., 2019).

Mama lake, Nawargaon Lake and Singada lake are significant water resources present nearby Wani Taluka of Yewatmal District in Maharashtra State. Lakes serves for other economic purposes such as fishing. Due to these various activities that take place in the lakes, coupled with farming going around the Lake, the lakes may be contaminated with these anthropogenic activities including some natural source of pollution that may find its way into this important aquatic ecosystem and deteriorates the quality of the water. Therefore, present study was designed to determine the physicochemical characteristics of these lakes.

MATERIAL AND METHOD:

Water samples were collected on monthly basis from 5 sampling stations of each lake between October 2020 and September-2021. Collected samples were analysed for physio-chemical properties. During each season, 60 water samples (Total 180 during three seasons) for laboratory analysis (5 from each lake during each month 5x4x3= 60) were taken from different sampling sites of each lake using a Van Dorn Sampler, and collected in clean 250-mL polyethylene bottles after pre-rinsing with sample water. The average values were calculated for analysis in this study (Gu et al. 2016). All samples were collected in cold boxes and transported to the laboratory. Physiochemical parameters such as temperature, pH, total dissolved solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, Alkalinity, hardness, chloride, fluoride, nitrite, nitrate and sulphate were determined using standard analytical procedure (APHA, 2005). The experimental data for each parameter was analysed using One Way ANOVA.

RESULTS:

Above Table 1 illustrates results of variation in water temperature of Mama lake, Nawargaon Lake and Singada lake. The average water temperature of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 24.24±2.663°C, 29.92±1.217°C and 28.65±4.319°C respectively. There is significant variation in water temperature of selected lake during winter season, water temperature of Nawargaon lake was noticeably ($P<0.05$) higher than water temperature of Mama lake and Singada Lake. The average water temperature of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 27.97±2.109°C, 32.75±2.213°C

and 27.71±2.041°C respectively. There is significant variation in water temperature of selected lake during summer season, water temperature of Nawargaon lake was noticeably (P<0.05) higher than water temperature of Mama lake and Singada Lake. The average water temperature of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 27.58±2.323°C, 32.39±2.327°C and 26.45±2.258°C respectively. There is significant variation in water temperature of selected lake during monsoon season, water temperature of Nawargaon lake was noticeably (P<0.05) higher than water temperature of Mama lake and Singada Lake.

Above Table 2 shows results of variation in water pH of Mama Lake, Nawargaon Lake and Singada lake. The average water pH of Mama Lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 7.23±0.096, 7.85±0.404 and 8.08±0.171 respectively. There is significant variation in water pH of selected lake during winter season, water pH of Singada lake was noticeably (P<0.05) higher than water pH of Mama Lake and Nawargaon Lake. The average water pH of Mama Lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 7.40±0.271, 8.38±0.287 and 8.28±0.222 respectively. There is significant variation in water pH of selected lake during summer season, water pH of Nawargaon lake was noticeably (P<0.05) higher than water pH of Mama Lake and Singada Lake. The average water pH of Mama Lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 8.03±0.096, 9.03±0.096 and 8.80±0.141 respectively. There is significant variation in water pH of selected lake during monsoon season, water pH of Nawargaon lake was noticeably (P<0.05) higher than water pH of Mama Lake and Singada Lake.

Above Table 3 demonstrate results of variation in water TDS of Mama Lake, Nawargaon Lake and Singada lake. The average water TDS of Mama Lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 187.00±6.831mg/L, 193.08±0.789mg/L and 194.00±0.229mg/L respectively. There is no significant variation in water TDS of selected lake during winter season, water TDS of Singada lake was slightly higher than water TDS of Mama Lake and Nawargaon Lake. The average water TDS of Mama Lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 191.78±0.903mg/L, 196.41±.947mg/L and 195.38±0.985mg/L respectively. There is significant variation in water TDS of selected lake during summer season, water TDS of Nawargaon lake was noticeably (P<0.05) higher than water TDS of Mama Lake and Singada Lake. The average water TDS of Mama Lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 193.75±0.550 mg/L, 198.47±0.536mg/L and 197.67±0.579mg/L respectively. There is significant variation in water TDS of selected lake during monsoon season, water TDS of Nawargaon lake was noticeably (P<0.05) higher than water TDS of Mama Lake and Singada Lake.

