

Water Quality Assessment of Kaliasote Dam of Bhopal, Madhya Pradesh with reference to its nutrient dynamics

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Abstract: In last few decades ever increasing population and unplanned urbanization have posed serious problems of sewage disposal and contamination of surface waters like lakes, reservoirs, dams, rivers etc. Most of these water resources also get contaminated due to weathering of rocks, leaching of soils etc as natural phenomena, ultimately causing nutrient enrichment in these surface water resources. Land use changes and the increase use of fertilizers in modern agricultural practices with subsequent leaching to watercourses, rivers and lakes, has further increased the risk of eutrophication and loss of biodiversity, finally deterioration in water quality (Pani, 2017). Therefore there has been a growing need for regular water quality assessment to understand the existing status of the water body so as to adopt necessary mitigative and conservation measures for abatement of pollution. Water quality can be assessed by various parameters such as BOD, temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, etc. along with heavy metals such as Pb, Cr, Fe, Hg, etc. which are of special concern because they produce water or chronic poisoning in aquatic animals. Harmful algal blooms are becoming increasingly common in freshwater ecosystems globally. Pollution by plastic debris is an increasing environmental concern in water bodies, where it affects open-water, shoreline and benthic environments (Bhateria and Jain, 2016). Hence keeping this in mind the water quality of Kaliasote Dam which is one of the important Dams of Bhopal was analyzed during the period 2015-2017 to understand the present status of water quality with reference to nutrient enrichment from both the autochthonous and allochthonous sources. The results of various parameters indicate that the water of the dam is moderately polluted and can be used only for domestic and irrigation purposes after treatment as per standard prescribed by CPCB.

Keywords: Anthropogenic activities, Pollution, Water Quality.

1. INTRODUCTION

Water quality assessment is very important, as the majority of the water used in urban cities comes from surface water. It is the measure of how suitable the water is from a biological, chemical and physical perspective. Water quality can be impacted negatively by both natural and human causes (Dubey, et al. 2011). Physico-chemical parameters like pH, Dissolve oxygen, hardness, nitrates phosphates have direct impact on water quality of any aquatic system. The changes in different parameters have a relationship with the external influence, anthropogenic activities, nutrient loading etc. These physico-chemical parameters have deep and strong relationship with biological parameters as well as the biodiversity of aquatic system.

Thus the assessment of water quality through physico-chemical and biological analysis for understanding the changes in constituents of water is very important as it can reflect directly on the biotic community of the aquatic system. The effects of pollution stress manifest themselves in several ways in the lake biota viz. change in the pattern of distribution, elimination of scientific strategy, dominance of tolerant species, change in diversity and morphological and physiological changes (Dixit and Pani, 2011).

Kaliasote Dam where the present study was conducted is mainly suffering from siltation due to rapid change in land use pattern from agriculture to housing. The construction and development activities along the catchment not only accelerated the soil erosion rate in the Dam but also resulted in discharging untreated sewage in the Dam. In coming days the catchment area of the Dam is expected to receive more pressure of habitation which could lead to increasing pollution stress on the Dam. Therefore it is imperative to start with preventive measures for the conservation of this Dam with an understanding of the present water quality status of the Dam.

2. MATERIAL AND METHODS

Description of Study area

The Kaliasote Dam (latitude 25° 11' 45' N and longitude 77° 24' E) was constructed near village Chuna Bhatti which about 4 km downstream of the Upper Lake (Bhoj Wetland) across the river Kaliasote, a tributary of Betwa River (Yamuna Basin) in Bhopal District (Map- 1). The dam is 1080 m long with maximum height of 34.25 m having gross storage capacity of 35.387 m. The Dam water is capable to irrigate an area of about 10.425 ha annually in Bhopal and adjoining agricultural Land (Choudhary and Rawtani, 2014).

The present study has been designed to assess the cumulative impact of various anthropogenic activities on the water quality of Kaliasote Dam of Bhopal. For this an extensive field survey was conducted in the catchment of the Dam including the inflow and out flow channels of the Dam. After the meticulous survey, five sampling stations were finalized for collection of samples so as to have a representation of the existing water quality with respect to various anthropogenic activities being performed in the catchment area of the Dam.

Sampling Stations

Total five sampling stations were selected.

Station -1 (near Bhadbhada Spill channel)

Station -2 (near Pandit Khusiram Aurvedic Hosptal)

Station -3. Center (Near Shiv Temple)

Station -4. Near Southern waste weir

Station -5. Near Dam adjoining WALMI (Water & Land Management Institute)



Map-1: Kaliasote Dam with sampling stations.

