Research Article

Analysis of Physico-Chemical Parameters of Water of Ponds/Lakes in and Around Arsikere Taluk, Hassan District, Karnataka, India

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ABSTRACT

Arsikere is one of the historical old towns originates during the Hoysala dynasty, holds several lakes/ponds in and around its geography. Published reports on physic-chemical parameters of lakes/ponds in and around Arsikere is poor. To know about the physico-chemical properties of lakes/ponds of Arsikere, as it is necessitated because water from these lakes/ponds are drinking source to various animal species including man some extent. Hence, present investigation was undertaken by selecting three perennial ponds namely: Arsikere pond or Doddakere, Kallanaikanahalli Kere and Kellengere Kere were selected within the circumference of five kilometer radius to investigate the water quality during different seasons from February, 2022 to January, 2023. Water samples were collected using standard methods and analyzed the physico-chemical parameters namely: temperature, pH, conductivity, turbidity, total suspended solids, dissolved oxygen, free carbon dioxide, Biochemical Oxygen Demand (BOD), calcium carbonate, chloride, total phosphorus, nitrogen and total hardness were measured in the laboratory. Results revealed quite interesting facts. The physical parameters such as temperature, pH, conductivity, turbidity and total suspended solids were not alike during different seasons and indicated significant difference between the ponds. Moreover, Spearman's correlation coefficient between pH, conductivity, turbidity and total suspended solids with water temperature indicated positive correlation during most of the seasons. Similarly, chemical parameters such as dissolved oxygen, free carbon dioxide, Biochemical Oxygen Demand (BOD), calcium carbonate, chloride, total phosphorus, nitrogen and total hardness were also differed significantly during different seasons between the ponds. Further, Spearman's correlation coefficient between dissolved oxygen, free carbon dioxide, Biochemical Oxygen Demand (BOD), calcium carbonate, chloride, total phosphorus, nitrogen and total hardness with water temperature indicated positive correlation during most of the seasons. Although, Arsikere pond or Doddakere, Kallanaikanahalli Kere and Kellengere Kere are located within the radius of five kilometers, but their topography is slightly varied and interestingly the physical and chemical parameters of these pond water were dissimilar and varied considerably. Water is one of the vital solvents, required by all living beings including man, its physico-chemical parameters as per the APHA standard norms are necessary to maintain the basic characteristics to understand the healthy status of aquatic habitat. Moreover, understanding the physico-chemical parameters of ponds/lakes imperative to maintain the health of aquatic habitats and in turn balance the biotic and abiotic components of aquatic ecosystems.

Keywords: Ponds, Lakes, Physico-chemical parameters, Seasonal variations.

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INTRODUCTION

Water is one of the indispensable natural resources on this planet earth. All living beings including man depend on water. Due to the water unique properties, it is being used for various purposes. All the human activities such as drinking, irrigation, washing and industrial

activities are directly depended on water and in turn almost every human developmental activity is directly or indirectly depended on water.[1] Interestingly, earth is having about 70% of water[2] that constitutes about 97% salt water and only 3% fresh water.[1] Surprisingly, fresh water habitats are highly diversified and marked by a wide range of physico-chemical conditions, which greatly influences the local aquatic biota.[3] Thus, the status of water depends on the locality and its topography.[4-6] Moreover, all living beings are directly or indirectly connected with water.[7] Obviously, fresh water bodies are the most important natural ecosystems for many organisms, which depend for their survival on these local water.[8] Therefore, water should be good for the sustenance of all forms of life, food production and economic development and for general well being. Measurement of productivity and energy of water body require the assessment of its physico-chemical characteristics, which moulded the activities of various living biota in aquatic ecosystem.[7] Thus, quality of water is expressed in terms of its physical, chemical and biological characteristics.[9] Therefore, monitoring of water quality in any aquatic bodies would be the first priority that could help manage and conserve local aquatic ecosystems. So, inland water bodies either ponds or lakes should be studied to record the physico-chemical parameters and measurements are to be taken to maintain their quality within acceptable levels.[4-6] On this line various researchers in and around the world have conducted water assessment regularly to reveal its quality.[10,1,4-6,9,2,11-13] have studied the water of lake, pond, reservoir at Tamil Nadu, Maharashtra, Telangana, Madhya Pradesh, Andhra Pradesh and Karnataka.[14] have determined the water quality index and suitability of an urban water body in Shimoga Town, Karnataka.[8,14-18] have analyzed the seasonal variations of physico-chemical parameters of Dams, Ponds, Reservoirs, Swamp and freshwater tank in different parts of India[19] have reported the importance of water quality on the avifaunal diversity at an inland pond, Kondagai village, Sivaganga district, South India. Furthermore,[20] recorded the seasonal dynamics of fighter plankton and its relationship with the environmental factors in Meghadrigedda Reservoir of Visakhapatnam, Andhra Pradesh, India[17] have reported the influence of water quality on avifaunal diversity in the Udhayamarthandapuram Bird Sanctuary, Thiruvarur district, Tamil Nadu[3] studied the physico-chemical properties and Microfaunal Diversity of Masoli reservoir, Madhya Pradesh. However, ppublished reports on physico-chemical characteristics of water quality in ponds/lakes located at the vicinity of Arsikere taluk of Hassan district are poor. Hence, the present investigation was necessitated.

MATERIALS AND METHODS

Study area

Arsikere is one of the historical old towns in Hassan district of Karnataka State, holds several lakes/ponds in and around its geography. The name Arsikere originates from one of the princesses of the Hoysala dynasty who built this town and lake.[22] The study area lies between latitude 13º04'30.4" to 13º32'50.6"N and longitude 76º01'40.4" to 76º25'53.7" E of Hassan district (Figure 1). The region is known for its dry zone, where water is very scarce commodity and vital for the local farmers and residents of Arsikere town. Three perennial ponds were selected within the circumference of five kilometer radius. Every pond is exposed with varying levels of human activity and land use patterns. The Arsikere pond or Doddakere, Kallanaikanahalli Kere and Kellengere Kere were selected for the present investigation (Figure 1).

