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Original Research Article

WATER QUALITY ASSESSMENT OF ANCHAR LAKE, SRINAGAR, INDIA

Samiyah ASHRAF[1], Simarjot KAUR[2], Sandeep SINGLA[3]
[1] MTech Student, Civil Engineering Department, RIMT University, Punjab, India
[2] Department of Chemistry, RIMT University, Punjab, India
[3] Civil Engineering Department, RIMT University, Punjab, India

Abstract

The aim of this study was to ascertain the current condition of the Anchar lake water body in the Indian state of J&K in terms of water quality using some main parameters such as pH, TDS, EC, DO, and nitrates content. For the years 2019 and 2020, samples were obtained for two seasons: summer and winter. The quantitative analysis of the experimental results indicates a general increasing trend and considerable variance in nitrates content, as well as a gradual decrease in pH, indicating that the lake's acidity is increasing, but only within the basicity range, with real values approaching neutrality: TDS and EC content suggest a very favorable situation, but when the overall parameters are tested, they show a defect. Since the sampling sites were well aerated, the dissolved oxygen content showed a growing pattern, and as a result, this metric proved to be useless in deciding the overall scenario in the lake. In the winter, the longitudinal trend line indicates a 10% decrease in pH, while in the summer, it shows a 4.4 percent decrease in pH. In winters, the longitudinal trend line reveals a 6.7 percent growth in nitrate content, while summers see a marginal decline. In the winter, the longitudinal trend line shows a 7% rise in dissolved oxygen, while in the summer, it shows a uniform trend.

Keywords: water quality, Anchar lake, TDS, pH, sewage, indices

[1] Corresponding author: MTech Student, Civil Engineering Department, RIMT University, Mandi Gobindgarh, Punjab, India, e-mail: mirsamiyah@gmail.com

1. INTRODUCTION

In the modern scenario, water is becoming a trending issue. With the increase in urbanization and industrialization, there is widespread effect on the natural resources as observed over the decades. One of the resources that need a special mention is the water bodies, which are most important for the survival of life on the earth. These water bodies are used for varying purposes. Various flora and fauna thrive over it. The water bodies can fulfil the need of human and animal kind and the plant life only when the quality parameters are as per the required standards and not falling below the minimum permissible limit, in which case required measures need to be taken. In Kashmir, there are numerous water bodies and there is a very delicate balance between the various resources and in spite of it, water quality issue has not yet got its due importance. A comprehensive water quality monitoring program need to be setup for assessment of the water quality status of the water bodies. After the collection of data, it is needed to be converted into a format that can be easily interpreted. The goal of these studies is to determine the changes in the concentrations of various constituents, which in turn help in determining the impacts over time due to human activities, improvements to waste water treatment facilities or land use changes.

Several studies have been conducted on the nutrient status and water quality of various water bodies around the globe. Various approaches have been used to find the effect of various anthropogenic activities on the health of water bodies. Actual testing has been incorporated in the majority of the tests to compare the results to deduce the present status and in turn, future inferences have been made. There have been studies conducted from time to time; some of these studies have been reviewed. Kaul and Saraf (1985) reported that the gross composition in terms of phosphorous, nitrogen, calcium, magnesium, potassium, sodium, and some organic compounds of Microphyll spicatum and Ceratophyllid demersum, occurring in lakes in Kashmir were studied. In Myriophyllum spicatum, the phosphorous level was maximum (0.53%) in June while an annual average concentration of (0.59%) was recorded in Ceratophyllum demersum. Nitrogen and calcium contents ranged between 3.63 and 5.41% and 1.3 and 6.0% respectively [1]. Bhat and Khan (2019) studies were conducted to evaluate P-adsorption in Dal Lake sediments, which lies in Kashmir, India, and to assess the impact of seasonality on P-adsorption. Results showed that at an initial concentration of 5 ppm, Hazratbal sediments adsorbed 70% of P and Gagribal sediment 58% of P. Analysis of various P fractions in sediments revealed that the total P in Hazratbal basin was one and a half-fold more than that of P in Gagribal basin. P adsorption and desorption mechanisms were consistent with the dissolution of the non-stoichiometric Fe-P phase. It is suggested that dredging would increase the P desorption[2]. Solim and Wanganeo (2008) reported Substantial watershed development has led to substantial amount total phosphorous (TP) loads to Dal Lake, a high-altitude Himalayan Lake known for its tourism and economic prospects. The lake's internal and external TP loads were estimated to be 1 and 5 g-2 yr-1, respectively. These loading rates are high in contrast to the lake's critical tolerance range of 0.1-0.2 gyr-1, resulting in significant eutrophication over time due to exceptionally high macrophyte biomass (average 3.2 kg m fresh weight) and bottom sediment enrichment. This study highlights the importance of reducing external TP loads as a primary development goal to combat internal TP loading and P storage within bottom sediments caused by historic anthropogenic loads[3]. Jamal et al. (2009) this study concluded that the ecological state of the Achar lake, which symbolizes as a socio-economic reform and national importance, is deteriorating. The water chemistry of the lake is modified. The evidence suggests that the lake is basic, as demonstrated by higher alkalinity and lower dissolved oxygen. Chemical contaminants such as nitrate-N, phosphorous, potassium, and ammonia-N, which lead to eutrophication of water bodies, were abundant. Since the geology of Kashmir imbues its water with high levels of iron, the lake waters showed a similar expression of iron. In the stagnant water fields, the heavy metals Cr, Cd, Cu, Ni, Mn and Zn accumulated in significant quantities. However, their regional distribution differed across the polluted zones. Their geographic distribution, on the other hand, varied across the contaminated areas. Waste effluents/municipal water from human dwellings, hotels, orchards and agricultural fields, are directly pumped into the lake as a result of human activities on the lake catchments. The chemical contamination of the lake and the creation of the novel red-bloom of Euglena shafiqii carpeted over the contaminated areas of the Achar lake appeared to be directly caused by human events [4]. Kanue et al. (2013) A research conducted in the Hazratbal Basin of Dal Lake, Kashmir. It included the examination of water samples collected from four locations in the Hazratbal Basin. According to the information gathered, the world-famous Dal Lake is rapidly eutrophicating as a result of contamination caused by agricultural activities in the river catchment, which has progressively enriched the lake with massive nutrient content, inputs of fertilizers, and organic matter [5]. Mushtaq et al. (2013a) investigated the water's basic chemical and physical properties in Dal Lake Srinagar. From June 2010 to April 2011, surface water was sampled on a monthly basis. A maximum of 20 physio-chemical parameters were measured at six separate sites around the lake's four basins. The results showed that the lake's water quality has declined as a result of anthropogenic activities and urban growth. The shallow depth (1 to 5 m), low clarity (1 to 2.7 m), and higher concentrations of other nutrients such as nitrates, phosphates, sulphates, and chloride indicate that the lake is eutrophic [6].

