Journal of Advanced Scientific Research

Available online through https://sciensage.info

ISSN
0976-9595
Research Article

A STUDY ON THE SEASONAL TREND OF PHYSICOCHEMICAL PARAMETERS OF MINOR-RAYA CANAL WATER OF TUNGABHADRA DAM HOSPET, KARNATAKA, INDIA

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Received: 27-04-2022; Revised: 09-07-2022; Accepted: 14-07-2022; Published: 31-08-2022

 https://doi.org/10.55218/JASR.2022137112

ABSTRACT

During Vijayanagara dynasty (about 400 years back), Raya canal has been built and serving the irrigation needs of the local population of the Hospet Taluk of Bellary district, Karnataka, India. The urban development of Hospet town has been taken place right up to the canal boundary and in certain places; the canal land has also been encroached. A large number of open channels and pipelines etc., have been directly connected to the canal and at many locations, the canal plays an important role as a drainage line or seepage disposal point. The canal water is polluted from disposal of untreated sewage, seepage of agricultural wastes, domestic wastes, washing activities, storm water drainage, cattle farming wastes and dumping of liquid & solid wastes. The people residing on either sides of the Raya canal were using the water extensively for the purpose of washing, bathing, drinking, fishing, cattle feeding etc. To understand the situation, at four different sample stations, (S1 to S4) along the course of Raya canal, water samples were collected on monthly basis to determine and evaluate seasonal changes in the physicochemical parameters like pH, EC, Temp, TH, TA, BOD, COD, chloride, nitrate, phosphate and DO. The comparison of statistics with the standard values prescribed by WHO (2004), ISI (1983), for drinking water and BIS (1991) for irrigation purpose; revealed the high level of BOD, COD, TA and low level of DO in the water content causes a hazardous effect on both aquatic and human lives.

Keywords: Tungabhadra dam, Raya canal, Physicochemical parameters, Seasonal variation, Pollution.

1. INTRODUCTION

Fresh water is limited, precious and vital resource which needs to be protected, conserved and used wisely. Unfortunately, lakes, rivers and streams throughout the world have been polluted. Due to vast population and negligence of human beings, the quality of water is deteriorated. Changes in the quality of water affect the biotic community of aquatic ecosystem. This ultimately reduces the primary productivity. It is difficult to understand the biological phenomenon without knowing the chemistry of water, which reveals much about metabolism of ecosystem. It explains the general hydro-biological interrelationship [1]. Extensive canal network was used to transport to remote places for irrigation in order to make an organized use of the river water. To meet the requirement of growing urbanization and industrialization, a significant quantity of river water is drawn into canals. Therefore, the qualities of canal water have become a subject of concern in recent years [2-9]. The irrigation water quality is an important factor for long term soil productivity. Poor quality water usage for a longer time makes the soil less productive or even barren depending on the quantity and type of constituents present in canal water. In our country, many areas are facing a serious problem of not only scarcity of water, but also of its poor quality. Less saline water sometimes appear to stimulate crop growth, because of the larger quantity of nutrient ions present. However, excess quantity of the soluble salts in water leads to their accumulation in the surface layer. Accurate and timely information on the quality of water is necessary which leads to implement the water quality improvement programmes efficiently. Raya canal water is polluted by various kinds of natural wastes, domestic wastes, washing activities, seepage of agricultural wastes and other factors creating water pollution problem particularly in fresh water system. In order to improve the production of crops, it is necessary to improve the quality of irrigation water. If poor quality canal water was used, it deteriorates soil properties [10-14] which results in loss of crop yield [15]. The repeated monitoring of water quality at regular intervals of time is necessity to observe the demand and pollution level of canal water. The present investigation reveals the quality of irrigation water's, parameters like, Temperature, pH, Electrical Conductivity (EC), Total Hardness (TH), Total Alkalinity (TA), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chloride, nitrate, phosphate and Dissolved Oxygen (DO) have been used for assessing the suitability of Canal water for irrigation and domestic purposes.

2. MATERIAL AND METHODS

2.1. Study Area

Hospet, is a Municipal city in Bellary District in central Karnataka, India. It is located on the bank of Tungabhadra River. The city is spread in an area of about 70.12 km^2. Hospet city is situated at the geographical position of 15° 16' 0" North 76° 24' 0" East and an altitude of about 467 meters above the sea level. The study area experiences a seasonal climate and broadly divided into four seasons. The winter (January and February) is followed by summer (March-May), the monsoon (June-September) and the post-monsoon (October-December) seasons.