Above Table 4 illustrates results of variation in water DO of Mama Lake, Nawargaon Lake and Singada lake. The average water DO of Mama Lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 6.53±0.506 mg/L, 5.92±0.084mg/L and 6.95±0.141mg/L respectively. There is significant variation in water DO of selected lake during winter season, DO of Singada lake was substantially (P<0.05) higher than DO of Mama lake and Nawargaon Lake. The average water DO of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 6.14±0.198mg/L, 5.95±0.075mg/L and

7.11±0.183mg/L respectively. There is significant variation in water DO of selected lake during summer season, DO of Singada lake was noticeably (P<0.05) higher than water DO of Mama lake and Nawargaon Lake. The average DO of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 6.71±0.541 mg/L, 6.54±0.771mg/L and 7.20±0.517mg/L respectively. There is no significant variation in DO of selected lake during monsoon season, however, DO of Singada lake was slightly higher than water DO of Mama lake and Nawargaon Lake.

Above Table 5 shows results of variation in water BOD of Mama lake, Nawargaon Lake and Singada lake. The average water BOD of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 2.95±0.064 mg/L, 2.95±0.242mg/L and 2.85±0.132mg/L respectively. There is no significant variation in BOD of selected lake during winter season, however, BOD of Singada lake was slightly lower than BOD of Mama lake and Nawargaon Lake. The average BOD of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 2.88±0.161mg/L, 3.07±0.257mg/L and 2.53±0.222mg/L respectively. There is significant variation in BOD of selected lake during summer season, BOD of Nawargaon lake was noticeably (P<0.05) higher than water BOD of Mama lake and Singada Lake. The average BOD of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 2.90±0.194 mg/L, 2.92±0.139mg/L and 2.45±0.208mg/L respectively. There is significant variation in BOD of selected lake during monsoon season, BOD of Nawargaon lake was considerably (P<0.05) higher than water BOD of Mama lake and Singada Lake.

Above Table 6 demonstrates results of variation in COD of Mama lake, Nawargaon Lake and Singada lake. The average COD of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 6.27±0.796 mg/L, 5.37±0.293mg/L and 6.02±0.214mg/L respectively. There is no significant variation in COD of selected lake during winter season, however, COD of Nawargaon lake was slightly lower than COD of Mama lake and Singada Lake. The average COD of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 6.07±1.086mg/L, 5.01±0.970mg/L and 5.60±0.563mg/L respectively. There is no significant variation in COD of selected lake during summer season, however, COD of Nawargaon lake was slightly lower than water COD of Mama lake and Singada Lake. The average COD of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 5.95±0.304 mg/L, 5.63±0.533mg/L and 6.40±0.594mg/L respectively. There is no significant variation in COD of selected lake during monsoon season, COD of Nawargaon lake was slightly lower than water COD of Mama lake and Singada Lake.

Above Table 7 illustrates results of variation in alkalinity of Mama lake, Nawargaon Lake and Singada lake. The average alkalinity of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 176.68±1.051mg/L, 175.60±0.579mg/L and 176.46±1.296mg/L respectively. There is no significant variation in alkalinity of selected lake during winter season, however, alkalinity of Nawargaon lake was slightly lower than alkalinity of Mama lake and Singada Lake. The average alkalinity of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 175.75±0.347mg/L, 177.91±0.225mg/L and 176.68±0.457mg/L respectively. There is significant variation in

alkalinity of selected lake during summer season, alkalinity of Nawargaon lake was substantially (P<0.05) higher than alkalinity of Mama lake and Singada Lake. The average alkalinity of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 175.96±1.462 mg/L, 151.93±10.223mg/L and 177.15±1.486mg/L respectively. There is no significant variation in alkalinity of selected lake during monsoon season, alkalinity of Nawargaon lake was slightly lower than water alkalinity of Mama lake and Singada Lake.

Above Table 8 illustrates results of variation in hardness of Mama lake, Nawargaon Lake and Singada lake. The average hardness of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 61.07±0.625mg/L, 62.85±0.509mg/L and 59.58±0.580mg/L respectively. There is significant variation in hardness of selected lake during winter season, hardness of Nawargaon lake was substantially (P<0.05) higher than hardness of Mama lake and Singada Lake. The average hardness of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 62.06±1.340mg/L, 63.46±0.931mg/L and 60.01±1.276mg/L respectively. There is significant variation in hardness of selected lake during summer season, hardness of Nawargaon lake was substantially (P<0.05) higher than hardness of Mama lake and Singada Lake. The average hardness of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 60.52±1.726 mg/L, 61.52±1.740mg/L and 59.21±0.736mg/L respectively. There is no significant variation in hardness of selected lake during monsoon season, hardness of Nawargaon lake was slightly lower than water hardness of Mama lake and Singada Lake.

