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Limnological Status of Sarvepalli Reservoir, Nellore District, Andhra Pradesh

K. Chalapathi[1*], K. Madhavi[1], C. Prabhanjan Kumar Reddy[1] and N. Jesintha[1]

[1]*College of Fishery Science, Muthukur, Nellore, Andhra Pradesh, 524344, India.*

Authors' contributions

This work was carried out in collaboration between all authors. Author KC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors KM, CPKR and NJ managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Present work was carried out to assess the physicochemical parameters of water samples of Sarvepalli reservoir of River Penna during November 2016 to May 2017 for seven months. Various water quality parameters including Air temperature, Water temperature, pH, Turbidity, total alkalinity, total hardness, Free *Carbon Dioxide* (CO_2), *Dissolved Oxygen* (D.O), *Biochemical Oxygen Demand* (BOD), Chlorides, (*Total Dissolved Solids)* TDS and total ammonia were estimated whereas, correlation coefficients between different parameters of both the stations upstream and downstream were also analysed. Water quality of the reservoir is following the drinking water standards concerning turbidity, pH, TDS, total alkalinity, total hardness and total ammonia except for BOD.

Keywords: Dissolved oxygen; biochemical oxygen demand; total dissolved solids.

E-mail: adnanamin2011@gmail.com;

1. INTRODUCTION

Water is essential to life and is the defining characteristic of Earth, the blue planet. Although water covers two-thirds of our world's surface, about 97.5% of it is salty, only 2.5% of the Earth's remaining water resources exist as freshwater. The more significant portion of this freshwater stock (68.9%) is in the form of ice, and permanent snow cover and groundwater comprises 29.9% of total freshwater resources. Only 0.3% of the total amount of freshwater on the Earth is much concentrated in lakes, reservoirs and river systems. The remaining 0.9% is contributed by soil moisture, swamp water and permafrost [1]. Lakes and reservoirs constitute the largest source of the usable freshwater on the Earth because they supply water for the population in the whole year. These lentic water bodies are shared and stable habitats of the biosphere [2]. Reservoirs are only semi-natural ecosystems, usually being the result of humans transformed a river into a lake for specific purposes, to provide a reliable and controllable resource. All human-made impoundments created by obstructing the surface flow, by erecting a dam of any description, on a river, stream or any watercourse, have been reckoned as reservoirs [3]. Reservoirs contribute as the single largest inland fishery resource of our country both regarding size and production potential. India has a total of 19,370 reservoirs, of which 19,134 are small, 180 are medium and 56 are large [4,5]. All these reservoirs spread over 15 states with an estimated 3.15 million ha (31,53,366 ha) surface area at full capacity and are expected to increase due to execution of various water projects in the country [6]. The Ministry of Agriculture, Government of India has classified reservoirs as small (<1000 ha), medium (1,000 to 5,000 ha) and large (>5000 ha) for fisheries management [7]. Andhra Pradesh stands at second place with a total reservoir area of 4,58,507 ha only after Madhya Pradesh (4,60,384 ha) and contributes to 14.54% of the total surface area (31,53,366 ha) of Indian reservoirs [8]. In India, with respect to the area of reservoirs, Andhra Pradesh ranks first in case of large reservoirs, with an area of 1,90,151 ha (out of 11,60,511 ha., contributing to 16.4%); second in case of medium sized reservoirs after Madhya Pradesh with an area of 66,429 ha (out of total 5,07,298 ha, contributing to 13.1%); third with 2898 units and with an area of 2,01,927 ha (out of total 14,85,557 ha., thereby contributing to 13.6%) in case of small reservoirs preceded by Tamil Nadu and Karnataka [9]. Sarvepalli reservoir is one of the major irrigation sources of Nellore district with 17.61 sq.km water spread area, 28.87 km free catchment area, 4796 hectares of registered ayacut and 6212 hectares of present ayacut values. It is the main of the source of irrigation for Sarvepalli constituency. Due to colossal development and population explosion in Nellore region from last one decade which has posed a direct threat to water bodies around the region. Thus, this study was designed to evaluate the Limnological status of Sarvepalli reservoir.