Sampling was conducted seasonally during which one litre water sample each were collected from the surface, middle and bottom layer by using Ruttner water sampler from the five identified sampling stations. An integrated sample was prepared by mixing the surface, middle and bottom samples proportionately so as to make a representation of water column of the particular sampling station. Collection, preservation and analysis of the water samples for various physico-chemical parameters were done following the standard methods described in APHA (2010). During present investigation following Physico-chemical Parameters were analyzed as per the procedure mentioned in APHA (2010).

Air Temperature	Total Alkalinity
Water Temperature	Total Hardness
pH	Biochemical Oxygen Demand
Total Dissolved Solids	Chemical Oxygen Demand (COD)
Conductivity	Nitrate
Dissolved Oxygen	Orthophosphate
Chloride	

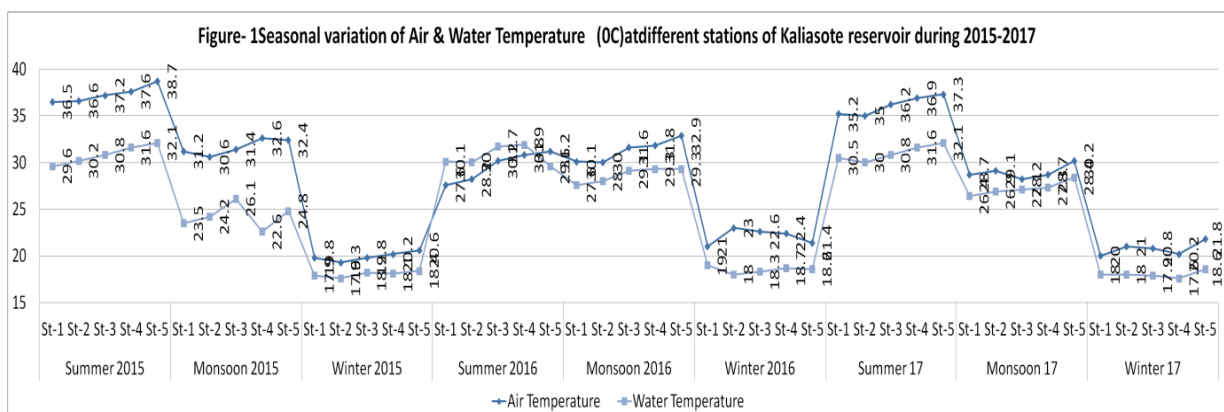
3. RESULT AND DISCUSSION

The observations of the analysis of various physico-chemical parameters of the water samples collected from the Kaliasote Dam is summarized in Table 1 with the range values .

Table 1: Range Values of various parameters in different seasons during 2015-2017

	Parameter	Min				Max				Mean
			Station	Season	Year		Station	Season	Year	
1	Air Temperature ($^{\circ}\text{C}$)	19.3	2	Winter	2015	38.7	5	Summer	2015	28.64
2	Water Temperature ($^{\circ}\text{C}$)	17.6	2, 4	Winter	2015, 17	32.1	5	Summer	2015	25.25
3	pH	7.1	4	Winter	2017	8.6	5	Summer	2017	7.78
4	TDS (mg/l)	80.6	2	Winter	2017	237.9	1	Summer	2015	173.22
5	Conductivity (mS/Cm ²)	0.14	3	Winter	2017	0.44	5	Monsoon	2017	0.29
6	DO (mg/l)	4.8	1	Monsoon	2016	9.2	5	Summer	2015	6.85
7	Chloride (mg/l)	12.98	2	Winter	2015	39.96	2	Monsoon	2016	24.78
8	Total Alkalinity (mg/l)	72	1	Summer	2016	126	4	Winter	2016	94.53
9	Total Hardness (mg/l)	58	4	Monsoon	2015	120	1	Winter	2016	80.90
10	BOD (mg/l)	1.2	4	Summer	2015	12	5	Monsoon	2017	4.33
11	COD (mg/l)	8	2	Summer	2015	31	3	Monsoon	2017	18.93
12	Nitrate (mg/l)	1.01	4	Winter	2016	2.87	1	Summer	2016	1.34
13	Orthophospahte (mg/l)	0.67	2	Winter	2016	1.96	5	Monsoon	2015	1.28