Above Table 9 illustrates results of variation in chloride of Mama lake, Nawargaon Lake and Singada lake. The average chloride of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 87.23±0.902mg/L, 97.65±3.808mg/L and 86.40±2.954mg/L respectively. There is significant variation in chloride of selected lake during winter season, chloride of Nawargaon lake was substantially (P<0.05) higher than chloride of Mama lake and Singada Lake. The average chloride of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 92.10±4.951mg/L, 103.02±4.705mg/L and 87.14±4.266mg/L respectively. There is significant variation in chloride of selected lake during summer season, chloride of Nawargaon lake was noticeably (P<0.05) higher than chloride of Mama lake and Singada Lake. The average chloride of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 90.31±6.667 mg/L, 100.93±6.286mg/L and 87.55±4.685mg/L respectively. There is significant variation in chloride of selected lake during monsoon season, chloride of Nawargaon lake was considerably (P<0.05) higher than water chloride of Mama Lake and Singada Lake.

Above Table 10 shows results of variation in fluoride of Mama lake, Nawargaon Lake and Singada lake. The average fluoride of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 0.693±0.041mg/L, 0.788±0.022mg/L and 0.883±0.029mg/L respectively. There is significant variation in fluoride of selected lake during winter season, fluoride of Singada lake was substantially (P<0.05) higher than fluoride of Mama lake and Nawargaon Lake. The average fluoride of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 0.793±0.060 mg/L, 0.788±0.057 mg/L and 0.855±0.053 mg/L respectively. There

is no significant variation in fluoride of selected lake during summer season, however, fluoride of Singada lake was slightly higher than fluoride of Mama lake and Nawargaon Lake. The average fluoride of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 0.858±0.047 mg/L, 0.818±0.047mg/L and 0.683±0.403mg/L respectively. There is no significant variation in fluoride of selected lake during monsoon season, fluoride of Mama lake was slightly higher than water fluoride of Nawargaon lake and Singada Lake.

Above Table 11 shows results of variation in nitrite of Mama lake, Nawargaon Lake and Singada lake. The average nitrite of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 0.058±0.005mg/L, 0.070±0.008mg/L and 0.083±0.005mg/L respectively. There is significant variation in nitrite of selected lake during winter season, nitrite of Singada lake was substantially ($P<0.05$) higher than nitrite of Mama lake and Nawargaon Lake. The average nitrite of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 0.070±0.008 mg/L, 0.085±0.013 mg/L and 0.088±0.070 mg/L respectively. There is no significant variation in nitrite of selected lake during summer season, however, nitrite of Singada lake was slightly higher than nitrite of Mama lake and Nawargaon Lake. The average nitrite of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 0.078±0.013 mg/L, 0.098±0.013mg/L and 0.098±0.013mg/L respectively. There is no significant variation in nitrite of selected lake during monsoon season, nitrite of Mama lake was slightly lower than water nitrite of Nawargaon lake and Singada Lake.

Above Table 12 shows results of variation in nitrate of Mama lake, Nawargaon Lake and Singada lake. The average nitrate of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 29.00±2.183mg/L, 37.38±2.158mg/L and 44.00±1.268mg/L respectively. There is significant variation in nitrate of selected lake during winter season, nitrate of Singada lake was substantially ($P<0.05$) higher than nitrate of Mama lake and Nawargaon Lake. The average nitrate of Mama lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 33.98±3.132 mg/L, 40.30±2.688 mg/L and 45.73±1.723 mg/L respectively. There is significant variation in nitrate of selected lake during summer season, however, nitrate of Singada lake was considerably ($P<0.05$) higher than nitrate of Mama lake and Nawargaon Lake. The average nitrate of Mama lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 42.73±2.787 mg/L, 47.85±2.536mg/L and 52.78±2.699 mg/L respectively. There is significant variation in nitrate of selected lake during monsoon season, nitrate of Mama Lake was substantially ($P<0.05$) higher than water nitrate of Nawargaon lake and Singada Lake.