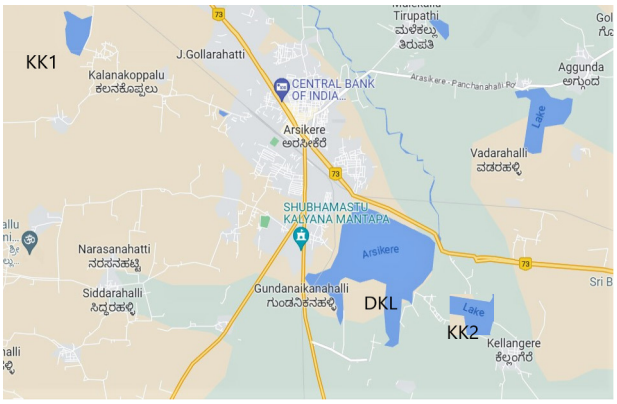

Figure 1: Map showing ponds/lakes of Arsikere Taluk, DKL: Doddakere Lake; KK1: Kallanaikanahalli Kere; KK2: Kellengere Kere.

METHODOLOGY

Water samples were collected from three lakes during different seasons for a period of one year i.e., from February, 2022 to January, 2023. Water samples were collected during the morning hours between 0800 and 0900 in a clean sterilized polythene bottles using standard methods as described in APHA.[23] The samples were collected during pre-monsoon (February to May), monsoon (June to September) and post-monsoon (October to January). The physico-chemical parameters namely: temperature, pH, turbidity, conductivity, dissolved oxygen, free carbon dioxide, Biochemical Oxygen Demand (BOD), total hardness, calcium carbonate, chloride, total phosphorus, total nitrogen and total suspended solids were measured in

the laboratory using standard methods as per APHA.[23] The collected data was complied and statistically analyzed using standard methods as per Saha.[24] The Pearson's correlations between water quality parameters and prevailed ecological conditions were made and analysis of variance was done to reveal the difference if any existed between the lakes/ponds, as these ponds/lakes are not alike with respect to their topography.

RESULTS

Physical parameters of water Temperature

The water temperature in three different ponds/lakes was ranged between 23^0 and 27^0C (Tables 1 to 3). The maximum water temperature was recorded in pre-monsoon season that was ranged from 26.88º to 27ºC with a mean of 26.96º±0.07ºC (Table 1), the minimum water temperature was recorded in post-monsoon season and it was ranged from 23.9º to 24ºC with a mean of 23.95±0.07 (Table 2) and the water temperature during monsoon season was ranged from 23º to 23.33ºC with a mean of 23.11º±0.19ºC (Table 3). The Kurskal Wallis Analysis of variance of water temperature during different seasons indicated significant difference (H=15.461; p>0.05) existed between the ponds/lakes in Arsikere (Table 4 and Figure 2).

Table 1: Spearman's coefficient correlations between physical parameters of water of different lakes during Pre-monsoon season in Arsikere.

Lake	Temperature (°C)	pH	Conductivity	Turbidity	TSS
DKL	27.0	8.5	744	2.1	18
KK1	27.0	8.3	678	13.5	28
KK2	26.88	8.42	385	17.4	42
Mean±SD	26.96±0.07	8.41±0.08	602.33±191.08	11.0±7.95	29.33±12.05
'r' value		-0.085	0.985	-0.689	-0.909
't' value		1.004	5.780	1.379	2.398

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Table 2: Spearman's coefficient correlations between physical parameters of water of different lakes during Monsoon season in Arsikere.

Lake	Temperature (°C)	pH	Conductivity	Turbidity	TSS
DKL	23.96	8.2	755	7.3	20
KK1	24.0	7.8	522	9.2	26
KK2	23.9	8.0	570	5.6	14
Mean±SD	23.95±0.07	8.0±0.20	615.66±123.03	7.36±1.80	20.0±6.00
'r' value		0.418	0.0389	0.0677	0.0643
't' value		1.101	1.001	1.002	1.002

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1**: Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Table 3: Spearman's coefficient correlations between physical parameters of water of different lakes during Post-monsoon season in Arsikere.

Lake	Temperature (ºC)	pH	Conductivity	Turbidity	TSS
DKL	23.33	8.5	845	6.2	516
KK1	23.0	8.2	709	3.8	436
KK2	23.0	8.3	710	5.6	442
Mean±SD	23.11±0.19	8.33±0.15	759.66±78.23	5.2±1.22	464.66±44.5
'r' value		0.217	0.999	0.693	0.996
't' value		1.024	26.737	1.387	11.961

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Table 4: Kursakl Wallis ANOVA of physical parameters of water of different lakes during different seasons in Arsikere.

Sl. No.	Physical parameters	Name of Lake	Season			'H' value
			Pre-monsoon	Monsoon	Post-monsoon	
1.	Temperature (±C)	DKL	27.0	23.96	23.33	15.461*
		KK1	27.0	24.0	23.0	
		KK2	26.88	23.9	23.0	
2.	pH	DKL	8.5	8.2	8.5	14.185*
		KK1	8.3	7.8	8.2	
		KK2	8.42	8.0	8.3	
3.	Conductivity	DKL	744	755	845	31.342*
		KK1	678	522	709	
		KK2	385	570	710	
4.	Turbidity	DKL	2.1	7.3	6.2	19.106*
		KK1	13.5	9.2	3.8	
		KK2	17.4	5.6	5.6	
5.	TSS	DKL	18	20	516	26.022*
		KK1	28	26	436	
		KK2	42	14	442	