2. MATERIALS AND METHODS

2.1 Study Area

Sarvepalli reservoir is located at a distance of 25 Km from Nellore city. It lies 6m high above the sea level. From Nellore anicut (which receives water from Somasila reservoir), water is supplied through sarvepalli canal to the sarvepalli reservoir. It has a total water spread area of 1761 ha. Sampling was carried at fortnightly intervals during the period from November-2016 to May-2017. Surface sampling was done in all the selected stations. On the basis of the local rainfall conditions, the study period consisted of monsoon (November & December), winter (January & February) and summer (March, April & May) seasons. We identified two sampling stations one representing the upstream and other is downstream based on the flow of water. The physico-chemical parameters such as temperature, pH, dissolved oxygen, total alkalinity, total hardness and transparency were analyzed fortnightly.

2.2 Meteorology

The amount of rainfall received in the region during the study period was obtained from the Irrigation Department, Nellore.

2.3 Air Temperature

Air temperature was recorded at each station at the beginning of the sampling using a standard mercury centigrade thermometer to the nearest 0.1º and expressed in degree Celsius.

2.4 Hydrography

Water samples were collected from the two selected sampling stations for a period of 7 months (November, 2016 to May, 2017) at fortnightly intervals in the early hours of the day between 7.00 AM to 9.00 AM. At each station, samples of surface (at a depth of one foot) waters were collected in duplicate and mixed together so as to portray the average condition in the respective area. Iodine treated double stoppered polythene bottles were used for collection of water samples (Table 1).

2.5 Water Temperature

Surface water temperatures were recorded immediately after the collection using a standard mercury centigrade thermometer to the nearest 0.1º and expressed in degree Celsius.

2.6 Dissolved Oxygen

Water samples for estimation of dissolved oxygen were collected in clean 125 mL stoppered glass bottles carefully avoiding air bubbles. The samples were then fixed immediately with Winkler's reagents standard mercury centigrade thermometer to the nearest 0.1º and expressed in degree Celsius.

2.7 Carbon Dioxide

Free CO_2 content was estimated by the titrimetric method using phenolphthalein indicator and sodium hydroxide.

2.8 Biochemical Oxygen Demand (BOD)

For the estimation of Biochemical Oxygen Demand, the water samples were collected in 300 mL oxygen bottles carefully avoiding air bubbles.

2.9 Total Ammonia

Water samples were collected in 150 mL amber coloured glass bottles and fixed following the phenol-hypochlorite method as described by [10].

Table 1. Location of sampling stations

Sl. No.	Stations	Latitude	Longitude
1	Sarvepalli Upstream (S1)	N 14º 17.921'	E 79º 59.788'
2	Sarvepalli Downstream (S2)	N 14º 16.310'	E 79º 59.832'

Fig. 1. Map showing the location of sampling stations Sarvepalli reservoir: S1 (upstream) & S2 (downstream)

2.10 Laboratory Analysis

2.10.1 Turbidity

Turbidity of water samples was estimated using digital Nephalometer (Model 341, EI) and expressed as NTU.

2.10.2 Total dissolved solids (TDS)

Gravimetric estimation of TDS was carried out by following the method described in [11] and the results were expressed in mg/L.

2.10.3 PH (Potentia Hydrogeni)

pH of water samples was measured potentiometrically using digital pH meter (Digital pH Meter-111, EI).

2.10.4 Chlorides

Chloride content was estimated by titrating the water sample with silver nitrate using potassium chromate as indicator and expressed in terms of mg/L.

3. RESULTS AND DISCUSSION METEOROLOGY

3.1 Rainfall

Maximum rainfall was observed during the month of December and no rainfall was observed during five months i.e., from January to May against seven (07) months of the present study. During the present investigation, the area experienced higher rainfall during November (N-E monsoon), which is in accordance with the observation made by [12].

3.2 Air Temperature

A significant variation in the value of air temperature has been observed due to the influence of climatological parameters. In general, the lower values of air temperature were observed in monsoon and winter, in comparison to summer season. Air temperature at upstream station was fluctuated between 27.6ºC in the month of December (monsoon) and 32.6ºC in the month of May (summer) with a variation of 5.0ºC and study period Mean (Mean ± SD) of 29.70± 2.06ºC (Table 2). Whereas in downstream air temperature ranged from 27.7ºC in the month of December (monsoon) to 32.6ºC in the month of May (summer) with a variation of 4.9ºC and study period Mean (Mean ± SD) of 29.84± 2.04ºC (Table 3). During the study period air temperatures recorded at Sarvepalli reservoir ranged from 27.6ºC to 32.6ºC with a Mean ± SD of 29.77±1.98ºC. Similar trend in air temperature was noticed by [13] while investigating on Anjanapura reservoir (28.16ºC to 33.5ºC) and [14] while working on Wyra reservoir (22.8ºC to 33.7ºC).

