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Studies on Physico-chemical Parameters of Kanigiri Reservoir, Nellore District, Andhra Pradesh

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A B S T R A C T

Present work was carried out to assess the physico-chemical parameters of water samples of Kanigiri reservoir of River Penna during November 2016 to May 2017 for a period of seven months. Various water quality parameters including Air temperature, Water temperature, pH, Turbidity, total alkalinity, total hardness, Free CO_2, DO, BOD, Chlorides, 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 in accordance with the drinking water standards with respect to turbidity, pH, TDS, total alkalinity, total hardness and total ammonia except for BOD.

Introduction

Earth, the water planet, is beset by water problems. The world is fast growing with its technologies and ever increasing population, so the dependence as well as exploitation of freshwater resources is also increasing rapidly. The distribution of water resources over the complete land mass of Earth is uneven and quite unrelated to population spread or economic development. The most important drivers of water use are population and economic development, and also changing societal views on the value of water. The latter refers to such issues as the prioritization of domestic and industrial water supply over irrigation water supply, and the extent to which water-saving technologies and water pricing are adopted.

Reservoirs are storage structures for surface water sources and exhibit wide variations in their morphometric limno-chemical and biological characteristics. The physico-chemical and biological characteristics of water in reservoirs are mostly influenced by the seasonal variations in river water inflow, water level fluctuations and the hydraulic residence time (Gikas *et al*., 2009). 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 the purpose of fisheries management (Srivastava *et al*., 1985).

Reservoirs are open, unstable, heterogeneous and interactive systems with characteristics typical for lakes as well as for rivers. In general, the environmental conditions in reservoirs are intermediate between those of rivers and lakes. These differences are reflected in their morphology, hydrology, physico-chemical and biological characteristics. India has a total of 19,370 reservoirs, of which 19,134 are small, 180 are medium and 56 are large (Dixitulu, 1999; Sugunan and Sinha, 2000).

Reservoirs are the basis for large-scale water management systems and this very role of them is witnessed in adjusting natural runoff with its seasonal variations and climatic irregularities to meet the pattern and demand for irrigated agriculture, power generation, domestic and industrial water supply and navigation (ICOLD, 1998). Reservoirs serves as best management tools in providing a dynamic solution to two (02) different problems with respect to the spatial distribution of fresh water resources i.e., the water that is going to have a severe negative impact in some areas by way of floods and inundation, now by virtue of having reservoirs, the same is turning in to a solution for other needy areas in mitigating catastrophic droughts. The construction of surface reservoirs can also bring about needful transformations in the temporal distribution of river runoff thereby providing a solution to scarcity of water resources during the low flow limiting periods and dry seasons.

River Pennar was originated from the Chennakesava hills of the Nandidurg range in Chikkaballapura district of Karnataka. It is also known as ‘Uttara Pinakini’ and is one of the major east flowing rivers of the South India that drains in to bay of Bengal. It is the third major river in Andhra Pradesh after Godavari and Krishna.

Materials and Methods

Study area

Kanigiri Reservoir is the main terminal storage reservoir on the left (northern) side of Sangam anicut. It gets its supplies from not only Sangam anicut but also from its own catchment area. The ayacut under the reservoir is served mainly by two channels – namely Southern Channel and Eastern Channel. The surplus water of the reservoir forms Malidevi Drain, Which also absorbs the field drainage and again supplies water for irrigating the fields on either side of it. Pyderu escape channel serves both as escape channel during floods and also as an irrigation channel feeding an extent of 5,400 acres. A pick-up anicut was constructed across this channel near Talamanchi (V) to feed Allur large Tank and Allur Ramanna Tanks (Fig. 1).

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 and December), winter (January and February) and summer (March, April and 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.

Meteorology

Rainfall

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

Air Temperature

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

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.

Water temperature

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

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.

Carbon dioxide

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

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.

Total ammonia

Water samples were collected in 150 mL amber coloured glass bottles and fixed following the phenol-hypochlorite method as described by Parsons *et al.,* (1989).

Laboratory analysis

Turbidity

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

Total Dissolved Solids (TDS)

Gravimetric estimation of TDS was carried out by following the method described in APHA (2005) and the results were expressed in mg/L.

pH (Potentia Hydrogeni)

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

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.

Results and Discussion

Meteorology

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 Perumal (1993).