Sarah et al. (2011) carried a study on Manasbal Lake, one of the high-elevation lakes in the Kashmir valley, India. The study assessed the variability of water quality of the lake for various purposes using Linear Geostatic. The dataset was then enhanced and some missing spatial values were estimated using geostatic theory (the theory of regionalized variables). The findings revealed that major ion concentrations in water samples are higher in the winter than in the summer [7]. According to Fazal et al. (2012), the ecology of Dal Lake has been negatively impacted by population growth and increased resource exploitation. The Lake ecosystem is clearly deteriorating; the lake is shrinking, the water quality is worsening, and mineral extraction is growing. The unpleasant aspect of this process is that the modifications are carried out by Hanjis, who are also the primary victims because the damage to the lake ecosystem directly affects Hanji livelihood and well-being. The Hanjis of Dal appear to be exploiting the lakes beyond their carrying capacity [8]. Khan et al. (2012). Investigating the current state of Dal Lake's sediment chemistry and hydrochemistry and , as well as the effect of anthropogenic disturbances. This research aims to document the effects of the human population on this lake, taking into account both disturbed and undisturbed areas, as well as the impact of human activities on the environment. This research also highlights the lake's current pollution status by contrasting different biochemical properties to previous data and proposes some remedial steps to prevent it from worsening further [9]. Bhat (2013) investigated the physicochemical properties of Dal Lake in Kashmir, under ambient condition. According to the findings, Dal Lake is rapidly eutrophicating as a result of rising anthropogenic impacts in its drainage basins. Pollution rates vary from one basin to the next. The addition of significant plant nutrients, especially phosphorus and nitrogen, derived from human wastes, disinfectants, and food production, was found to be the main cause of pollution in the Dal basins [6]. Ali (2014) conducted a study comparing Zooplanktons at the selected sites of Dal Lake, Wular Lake, Anchar Lake, and Manasbal Lake to determine changes in water quality over time. Once a month, samples were taken from both the top and the bottom of the lake for physicochemical analysis of company water. The findings showed that the number of Zooplanktons in the lakes has declined over the last decade due to anthropogenic activities [10]. Amin et al. (2014) investigated the water quality index (WQI), that is a valuable statistical method for simplification, monitoring, and analyzing complex data collected for any body of water. Any WQI model may describe the degree of water pollution with a simple number. The index is used to help people understand general water pollution, communicate water quality status, and demonstrate the need for and efficacy of preventive measures. The study discovered that the shift in WQI value follows a similar pattern in all cases during the study period [11].

Lone et al. (2018) investigated Dal Lake's phytoplanktonic enumeration and ecological status. The research aims to provide insight into the spatiotemporal patterns in tourist flow as well as changes in the lake's ecology and climate. The Dal Lake's long-term viability is dependent on management and ecotourism [12]. Keeping in view the above facts, the monitoring of water quality and nutrient status changes in the lake were performed with the following specific objectives of the study (a) Monitoring and analysis of the water quality status of Anchar lake. (b) Comparing the present experimental results with the previous records available. (c) To monitor long range trends in the selected water quality parameters. (d) Identification of most polluted reaches and proposing conservation and management scenarios.

2. MATERIALS AND METHODS

The study was carried out to determine the current water quality and nutrient status of Anchar Lake using some normal methods and statistical analysis at the National Institute of Technology Srinagar, in collaboration with Lakes and Waterways Development Authority (LAWDA) during the year 2019 and 2020. The details of the sampling sites, techniques followed and materials used during the course of investigation are presented below.

2.1. Area of study

The study area was chosen to be the Anchar Lake catchment, which is located in the state of J&K. Jammu & Kashmir is located between 34° 9′ 0″ N latitude and 74° 47′ 0″ E longitude in the north western Himalayan zone. The Kashmir valley occupies 1.6 million hectares and is situated in the state's temperate zone. The area benefits from ample precipitation, intense solar radiation, nice temperatures, and, above all, freshwater lakes, wetlands, and tarns. Anchar Lake is the largest lake in the state of J&K, located between 34°5' and 34°6' N latitude and 74°' to 74°9' E longitude at an altitude of 1583 m. Telbal river, a perennial inflow channel, joins the lake from the north and provides about 80% of the water. An outflow channel channels the lake water into the tributary on the south-east side. The lake has a maximum depth of 16 meters and a mean depth of 14 meters. The natural annual water level fluctuation range is 0.7 m, and the lake's shore line is covered on one side by mountain ranges and on the other by a large city. The Anchar Lake's gross catchment area is 337.17 kilometers2. Fig. 3.1 is a sketch map depicting the various parts of Anchar Lake.

2.2. Methodology

The research is undertaken to evaluate the present water quality and nutrient status of Anchar lake using some standard methods simultaneously statistical analysis were also carried out in the Dept. of Civil Engineering at NIT Srinagar, in collaboration with lakes and Waterways Development Authority (LAWDA) during the year 2020. Various laboratory experiments and statistical tests will be carried on for determination of pH, dissolved oxygen, electrical conductivity, TDS, and nitrate-nitrogen at selected six sites of the water body for getting an overall scenario of it.

Sampling points

In the present study different locations will be used for collecting the samples. The details of the sites used in the research are as follows:

Site 1: This location is close to the Holy Shrine of Jenab-Sahib Soura. The lake is fed by a series of springs that can be found in its basin at this location. Designated as D1

Site 2: This location is on the lake's western shoreline, where the Sindh Nalla joins the water. Designated as D2

Site 3: The location of this site is near the lake's centre. The lake's maximum depth is at this location. Designated as D3

Site 4: This location is close to the Kather-Sahib Dam, which is a local attraction. The lake is heavily contaminated with dense macrophytes at this location. Designated as D4

Site 5: This location is close to the Sangam village. The water from the lake flows out of this point and into the Jhelum River. Designated as D5

Site 6: The location of this site is in the lake's north-east corner. The lake collects toxic effluents and sewage waste from SKIMS' drainage system at this location. Designated as D6.

2.3. Water-quality Indices

2.3.1 pH

The pH of an environment, such as a body of water, is frequently used to characterize it. The negative logarithm of the hydrogen ion concentration is pH= -log[H+], where the brackets around the H+ symbolize "concentration." pH is a measure of the acidity of water or soil based on its hydrogen ion concentration and is mathematically defined as pH= -log[H+]. On a logarithmic scale, a material's pH ranges from 1 to 14, with pH 1-6 being acidic, pH 7 being neutral, and pH 8-14 being basic. Higher [H+] is associated with lower pH, and lower pH is associated with higher [H+]. To check the pH of a sample, use a meter and probe or litmus notebook. A pH meter was used in this research.

After obtaining the pH values from pH meter for different sites T-test was carried out to calculate the mean, variance, P-value (phenolphthalein used) and T-value in order to compare present results obtained with the previous results in order to show the present situation of the lake. Trend analysis line was also prepared to determine value of pH during the two seasons i.e., winter and summer.

2.3.2 Electrical-conductivity (EC)

Electrical conductivity is a measure of the ability of dissolved material in aqueous solution to conduct electric current. The EC would be higher if there is more dissolved material in a water sample. The electrical conductivity meter was used to calculate it (EC meter).

Procedure for determining the Electrical-conductivity of lake water by using EC meter:

1. Switch on the EC meter and optimise the probe with a known conductivity standard solution. Calibration processes differ by instruments, so it's best to stick to the assembly specifications. When measuring a wide range of EC, the meters should be calibrated before each use (before each set of measurements, not between every sample).
2. Measure the EC of the standard solutions in measure mode rather than calibrate mode to verify calibration.
3. Fill a glass or plastic container halfway with sample water. Collect sufficient sample to submerge the probe tip in it; rinse the probe with deionized water (and blow dry) or with sample before sticking it into the collection vessel.
4. Immerse the probe in the specimen and wait for the EC reading to stabilize on the meter. When the EC reading is stable, take the measurement.