3.3 Hydrography Water Temperature

A significant variation in the value of water temperature has been observed due to the influence of climatological parameters. In general, the lower values of air temperature were observed in monsoon and winter, in comparison to summer season. Water temperature at upstream station fluctuated between 27.3ºC in the month of December (monsoon) and 32.3ºC in the month of May (summer) with a variation of 5ºC and study period Mean (Mean ± SD) of 29.45±2.10ºC (Table 2). Whereas in downstream water temperature ranged from 27.5ºC in the month of December (monsoon) to 32.4ºC in the month of May (summer) with a variation of 4.9ºC and study period Mean (Mean ± SD) of 29.67 ± 2.07ºC (Table 3). During the study period, it varied between 27.3ºC and 32.4ºC (Mean ± SD of 29.56 ± 2.02ºC). Similar type of observations was made by [15] in case of Lower Manair reservoir (24ºC to 30.0ºC), [13] in Anjanapura reservoir (25.25ºC to 30.25ºC).

3.4 Turbidity

Turbidity is an expression of light scattering and light absorption properties of water and is caused by the presence of suspended matter, such as clay, silt, colloidal organic particles, plankton etc. It is a measure of the interference due to presence of suspended matter to the passage of light. Turbidity due to abiotic colloidal micelles (organic and inorganic) is of paramount importance as these micelle by virtue of their extensive surface area coupled with electrical charge keep nutrient ions adsorbed on their surface rendering equilibrium concentrations of these ions in water phase. Water turbidity in upstream was fluctuated between 2.5 NTU during the month of May (summer) and 4.8 NTU in the month of December (monsoon) with a variation of 2.3 NTU and study period Mean (Mean ± SD) of 3.62±0.89 NTU (Table 2). Whereas In downstream water turbidity ranged from 2.6 NTU in the month of May (summer) to 5.1 NTU in the month of December (monsoon) with a variation of 2.5 NTU and study period Mean (Mean ± SD) of 3.87±0.89 NTU (Table 3). During the present studies, it fluctuated between 2.5 NTU and 5.1 NTU (Mean ± SD of 3.75 ± 0.87 NTU). Similar studies were made by [16] documented turbidity values ranging from 0.91 to 3.14 NTU in Harsi reservoir. [14] observed turbidity values ranging from 0.5 to 2.2 NTU in Wyra reservoir.

3.5 Total Dissolved Solids (TDS)

Total dissolved solid concentration is indicative of the degree of mineralization of water. Dissolved solids in water originate from natural sources and depend up on location, geological nature of the basin, drainage, rainfall, bottom deposits and inflowing water. Dissolved solids in the upstream station was fluctuated between 210.0 mg/L in the month of November (monsoon) and 318.0 mg/L in the month of May (summer) with a variation of mg 108.0 /L and study period Mean (Mean ± SD) of 256.71±35.09 mg/L (Table 2). Whereas in downstream total dissolved solids ranged from 198.0 mg/L in the month of November (monsoon) to 296.0 mg/L in the months of March & May (summer) with a variation of 98.0 mg/L and study period Mean (Mean± SD) of 247.43 ± 34.95 mg/L (Table 3). Total dissolved solids of the Sarvepalli reservoir fluctuated between 198.0 mg/L and 318.0 mg/L (Mean ± SD of 252.07±34.06 mg/L). The observations on TDS clearly indicate that, TDS values were high in summer months followed by winter and monsoon months. The highest values observed during summer season can be attributed to the intense solar radiation and associated high rate of evaporation in comparison to cooler periods during monsoon,