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

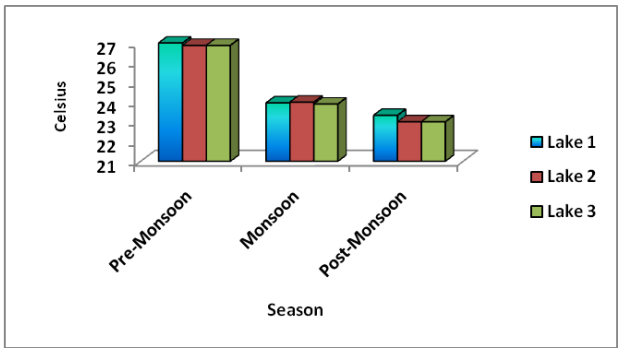

Figure 2: Water temperature of different lakes during various seasons.

pH

The pH in the water of ponds/lakes was ranged between 8.3 and 8.5 (Tables 1 to 3). The pH of water during pre-monsoon season was ranged from 8.3 to 8.5 with a mean of 8.41±0.08 and the Spearman's correlation coefficient between pH and water temperature indicated negative correlation (r=-0.085; t=1.004) between the lakes during pre-monsoon season (Table 1). During monsoon season it was ranged from 7.8 to 8.2 with a mean of 8.00±0.20 and the Spearman's correlation coefficient between pH and water temperature indicated positive correlation (r=0.418; 1.101) between the lakes during monsoon season (Table 2). However, during post-monsoon season the pH of water was 8.2±8.5 with a mean of 8.33±0.15 and the Spearman's correlation coefficient between pH and water temperature indicated positive correlation (r=0.217; t=1.024) between the lakes during post-monsoon season (Table 3). The Kurskal Wallis Analysis of variance of water pH indicated significant difference (H=14.185; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 4 and Figure 3). Thus, seasonal variations observed with the pH levels in the water of these ponds/lakes and there was a considerable correlation existed with the water temperature.

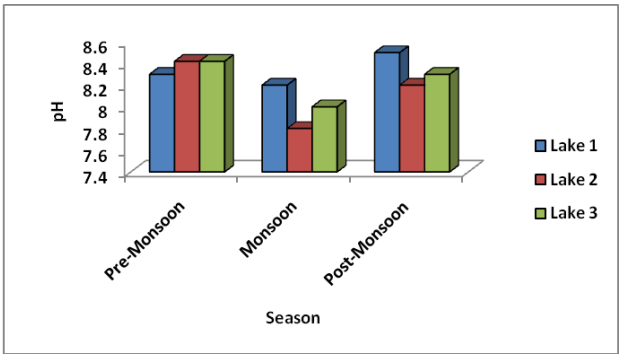

Figure 3: Water pH of different lakes during various seasons.

Conductivity

The water conductivity of different ponds/lakes was ranged between 385 and 845 µS/cm (Tables 1 to 3). The conductivity of water during pre-monsoon season was ranged from 385 to 744 µS/cm with a mean of 602.33±191.08 µS/cm and the Spearman's correlation coefficient between the conductivity and water

temperature indicated significant positive correlation (r=0.985; t=5.780) between the lakes during pre-monsoon season (Table 1). During post-monsoon season the conductivity was ranged from 522±755 µS/cm with a mean of 615.66±123.03 µS/cm and the Spearman's correlation coefficient between conductivity and water temperature indicated considerable positive correlation (r=0.0389; t=1.001) between the lakes during monsoon season (Table 2). However, during post-monsoon season, the conductivity was ranged from 709 to 845µS/cm with a mean of 759.66±78.23µS/cm and the Spearman's correlation coefficient between conductivity and water temperature indicated significant positive correlation (r=0.999; t=26.7373) between the lakes during post-monsoon season (Table 3). Further, the Kurskal Wallis Analysis of variance of water conductivity indicated significant difference (H=31.342; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 4 and Figure 4). Thus, seasonal variations observed with the conductivity levels in the water of these ponds/lakes.

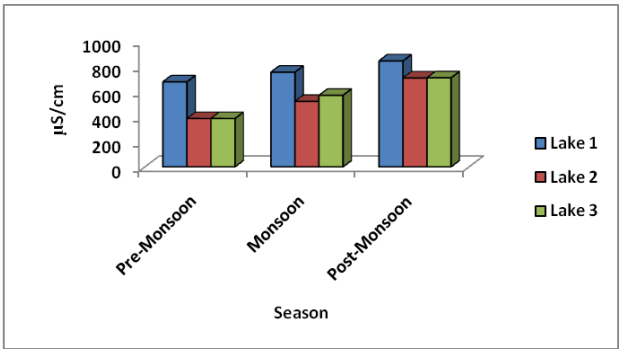

Figure 4: Water conductivity of different lakes during various seasons.

Turbidity

The water turbidity of different ponds/lakes was ranged between minimum 2.1 and maximum 17.4 Nephelometric Turbidity Units (NTU) (Tables 1 to 3). The water turbidity was ranged from 2.1 to 17.4 NTU with a mean of 11.0±7.95 NTU and the Spearman's correlation coefficient between the turbidity and water temperature indicated negative correlation (r=-0.689; t=1.379) between the lakes during pre-monsoon season (Table 1). During monsoon season, the water turbidity was ranged from 5.6 to 9.2 NTU with a mean of 7.36±1.80 NTU and the Spearman's correlation coefficient between the turbidity and water temperature indicated considerable positive correlation (r=0.0677; t=1.002) between the lakes (Table 2). However, during post-monsoon season, the turbidity was ranged from 3.8 to 6.2 NTU with a mean of 5.2±1.22 NTU and the and the Spearman's correlation coefficient between the turbidity and water temperature indicated significant positive correlation (r=0.693; t=1.387) between the lakes during post-monsoon season (Table 3). Further, the Kurskal Wallis Analysis of variance of water turbidity indicated significant difference (H=19.106; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 4 and Figure 5). Thus, seasonal variations observed with the turbidity levels in the water of these ponds/lakes.