After obtaining the Electrical conductivity (EC) values from EC meter for different sites T-test was carried out to calculate the mean, variance, P-value and T-value are used to compare current results to previous results in order to represent the lake's current state. Trend analysis line was also prepared to determine value of EC during the two seasons i.e. winter and summer.

2.3.3 Total-dissolved-solids (TDS)

It is a measurement of the molecular, ionized, or microgranular suspended content of all inorganic and organic compounds in a solvent. TDS was determined with the help of values of EC. If the value of EC was found to be less than 500µS/cm then it is multiplied by 0.55 to attain the value of TDS. After obtaining the total dissolved salts values from TDS meter for different sites T-test was carried out to calculate the mean, variance, P-value and T-value in order to compare the obtained results with previous records. Graphs were then created to compare the current results to previous information in order to depict the lake's current state. Trend analysis line was also prepared to determine the value of TDS during the two seasons i.e., winter and summer.

2.3.4 Dissolved oxygen (DO)

The Winkler technique can be used to quantify dissolved oxygen. The Winkler method is a method for determining the concentration of dissolved oxygen in water bodies. Higher dissolved oxygen concentrations are associated with high

productivity and low pollution, and higher dissolved oxygen concentrations are used as an indicator of a water body's health. This test is done on-site because there might be a change in oxygen content if samples are collected and tested separately.
Dissolved oxygen must be measured as soon as possible and with as much precision as possible. Samples should be measured in the field as soon as possible after collection.

2.3.5 Winkler method

Winkler method was used to determine the content of dissolved oxygen of lake in the present study.
List of Reagents: a) alkali iodide azide = 2ml b) manganese sulphate = 2ml c) concentrated sulphuric acid = 2ml d) starch solution = 2ml e) Sodium-thiosulfate

3. RESULTS AND DISCUSSIONS

The test results for various water quality parameters were found by using standard methods, statistical analysis was also carried out to find the significance of data and whether various parameters have significantly varied over the years and trend analysis line was also obtained to formulate the long-term effect of various parameters on the quality of the lake.

3.1 pH

pH was determined with the help of a pH meter. After then statistical test i.e., T-test was carried out for comparison of present values with the previous records. The mean values of the pH from the year 2014-2019 are shown in the **table 1** and mean value of present data i.e., 2020 is shown in **table 2.** The graph shown in **figure 1** depicts the comparison between the previously known data and the data analysed for the present year corresponding to our study. The mean and variance of pH data for different sites for the prescribed period are shown in **table 3**. the table shows the values for the data that has been compiled for the years 2014-2019 and also actual analysis hat was carried during the year 2020. The statistical analysis of collected data and analysed data is shown in **table 4**. The table show that the pH is significantly varying for the samples collected at one site (D_5) both at surface as well as on bottom and was not significantly varying for other sites. After comparing the mean values of pH for the year 2014-2019 with present mean values for the year 2020 with the help of a graph it was depicted that the present pH at different sites were found to be lesser than the previous ones indicating towards acidity of the lake water. The main reason for the acidity in lake is due to carbon dioxide. Photosynthesis uses up dissolved carbon dioxide which act as carbonic acid resulting in increase of acidity. The chemicals coming from agricultural runoff and waste water discharge also increases the acidity of the lake water. This points towards the deteriorating trend at all the sites for the perspective of pH.

Table 1. Mean values of pH for the year 2014-2019

YEAR	D_1	D_2	D_3 (S)	D_3 (B)	D_4	D_5 (S)	D_5 (B)	D_6
JANUARY	7.7	7.6	7.8	7.7	7.8	8.0	7.8	7.8
FEBUARY	7.9	7.7	8.0	7.7	7.8	8.0	7.8	7.8
MARCH	7.8	7.7	7.8	7.7	7.8	7.9	7.8	7.8
APRIL	8.0	7.9	8.2	7.8	8.0	8.2	7.8	8.1
MAY	8.0	8.0	8.1	7.9	8.0	8.1	7.9	7.9
JUNE	7.9	7.8	8.0	7.9	8.0	8.2	8.1	8.1
JULY	8.0	7.9	8.3	8.0	8.1	8.4	8.2	8.3
MEAN	7.9	7.8	8.0	7.8	7.9	8.1	7.9	8.0

Table 1. Mean values of pH for the year 2020

YEAR	D_1	D_2	D_3 (S)	D_3 (B)	D_4	D_5(S)	D_5(B)	D_6
JANUARY	7.4	7.9	8.0	8.2	8.5	8.0	7.5	7.0
FEBUARY	7.5	6.5	7.0	4.5	6.0	7.8	5.0	6.2
MARCH	7.0	5.5	7.2	5.0	6.5	7.1	5.0	6.5
APRIL	8.2	6.5	7.3	4.5	6.8	7.5	6.0	6.9
MAY	8.2	8.0	8.3	8.0	8.2	8.3	8.0	8.0
JUNE	8.0	8.0	8.1	7.8	8.5	5.6	7.8	8.0
JULY	8.0	8.2	9.0	8.2	7.4	7.0	8.0	8.5
MEAN	7.7	7.2	7.8	6.6	7.4	7.3	6.7	7.3

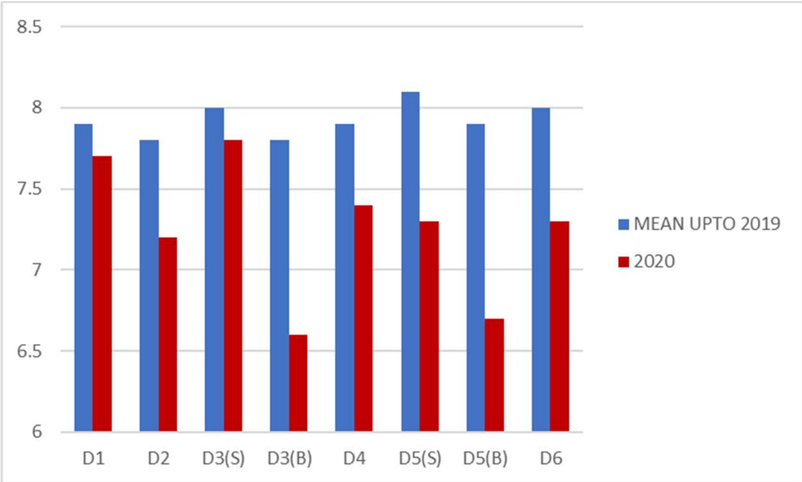

Fig. 1. Comparison of mean values of pH

Table 2. Test results of different sites for pH

Sites	Year	Mean	Variance
D1	2014-19	7.9	0.01
	2020	7.7	0.2
D2	2014-19	7.8	0.01
	2020	7.2	1.1
D3(S)	2014-19	8.0	0.02
	2020	7.8	0.5
D3(B)	2014-19	7.8	0.02
	2020	6.6	3.31
D4	2014-19	7.9	0.01
	2020	7.4	1.03
D5(S)	2014-19	8.1	0.03
	2020	7.3	0.79
D5(B)	2014-19	7.9	0.02
	2020	6.7	1.9
D6	2014-19	8.0	0.04
	2020	7.3	0.75

Table 3. Statistical analysis of different sites for pH

Sites	T-Value	P-Value
D_1	0.95637	0.357757
D_2	1.500756	0.159264
D_3 (S)	0.808315	0.434642
D_3(B)	1.841281	0.090423
D_4	1.49316	0.161215
D_5(S)	2.37862	0.03485*
D_5 (B)	2.269345	0.042488*
D_6	2.124343	0.055107

From the above **tables** it is observed that D_5 site at the surface as well as on the bottom is found to be significantly decreasing i.e., the present values (2020) obtained differ significantly from the previous results (2014-2019).