Table 2. Sarvepalli reservoir upstream

		A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
Nov.	1st F	27.8	27.5	4.6	210	7.8	4.4	1	145	8.8	0.39	178	212
	2nd F	27.9	27.4	4.4	232	7.9	4.2	4	124	9.4	0.3	164	240
Dec.	1st F	27.6	27.3	4.8	226	8	4.8	8	139	8.4	0.27	162	240
	2nd F	28	27.8	4.4	220	7.9	4.9	6	122	9	0.25	148	238
Jan.	1st F	28.3	28.1	4.5	248	7.9	4.9	6	128	6.4	0.18	172	252
	2nd F	28.5	28.2	4.4	218	8	5	8	112	5.6	0.14	186	246
Feb.	1st F	27.8	27.5	3.5	242	8.2	5	4	132	6	0.1	168	210
	2nd F	28.2	28	3.9	252	8.1	5.4	2	126	6.4	0.08	174	252
Mar.	1st F	31.2	31	2.6	272	8.5	6	2	165	4.8	0.05	184	226
	2nd F	31.9	31.6	2.9	306	8.4	6.2	0	154	5.9	0.08	232	194
Apr.	1st F	31.7	31.5	2.8	294	8.6	6.8	1	204	4.8	0.03	192	192
	2nd F	32	32	2.6	264	8.4	7	0	168	5.4	0.02	212	176
May	1st F	32.3	32.1	2.5	318	8.6	7	2	192	5.4	0.06	186	186
	2nd F	32.6	32.3	2.8	292	8.3	7.2	2	180	5	0.08	204	202

A.T-Air Temperature, W.T-Water Temperature, T-Turbidity, TDS-Total Dissolved Solids, D.O-Dissolved oxygen, CO_2-Carbon dioxide, Cl-Chlorides, BOD-Biochemical Oxygen Demand, NH_3-Toatl ammonia, T.A-Total alkalinity, T.H-Total hardness.

Table 3. Sarvepalli reservoir downstream

		A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
Nov.	1st F	28.1	27.9	4.9	206	7.9	4.6	2	118	8.2	0.26	170	208
	2nd F	28.4	28.2	4.6	198	7.7	4.8	6	102	8.6	0.24	158	216
Dec.	1st F	27.7	27.5	5.1	212	7.9	5.1	4	126	8	0.23	158	226
	2nd F	28.1	27.9	4.6	204	8	5	6	106	7.9	0.19	126	230
Jan.	1st F	28.4	28.2	4.8	232	7.8	5	6	118	5.2	0.19	160	212
	2nd F	28.6	28.3	4.6	236	7.8	5.4	2	110	4.8	0.15	138	220
Feb.	1st F	28	27.8	3.8	238	8.2	5.2	1	110	5.9	0.12	168	198
	2nd F	28	27.9	4.1	248	8	5.2	0	104	6.6	0.06	145	218
Mar.	1st F	31.4	31.3	2.9	296	8.3	6.3	0	112	4.4	0.01	198	186
	2nd F	32	32.1	3.1	282	8.4	6.4	0	136	5.3	0.04	204	204
Apr.	1st F	31.9	31.7	3.2	286	8.4	7.2	0	158	4.6	0.03	188	208
	2nd F	32.1	31.9	2.9	258	8.3	7.5	0	142	5.2	0.02	182	192
May	1st F	32.5	32.3	2.6	296	8.5	7.4	0	144	4.8	0.04	194	182
	2nd F	32.6	32.4	3	272	8.4	7.6	0	132	4.8	0.12	192	168

A.T-Air Temperature, W.T-Water Temperature, T-Turbidity, TDS-Total Dissolved Solids, D.O-Dissolved oxygen, CO_2-Carbon dioxide, Cl-Chlorides, BOD-Biochemical Oxygen Demand, NH_3-Toatl ammonia, T.A-Total alkalinity, T.H-Total hardness which might have diluted the water to certain extent. Similar type of observations was made by [17] documented TDS values in the range of 178 to 290 mg/L in Mhaswad reservoir. [18] reported total dissolved solids ranging from 149 to 211.2 mg/L in case of a flood plain reservoir on river Ravi.