Above Table 13 shows results of variation in sulphate of Mama lake, Nawargaon Lake and Singada lake. The average sulphate of Mama lake, Nawargaon Lake and Singada lake during winter season (Oct, Nov, Dec, Jan) was 32.80±1.211mg/L, 43.43±5.652mg/L and 59.75±4.909mg/L respectively. There is significant variation in sulphate of selected lake during winter season, sulphate of Singada lake was substantially ($P<0.05$) higher than sulphate of Mama lake and Nawargaon Lake. The average sulphate of Mama Lake, Nawargaon Lake and Singada lake during summer season (Feb, Mar, Apr, May) was 36.25±3.189 mg/L, 50.53±3.144 mg/L and 64.54±2.918 mg/L respectively. There is significant variation in sulphate of selected lake during summer season, however, sulphate

of Singada lake was considerably (P<0.05) higher than sulphate of Mama Lake and Nawargaon Lake. The average sulphate of Mama Lake, Nawargaon Lake and Singada lake during monsoon season (Jun, Jul, Aug, Sep) was 56.23±7.191 mg/L, 70.18±7.139mg/L and 78.10±4.387 mg/L respectively. There is significant variation in sulphate of selected lake during monsoon season, sulphate of Singada lake was substantially (P<0.05) higher than water sulphate of Nawargaon Lake and Mama Lake.

CONCLUSION:

The results of seasonal variation and physico–chemical study of the lake water samples, helps us to conclude regarding the quality of the water samples studied. It is evident from the results that there is significant variation in physical properties of water from selected lakes. Temperature, pH and TDS of Nawargaon lake is higher than Mama and Singada lake. In addition to this, there is significant variation in chemical properties such as DO, BOD, Hardness, Chloride, Nitrate and Sulphate. Nawargaon and Singada lake show higher level of nitrate and sulphate levels. It also observed that level of chemical parameters of selected lakes rise to the maximum during monsoon season and summer season as compare to winter season. It is also evident that lakes such as Singada and Nawargaon are in the close proximity of locality or supplied by tributaries running through populated areas which shows effect on water quality of these lakes.

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Table 1: Temperature (°C)

Season	Lake	Mean (°C)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	24.24	±2.663	1.332	3.9213	0.0596 (<0.05)
	Nawargaon	29.92	±1.217	0.609		
	Singada	28.65	±4.319	2.159		
	Total	**26.60**	**±2.772**	**0.800**		
Summer	Mama	27.97	±2.109	1.055	7.144	0.0139 (<0.05)
	Nawargaon	32.75	±2.213	1.106		
	Singada	27.71	±2.041	1.021		
	Total	**31.69**	**±2.223**	**0.642**		
Monsoon	Mama	27.58	±2.323	1.161	7.506	0.0121 (<0.05)
	Nawargaon	32.39	±2.327	1.164		
	Singada	26.45	±2.258	1.129		
	Total	**27.60**	**±2.915**	**0.842**	**12.381**	**0.0001**

Table 2: pH

Season	Lake	Mean (pH)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	7.23	±0.096	0.048	11.545	0.0030 (<0.05)
	Nawargaon	7.85	±0.404	0.202		
	Singada	8.08	±0.171	0.085		
	Total	**7.57**	**±0.392**	**0.113**		
Summer	Mama	7.40	±0.271	0.135	16.844	0.0009 (<0.05)
	Nawargaon	8.38	±0.287	0.144		
	Singada	8.28	±0.222	0.111		
	Total	**8.42**	**±0.567**	**0.164**		
Monsoon	Mama	8.03	±0.096	0.048	86.203	0.0000
	Nawargaon	9.03	±0.096	0.048		
	Singada	8.80	±0.141	0.071		
	Total	**8.38**	**0.359**	**0.104**	**14.372**	**0.0000**