After then trend analysis line was also prepared to determine the value of pH during the two seasons i.e., winter and summer. This trend line shown in **Figure 2 and 3.**

The trend line for pH shows that there is a gradual decreasing trend in winters as in summers the decrease is relatively abrupt. This shows that temperature has a significant role to play in pH fluctuations. With temperature rise fluctuations are more in pH. In the winter, the linear trend line shows a 10% decrease in pH, and in the summer, it shows a 4.4 percent reduction in pH.

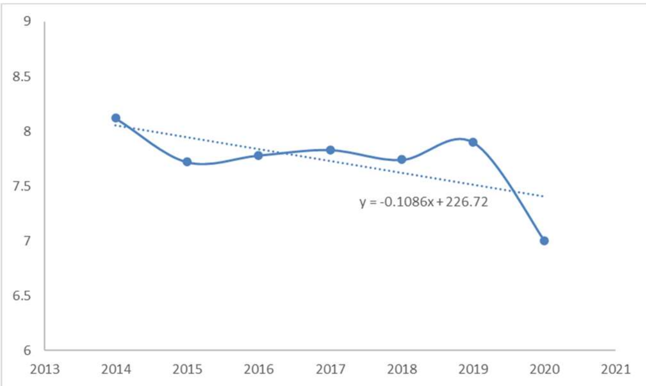

Fig. 1. Trendline for pH for winter season

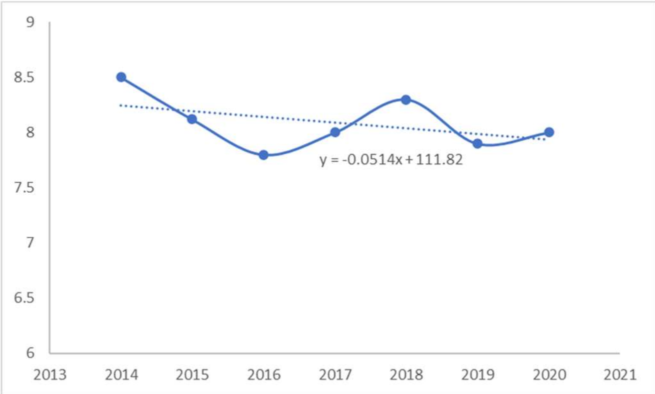

Fig. 2. Trendline for pH for summer season

3.2 Electrical conductivity

The values of EC were determined with the help of EC meter. After then statistical test i.e., t-test was carried out for comparison of present values with the previous records. The mean values of the EC from year 2014-2019 are shown in the **table 5** and mean values of present data i.e., for the year 2020 is shown in **table 6**. The graph shown in **figure 4** depicts the comparison between the previously known data and the presently analysed data corresponding to our study.

The mean and variance of EC data for different sites for the prescribed period are shown in **table 7.** The table shows the values for the data that has been compiled for the years 2014-2019 and also actual analysis that was carried during the year 2020. The statistical analysis of collected data and analysed data is shown in **table 8**. The table shows that the EC is significantly varying for the samples collected at three sites (D_1, D_2 and D_3) and were not significantly varying for other sites.

Table 4. Mean values of EC (µS/cm) for the year 2014-2019

YEAR	D_1	D_2	D_3 (S)	D_3 (B)	D_4	D_5 (S)	D_5 (B)	D_6
JANUARY	314.1	262.3	247.0	262.1	253.6	220.0	234.5	231.8
FEBUARY	311.1	258.6	244.5	254.8	246.6	220.8	233.8	247.0
MARCH	333.6	287.5	254.5	275.1	263.8	248.0	270.8	282.0
APRIL	316.3	284.5	237.6	254.8	247.3	241.5	267.5	270.6
MAY	215.5	218.6	180.8	200.5	194.3	196.8	212.1	217.5
JUNE	209.1	209.8	156.3	197.0	159.6	171.0	180.5	173.0
JULY	231.1	211.6	184.5	201.3	161.3	162.3	175.8	168.5
MEAN	275.8	247.5	215.0	235.1	218.1	208.6	225.0	227.2

Table 5. Mean values of EC (µS/cm) for the year 2020

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JAN 20	205.0	240.0	230.0	225.0	210.0	225.0	240.0	210.0
FEB 20	205.0	206.0	210.0	210.0	190.0	195.0	215.0	210.0
MARCH 20	110.0	160.0	115.0	145.0	188.0	190.0	150.0	155.0
APRIL 20	120.0	130.0	145.0	155.0	175.0	190.0	144.0	190.0
MAY 20	118.0	186.0	164.0	190.0	139.0	148.0	144.0	188.0
JUNE 20	111.0	181.0	160.0	180.0	230.0	220.0	215.0	225.0
JULY 20	115.0	173.0	106.0	149.0	218.0	209.0	211.0	236.0
MEAN	140.5	182.2	161.4	179.1	192.8	196.7	188.4	202.0

After comparing the mean values of EC for the year 2014-2019 with the present mean values for the year 2020 with the help of a graph it was depicted that the present values of EC (2020) at all sites were found to be lesser than the previous ones(2014-2019). The lesser values can clearly be credited to the lesser values of total dissolved solids.

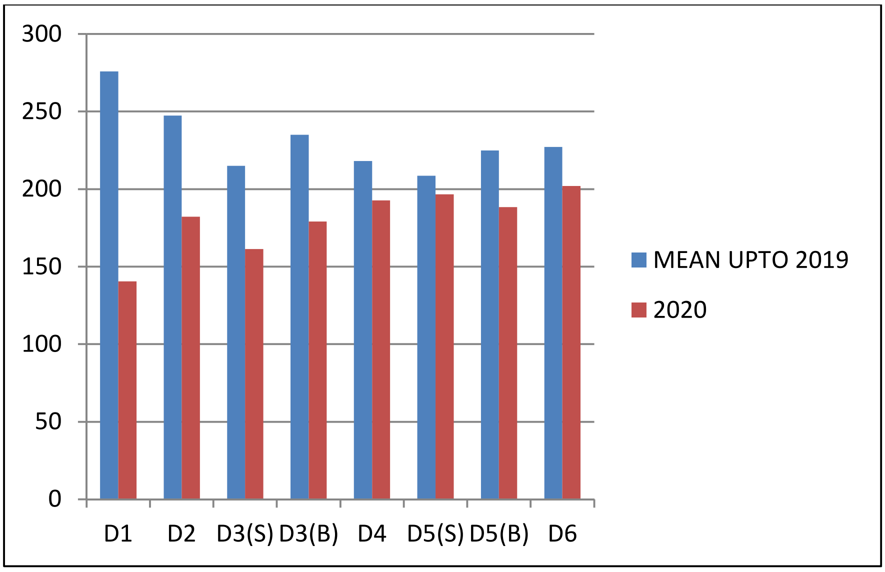

Fig. 3. Comparison of mean values of EC (µS/cm)