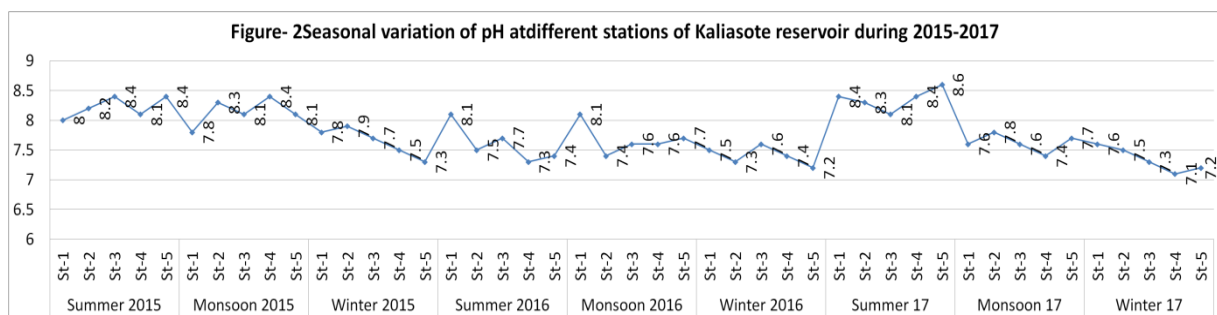
Temperature is one of the most important ecological features and its measurement is a useful indicator of biochemical and biological activity in a water body. Temperature is known to influence pH, alkalinity and DO concentration in the water (Aggarwal and Arora, 2012). Considering its importance in governing all the ecological processes in an aquatic environment, both air and water temperature at different stations of Kaliasote Dams was investigated for the period 2015-2017 at seasonal intervals. Air temperature during the period of investigation ranged from 19.3 to – 38.7 $^{\circ}\text{C}$ (Figure-1). The minimum value was recorded at station-2 during winter season, 2015 while the maximum value was observed at Station-5 during summer season, 2015 (Table-1). Water temperature on the other hand ranged from 17.6-32.1 $^{\circ}\text{C}$. The minimum value was recorded at station-2&4 during winter, 2015&2017 while the maximum value was observed at Station-5 during summer season, 2015 as that of air temperature.



Water temperature during the period of investigation, was found to have direct relation with atmospheric temperature; it increased or decreased with the changes in atmospheric temperature. Misra et al. (2006) has also found the similar trend in temperature variations. Close relationship between atmospheric temperature and surface water temperature has also been reported by Bhatia et. al. (1970). The variation in temperature during the period of investigation at some points may also be due to different timings of collection and influence of season as reported in other case study also (Jayram et. al. 2003).

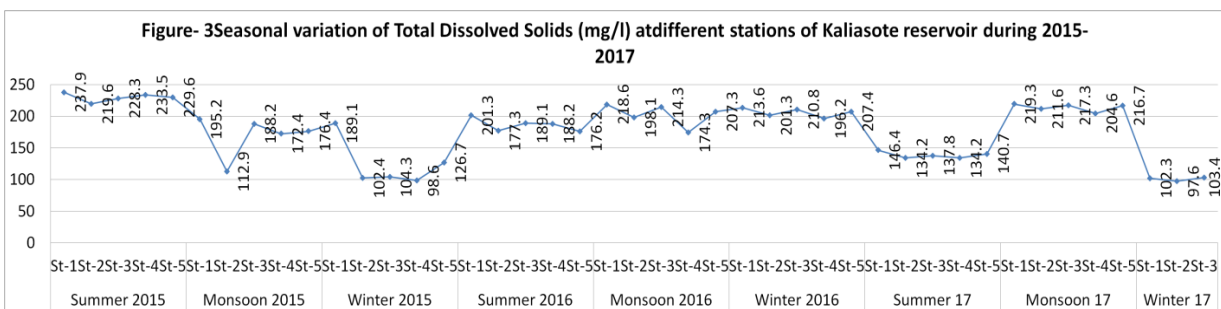
The variation in temperature during the period of investigation has affected the pH values of the Dam.

The hydrogen ion concentration or pH is the most important and commonly studied property of natural water and wastewater. The measurement of pH is of great importance because chemical and biochemical reaction in an aquatic body takes place at a particular pH and plays an important role in productivity of waterbody. In Kaliasote Dam the pH values in most of the places were observed to be slightly alkaline. pH during the period of investigation ranged from 7.1 to 8.6 (Figure-2). The minimum value was recorded at station-4 during winter, 2017 while the maximum value was observed at Station-5 during summer season, 2017.