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 27.8 ºC in the month of November (monsoon) and 32.4 ºC in the month of May (summer) with a variation of 4.6 ºC and a study period Mean (Mean ± SD) of 29.76 ± 2.00 ºC (Table 1). Whereas in downstream air temperature ranged from 27.9 ºC in the month of December (monsoon) to 32.7 ºC in the month of May (summer) with a variation of 4.8 ºC and study period Mean (Mean ± SD) of 30.04 ± 1.95 ºC (Table 2).

During the study period air temperatures recorded at Kanigiri reservoir ranged from 27.80˚C to 32.70˚C with a Mean ± SD of 29.9 ± 1.91˚C. Similar trend in air temperature was noticed by Basavaraja *et al.*, (2014) while investigating on Anjanapura reservoir (28.16˚C to 33.5˚C) and Mohammad *et al.*, (2015) while working on Wyra reservoir (22.8˚C to 33.7˚C).

Hydrography

Water temperature

Water temperature is of enormous significance as it regulates the biological activities and governs the solubility of gases in water. Temperature of water depends upon time of collection, water depth besides solar radiation, climate and topography. 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 27.5 ºC February (winter) and 32.3 ºC in the month of May (summer) with a variation of 4.8 ºC and a study period Mean (Mean ± SD) of 29.56 ± 2.02 ºC (Table 1). Whereas in downstream water temperature ranged from 27.7 ºC in the month of December (monsoon) to 32.5 ºC in the month of May (summer) with a variation of 4.8 ºC and study period Mean (Mean ± SD) of 29.81 ± 1.93 ºC. (Table 2)

During the study period, it varied between 27.5˚C and 32.5˚C (Mean ± SD of 29.68 ± 1.91˚C). Similar type of observations was made by Thirupathaiah *et al.*, (2012) in case of Lower Manair reservoir (24˚C to 30.0˚C). Basavaraja *et al.*, (2014) in Anjanapura reservoir (25.25˚C to 30.25˚C). Bharamal and Korgaonkar (2014) while working on Tillari dam (22˚C to 33˚C). Sreenivasulu *et al.*, (2014) in case of Ramanna tank (25.82˚C to 31.38˚C). Tembhare (2015) while documenting on Kalisarar dam (25˚C to 32.5˚C).

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.

Relatively higher turbidity values observed during monsoon season could be due to the washing of silt, sediments, debris, organic and inorganic particles into the reservoir. It kept on decreased towards summer (as the time progresses), which might be due the settlement of suspended particles due to relatively stagnant water conditions that exists during non-monsoon months.

Water turbidity in upstream was fluctuated between 2.2 NTU during the month of May (summer) and 4.6 NTU in the month of December (monsoon) with a variation of 2.4 NTU and study period Mean (Mean ± SD) of 3.40 ± 0.92 NTU (Table 1). Whereas In downstream water turbidity ranged from 2.4 NTU in the month of May (summer) to 4.9 NTU in the month of December (monsoon) with a variation of 2.5 NTU and study period Mean (Mean ± SD) of 3.63 ± 0.92 NTU (Table 2).

During the present studies, it fluctuated between 2.2 NTU and 4.9 NTU (Mean ± SD of 3.51 ± 0.89 NTU). Similar studies were made by Pawaiya *et al.,* (2014) documented turbidity values ranging from 0.91 to 3.14 NTU in Harsi reservoir. Mohammad *et al.,* (2015) observed turbidity values ranging from 0.5 to 2.2 NTU in Wyra reservoir. Tembhare (2015) recorded turbidity in the range of 1.6 to 3.9 NTU in case of Kalisarar Dam.

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 179 mg/L in the month of November (monsoon) and 272 mg/L in the month of March (summer) with a variation of mg 93 mg/L and a study period Mean (Mean ± SD) of 219.57 ± 29.47 mg/L (Table 1). whereas in downstream total dissolved solids ranged from 158 mg/L in the month of November (monsoon) to 236 mg/L in the month of May (summer) with a variation of 78 mg/L and study period Mean (Mean ± SD) of 197.43 ± 23.77 mg/L (Table 2).

Total dissolved solids of the Kanigiri reservoir fluctuated between 158 mg/L and 272 mg/L (Mean ± SD of 208.50 ± 28.08 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, which might have diluted the water to certain extent. Based on the observed TDS values these can be considered as medium to high productive reservoirs.