Table 6. Test Results of different sites for EC(μS/cm)

sites	year	mean	variance
D1	2014-19	275.8	2963.7
	2020	140.5	1949.6
D2	2014-19	247.5	1141.3
	2020	182.2	1204.2
D3(S)	2014-19	215.0	1584.6
	2020	161.4	2094.6
D3(B)	2014-19	235.1	1150.9
	2020	179.1	971.8
D4	2014-19	218.1	2038.1
	2020	192.8	926.1
D5(S)	2014-19	208.6	1101.1
	2020	196.7	659.9
D5(B)	2014-19	225.0	1439.5
	2020	188.4	1667.6
D6	2014-19	227.2	1963.8
	2020	202.0	727.0

Table 7. Statistical Analysis of different sites for EC (μS/cm)

SITES	T-VALUE	P-VALUE
D1	5.107258	0.000259*
D2	3.567828	0.003868*
D3(S)	2.338782	0.037468*
D3(B)	3.214414	0.007431*
D4	1.227592	0.243137
D5(S)	0.752047	0.466518
D5(B)	1.736955	0.107969
D6	1.286021	0.222696

From the above tables it is observed that site D1, D2 (area) and D3 (Central) shows significant variation for 2020 than the records of past years (2014-2019) i.e. the present values obtained differ significantly from the past values of EC. After then trend analysis line was also prepared to determine value of EC during the two seasons i.e., winter and summer. This trend line is shown in **Figure 5 and 6.** The trend line for EC shows that there is a moderately decreasing trend in winters while as in summers fluctuation varies around the value of 200 μS/cm.

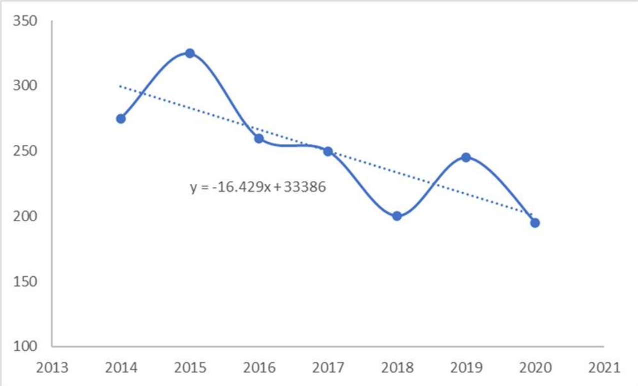

Fig. 4. Trendline for EC (μS/cm) for winter season

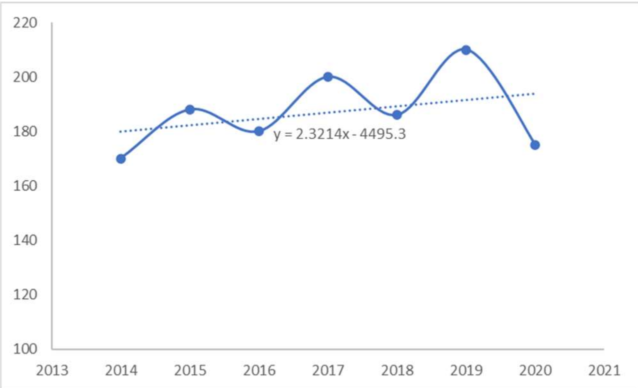

Fig. 5. Trendline for EC (μS/cm) for summer season

3.3 Total dissolved salts (TDS)

TDS was determined with the help of values of EC. If the value of EC was less than 500 μ S/cm then it is multiplied by 0.55 to attain the value of TDS. After then statistical test i.e. t-test was carried out for comparison of present values with the previous records. The mean values of the TDS from the year 2014-2019 are shown in the **Table 9** and mean values of present data i.e., for the year 2020 is shown in **Table 10**. The graph shown in **Figure 7** depicts the comparison between the previously known data corresponding to our study.

The mean and variance of TDS data for different sites for the prescribed period are shown in **Table 11**. The Table shows the values for the data that has been compiled for the years 2014-2019 and also actual analysis that was carried during the year 2020. The statistical analysis of collected data and analysed data is shown in **Table 12**. The Table shows that the TDS is significantly varying for the samples collected at three sites (D1, D2 and D3) and were not significantly varying for other sites.

Table 8. Mean values of TDS (mg/l) for the year 2014-2019

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JANUARY	172.7	144.2	136.6	144.2	139.5	121.0	128.9	127.5
FEBRUARY	171.1	142.2	133.7	140.1	135.6	121.4	128.6	135.8
MARCH	183.5	158.0	141.8	151.2	145.0	136.2	148.9	155.0
APRIL	173.9	156.4	130.7	140.1	136.0	132.8	147.1	148.8
MAY	118.5	120.2	99.4	110.2	106.8	108.2	116.6	119.6
JUNE	115.0	115.4	90.1	108.3	87.8	94.0	99.2	95.1
JULY	127.1	116.4	102.8	110.7	88.7	89.2	96.7	92.6
MEAN	151.7	136.1	119.3	129.3	119.9	114.7	123.7	124.5

Table 9. Mean values of TDS (mg/l) for the year 2020

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JANUARY	112.7	132.0	126.5	123.7	115.5	123.7	132.0	115.5
FEBRUARY	112.7	113.3	115.5	115.5	104.5	107.2	118.2	115.5
MARCH	60.5	88.0	63.25	115.5	103.4	104.5	82.5	85.2
APRIL	66.0	71.5	79.7	85.2	96.2	104.5	79.2	104.5
MAY	64.9	102.3	90.2	104.5	76.45	81.4	79.2	103.4
JUNE	61.0	99.5	88.0	99.0	126.5	121.0	118.2	123.7
JULY	63.2	95.1	58.3	81.9	119.9	114.9	116.0	129.8
MEAN	77.3	100.2	88.78	98.5	106.0	108.1	103.6	111.1

After comparing the mean values of TDS for the year 2014-2020 with the present mean values of year 2020 with the help of a graph it was depicted that the present values of TDS at different sites were found to be lesser than the previous ones. The lesser values can clearly be credited to the lesser values of total dissolved salts.