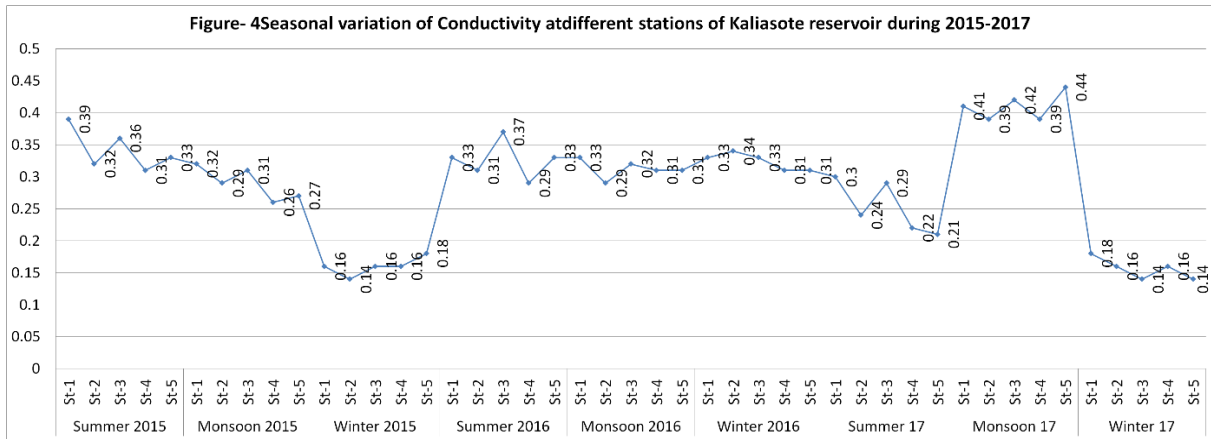
During the period of investigation a close look of the seasonal variation also depicted slightly higher values of pH during the summer months compared to monsoon and winter months. Misra et al (1994) also found similar results in case of Upper Lake which depicted slightly alkaline nature and pH varied from 7.1 to 9.5. In Kaliasote Dam the pH in general was slightly alkaline and shows comparatively better quality for sustainability of macro-benthic community in the Dam.

Hydrogen ion activities in a water body also related to Total Dissolved Solids (TDS). Total dissolved solids information is used to determine the overall ionic effect in a water source. Total dissolved solids in natural water mainly composed of a large variety of salts and inorganic minerals i.e., dissolved solids such as chlorides, carbonates, bicarbonates, nitrate, phosphate etc. which impart particular taste to water at higher concentration. TDS when present in excess in the water may create an imbalance for aquatic life. Certain physiological effects on plants and animals are often affected by the number of available ions in the water. Total Dissolved Solids during the period of investigation ranged from 80.6 to 237.9 mg/l (Figure-3). The minimum value was recorded at station-2 during winter, 2017 while the maximum value was observed at Station-1 during summer season, 2015.



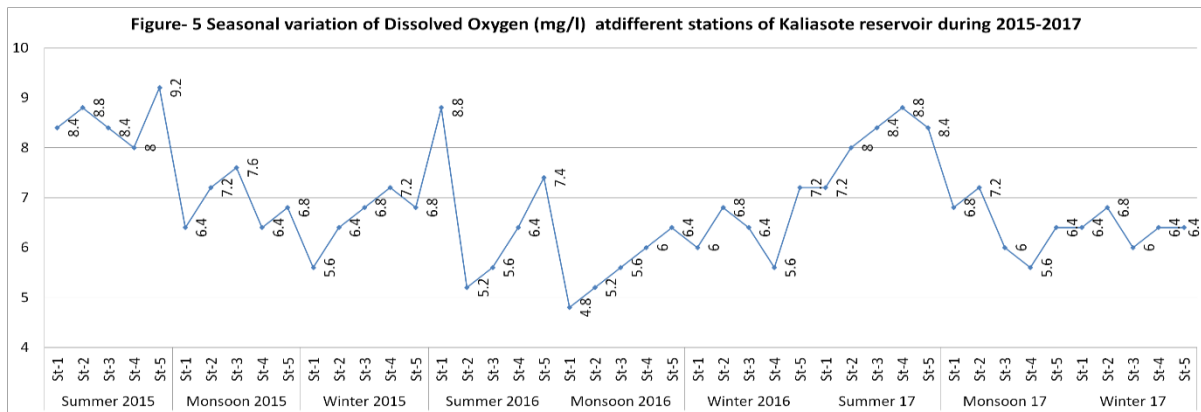
During period of investigation, higher values of TDS in Kaliasote Dam were recorded at some stations which may be because of agitation of water due to topographical variations.

Values of TDS influence the conductivity of water in a water body. Conductivity in Kaliasote Dam during the period of investigation ranged from 0.14 to 0.44 mS/cm (Figure-4). The minimum value was recorded at station-3 during winter, 2017 while the maximum value was observed at Station-5 during monsoon season, 2017. Changes in the conductivity values during present investigations were observed in conformity with the changes in Total Dissolved Solids.