3.6 pH

pH of any aqueous system is suggestive of its acid-base equilibrium achieved by various dissolved compounds in it. pH of water is a master variable because many reactions that control water quality are pH dependent. pH of water in the upstream station was fluctuated between 7.8 in the month of November (monsoon) and 8.6 in the months of April & May (summer) with a variation of 0.8 and study period Mean (Mean ± SD) of 8.19±0.28 (Table 2). Whereas in downstream water pH ranged from 7.7 in the month of November (monsoon) to 8.5 in the month of May (summer) with a variation of 0.8 and study period Mean (Mean ± SD) of 8.11± 0.27 (Table 3). In Sarvepalli reservoir it ranged between 7.7 and 8.6 (Mean ± SD of 8.15±0.27). Maximum values observed during summer might be due to increased photosynthetic activity. The decrease in pH during monsoon may be due to greater inflow of water, while during winter could be due to decreased photosynthetic activity. Similar studies were observed by [19] reported the average pH value of Hirakud reservoir as 8.2. [20] documented pH values of 7.2 to 9.5 for Mansarovar reservoir of Bhopal. [21] noticed pH in the range of 7.0 to 8.3 in Amaravathy reservoir. [22] observed pH values ranging from 7.3 to 8.8 in Tamdalge tank waters. [23] documented pH values which ranged from 6.54 to 8.6 in case of Hirahalla reservoir.

3.7 Dissolved Oxygen (D.O)

Dissolved oxygen (D.O) is the prime important critical factor in natural waters both as regulator of metabolic processes of biota and as a vital indicator of water quality, ecological and trophic status of a reservoir. This is due to its importance as a respiratory gas, and its significant role in both chemical and biological reactions of an ecosystem. Dissolved oxygen content of water in the upstream station was fluctuated between 4.2 mg/L in the month of November (monsoon) and 7.2 mg/L in the month of May (summer) with a variation of 3.0 mg/L and study period Mean (Mean ± SD) of 5.63±1.05 mg/L (Table 2). whereas **i**n downstream station, dissolved oxygen content ranged from 4.6 mg/L in the month of November (monsoon) to 7.6 mg/L in the month of May (summer) with a variation of 3.0 mg/L and study period Mean (Mean ± SD) of 5.91±1.12 mg/L (Table 3). Dissolved oxygen content of Sarvepalli reservoir fluctuated between 4.2 and 7.6 mg/L (Mean ± SD of 5.77± 1.05 mg/L). From these findings it is seen that, highest dissolved oxygen concentrations were observed during summer. These highest values can be attributed to high rate of photosynthetic activity that might have resulted in the liberation of oxygen as a by-product. Lowest oxygen concentrations were observed in the month of November, then oxygen levels slightly increased to December (the month of highest rainfall during the study period) and this might be due to cumulative effect of wind generated turbulence, resultant mixing coupled with rainfall during this period. Similar findings was observed by [24] recorded D.O values ranging from 5.79 to 8.19 mg/L in waters from Bhandaradara reservoir. [25] documented D.O values of waters from Grand anicut as ranging from 4.7 to 5.8 mg/L. [26] observed D.O values in the range of 6.12 to 7.05 mg/L, 5.99 to 6.26 mg/L and 6.62 to 7.09 mg/L in case of Aji, Nyari and Lalpari reservoirs of Sourashtra respectively.

3.8 Carbon Dioxide (CO_2)

Carbon dioxide is particularly influential in regulating pH. Organic decomposition, respiration, photosynthesis, diffusion and run-off etc. brings about changes in the carbon dioxide concentrations of water. It is highly soluble in natural waters but is a minor constituent of the atmosphere and remains present in equilibrium concentration by giving an acidic reaction in water. Its absence or low concentrations recorded in most of the times may be due to the alkaline nature of the water in both the reservoirs. CO_2 content of water in the upstream station was fluctuated between 0.0 mg/L in the months of March & April (summer) and 8.0 mg/L in the month of December (monsoon) with a variation of 8.0 mg/L and study period Mean (Mean ± SD) of 3.29±2.76 mg/L (Table 2) Whereas in downstream CO_2 levels of water ranged from 0.0 mg/L in the months of February, March, April & May (winter & summer) to 6.0 mg/L in the months of November, December and January (monsoon & winter) with a variation of 6.0 mg/L and study period Mean (Mean ± SD) of 1.93±2.5 mg/L (Table 3). Free CO_2 content of Sarvepalli reservoir varied from 0 mg/L to 8 mg/L (Mean ± SD of 2.61±2.62 mg/L) More or less higher values observed during monsoon and winter seasons can be attributed to decreased photosynthetic rates during these seasons besides decomposition of allochthonous organic matter that have entered in to the reservoir through runoff. Similar type of observations was made by [27] recorded CO_2 levels ranging from 0 to 8.93 mg/L in case of Savitri reservoir. [28,29] noticed free CO_2 in the range of 0 to 9.3 in Raipur reservoir.