Similar type of observations was made by Lubal *et al.,* (2012) documented TDS values in the range of 178 to 290 mg/L in Mhaswad reservoir. Hussain *et al.,* (2013) reported total dissolved solids ranging from 149 to 211.2 mg/L in case of a flood plain reservoir on river Ravi. Pawaiya *et al.,* (2014) observed TDS in the range of 131.25 to 201 mg/L in case of Harsi reservoir.

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 months of November and January (monsoon and winter) and 8.5 in the months of April (summer) with a variation of 0.7 and a study period Mean (Mean ± SD) of 8.11 ± 0.24 (Table 1). Whereas in downstream water pH ranged from 7.8 in the month of November (monsoon) to 8.4 in the months of April and May (summer) with a variation of 0.6 and study period Mean (Mean ± SD) of 8.10 ± 0.23 (Table 2).

In Kanigiri reservoir it fluctuated between 7.8 and 8.5 (Mean ± SD of 8.11 ± 0.22 mg/L). 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 Sugunan and Yadava (1992) reported the average pH value of Hirakud reservoir as 8.2. Kulshrestha *et al.,* (1992) documented pH values of 7.2 to 9.5 for Mansarovar reservoir of Bhopal. Thirumathal *et al.,* (2002) noticed pH in the range of 7.0 to 8.3 in Amaravathy reservoir. Manjare *et al.,* (2010) observed pH values ranging from 7.3 to 8.8 in Tamdalge tank waters. Murthuzasab *et al.,* (2010) documented pH values which ranged from 6.54 to 8.6 in case of Hirahalla reservoir. Sangpal *et al.,* (2011) in Ujjani reservoir recorded the pH in the range of 7.17 to 9.15. Simpi *et al.,* (2011) noticed pH values in the range of 7.5 to 8.4 in Hosahalli tank waters. Lubal *et al.,* (2012) observed pH in the range of 7.2 to 8.6 in case of Mhaswad reservoir. Mathavan and Nambirajan (2012) documented pH values ranging from 6.9 to 8.9 in case of Grand anicut. Meshram (2013) recorded pH in the range of 7.95 to 8.51 in case of Tandula dam. Muralidharan and Waghode (2014) observed pH values in the range of 7.4 to 9.1 and 6.9 to 9.0 in case of Tawa and Halali reservoirs respectively.

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 4.8 mg/L in the months of November and January (monsoon and winter) and 8.0 mg/L in the month of April (summer) with a variation of 3.2 mg/L and a study period Mean (Mean ± SD of) 6.12 ± 1.25 mg/L (Table 1). whereas **i**n downstream station, dissolved oxygen content ranged from 4.8 mg/L in the month of November (monsoon) to 8.3 mg/L in the month of April (summer) with a variation of 3.5 mg/L and study period Mean (Mean ± SD) of 6.41 ± 1.34 mg/L (Table 2).

Dissolved oxygen content of Kanigiri reservoir fluctuated between 4.8 and 8.3 mg/L (Mean ± SD of 6.27 ± 1.26 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 were observed by Kamble *et al.,* (2011) recorded D.O values ranging from 5.79 to 8.19 mg/L in waters from Bhandaradara reservoir. Mathavan and Nambirajan (2012) documented D.O values of waters from Grand anicut as ranging from 4.7 to 5.8 mg/L. Bhadja and Vaghela (2013) 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. Idowu *et al.,* (2013) in Ado-Ekiti reservoir of Nigeria noticed D.O values ranging from 4.08 to 8.98 mg/L. Meshram (2013) documented D.O values ranging from 5.99 to 7.09 mg/L in case of Tandula dam. Basavaraja *et al.,* recorded (2014) DO values in the range of 5.72 to 8.28 mg/L in Anjanapura reservoir. Sreenivasulu *et al.,* (2014) noticed D.O values ranging from 4.55 to 7.06 mg/L in the waters of Ramanna tank. Mohammad *et al.,* (2015) observed D.O in the range of 4.1 to 6.5 mg/L in case of Wyra reservoir.

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 and April (summer) and 6.0 mg/L in the month of December (monsoon) with a variation of 6.0 mg/L and a study period Mean (Mean ± SD) of 2.07 ± 1.77 mg/L (Table 1). Whereas in downstream CO_2 levels of water ranged from 0.0 mg/L in the months of February, March, April, May (winter and summer) to 6.0 mg/L in the months of January (winter) with a variation of 6.0 mg/L and study period Mean (Mean ± SD) of 1.57 ± 1.91 mg/L (Table 2).