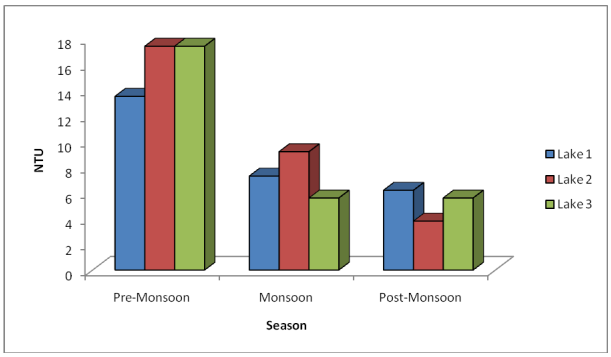

Figure 5: Turbidity in the water of different lakes during various seasons.

Total Suspended Solids (TSS)

The TSS in the water of different ponds/lakes was ranged between minimum 14 and maximum 516 during different seasons (Tables 1 to 3). The TSS in the water ranged from 18 to 42 with a mean of 29.33±12.05 and the Spearman's correlation coefficient between the TSS and water temperature indicated considerable negative correlation (r=-0.909; t=2.398) between the ponds/lakes during pre-monsoon season (Table 1). During monsoon season, the TSS in the water ranged from 14 to 26 with a mean of 20.0±6.00 and the Spearman's correlation coefficient between the TSS and water temperature indicated considerable positive correlation (r=0.0643; t=1.002) between the ponds/lakes (Table 2). However, during post-monsoon season, the TSS was very high compared to pre-monsoon and monsoon seasons and it was ranged from 436 to 516 with a mean of 464±44.5 and the Spearman's correlation coefficient between the TSS and water temperature indicated significant positive correlation (r=0.996; t=11.961) between the ponds/lakes (Table 3). Further, the Kurskal Wallis Analysis of variance of TSS in water indicated significant difference (H=26.022; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 4 and Figure 6). Thus, seasonal variations observed with the total suspended solids in water of these ponds/lakes.

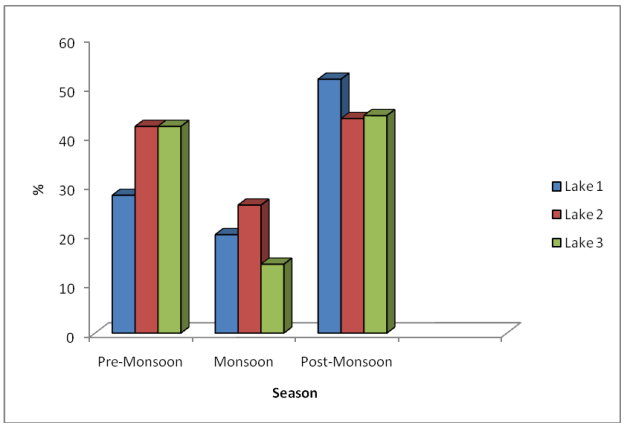

Figure 6: TSS in the water temperature of different lakes during various seasons.

Chemical parameters of water Dissolved Oxygen (DO)

DO in the water of different ponds/lakes was ranged between minimum 6.0mg/L and maximum 7.3 mg/L during different seasons (Tables 5 to 7). The DO in the water ranged from 6.5 mg/L to 6.6 mg/L with a mean of 6.57±0.15 mg/L and the Spearman's correlation coefficient between the DO and water temperature indicated considerable positive correlation (r=0.220; t=1.025) between the ponds/lakes during pre-monsoon season (Table 5). During monsoon season, DO in the water ranged from 6.0 mg/L to 6.8 mg/L with a mean of 6.5±0.43 mg/L and the Spearman's correlation coefficient between the DO and water temperature indicated considerable positive correlation (r=0.072; t=1.002) between the ponds/lakes (Table 6). However, during post-monsoon season, the DO was very high compared to pre-monsoon and monsoon seasons and it was ranged from 7.2 mg/L to 7.3 mg/L with a mean of 7.23±0.06 mg/L and the Spearman's correlation coefficient between the DO and water temperature indicated considerable negative correlation (r=-0.346; t=1.006) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of DO in water indicated significant difference (H=12.456; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 7). Thus, seasonal variations observed with the dissolved oxygen in the water of these ponds/lakes.

Table 5: Spearman's coefficient correlations between chemical parameters of water of different lakes during Pre-monsoon season in Arsikere.

Lake	Temperature (°C)	DO (mg/L)	CO_2 (mg/L)	BOD (mg/L)	COD (mg/L)	CL (mg/L)	Total P (mg/L)	N (mg/L)	Total Hardness (mg/L)
DKL	27.0	6.6	4.0	12.0	64.0	95.0	0.08	2.1	212.0
KK1	27.0	6.6	3.8	18.0	80.0	95.0	0.012	1.7	116.0
KK2	26.88	6.5	4.0	26.0	120.0	75.0	0.09	1.9	80.0
Mean±SD	26.96±0.07	6.57±0.15	3.93±0.11	18.66±7.02	88.0±28.84	88.33±11.55	0.061±0.04	1.9±0.20	136±68.25
'r' value		0.220	0.0	-0.903	-0.961	1.00	-0.604	0.072	0.711
't' value		1.025	0.00	2.325	3.610	0.00	1.254	1.00	1.422

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Table 6: Spearman's coefficient correlations between chemical parameters of water of different lakes during Monsoon season in Arsikere.

Lake	Temperature (°C)	DO (mg/L)	CO_2 (mg/L)	BOD (mg/L)	COD (mg/L)	CL (mg/L)	Total P (mg/L)	N (mg/L)	Total Hardness (mg/L)
DKL	23.96	6.0	5.8	2.2	32	95.0	0.08	2.1	240
KK1	24.0	6.8	5.0	3.1	40	95.0	0.012	1.7	96.0
KK2	23.9	6.7	6.1	4.2	32	75.0	0.09	1.9	180.0
Mean±SD	23.95±0.07	6.5±0.43	5.63±0.57	3.16±1.00	34.66±4.61	88.33±11.54	0.061±0.29	1.9±0.2	172±72.33
'r' value		0.0719	0.0024	0.0158	0.0745	1.00	-0.604	0.072	0.723
't' value		1.002	1.001	1.000	1.002	0.00	1.254	1.00	1.003

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Table 7: Spearman's coefficient correlations between chemical parameters of water of different lakes during Post-monsoon season in Arsikere.