Table 3: Total Dissolved Solids (TDS) (mg/l)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	187.00	±6.831	3.416	3.6655	0.0685 (N.S.)
	Nawargaon	193.08	±0.789	0.395		
	Singada	194.00	±0.229	0.115		
	Total	**190.84**	**±4.668**	**1.348**		
Summer	Mama	191.78	±0.903	0.452	26.4506	0.0002
	Nawargaon	196.41	±0.947	0.473		
	Singada	195.38	±0.985	0.492		
	Total	**195.98**	**±2.424**	**0.700**		
Monsoon	Mama	**193.75**	±0.550	0.275	82.771	0.0000
	Nawargaon	198.47	±0.536	0.268		
	Singada	197.67	±0.579	0.289		
	Total	**195.68**	**±1.695**	**0.489**	**9.8129**	**0.0005**

Table 4: Dissolved Oxygen (DO) (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	6.53	±0.506	0.253	11.4755	0.0033
	Nawargaon	5.92	±0.084	0.042		
	Singada	6.95	±0.141	0.071		
	Total	**6.46**	**±0.470**	**0.136**		
Summer	Mama	6.14	±0.198	0.099	59.4946	0.0000
	Nawargaon	5.95	±0.075	0.038		
	Singada	7.11	±0.183	0.091		
	Total	**6.13**	**±0.506**	**0.146**		
Monsoon	Mama	**6.71**	±0.541	0.271	1.2267	0.3380 (N.S.)
	Nawargaon	6.54	±0.771	0.386		
	Singada	7.20	±0.517	0.258		
	Total	**7.09**	**±0.315**	**0.0908**	**14.681**	**0.0000**

Table 5: Biochemical Oxygen Demand (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	2.95	±0.064	0.032	0.5269	0.6076 (N.S.)
	Nawargaon	2.95	±0.242	0.121		
	Singada	2.85	±0.132	0.066		
	Total	**2.91**	**±0.140**	**0.040**		
Summer	Mama	2.88	±0.161	0.081	6.4736	0.0181
	Nawargaon	3.07	±0.257	0.129		
	Singada	2.53	±0.222	0.111		
	Total	**2.98**	**±0.210**	**0.061**		
Monsoon	Mama	2.90	±0.194	0.097	8.4054	0.0087
	Nawargaon	2.92	±0.139	0.069		
	Singada	2.45	±0.208	0.104		
	Total	**2.61**	**±0.249**	**0.0719**	**11.1482**	**0.0002**

Table 6: Chemical Oxygen Demand (COD)(mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	6.27	±0.796	0.398	3.3775	0.0805 (N.S.)
	Nawargaon	5.37	±0.293	0.147		
	Singada	6.02	±0.214	0.107		
	Total	**6.09**	**±0.734**	**0.212**		
Summer	Mama	6.07	±1.086	0.543	1.3758	0.3011 (N.S.)
	Nawargaon	5.01	±0.970	0.485		
	Singada	5.60	±0.563	0.281		
	Total	**5.45**	**±0.655**	**0.175**		
Monsoon	Mama	**5.95**	±0.304	0.152	2.4946	0.1374 (N.S.)
	Nawargaon	5.63	±0.533	0.267		
	Singada	6.40	±0.594	0.297		
	Total	**6.01**	**±0.558**	**0.161**	**3.7972**	**0.0322**

Table 7: Alkalinity (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	176.68	±1.051	0.525	1.2436	0.3335 (N.S.)
	Nawargaon	175.60	±0.579	0.289		
	Singada	176.46	±1.296	0.648		
	Total	**176.13**	**±1.044**	**0.302**		
Summer	Mama	175.75	±0.347	0.173	37.1945	0.0000
	Nawargaon	177.91	±0.225	0.113		
	Singada	176.68	±0.457	0.229		
	Total	**178.48**	**±6.004**	**1.733**		
Monsoon	Mama	175.96	±1.462	0.731	1.1006	0.3736 (N.S.)
	Nawargaon	151.93	±10.223	5.112		
	Singada	177.15	±1.486	0.743		
	Total	**176.76**	**±1.099**	**0.317**	**1.3911**	**0.2630**

Table 8: Hardness (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	61.07	±0.625	0.312	32.7697	0.0001
	Nawargaon	62.85	±0.509	0.255		
	Singada	59.58	±0.580	0.290		
	Total	**61.22**	**±1.359**	**0.392**		
Summer	Mama	62.06	±1.340	0.670	8.4203	0.0087
	Nawargaon	63.46	±0.931	0.466		
	Singada	60.01	±1.276	0.638		
	Total	**62.61**	**±1.358**	**0.392**		
Monsoon	Mama	60.52	±1.726	0.863	2.4646	0.1401 (N.S.)
	Nawargaon	61.52	±1.740	0.870		
	Singada	59.21	±0.736	0.368		
	Total	**59.60**	**±0.894**	**0.258**	**18.2341**	**0.0000**