Free CO_2 content of Kanigiri reservoir varied from 0 mg/L to 6 mg/L (Mean ± SD of 1.82 ± 1.79 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 Lianthuamluaia *et al.,* (2013) recorded CO_2 levels ranging from 0 to 8.93 mg/L in case of Savitri reservoir. Saxena and Saksena (2012) noticed free CO_2 in the range of 0 to 9.3 in Raipur reservoir.

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 88 mg/L in the month of January (winter) and

132 mg/L in the month of April (summer) with a variation of 44 mg/L and a study period Mean (Mean ± SD) of 113.64 ± 16.44 mg/L (Table 1). whereas in downstream station, chlorides ranged from 68 mg/L in the month of February (winter) to 126 mg/L in the month of April (summer) with a variation of 58 mg/L and study period Mean (Mean ± SD) of 101.86 ± 18.12 mg/L (Table 2).

The concentration of chlorides in the Kanigiri reservoir fluctuated between 68 mg/L and 132 mg/L (Mean ± SD of 107.75 ± 17.68 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 Pisca *et al.,* (2000) noticed chlorides in the range of 33.25 to 97.93 mg/L from the waters of Ibhrahim reservoir. Jadoon *et al.,* (2013) expressed chloride levels ranging from 57.5 to 100.1 mg/L in case of Darbandikhan reservoir, Iraq. Mohammad *et al.,* (2015) reported chlorides in the range of 80 to 240 mg/L in case of Wyra reservoir.

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 4.3 mg/L in the month of March (summer) and 8.2 mg/L in the months of November (monsoon) with a variation of 3.9 mg/L and a study period Mean (Mean ± SD) of 5.9 ± 1.24 mg/L (Table 1). Whereas in downstream station, BOD of water ranged from 3.8 mg/L in the month of March (summer) to 7.8 mg/L in the month of November (monsoon) with a variation of 4 mg/L and study period Mean (Mean ± SD) of 5.4 ± 1.26 mg/L (Table 2).

BOD of water from Kanigiri reservoir varied between 3.8 mg/L and 8.2 mg/L (Mean ± SD of 5.65 ± 1.23 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 Bhadja and Vaghela (2013) documented BOD values ranging from 3.95 to 5.14 mg/L in case of Lalpari reservoir. Muralidharan and Waghode (2014) 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. Gayathri *et al.,* (2015) noticed BOD levels ranging from 5.51 to 6.2 mg/L in case of Manchanabele reservoir.

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 March (summer) and 0.35 mg/L in the month of November (monsoon) with a variation of 0.33 mg/L and a study period

Mean (Mean ± SD) of 0.12 ± 0.10 mg/L (Table 1). whereas in downstream station, ammonia concentrations ranged from 0.03 mg/L in the months of March and April (summer) to 0.25 mg/L in the month of November (monsoon) with a variation of 0.22 mg/L and study period Mean (Mean ± SD) of 0.09 ± 0.07 mg/L (Table 2).

Ammonia content of the Kanigiri reservoir varied between 0.02 mg/L and 0.35 mg/L (Mean ± SD of 0.11 ± 0.09 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 Lianthuamluaia *et al.,* (2013) recorded ammonia levels ranging from 0.026 to 0.18 mg/L in case of Savitri reservoir. Pawaiya *et al.,* (2014) reported ammonia concentrations in the range of 0.39 to 0.84 mg/L from Harsi reservoir. Pulugandi (2014) noticed ammonia concentrations ranging from 0.49 to 1.08 mg/L from the waters of Vembakottai reservoir.

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 124 mg/L in the month of February (winter) and 184 mg/L in the month of May (summer) with a variation of 60 mg/L and a study period Mean (Mean ± SD) of 158.64 ± 18.06 mg/L (Table 1). Whereas In downstream station, alkalinity of water ranged from 128 mg/L in the month of November (monsoon) to 210 mg/L in the month of March (summer) with a variation of 82 mg/L and study period Mean (Mean ± SD) of 159.5 ± 24.31 mg/L (Table 2).

During the present investigation, alkalinity values fluctuated between 124 mg/L and 210 mg/L (Mean ± SD of 159.07 ± 20.64 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. Slightly higher values of alkalinity were observed during summer as was observed in case of pH.