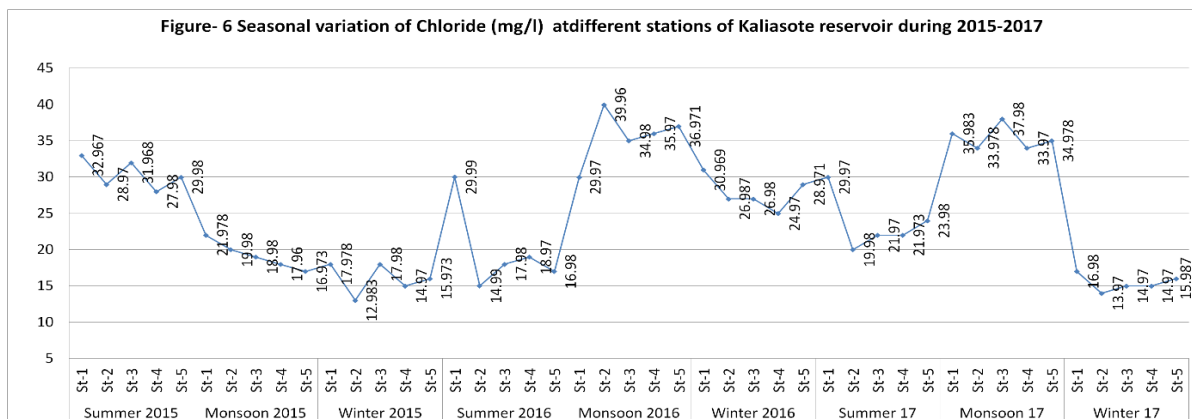
Chemically pure water has low electrical conductivity while high values of electrical conductance show presence of ionic solids in water. In Kaliasote Dam moderate range of conductivity values were observed. Khtatavakar, et. al. (1993) have also observed the similar seasonal pattern in their study of Shambhu Lake of Satera.

Dissolved Oxygen (DO) is an important parameter to understand the trophic status of a water body. (DO) in the Dam during the period of investigation ranged from 4.8 to 9.2 mg/litre (Figure-5). The minimum value was recorded at station-1 during monsoon, 2017, while the maximum value was observed at Station-5 during summer season, 2015.



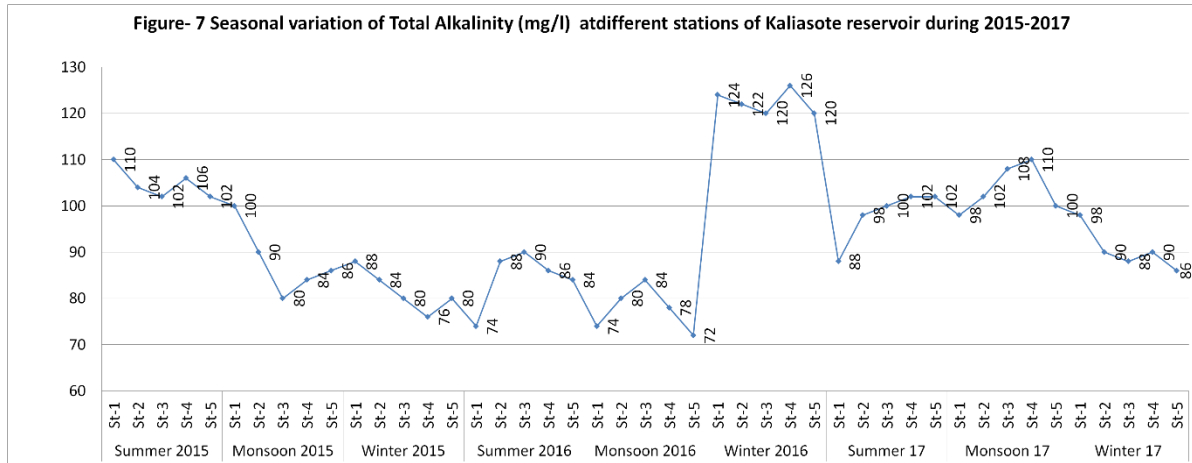
High dissolved oxygen concentration during summer months could be on account of high photosynthetic activity by the standing phytoplankton crop and macrophytic vegetation in presence of optimum light. In Kaliasote Dam a moderate range of Dissolved Oxygen concentration was observed during most of the period of investigation (Figure-5).

Chloride occurs in all natural water in widely varying concentration. As the mineral content increases chloride content also increases. Chloride during the period of investigation ranged from 12.983 to 39.96 mg/l (Figure-6). The minimum value was recorded at station-2 during winter, 2015 while the maximum value was observed at Station-2 during monsoon season, 2016.