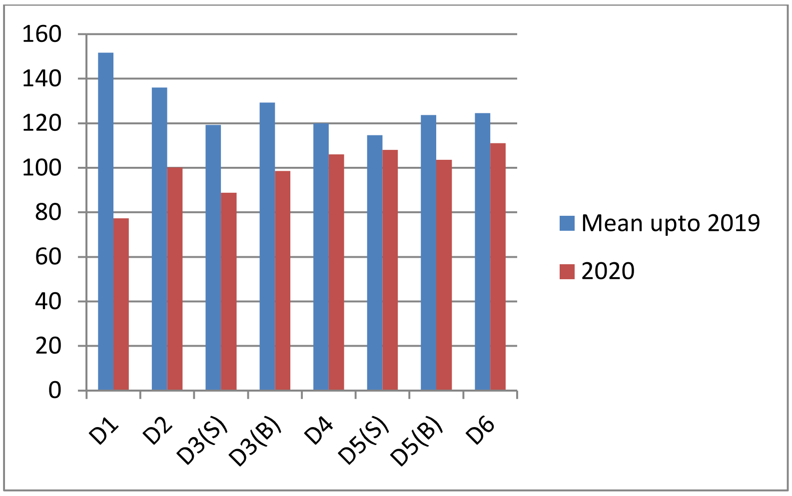

Fig. 6. Comparison of mean values of TDS (mg/l)

Table 10. Test results of different sites for TDS (mg/l)

Sites	Year	Mean	Variance
D1	2014-2019	151.7	897.2
	2020	77.3	589.7
D2	2014-2019	136.1	344.9
	2020	100.2	364.2
D3(S)	2014-2019	119.3	444.6
	2020	88.7	633.6
D3(B)	2014-2019	129.3	347.2
	2020	98.5	293.9
D4	2014-2019	119.9	616.4
	2020	106.0	280.1
D5(S)	2014-2019	114.7	332.0
	2020	108.1	199.6
D5(B)	2014-2019	123.7	435.1
	2020	103.6	504.4
D6	2014-2019	124.5	711.2
	2020	111.1	219.9

Table 11. Statistical Analysis of different sites for TDS (mg/l)

SITES	T-VALUE	P-VALUE
D1	5.106697	0.000259*
D2	3.568003	0.003867*
D3(S)	2.462829	0.029883*
D3(B)	3.215362	0.007418*
D4	1.227478	0.243179
D5(S)	0.750851	0.467212
D5(B)	1.737363	0.107895
D6	1.147948	0.275343

From the above Table it is observed that site D1, D2 and D3 shows significant variation for 2020 than the records of past six years i.e the present values obtained differ significantly.
After then trend analysis line was also prepared to determine value of TDS during the two seasons i.e. winter and summer. This trend line is shown in **figure 8** and **9**. The trend line for TDS shows that there is a decreasing trend in winters while as in summers the trend line is relatively uniform.

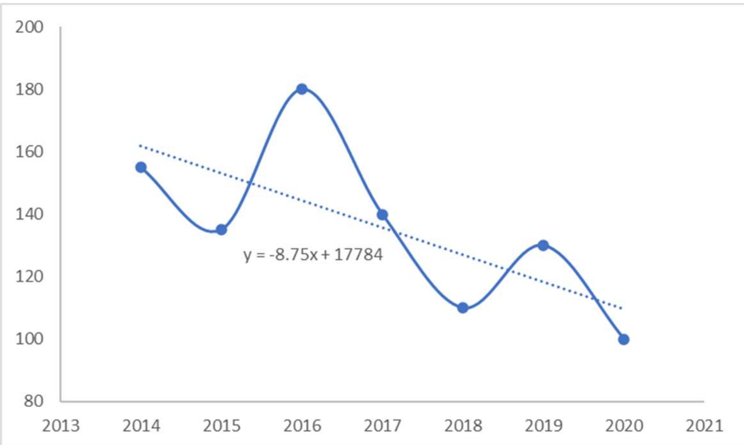

Fig. 7. Trendline for TDS (mg/l) for winter season

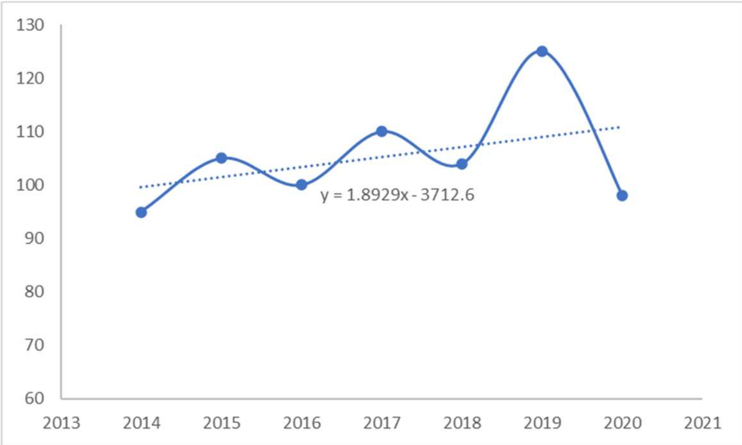

Fig. 8. Trendline for TDS (mg/l) for summer season

3.4 Dissolved oxygen (DO)

The values of Dissolved oxygen were determined from Winkler method. After then statistical test i.e. T-Test was carried out for comparison of present values with the previous records. The mean values of the DO from the year 2014-2019 are shown in the **Table 13** and mean values of present data i.e. for the year 2020 is shown in **Table 14**. The graph shown in **Figure 10** depicts the comparison between the previously known data corresponding to our study.
The mean and variance of DO data for different sites for the prescribed period are shown in **Table 15**. The table shows the values for the data that has been compiled for the years 2014-2019 and also actual analysis that was carried during the year 2020. The statistical analysis of collected data and analysed data is shown in **Table 16**. The Table shows that the DO for all the sites was non-significant.

Table 12. Mean values of DO (mg/l) for the year 2014-19

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JANUARY	7.7	6.9	7.6	6.3	7.0	7.1	6.2	7.1
FEBRUARY	7.4	6.7	7.4	6.3	6.9	7.4	6.2	7.0
MARCH	6.0	5.9	6.8	4.8	6.8	7.2	5.2	5.8
APRIL	7.4	5.6	7.1	4.9	6.4	7.2	5.5	6.5
MAY	7.5	5.6	7.0	4.9	6.4	7.2	5.1	6.2
JUNE	7.5	5.9	7.2	5.1	6.1	7.3	5.3	6.3
JULY	7.5	5.9	7.0	4.8	6.4	7.1	5.3	6.5
MEAN	7.3	6.1	7.2	5.3	6.6	7.2	5.5	6.5

Table 13. Mean values of DO (mg/l) for the year 2020

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JAN	7.0	5.5	7.2	5.0	6.5	7.1	5.0	6.5
FEB	7.2	5.8	7.0	6.5	5.8	6.2	5.6	6.5
MARCH	6.5	7.0	7.5	6.0	8.0	7.0	6.0	6.5
APRIL	7.2	4.8	7.2	6.0	6.0	6.8	5.8	6.8
MAY	5.6	3.7	7.6	6.0	6.9	7.0	2.8	6.0
JUNE	5.8	4.8	7.8	6.2	6.9	7.7	7.5	6.0
JULY	7.6	2.5	4.6	3.2	4.0	4.5	5.0	5.5
MEAN	6.7	4.8	6.9	5.5	6.3	6.6	5.3	6.2

After comparing the mean values of DO for the year 2014-2019 with the present mean values of year 2020 with the help of a graph it was depicted that the present values of DO (2020) at different sites were found to be lesser than the previous ones (2014-2019). The lesser values can clearly be predicted that there is lesser amount of oxygen present in lake.