Similar type of observations was made by Manjare *et al.,* (2010) noticed alkalinity in the range of 121.25 to 200 mg/L in Tamdalge tank waters. Simpi *et al.,* (2011) observed total alkalinity values in the range of 110 to 165 mg/L in case of Hosahalli tank waters. Lubal *et al.,* (2012) documented alkalinity in the range of 182 to 270 mg/L from Mhaswad reservoir. Hussain *et al.,* (2013) recorded total alkalinity in the range of 100 to 119 mg/L in a flood plain reservoir on river Ravi. Pulugandi (2014) reported alkalinity values ranging from 144.3 to 582 mg/L in case of Vembakottai reservoir, Tamil Nadu. Sreenivasulu *et al.,* (2014) noticed total alkalinity ranging from 284.5 to 399 mg/L in case of Ramanna tank waters.

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 152 mg/L in the month of May (summer) and 266 mg/L in the month of December (monsoon) with a variation of 114 mg/L and a study period Mean (Mean ± SD) of 218.07 ± 39.34 mg/L (Table 1). Whereas in downstream station, hardness levels ranged from 144 mg/L in the month of May (summer) to 258 mg/L in the month of December (monsoon) with a variation of 114 mg/L and study period Mean (Mean ± SD) of 200.43 ± 35.77 mg/L (Table 2).

During the present investigation, hardness values fluctuated between 144 mg/L and 266 mg/L (Mean ± SD of 209.25 ± 37.29 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 Thirupathaiah *et al.,* (2012) recorded hardness values ranging from 159 to 188 mg/L in case of Lower Manair reservoir. Bhadja and Vaghela (2013) 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. Hussain *et al.,* (2013) documented total hardness values in the range of 120 to 160 mg/L in case of a flood plain reservoir on river Ravi. Meshram (2013) noticed total hardness ranging from 221 to 265 mg/L in Tandula dam waters. Sreenivasulu *et al.,* (2014) reported total hardness values ranging from 119 to 165 mg/L in Ramanna tank waters. In Harsi reservoir, Pawaiya *et al.,* (2014) noticed total hardness in the range of 63 to 103 mg/L. Gayathri *et al.,* (2015) observed hardness values ranging from 174 to 192 mg/L in the waters of Manchanabele reservoir. Mohammad *et al.,* (2015) documented hardness values in the range of 180 to 240 mg/L from waters of Wyra reservoir.

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% and 95% level of significance. (Table 3 and 4 representing stations K1 and K2 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 and water temperature; air temperature and TDS; air temperature and pH; air temperature and D.O. Same was observed between water temperature and pH; water temperature and TDS; water temperature and D.O. Highly significant (at 99% level) negative correlation were observed among air temperature and turbidity; turbidity and pH; turbidity and D.O; turbidity and TDS.

It is concluded that the concentrations of TDS estimated for the waters of both the stations fell within tolerable limits for drinking water as they did not exceed 500 ppm (EPA, 1976; WHO, 1984: WHO, 2004; BIS, 1991; BIS, 2012) thereby they are suitable as a source of drinking water supply. With mean TDS values of 219.57 mg/L (Upstream) and 197.43 mg/L (Upstream), it is evident that, they can support good fish production, as per Jhingran and Sugunan (1990) who noticed TDS values of more than 200 ppm in case of high productive reservoirs.