Table 9: Chloride (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	87.23	±0.902	0.451	19.6008	0.0005
	Nawargaon	97.65	±3.808	1.904		
	Singada	86.40	±2.954	1.477		
	Total	**89.89**	**±4.837**	**1.396**		
Summer	Mama	92.10	±4.951	2.475	12.2159	0.0027
	Nawargaon	103.02	±4.705	2.353		
	Singada	87.14	±4.266	2.133		
	Total	**100.53**	**±5.108**	**1.475**		
Monsoon	Mama	**90.31**	±6.667	3.334	5.6582	0.0256
	Nawargaon	100.93	±6.286	3.143		
	Singada	87.55	±4.685	2.342		
	Total	**87.03**	**±3.685**	**1.064**	**28.9231**	**0.0000**

Table 10: Fluoride (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	0.693	±0.041	0.021	36.0311	0.0001
	Nawargaon	0.788	±0.022	0.011		
	Singada	0.883	±0.029	0.014		
	Total	**0.781**	**±0.084**	**0.024**		
Summer	Mama	0.793	±0.060	0.030	1.7762	0.2238 (N.S.)
	Nawargaon	0.788	±0.057	0.028		
	Singada	0.855	±0.053	0.026		
	Total	**0.798**	**±0.043**	**0.012**		
Monsoon	Mama	0.858	±0.047	0.023	0.6052	0.5668 (N.S.)
	Nawargaon	0.818	±0.047	0.023		
	Singada	0.683	±0.403	0.202		
	Total	**0.807**	**±0.232**	**0.067**	**0.099**	**0.9060**

Table 11: Nitrite (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	0.058	±0.005	0.003	15.9925	0.0011
	Nawargaon	0.070	±0.008	0.004		
	Singada	0.083	±0.005	0.025		
	Total	**0.068**	**±0.012**	**0.003**		
Summer	Mama	0.070	±0.008	0.004	3.2995	0.0842 (N.S.)
	Nawargaon	0.085	±0.013	0.007		
	Singada	0.088	±0.010	0.005		
	Total	**0.084**	**±0.016**	**0.005**		
Monsoon	Mama	**0.078**	±0.013	0.006	3.3594	0.0813 (N.S.)
	Nawargaon	0.098	±0.013	0.006		
	Singada	0.098	±0.013	0.006		
	Total	**0.089**	**±0.011**	**0.003**	**8.5479**	**0.0010**

Table 12: Nitrate (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	29.00	±2.183	1.092	61.4798	0.0000
	Nawargaon	37.38	±2.158	1.079		
	Singada	44.00	±1.268	0.634		
	Total	**35.23**	**±6.419**	**1.853**		
Summer	Mama	33.98	±3.132	1.566	20.7448	0.0004
	Nawargaon	40.30	±2.688	1.344		
	Singada	45.73	±1.723	0.862		
	Total	**41.84**	**±5.124**	**1.479**		
Monsoon	Mama	**42.73**	±2.787	1.394	14.1063	0.0017
	Nawargaon	47.85	±2.536	1.268		
	Singada	52.78	±2.699	1.349		
	Total	**47.50**	**±4.354**	**1.257**	**15.7033**	**0.0000**

Table 13: Sulphate (mg/L)

Season	Lake	Mean (mg/L)	S.D.	S.E.	F- Stat	P Value
Winter	Mama	32.80	±1.211	0.606		
	Nawargaon	43.43	±5.652	2.826	38.4551	0.0000
	Singada	59.75	±4.909	2.454		
	Total	**41.76**	**±11.558**	**3.337**		
Summer	Mama	36.25	±3.189	1.595		
	Nawargaon	50.53	±3.144	1.572	84.0322	0.0000
	Singada	64.54	±2.918	1.459		
	Total	**54.71**	**±12.843**	**3.708**		
Monsoon	Mama	**56.23**	±7.191	3.596		
	Nawargaon	70.18	±7.139	3.569	12.0724	0.0028
	Singada	78.10	±4.387	2.194		
	Total	**67.46**	**±8.946**	**2.583**	**15.7073**	**0.0000**