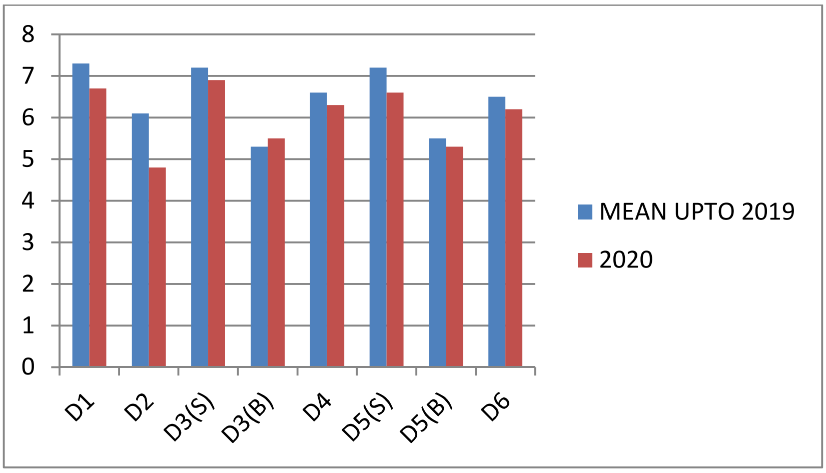

Fig. 9. Comparison of mean values of DO (mg/l)

Table 14. Test results of different sites for DO (mg/l)

SITES	YEAR	MEAN	VARIANCE
D1	2014-19	7.3	0.3
	2020	6.7	0.5
D2	2014-19	6.1	0.2
	2020	4.8	2.1
D3(S)	2014-19	7.2	0.06
	2020	6.9	1.1
D3(B)	2014-19	5.3	0.5
	2020	5.5	1.2
D4	2014-19	6.6	0.1
	2020	6.3	1.5
D5(S)	2014-19	7.2	0.01
	2020	6.6	1.06
D5(B)	2014-19	5.5	0.1
	2020	5.3	2.0
D6	2014-19	6.5	0.2
	2020	6.2	0.19

Table 15. Statistical analysis of different sites for DO (mg/l)

SITES	T-VALUE	P-VALUE
D1	1.725292	0.110109
D2	2.133726	0.054194
D3(S)	0.512958	0.617292
D3(B)	-0.43722	0.669715
D4	0.685821	0.50586
D5(S)	1.634421	0.128113
D5(B)	0.33088	0.746441
D6	1.099046	0.293309

The inference of DO for all the sites was found to be non-significant. After then trend analysis line was also prepared to determine value of DO during the two seasons i.e., winter and summer.

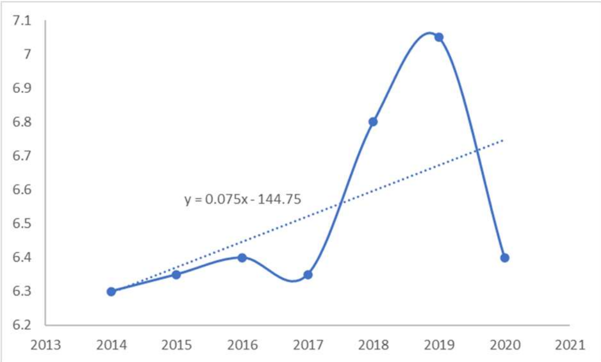

Fig. 10. Trendline for DO (mg/l) for winter season

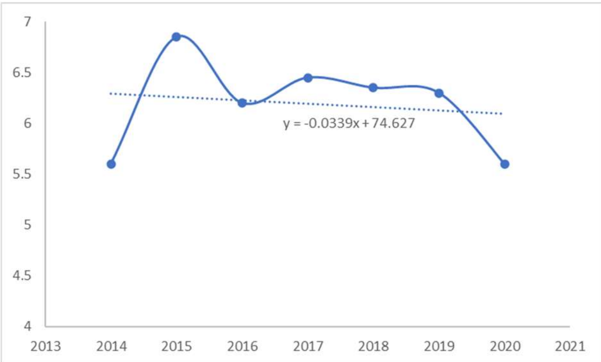

Fig. 11. Trendline for DO (mg/l) for summer season

This trend line is shown in **figure 11** and **12**. The trend line for DO shows a steep increasing trend while as in summers it shows a uniform fluctuation around a value of 6.In winters the health of water body if described by the help of DO is much better as compared in summers. In the winter, the trend line shows a 7% increase in dissolved oxygen, and in the summer, it shows a uniform trend.

3.5 Nitrate-nitrogen

The values of Nitrate-nitrogen were obtained on a D-500 Quality Analysis machine. After then statistical test i.e. t-test was carried out for comparison of present values with the previous records. The mean values of the Nitrate-nitrogen from the year 2014-2019 are shown in the **Table 17** and mean values of present data i.e. for the year 2020 is shown in **Table 18**.

The graph shown in **figure 13** depicts the comparison between the previously known data corresponding to our study.
The mean and variance of Nitrate-Nitrogen data for different sites for the prescribed period are shown in **Table 19**. The Table shows the values for the data that has been compiled for the years 2009-2014 and also actual analysis that was carried during the year 2015. The statistical analysis of collected data and analysed data is shown in **Table 20**. The Table shows that the Nitrate-nitrogen is significantly varying for the samples collected at one site (D5) and were not significantly varying for other sites.

Table 16. Mean values of Nitrate-nitrogen (μg/l) for the year 2014-2019

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JAN	412.0	417.6	348.1	370.5	348.3	344.8	344.8	363.5
FEB	386.6	398.8	359.6	357.0	353.3	356.0	356.0	366.6
MARCH	421.0	451.8	397.0	411.0	406.6	426.5	426.5	442.5
APRIL	450.8	385.0	426.6	392.3	412.8	369.3	369.3	414.1
MAY	430.5	447.3	431.5	404.8	387.3	385.1	385.1	391.8
JUNE	395.8	461.1	406.0	406.1	367.8	344.6	344.6	363.8
JULY	531.1	528.1	547.1	520.0	527.1	476.8	476.8	506.3
MEAN	432.5	441.4	416.5	408.8	400.5	386.1	386.1	406.9

Table 17. Mean values of Nitrate-nitrogen (μg/l) for the year 2020

YEAR	D1	D2	D3(S)	D3(B)	D4	D5(S)	D5(B)	D6
JAN	375.0	522.0	396.0	406.0	385.0	472.0	495.0	375.0
FEB	345.0	470.0	360.0	395.0	370.0	450.0	502.0	390.0
MARCH	335.0	529.0	422.0	396.0	450.0	495.0	472.0	485.0
APRIL	422.	375.0	415.0	350.0	465.0	502.0	495.0	475.0
MAY	622.0	336.0	409.0	395.0	412.0	425.0	436.0	405.0
JUNE	600.0	330.0	400.0	340.0	400.0	415.0	430.0	390.0
JULY	435.0	509.0	466.0	480.0	405.0	390.0	410.0	430.0
MEAN	447.7	438.7	409.7	394.5	412.4	449.8	462.8	421.4

After comparing the mean values of Nitrate-nitrogen for the year 2014-2019 with the present mean values of year 2020 with the help of a graph it was depicted that the present values of Nitrate-nitrogen at all sites were found to be greater than the previous ones. This points towards the sewage disposal and hence deteriorating trend at these particular sites with reference to the nitrate content.