3.9 Chlorides

Chlorides occur naturally in waters. Discharge of sewage contributes to chlorides there by their concentration serves as an indicator of pollution by sewage. Chloride concentration of water in the upstream station was fluctuated between 112.0 mg/L in the month of January (winter) and 204.0 mg/L in the month of April (summer) with a variation of 92.0 mg/L and study period Mean (Mean ± SD) of 149.36±28.52 mg/L (Table 2). whereas in downstream station, chlorides ranged from 102.0 mg/L in the month of November (monsoon) to 158.0 mg/L in the month of April (summer) with a variation of 56.0 mg/L and study period Mean (Mean ± SD) of 122.71±17.29 mg/L (Table 3). The concentration of chlorides in the Sarvepalli reservoir fluctuated between 102 mg/L and 204 mg/L (Mean ± SD of 136.04±26.34 mg/L). Higher values of chlorides were observed during summer and monsoon samplings compared to winter. Higher values of summer could be attributed to high rate of evaporation, which might have resulted in increase in their concentration, while high values observed in monsoon samplings might be due to the entry of runoff including sewage from the catchment area. Similar studies was made by [30] noticed chlorides in the range of 33.25 to 97.93 mg/L from the waters of Ibhrahim reservoir. [31] expressed chloride levels ranging from 57.5 to 100.1 mg/L in case of Darbandikhan reservoir, Iraq. [14] reported chlorides in the range of 80 to 240 mg/L in case of Wyra reservoir.

3.10 Biochemical Oxygen Demand (BOD)

BOD gives a quantitative measure of biodegradable carbonaceous organic matter present in the water. It is the measure of the extent of pollution in the water body, its value provides an information regarding quality of water and helps in deciding the suitability of water for consumption and other purposes. The untreated discharge of municipal and domestic waste in to water bodies increases the amount of organic matter. BOD of water in the upstream station was fluctuated between 4.8 mg/L in the months of March & April (summer) and 9.4 mg/L in the month of November (monsoon) with a variation of 4.6 mg/L and study period Mean (Mean ± SD) of 6.52±1.65 mg/L (Table 2). Whereas in downstream station, BOD of water ranged from 4.4 mg/L in the month of March (summer) to 8.6 mg/L in the month of November (monsoon) with a variation of 4.2 mg/L and study period Mean (Mean ± SD) of 6.02 ± 1.52 mg/L (Table 3). BOD of water from Sarvepalli reservoir varied between 4.4 mg/L and 9.4 mg/L (Mean ± SD of 6.27±1.55 mg/L). More or less higher BOD values were observed in monsoon and winter seasons compared to summer season. To certain extent this can be ascribed to entry of allochthonous organic matter through runoff during rainy season, which up on being subjected to aerobic degradation might have resulted in high BOD values. Similar results were found by [26] documented BOD values ranging from 3.95 to 5.14 mg/L in case of Lalpari reservoir. [32] recorded BOD values in the range of 2.65 to 6.94 mg/L and 3.2 to 6.8 mg/L in case of Tawa and Halali reservoirs respectively. [33] noticed BOD levels ranging from 5.51 to 6.2 mg/L in case of Manchanabele reservoir.