Lake	Temperature (°C)	DO (mg/L)	CO_2 (mg/L)	BOD (mg/L)	COD (mg/L)	CL (mg/L)	Total P (mg/L)	N (mg/L)	Total Hardness (mg/L)
DKL	23.33	7.2	5.0	4.8	19	73	0.89	1.8	280
KK1	23.0	7.3	4.8	5.2	30	97	0.02	1.8	21.0
KK2	23.0	7.2	4.9	5.4	26	54	0.09	1.8	208
Mean±SD	23.11±0.19	7.23±0.06	4.9±0.10	5.13±0.31	25.0±5.56	74.66±21.54	0.33±0.48	1.8±0.0	169.66±133.68
'r' value		-0.346	0.866	-0.932	-0.933	-0.066	0.984	-	0.714
't' value		1.066	2.000	2.762	2.783	1.002	5.780	-	1.494

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1**: Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

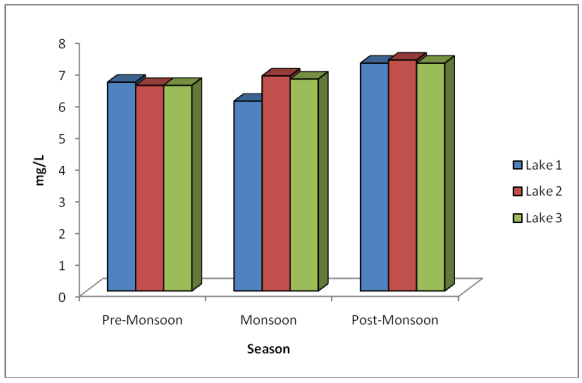

Figure 7: DO recorded in the water temperature of different lakes during various seasons.

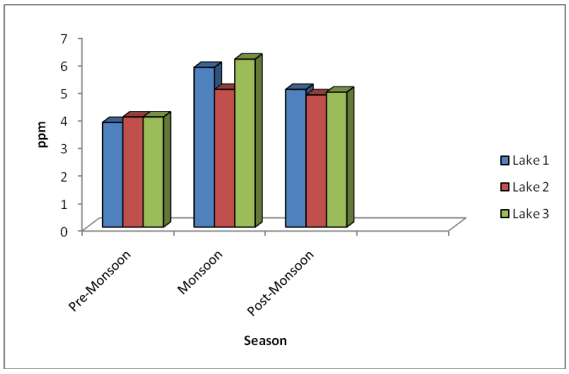

Figure 8: CO_2 recorded in the water temperature of different lakes during various seasons.

Dissolved Carbon dioxide (CO_2)

CO_2 in the water of different ponds/lakes was ranged between minimum 3.8mg/L and maximum 6.1 mg/L during different seasons (Tables 5 to 7). The CO_2 in the water ranged from 3.8 mg/L to 4.0 mg/L with a mean of 3.93±0.11 mg/L and the Spearman's correlation coefficient between the CO_2 and water temperature indicated no correlation (r=0.00; t=0.0) between the ponds/lakes during pre-monsoon season (Table 5). During monsoon season, CO_2 in the water ranged from 5.0 mg/L to 6.1mg/L with a mean of 5.63±0.57mg/L and the Spearman's correlation coefficient between the CO_2 and water temperature indicated little positive correlation (r=0.0024; t=1.001) between the ponds/lakes (Table 6). However, during post-monsoon season, the CO_2 was ranged from 4.8mg/L to 5.0mg/L with a mean of 4.9±0.10mg/L and the Spearman's correlation coefficient between the CO_2 and water temperature indicated significant positive correlation (r=0.866; t=2.000) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of CO_2 in water indicated significant difference (H=10.55; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 8). Thus, seasonal variations observed with the dissolved carbon dioxide in the water of these ponds/lakes.

Biological Oxygen Demand (BOD)

BOD in the water of different ponds/lakes was ranged between minimum 2.2 mg/L and maximum 26.0 mg/L during different seasons (Tables 5 to 7). The BOD was high in the water of different lakes during pre-monsoon season compared to monsoon and post-monsoon seasons and it was ranged from 12.0mg/L to 26.0mg/L with a mean of 18.66±7.02 mg/L and the Spearman's correlation coefficient between the BOD and water temperature indicated considerable negative correlation (r=-903; t=2.325) between the ponds/lakes during pre-monsoon season (Table 5). During monsoon season, BOD was less in the water and it was ranged from 2.2 mg/L to 4.2 mg/L with a mean of 3.16±1.00 mg/L and the Spearman's correlation coefficient between the BOD and water temperature indicated little positive correlation (r=0.0158; t=1.000) between the ponds/lakes (Table 6). However, during post-monsoon season, the BOD was little higher compared to monsoon season and lower compared to pre-monsoon season, but it was ranged from 4.8 mg/L to 5.4 mg/L with a mean of 5.13±0.31 mg/L and the Spearman's correlation coefficient between the BOD and water temperature indicated significant negative correlation (r=-0.932; t=2.762) between the ponds/lakes (Table 7). Further, the

Table 8: Kursakl Wallis ANOVA of Chemical parameters of water of different lakes during various seasons in Arsikere.