Table.1 Kanigiri 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	27.6	4.4	179	7.9	4.4	1	145	8.8	0.39	178	212
	2nd F	28.0	27.8	4.3	184	7.8	4.2	4	124	9.4	0.3	164	240
Dec.	1st F	27.9	27.6	4.6	186	8.1	4.8	8	139	8.4	0.27	162	240
	2nd F	28.2	28.0	4.2	204	7.9	4.9	6	122	9	0.25	148	238
Jan.	1st F	28.4	28.2	4.3	202	7.8	4.9	6	128	6.4	0.18	172	252
	2nd F	28.6	28.5	4.2	216	8.0	5	8	112	5.6	0.14	186	246
Feb.	1st F	28.2	28.0	3.3	214	8.1	5	4	132	6	0.1	168	210
	2nd F	27.8	27.5	3.6	196	7.9	5.4	2	126	6.4	0.08	174	252
Mar.	1st F	31.4	31.2	2.3	272	8.3	6	2	165	4.8	0.05	184	226
	2nd F	31.8	31.4	2.7	248	8.2	6.2	0	154	5.9	0.08	232	194
Apr.	1st F	31.7	31.5	2.6	245	8.5	6.8	1	204	4.8	0.03	192	192
	2nd F	32.0	32.0	2.3	232	8.3	7	0	168	5.4	0.02	212	176
May	1st F	32.4	32.3	2.2	256	8.4	7	2	192	5.4	0.06	186	186
	2nd F	32.4	32.2	2.6	240	8.4	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.2 Kanigiri 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	27.8	4.8	162	7.9	4.6	2	118	8.2	0.26	170	208
	2nd F	28.3	28.1	4.4	158	7.8	4.8	6	102	8.6	0.24	158	216
Dec.	1st F	28.0	27.9	4.9	188	8.0	5.1	4	126	8	0.23	158	226
	2nd F	27.9	27.7	4.4	174	7.9	5	6	106	7.9	0.19	126	230
Jan.	1st F	28.9	28.7	4.5	186	7.8	5	6	118	5.2	0.19	160	212
	2nd F	29.2	29.0	4.3	198	7.9	5.4	2	110	4.8	0.15	138	220
Feb.	1st F	28.5	28.2	3.6	196	8.0	5.2	1	110	5.9	0.12	168	198
	2nd F	28.7	28.5	3.8	182	8.1	5.2	0	104	6.6	0.06	145	218
Mar.	1st F	31.6	31.1	2.5	226	8.3	6.3	0	112	4.4	0.01	198	186
	2nd F	32.1	31.8	2.9	212	8.3	6.4	0	136	5.3	0.04	204	204
Apr.	1st F	31.9	31.7	2.9	216	8.4	7.2	0	158	4.6	0.03	188	208
	2nd F	32.4	32.2	2.6	220	8.3	7.5	0	142	5.2	0.02	182	192
May	1st F	32.3	32.1	2.4	236	8.3	7.4	0	144	4.8	0.04	194	182
	2nd F	32.7	32.5	2.8	210	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.

Table.3 Correlation Co-efficient values observed between different physico-chemical parameters of water at Station K1

	A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
A.T	1.000	.999**	-.918**	.892**	.888**	.920**	-.561*	.544*	-.786**	-0.488	.616*	-.919**
W. T		1.000	-.917**	.889**	.887**	.924**	-.554*	.538*	-.787**	-0.480	.606*	-.914**
T			1.000	-.907**	-.860**	-.904**	.683**	-0.366	.824**	.618*	-0.403	.895**
TDS				1.000	.825**	.759**	-0.447	0.272	-.903**	-.676**	0.427	-.785**
pH					1.000	.916**	-0.494	.552*	-.771**	-0.486	0.504	-.866**
D.O						1.000	-.620*	.556*	-.738**	-0.457	.537*	-.914**
CO_2							1.000	-0.471	0.242	0.226	-0.057	.639*
Cl								1.000	-0.041	0.308	.572*	-0.487
BOD									1.000	.831**	-0.400	.709**
NH3										1.000	-0.159	0.510
T A											1.000	-.634*
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.4 Correlation Co-efficient values observed between different physico-chemical parameters of water at Station K2

	A.T	W. T	T	TDS	pH	D.O	CO_2	Cl	BOD	NH3	T A	T.H
A.T	1.000	.999**	-.926**	.870**	.905**	.956**	-.655*	.660*	-.725**	-.661*	.734**	-.788**
W. T		1.000	-.916**	.866**	.904**	.960**	-.647*	.666**	-.716**	-.654*	.726**	-.779**
T			1.000	-.885**	-.894**	-.894**	.738**	-0.480	.763**	.773**	-.699**	.896**
TDS				1.000	.819**	.833**	-.663**	0.495	-.851**	-.800**	.729**	-.834**
pH					1.000	.954**	-.751**	.667**	-.652*	-.685**	.677**	-.815**
D.O						1.000	-.676**	.698**	-.653*	-.654*	.661**	-.793**
CO_2							1.000	-0.389	0.412	.581*	-.591*	.832**
Cl								1.000	-0.195	-0.034	0.472	-0.319
BOD									1.000	.883**	-.590*	.634*
NH3										1.000	-.667**	.791**
T A											1.000	-.662**
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.

Fig.1 Map showing the location of sampling stations

No.	Stations	Latitude	Longitude
1	Kanigiri Upstream (K1)	N 14^0 32.877′	E 79^0 51.616′
2	Kanigiri Downstream (K2)	N 14^0 32.711′	E 79^0 51.530′

Relatively higher turbidity values observed during monsoon season could be due to the washing of silt, sediments, debris, organic and inorganic particles into the reservoir. It kept on decreased towards summer (as the time progresses), which might be due the settlement of suspended particles due to relatively stagnant water conditions that exists during non-monsoon months.

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