3.11 Total Ammonia

Ammonia in higher concentrations is harmful to fish and other aquatic life. The toxicity of ammonia increases with increase in pH, as at higher pH, most of the ammonia remains in its gaseous (unionized) form. Total ammonia levels of water in the upstream station was fluctuated between 0.02 mg/L in the month of April (summer) and 0.39 mg/L in the month of November (monsoon) with a variation of 0.37 mg/L and study period Mean (Mean ± SD) of 0.15±0.11 mg/L (Table 2). whereas in downstream station, ammonia concentrations ranged from 0.01 mg/L in the month of March (summer) to 0.26 mg/L in the month of November (monsoon) with a variation of 0.25 mg/L and study period Mean (Mean ± SD) of 0.12±0.09 mg/L (Table 3). Ammonia content of the Sarvepalli reservoir varied between 0.01 mg/L and 0.39 mg/L (Mean ± SD of 0.13±0.10 mg/L). In most of the instances, higher ammonia content observed during monsoon and subsequent winter seasons could be due to the decomposition of organic matter that has entered into these reservoirs through rain fall during monsoon season from the catchment area. Similar type of observations was made by [27] recorded ammonia levels ranging from 0.026 to 0.18 mg/L in case of Savitri reservoir. [16]

reported ammonia concentrations in the range of 0.39 to 0.84 mg/L from Harsi reservoir. [34] noticed ammonia concentrations ranging from 0.49 to 1.08 mg/L from the waters of Vembakottai reservoir.

3.12 Total Alkalinity

Alkalinity of water is its capacity to neutralize acids. Weathering of rocks is the potential source of it and it imparts buffering capacity to water, there by helps in stabilizing the pH of water. Though incidence of nitrates, borates, silicates contributes to alkalinity, it is primarily due to the presence of carbonates, bicarbonates and hydroxyl ions in free state in water. The influence of photosynthesis on pH is greater in low alkalinity waters because of their low buffering capacity. Total alkalinity in the upstream station was fluctuated between 148 mg/L in the month of December (monsoon) and 232 mg/L in the month of March (Summer) with a variation of 84 mg/L and study period Mean (Mean ± SD) of 183± 21.95 mg/L (Table 2). Whereas In downstream station, alkalinity of water ranged from 126 mg/L in the month of December (monsoon) to 204 mg/L in the month of March (summer) with a variation of 78 mg/L and study period Mean (Mean ± SD) of 170.07±23.93 mg/L (Table 3). During the present investigation, alkalinity values fluctuated between 126 mg/L & 232 mg/L (Mean ± SD of 176.54±23.05 mg/L). From the observed alkalinity values, waters from both the reservoirs can be considered as moderate alkalinity waters. The observed summer higher values compared to monsoon and winter seasons might have resulted from the effect of pH on the relative proportions of different forms (CO_2, HCO_3^- and CO_3^{-2}) of inorganic carbon. Similar type of observations was made by [22] noticed alkalinity in the range of 121.25 to 200 mg/L in Tamdalge tank waters. [35] observed total alkalinity values in the range of 110 to 165 mg/L in case of Hosahalli tank waters. [17] documented alkalinity in the range of 182 to 270 mg/L from Mhaswad reservoir. [18] recorded total alkalinity in the range of 100 to 119 mg/L in a flood plain reservoir on river Ravi. [34] reported alkalinity values ranging from 144.3 to 582 mg/L in case of Vembakottai reservoir, Tamil Nadu. [36] noticed total alkalinity ranging from 284.5 to 399 mg/L in case of Ramanna tank waters.

3.13 Total Hardness

The principle ions causing hardness in water are the divalent cations, especially calcium and magnesium in case of surface waters. Dissolution of limestone is the primary source of these ions in water. Total hardness of water in the upstream station was fluctuated between 176.0 mg/L in the month of April (summer) and 252.0 mg/L in the month of January (winter) with a variation of 76.0 mg/L and study period Mean (Mean ± SD) of 219±26.18 mg/L (Table 2). Whereas in downstream station, hardness levels ranged from 168 mg/L in the month of May (summer) to 230 mg/L in the month of December (monsoon) with a variation of 62 mg/L and study period Mean (Mean ± SD) of 204.86±17.81 mg/L (Table 3). During the present investigation, hardness values fluctuated between 168 mg/L & 252 mg/L (Mean ± SD of 211.93±22.71 mg/L). Higher values of hardness observed during monsoon and winter seasons are probably due to the addition of dissolved minerals from sedimentary rocks, large quantities of sewage and detergents in to the reservoir through surface runoff from surrounding watershed area. Similar observations were found by [15] recorded hardness values ranging from 159 to 188 mg/L in case of Lower Manair reservoir. [26] reported total hardness values in the range of 221 to 258 mg/L, 231.5 to 251 mg/L and 243.5 to 265 mg/L from Aji, Nyari and Lalpari reservoirs of Sourashtra respectively. [18] documented total hardness values in the range of 120 to 160 mg/L in case of a flood plain reservoir on river Ravi. [37] noticed total hardness ranging from 221 to 265 mg/L in Tandula dam waters. [31,36] reported total hardness values ranging from 119 to 165 mg/L in Ramanna tank waters.