Sl. No.	Chemical parameters	Name of Lake	Season			'H' value
			Pre-monsoon	Monsoon	Post-monsoon	
		DKL	6.6	6.0	7.2	
1.	DO	KK1	6.6	6.7	7.3	12.456*
		KK2	6.5	6.7	7.2	
		DKL	4.0	5.8	5.0	
2.	CO_2	KK1	3.8	5.0	4.8	10.55*
		KK2	4.0	6.1	4.9	
		DKL	1.2	2.2	4.8	
3.	BOD	KK1	1.8	3.1	5.2	27.352*
		KK2	2.6	4.2	5.4	
		DKL	64	32	32	
4.	COD	KK1	80	40	30	13.121*
		KK2	120	32	26	
		DKL	95	142	73	
5.	Chloride (Cl)	KK1	95	152	97	19.150*
		KK2	75	87	54	
		DKL	0.08	0.10	0.89	
6.	Phosphorus (P)	KK1	0.012	-	0.02	19.852*
		KK2	0.09	0.097	0.09	
		DKL	2.1	6.4	1.8	
7.	Nitrogen (N)	KK1	1.7	5.6	1.8	10.594
		KK2	1.9	6.4	1.8	
		DKL	212	240	280	
8.	Total Hardness ($CaCO_3$)	KK1	116	96	21	35.465*
		KK2	80	180	208	

Note: Each value is a mean of five observations.
*Values are significant at 5% level. **DKL:** Doddakere Lake; **KK1:** Kallanaikanahalli Kere; **KK2:** Kellengere Kere.

Kurskal Wallis Analysis of variance of BOD in water indicated significant difference (H=27/352; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 9). Thus, seasonal variations observed with the biological oxygen demand in the water of these ponds/lakes.

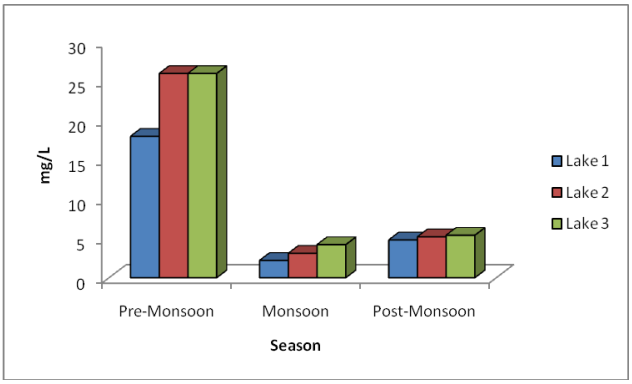

Figure 9: BOD recorded in the water temperature of different lakes during various seasons.

Chemical Oxygen Demand (COD)

COD in the water of different ponds/lakes was little high compared to BOD and it was ranged between minimum 19.0 mg/L and maximum 120.0 mg/L during different seasons (Tables 5 to 7). The COD was high in the water during pre-monsoon season compared to monsoon and post-monsoon seasons and it was ranged from 64.0 mg/L to 120.0 mg/L with a mean of 88.0±28.84 mg/L and the Spearman's correlation coefficient between the COD and water temperature indicated considerable negative correlation (r=-961; t=3.610) between the ponds/lakes during pre-monsoon season (Table 5). During monsoon season, COD was ranged from 32.0 mg/L to 40.0 mg/L with a mean of 34.66±4.61mg/L and the Spearman's correlation coefficient between the COD and water temperature indicated little positive correlation (r=0.0745; t=1.002) between the ponds/lakes (Table 6). However, during post-monsoon season, the COD was ranged from

19.0 mg/L to 30.0 mg/L with a mean of 25.0±5.56 mg/L and the Spearman's correlation coefficient between the COD and water temperature indicated significant negative correlation (r=-0.933; t=2.783) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of COD in water indicated significant difference (H=13.121; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 10). Thus, seasonal variations observed with the chemical oxygen demand in the water of these ponds/lakes.

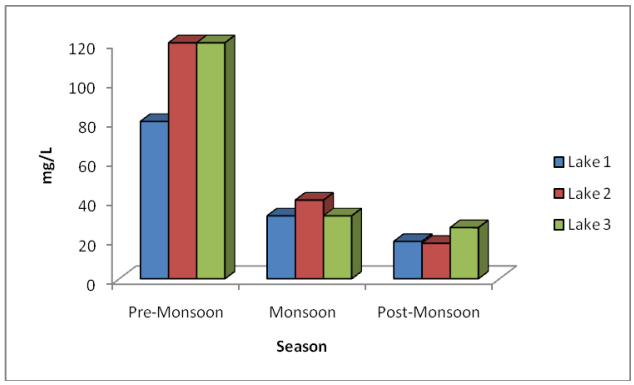

Figure 10: COD recorded in the water temperature of different lakes during various seasons.

Chlorine (Cl) content

Chlorine content in the water of different ponds/lakes was ranged between minimum 54.0 mg/L and maximum 97.0 mg/L during different seasons (Tables 5 to 7). The chlorine content was almost similar in the water during pre-monsoon and monsoon seasons compared to post-monsoon season and it was ranged from 75.0 mg/L to 95.0 mg/L with a mean of 88.33±11.55 mg/L and the Spearman's correlation coefficient between the chlorine and water temperature indicated no correlation (r=1.000; t=0.00) between the ponds/lakes during pre-monsoon and monsoon seasons (Tables 5 and 6). However, during post-monsoon season, the chlorine content was ranged from 54.0 mg/L to 97.0 mg/L with a mean of 74.66±21.54 mg/L and the Spearman's correlation coefficient between the chlorine content and water temperature indicated considerable negative correlation (r=-0.066; t=1.002) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of chlorine content in water indicated significant difference (H=19.150; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 11). Thus, seasonal variations observed with the chlorine content in the water of these ponds/lakes.

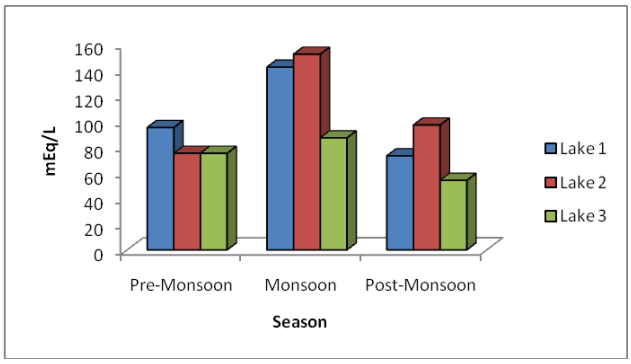

Figure 11: Chloride content recorded in the water temperature of different lakes during various seasons.