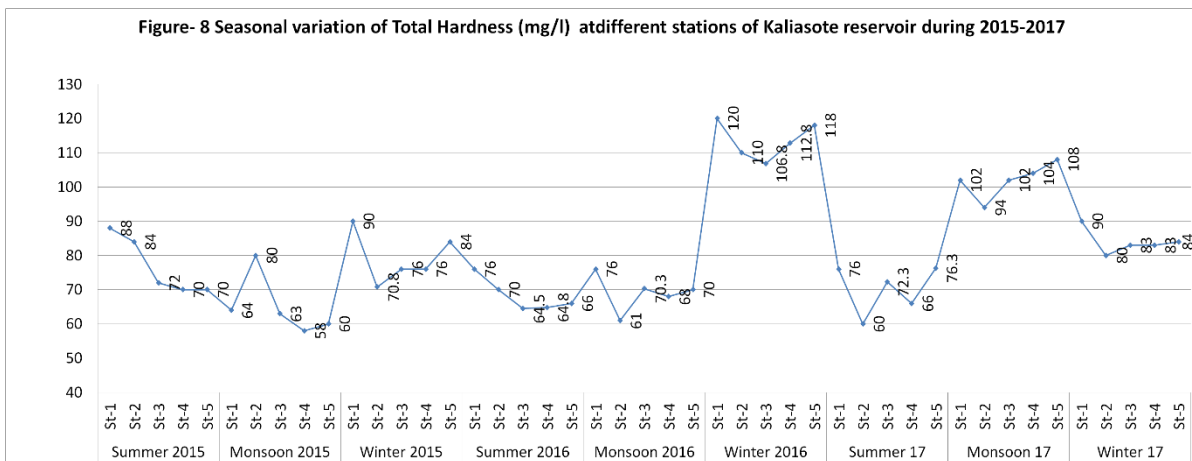


High chloride content in general indicates pollution in the waterbody. High chloride content may also be attributed to quantity of domestic sewage. Pani and Misra (2005), reported that a high value of chloride gives indication of pollution due to sewage. However in Kaliasote Dam a lower range of chloride values depicted comparatively better quality of water.

Alkalinity is an important parameter for fish and aquatic life because it protects or buffers against pH changes and makes water less vulnerable to acid rain. The main sources of natural alkalinity are rocks, which contain mainly carbonate and bicarbonate compounds. Borates, silicates, and phosphates may also contribute to alkalinity. In Kaliasote Dam Total Alkalinity during the period of investigation ranged from 72 to 126 mg/l (Figure-7). The minimum value was recorded at station-1 during summer, while the maximum value was observed at Station-4 during winter season, 2016.

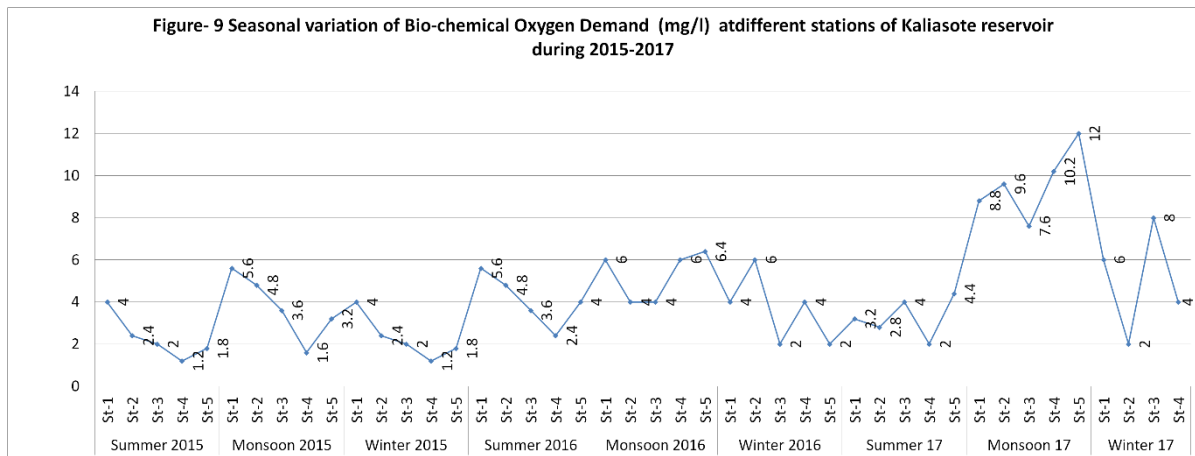


Total hardness in water is the sum of the concentrations of alkaline earth metal (eg. Ca⁺⁺, Mg⁺⁺). In most fresh water nearly all the hardness is imparted by the calcium and magnesium ions which are in combination with bicarbonates and carbonates (temporary hardness) apart from sulphates, chlorides and nitrates. Total Hardness of Kaliasote Dam during the period of investigation ranged from 58 to 120 mg/l. The minimum value was recorded at station-4 during monsoon, 2015, while the maximum value was observed at Station-1 during winter season, 2016 (Figure-8).