3.14 Statistical Analysis

The degree of relationship that existed among the parameters under the study were represented station wise in-terms of Correlation co-efficient at 99% & 95% level of significance. (Tables 4, 5 representing stations S1 and S2 respectively). From the correlation co- efficient values obtained based on the relationship that existed among different physico- chemical parameters of the reservoir stations under study, Highly significant (at 99% level) positive correlation were observed among air temperature & water temperature; air temperature & TDS; air temperature & pH; air temperature & D.O. Same was observed between water temperature & pH; water temperature & TDS; water temperature & D.O. Highly significant (at 99% level) negative correlation were observed among air temperature & turbidity; turbidity & pH; turbidity & D.O; turbidity & TDS.

Table 4. Correlation Co-efficient values observed between different physico-chemical parameters of water at Station S1

	A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
A.T	1.000	.999**	-.920**	.894**	.872**	.953**	-.661*	.853**	-.737**	-.735**	.791**	-.778**
W. T		1.000	-.922**	.888**	.875**	.960**	-.662**	.853**	-.746**	-.747**	.787**	-.780**
T			1.000	-.874**	-.947**	-.908**	.723**	-.808**	.792**	.843**	-.686**	.785**
TDS				1.000	.885**	.866**	-.621*	.806**	-.708**	-.753**	.677**	-.666**
pH					1.000	.880**	-.593*	.841**	-.802**	-.854**	.611*	-.727**
D.O						1.000	-.601*	.852**	-.790**	-.819**	.703**	-.758**
CO_2							1.000	-.649*	0.385	0.425	-.661*	.735**
Cl								1.000	-.589*	-.550*	0.531	-.801**
BOD									1.000	.919**	-.637*	0.470
NH3										1.000	-.585*	0.480
T A											1.000	-.680**
T.h												1.000

***. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).*

A.T-Air Temperature, W.T-Water Temperature, T-Turbidity, TDS-Total Dissolved Solids, D.O-Dissolved oxygen, CO_2-Carbon dioxide, Cl-Chlorides, BOD-Biochemical Oxygen Demand, NH_3-Toatl ammonia, T.A-Total alkalinity, T.H-Total hardness.

Table 5. Correlation Co-efficient values observed between different physico-chemical parameters of water at Station S2

	A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
A.T	1.000	.999**	-.919**	.860**	.868**	.955**	-.667**	.765**	-.708**	-.747**	.833**	-.777**
W. T		1.000	-.921**	.865**	.872**	.947**	-.671**	.759**	-.703**	-.755**	.842**	-.771**
T			1.000	-.908**	-.931**	-.900**	.782**	-.610*	.729**	.886**	-.793**	.808**
TDS				1.000	.869**	.828**	-.800**	.627*	-.864**	-.905**	.783**	-.705**
pH					1.000	.868**	-.782**	.716**	-.650*	-.808**	.785**	-.738**
D.O						1.000	-.693**	.800**	-.723**	-.759**	.722**	-.757**
CO_2							1.000	-0.512	.638*	.796**	-.660*	.649*
Cl								1.000	-0.508	-0.511	.674**	-0.439
BOD									1.000	.780**	-.561*	.620*
NH3										1.000	-.596*	.533*
T A											1.000	-.790**
T.H												1.000

***. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).*

A.T-Air Temperature, W.T-Water Temperature, T-Turbidity, TDS-Total Dissolved Solids, D.O-Dissolved oxygen, CO_2-Carbon dioxide, Cl-Chlorides, BOD-Biochemical Oxygen Demand, NH_3-Toatl ammonia, T.A-Total alkalinity, T.H-Total hardness.

4. CONCLUSION

Present study concludes that all the water quality parameters are well in the tolerable limit for domestic usage except some are on edge like Turbidity and TDS which is due to direct influence by a continuous influx of domestic sewage and other anthropogenic activities in the reservoirs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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