Total Phosphate content

Total phosphate content in the water of different ponds/lakes was less (less than 1mg/L) it was ranged between minimum 0.012 mg/L and maximum 0.89 mg/L during different seasons (Tables 5 to 7). The phosphate content in the water was almost same during pre-monsoon and monsoon seasons and it was ranged from 0.012 mg/L to 0.09 mg/L with a mean of 0.061±0.04 mg/L and the Spearman's correlation coefficient between the total phosphate content and water temperature indicated significant negative correlation (r=-0.604; t=1.254) between the ponds/lakes during pre-monsoon and monsoon seasons (Tables 5 and 6). However, during post-monsoon season, the phosphate content in the water ranged from 0.02 mg/L to 0.89 mg/L with a mean of 0.33±0.48 mg/L and the Spearman's correlation coefficient between the total phosphate content and the water temperature indicated significant positive correlation (r=0.984; t=5.780) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of total phosphate content in water indicated significant difference (H=19.852; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 12). Thus, seasonal variations observed with the total phosphate content in the water of these ponds/lakes.

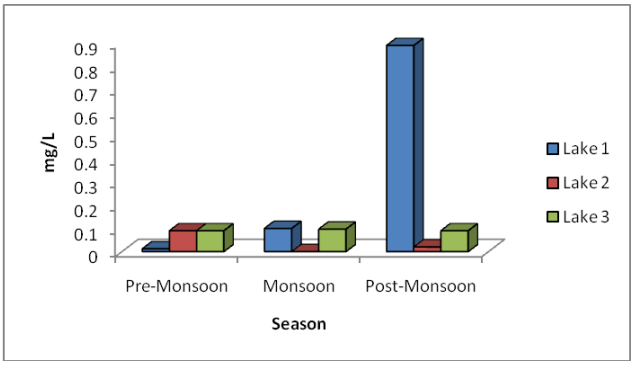

Figure 12: Phosphate content recorded in the water temperature of different lakes during various seasons.

Nitrogen (N) content

Nitrogen content in the water of different ponds/lakes was ranged between minimum 1.7 mg/L and maximum 2.1 mg/L during different seasons (Tables 5 to 7). The nitrogen content in the water was almost same during pre-monsoon and monsoon seasons and it was ranged from 1.7 mg/L to 2.1 mg/L with a mean of 1.9±0.20 mg/L and the Spearman's correlation coefficient between the nitrogen content and water temperature indicated considerable positive correlation (r=0.072; t=1.00) between the ponds/lakes during pre-monsoon and monsoon seasons (Tables 5 and 6). However, during post-monsoon season, nitrogen content in the water was almost same i.e., 1.8mg/L in ponds/lakes and the Spearman's correlation coefficient between the total phosphate content and the water temperature indicated significant no correlation (r=0.00; t=00) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of nitrogen content in water indicated significant difference (H=10.594; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 13). Thus, seasonal variations observed with the nitrogen content in the water of these ponds/lakes.

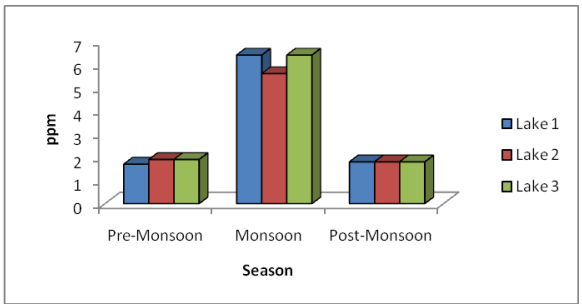

Figure 13: Nitrate content recorded in the water temperature of different lakes during various seasons.

Total Hardness ($CaCO_3$)

Total hardness in the water of different ponds/lakes was ranged between minimum 21 and maximum 280 during different seasons (Tables 5 to 7). Total hardness was ranged from 80.0 to 212.0 with a mean of 136.0±68.25 and the Spearman's correlation coefficient between the total hardness and water temperature indicated significant positive correlation (r=0.711; t=1.422) between the ponds/lakes during pre-monsoon season (Table 5). During monsoon season, total hardness was ranged from 96.0 to 240.0 with a mean of 172.0±72.33 and the Spearman's correlation coefficient between the total hardness and water temperature indicated significant positive correlation (r=0.723; t=1.003) between the ponds/lakes (Table 6). However, during post-monsoon season, the total hardness in the water ranged from 21.0 to 280 with a mean of 169.66±133.68 and the Spearman's correlation coefficient between the total hardness and water temperature indicated significant positive correlation (r=0.714; t=1.494) between the ponds/lakes (Table 7). Further, the Kurskal Wallis Analysis of variance of COD in water indicated significant difference (H=35.465; p>0.05) existed during different seasons between the ponds/lakes in Arsikere (Table 8 and Figure 14). Thus, seasonal variations observed with the total hardness ($CaCO_3$) in the water of these ponds/lakes.

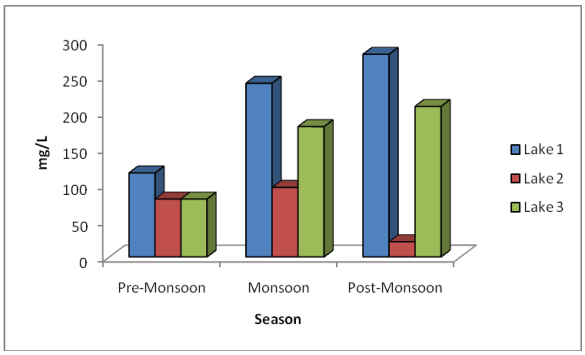

Figure 14: Total hardness recorded in the water temperature of different lakes during various seasons.