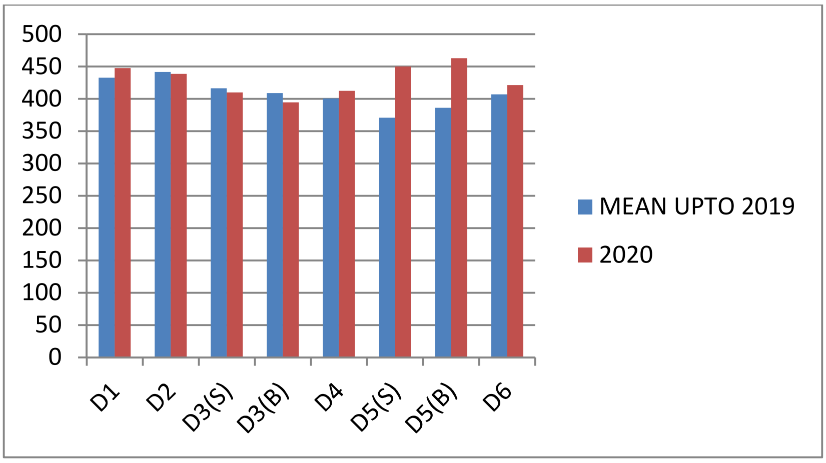

Fig. 12. Comparison of mean values of Nitrate-nitrogen (µg/l)

Table 18. Test results of different sites for Nitrate-nitrogen (µg/l)

SITES	YEAR	MEAN	VARIANCE
D1	2014-19	432.5	2345.4
	2020	447.7	13821.9
D2	2014-19	441.4	2269.8
	2020	438.7	7905.9
D3(S)	2014-19	416.5	4298.6
	2020	409.7	1016.9
D3(B)	2014-19	408.8	2802.3
	2020	394.5	2065.9
D4	2014-19	400.5	3736.8
	2020	412.4	1156.2
D5(S)	2014-19	370.9	1402.8
	2020	449.8	1771.1
D5(B)	2014-19	386.1	2412.0
	2020	462.8	1379.4
D6	2014-19	406.9	2798.5
	2020	421.4	1897.6

Table 19. Statistical Analysis of different sites for Nitrate-nitrogen(μg/l)

SITES	T-VALUE	P-VALUE
D1	-0.31509	0.758104
D2	0.07119	0.944419
D3(S)	0.249702	0.807041
D3(B)	0.5408	0.598541
D4	-0.45117	0.659909
D5(S)	-3.70423	0.003012
D5(B)	-3.29419	0.006409
D6	-0.55798	0.587118

From the above Table it is observed that site D5 (Central site) shows significant variation for 2020 than the records of past six years i.e., the present values obtained differ significantly.

After then trend analysis line was also prepared to determine value of Nitrate-Nitrogen during the two seasons i.e., winter and summer. This trend line is shown in **figure 14 and 15**.

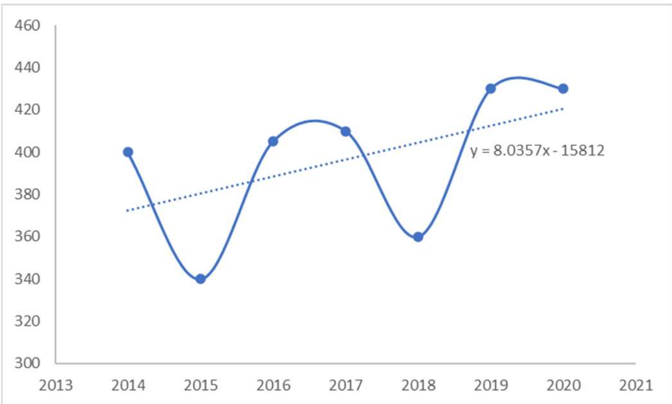

Fig. 13. Trendline of Nitrate-nitrogen(μg/l) for winter season

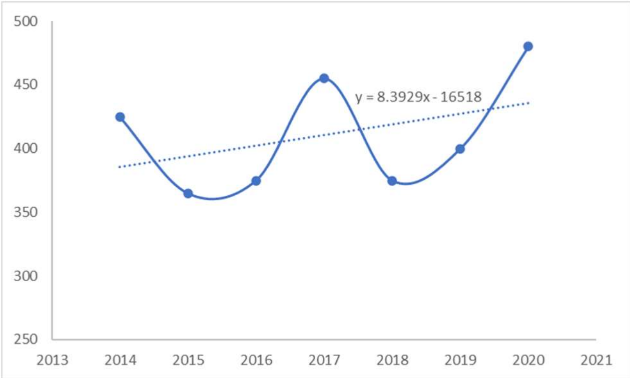

Fig. 15. Trendline of Nitrate-nitrogen(µg/l) for summer season

uThe trend line for Nitrate-Nitrogen shows a similar increasing trend in summers as well as in winters. This point towards the sewage disposal and hence deteriorating trend with reference to the nitrate content. In winters, the linear trend line shows a 6.7 percent increase in nitrate content, while summers show a slight decrease.

4. CONCUSIONS

The catchment of Anchar Lake was taken as the study area which is located in the state of J&K. It is an urban valley lake situated between 34o6′ to 34o7′N latitude and 74o7' to 74o8′E longitude, at an altitude of 1583 m. The present study revealed that the water quality in and around the inhabited areas within the lake has deteriorated to much greater extents as it was evident from high values of Nitrates, low value of pH was also found at some of the sites. Also, it was seen that, despite the denial of the concerned authorities, the number of structures in the lake has increased phenomenally, and other socio-economic parameters are also displaying an ever-increasing tendency. Based on the results of the study, following conclusions have been drawn from the present study.

1. The main reason of the Lake water quality degradation is anthropogenic activities which includes encroachments, direct sewage disposal.

2. The results indicate that the value of parameter pH at site D5 is lesser than the previous records. At surface the mean value of pH was found as 7.3 (Range 7.7-8.4) and at the bottom it was found 6.7 (Range 7.4-8.2) which indicates towards acidity of the lake water.

3. The trend line indicates a 10% decrease in pH in the winter and a 4.4 percent reduction in the summer.

4. The test results of mean electrical conductivity for the year 2015 at sites D1, D2 and D3 (surface) and D3 (bottom) were 140.5, 182.2, 161.4 and 179.1 µ S/cm respectively (Range 150-300 µ S/cm) which were found to be less than the data of the previous years (2009-14).

5. The trend line for EC shows that there is a moderately decreasing trend in winters while as in summers fluctuation varies around the value of 200 µ S/cm. The lesser values can clearly be credited to the lesser values of total dissolved solids.

6. The results indicate that the mean value of TDS at sites D1, D2, D3(surface) D3 (bottom) were 77.3, 100.2, 88.78 and 98.5 respectively (Range 90-150 mg/l) which were found to be lesser than the previous ones.

7. The trend line for TDS shows that there is a decreasing trend in winters while as in summers the trend line is relatively uniform.

8. The trend line for DO in winters showed an increase by 7%.

9. Nitrate-Nitrogen indicated increased values at the sites D1, D4, D5(surface), D5 (bottom) and D6 viz. 447.7, 412.5, 449.8, 462.8 and D4 21.4 µ g/l, respectively.

10. The trend line for Nitrate-nitrogen shows a similar increasing trend in summers as well as in winters.

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