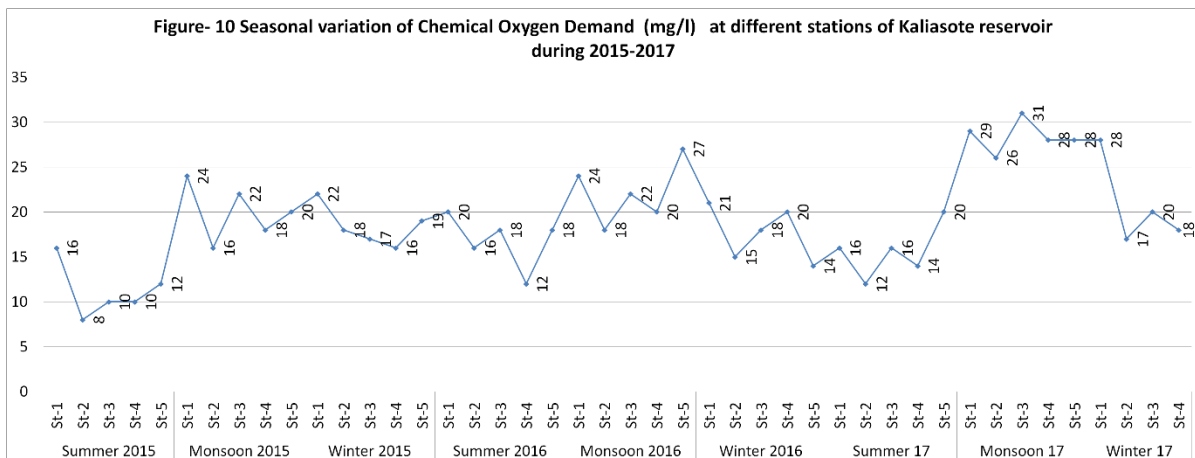


Hirekhan and Patil (2003), stated that in the hardness of water, CaCO₃ is an important measure of pollution and its increase pertains to the excess presence of Ca, Mg and Fe.

Bio-chemical Oxygen Demand during the period of investigation ranged from 1.2 to 12 mg/l (Figure-9). The minimum value was recorded at station-4 during summer, 2015 while the maximum value was observed at Station-5 during monsoon season, 2017.

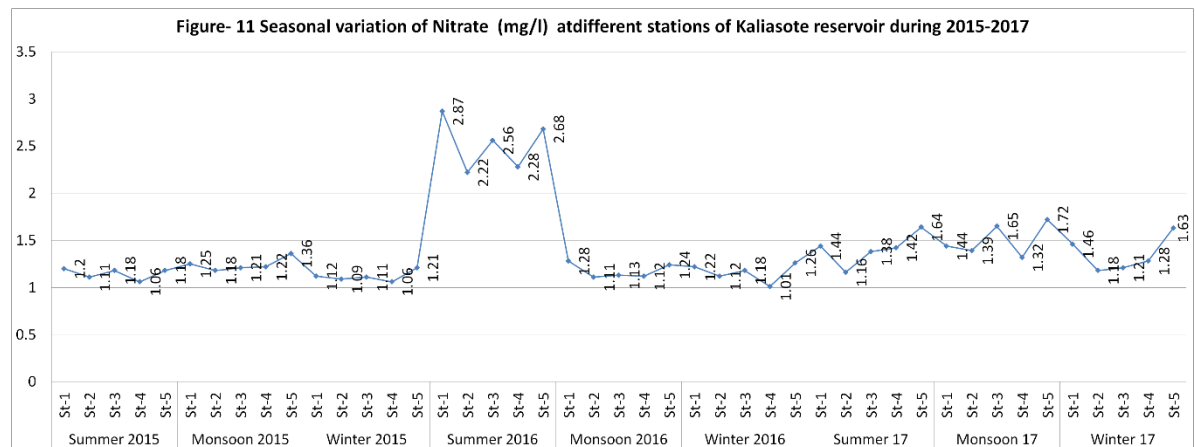


Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of organic matter. COD values convey the amount of dissolved oxidisable organic matter including the non- biodegradable matters present in it ((Choudhary and Rawtani, 2014). Chemical Oxygen Demand during the period of investigation ranged from 8 to 31 mg/l (Figure-10). The minimum value was recorded at station-2 during summer, 2015 while the maximum value was observed at Station-3 during monsoon season, 2017.