DISCUSSION

Water is one of the vital solvents, required by all living beings for their survival. The physico-chemical parameters of water are necessary basic characteristics to understand the status of every aquatic habitat. Water parameter is essential because each and every water bodies have different chemical compositions, and they are subjected to constant change because of anthropogenic activities. Understanding the physico-chemical parameters of ponds/lakes is crucial to maintain the health and balance the biotic and abiotic components of aquatic ecosystems. It was witnessed by the present investigations by assessing the water physical parameters such as temperature, pH, conductivity, turbidity, total suspended solids and the chemical parameters such as dissolved oxygen, carbon dioxide, biological and chemical oxygen demand, content of chlorine, phosphate and nitrogen and total hardness ($CaCO_3$) at three different ponds/lakes during pre-monsoon, monsoon and post-monsoon seasons. Surprisingly, all the physical and chemical parameters were dissimilar and varied significantly between the ponds/lakes during different seasons in the study area. Therefore, assessing water quality at regular intervals either seasonally or monthly is very much necessitated. On this line various researchers[10,16,8,25] have reported the water quality and revealed how important water is

for the survival at various living beings including man. Thus, all these researchers published reports elucidated the importance of physico-chemical properties of water that could help restore the micro fauna and their diversity[15] Therefore, water quality analysis at ponds or lakes is essential to know about the avifaunal diversity of different aquatic habitats. In the present study, the water bodies are associated with higher bird species richness as an aspect of understanding and conserving bird biodiversity. Water contamination is crucial for implementing measures to prevent and conservation of bird diversity by preserving their habitats and ensuring the availability of essential resources in the study area.

Hence, local biodiversity is influenced by water quality and its biotic components of the aquatic habitat.[21] Our observations are on par with the observations of previous researchers.[20,21,3] Further, Spearman's correlation coefficient between water temperature, few physical parameters (example: pH, conductivity, turbidity and total suspended solids) and chemical parameters (example: Dissolved oxygen, carbon dioxide, biological and chemical oxygen demand, chlorine, phosphate, nitrogen and total hardness in terms of $CaCO_3$) revealed quite considerable correlation ship during different seasons. This indicates that water temperature is vital and it interferes with physical and chemical parameters and helps reveal the quality and healthy status of aquatic habitats. Since, temperature is one of the critical physico-chemical parameters that greatly affect the quality of water and in turn health of aquatic organisms in pond/lake ecosystems. Higher temperature increases the solubility of some pollutants, making them more available for uptake by aquatic organisms. The pH is another important physical parameter, plays a significant role in determining the water quality. The pH also affects the solubility of chemical substances and pollutants in water. The acidic water dissolves the heavy metals such as lead and copper, which are absorbed by fish and other aquatic organisms. It leads to biomagnifications of heavy metals. Therefore, pH analysis is crucial and its normal range should be monitored as per APHA.[23] Moreover, **c**onductivity measures the ability of water to conduct an electrical current, which is influenced by the presence of dissolved salts and ions. So, normal water conductivity matters much as it has correlation with other physical and chemical parameters of water. Hence, it should be normal as per APHA.[23] High levels of turbidity could have a negative impact on aquatic life by reducing the amount of light penetrative in the water and making difficult for aquatic plants to carry out photosynthesis and food for fish and other aquatic biota. Therefore, turbidity should be below the norms in the water as prescribed by the APHA.[23] Furthermore, Total Suspended Solids (TSS) re include organic matter, silt and debris if their concentration is more than the prescribed limit of APHA[23], which affects the clarity and quality of water and in turn impact the aquatic life. Similar type of observations was reported by several researchers.[10,21,20,16,8,25,3]

Similarly, the chemical parameters such as dissolved oxygen (DO) are a very important and crucial chemical parameter that affects the survival of aquatic life. Additionally, low DO levels could have negative impact on other aquatic organisms such as insects and crustaceans, larval forms etc. Therefore, normal DO in the pond/lake water is very essential as per the description of APHA.[23] However, Free carbon dioxide can originate from both natural and man-made sources. The excess carbon dioxide from human activities would cause acidification in the pond/lake water, which have harmful effects on aquatic life. Therefore, carbon dioxide in the pond/lake water should be less as per the description of APHA.[23] The nitrogen is measured to know the different forms of nitrogen in the water such as nitrates, nitrites and ammonia. More nitrogen in water leads to the growth of harmful algal blooms and that leads to the development of eutrophication and finally results depletion adequate amount of oxygen in the water for aquatic organisms. In addition, some types of algae could deplete oxygen in the water, creating dead zones where no aquatic life can survive. Therefore, nitrogen monitoring and maintains is very essential to have a quality water in the pond/lake. Thus, it is imperative to maintain nitrogen as per APHA.[23] During the present investigation, chloride, phosphate and total hardness ($CaCO_3$) analysis was made and the results indicated that all the three ponds/lakes exhibited significant variance during different seasons. Total hardness help reveal indirectly the amount of dissolved calcium and magnesium ions present in the water. However, chloride content is important as its high level indicate the contamination from saltwater intrusion or wastewater discharge. The phosphorus is an essential nutrient for plant growth, but excessive amounts lead to harmful algal blooms and oxygen depletion in the water. Therefore, all these chemical parameters are very vital for the maintenance of quality of water in pond/lake. Hence, chloride, phosphate and total hardness ($CaCO_3$) of water should be below the standard norms as prescribed by the APHA.[2] Our observations are on par with the observations of previous researchers.[1-6,8-13,15-18,20,21,26,27]

CONCLUSION

Present study revealed the physico-chemical characteristics of three ponds which are vital to the local people of Arsikere of Hassan District in Karnataka. These ponds provide sources of water for drinking, irrigation, fishing and other activities. Interestingly, physico-chemical parameters exhibited wide range of fluctuations during different seasons among these ponds. So, water quality is not alike during most of the year, but alters accordingly during different seasons which have considerable implications on local flora, fauna and biodiversity. Pond water exhibit ubiquitous properties, indicates seasonal variations in its physico-chemical characteristics which need regular monitoring for the safe use of quality water for public use and in turn to restore local biodiversity as well.

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