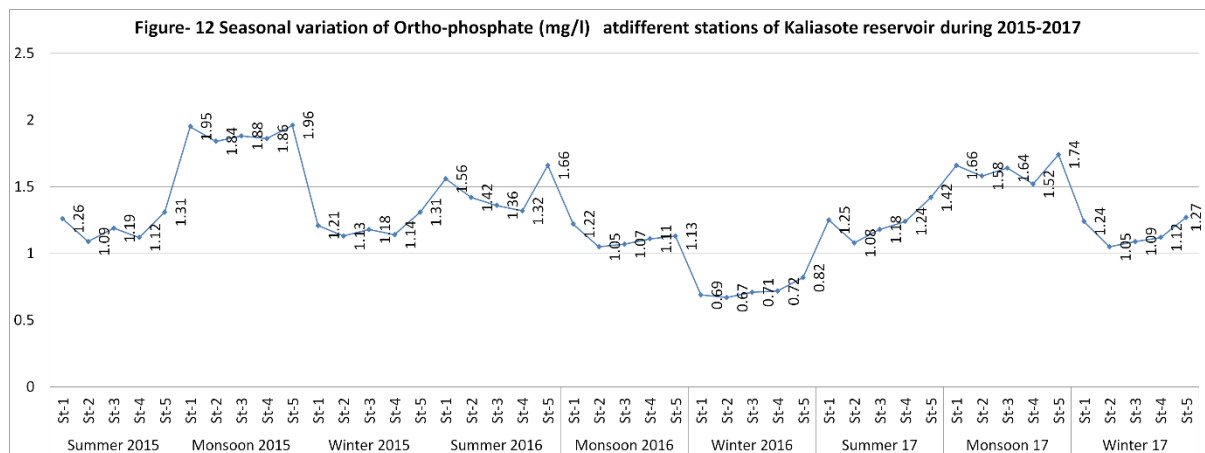


Nitrates derived from agriculture sources. The introduction of large quantity of nutrients, mainly nitrogen and phosphorus to lake water can cause eutrophication problems (Kouimtzi et. al., 1994). Nutrient pollution especially not only with phosphorus but also with nitrogen coming from urban runoff and sanitary sewer systems can lead to eutrophication of the receiving water bodies, Stevens, (2005).

Nitrate during the period of investigation ranged from 1.01 to 2.87 mg/l. The minimum value was recorded at station-4 during winter, 2016 while the maximum value was observed at Station-1 during summer season, 2016 (Figure-11).



Ortho-phosphate on the other hand during the period of investigation ranged from 0.52 to 1.66 mg/l. The minimum value was recorded at station-1 during winter, while the maximum value was observed at Station-2 during summer season (Figure-12). Phosphates enter waterways from human and animal wastes. The element phosphorus is necessary for plant and animal growth. Nearly all fertilizers contain phosphates (chemical compounds containing the element, phosphorous). When it rains, varying amounts of phosphates wash from farm soils into nearby waterways. Phosphates stimulate the growth of plankton and water plants that provide food for fish. This may increase the fish population and improve the waterway's quality of life. If too much phosphate is present, algae and water weeds grow wildly, choke the waterway, and use up large amounts of oxygen, due to which many fish and aquatic organisms may die.



There has been a greater evidence of progressive deterioration of the water quality not only in India but also all over the world (Pani and Misra, 2005). While the natural factors like dust, storm, runoffs and weathering of minerals are slow process in causing eutrophication but modern civilization, industrialization and increase in pollution have lead to fast degradation of our fresh resources (Pandey et al, 2010). With the increase in human population and their activities the self-purification power of water resources has diminished, leading to severe problems. In urban areas the situation is still worse where the water body is subject to much greater human pressure including direct discharge of sewage and industrial waste, which often contains heavy metals (Pani, and Mishra, 1993).

The present investigation concludes that the water quality of the Kaliasote Dam is being deteriorated at several places due to various factors. The high concentration of COD (4 mg/l to 48 mg/l) reveals high degree of organic pollution at some intervals. Similarly high concentrations of inorganic constituents like total hardness (104 mg/l to 134 mg/l), total alkalinity etc also indicate deteriorating water quality of the Dam. All the water samples contain significant amount of nitrate and orthophosphate that provides nutrition for the growth and multiplication of microorganisms. Thus, by detailed analysis of data it can be concluded that the quality of water in general with respect to most of the parameters were observed to be well within permissible limits of class – C of Central Pollution Control Board (CPCB, New Delhi) under designated best uses of water for irrigation and drinking water after conventional treatment.

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Legend of Figures

Figure- 1 Seasonal variation of Air & Water Temperature (°C) at different stations of Kaliasote reservoir during 2015-2017

Figure- 2 Seasonal variation of pH at different stations of Kaliasote reservoir during 2015-2017

Figure- 3 Seasonal variation of Total Dissolved Solids (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 4 Seasonal variation of Conductivity at different stations of Kaliasote reservoir during 2015-2017

Figure- 5 Seasonal variation of Dissolved Oxygen (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 6 Seasonal variation of Chloride (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 7 Seasonal variation of Total Alkalinity (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 8 Seasonal variation of Total Hardness (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 9 Seasonal variation of Bio-chemical Oxygen Demand (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 10 Seasonal variation of Chemical Oxygen Demand (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 11 Seasonal variation of Nitrate (mg/l) at different stations of Kaliasote reservoir during 2015-2017

Figure- 12 Seasonal variation of Ortho-phosphate (mg/l) at different stations of Kaliasote reservoir during 2015-2017