Vijayanagara canals are historically important which serves the irrigation needs of the local population of Hospet taluk. They have been about 400 years back during Vijayanagara dynasty. There are 19 canals taking off from Tungabhadra River. Out of 19 canals, 18 are in Karnataka and one in Andhra Pradesh. Out of 18 canals, two canals namely Raya and Basavanna canals gets the water through gated sluices provided in the right side of the Tungabhadra (T B) Dam. The Raya canal was on the right bank of river Tungabhadra and was being fed through the weir located on the upstream of Tungabhadra dam. It was crossing the present dam alignment at about 3.5 km below the weir. The Raya channel runs for about 27.74 km through Municipal area of the Hospet town towards Kamalapur Lake (East) via Naganahalli village. The urban development of Hospet town has taken place right up to the channel boundary and in certain places; the channel land has also been encroached. The used water, filth including the drainage is fed into the canals at different places and the water appears to be polluted. The Raya canal water were being extensively used by the people residing on each side of the canal for the purpose of washing, bathing, cattle feeding, fishing etc. It has also been reported that most of the people living adjacent to the canal drink the water on account of which several water-bourne diseases have been reported [16]. A lot of inlets in the form of open channels, pipelines etc., have been directly linked to the canal and at different places, the canal functions as either a seepage disposal point or drainage line. The canal water polluted from disposal of untreated sewage, seepage of agricultural wastes, washing activities, storm water drainage, cattle farming wastes and dumping of liquid & solid wastes.

A

B

C

D

E

F

G

H

A: *Degradable and non-degradable wastes disposal;* ***B:*** *Point and non-point wastes disposal;* ***C** & **D:*** *Sewage discharge from residential area;* ***E** & **F: S**eepage of agricultural wastes and* ***G** & **H:*** *Encroachment of canal and domestic discharge points.*

Fig. 1: Study site-Raya canal

2.2. Sampling and sampling sites

A plastic bottle of capacity 2 liters were used to collect the sample, pH and temperature of canal water measured at the time of sample collection. The water samples were collected on a monthly basis from January-2021 to December-2021. The replicates of water samples taken from each of the four sampling sites were done during morning hours in between 10.30 am to 11.30 am. On the canal side, the water samples were collected at a depth of 1 to 2 feet from sites, S1 to S4 (Fi. 1 and Fig. 2). The collected water samples were stored at 4°C. The methods of analyzing the quality of water samples of Raya canal were performed by selecting four sampling stations, on the basis of peculiarity of the location rather than equidistance. Surface water samples were collected from the study area by dip (grab) sampling method. All the results showed in the Tables 2 to 5 are representing an average value of 2-3 recorded reading or measured values of the parameters. A brief outlines of the location and topographical details of each sampling areas are shown in Table 1.

Table 1: The location and topographical details of each sampling area of Raya canal

Station (Dist. From TB dam)	Description of Sampling Point	Level of Pollution	Latitude	Longitude	Remarks
St. 1 (0 km)	*Gate of the dam*	Non-Polluted	15° 15' 36.65" N	76° 20' 21.95" E	Reservoir No Sewage discharge
St.2 (4 km)	Small Road Bridge	Less Polluted	15° 16' 37.34" N	76° 21' 38.76" E	Sewage discharge to the canal. Seepage of agricultural wastes, Washing activities, Point and non-point wastes disposal
St.3 (8 km)	*Railway Station Road Bidge*	Medium Polluted	15° 16' 54.53" N	76° 23' 15.26" E	Washer man (Dhobhi Ghat), Seepage of agricultural wastes, Residential area domestic and solid waste, commercial area, scrap dealers, drum cleaners, automobile garages, Sewage discharge to the canal. Point and non-point wastes disposal
St. 4 (14 km)	Naganahalli Village	Highly Polluted	15° 17' 45.36" N	76° 24' 06.41" E	Seepage of agricultural wastes, Residential area domestic and solid waste, Cattle and dairy farmers, Agriculture activities, sewage discharge to the canal. Point and non-point wastes disposal

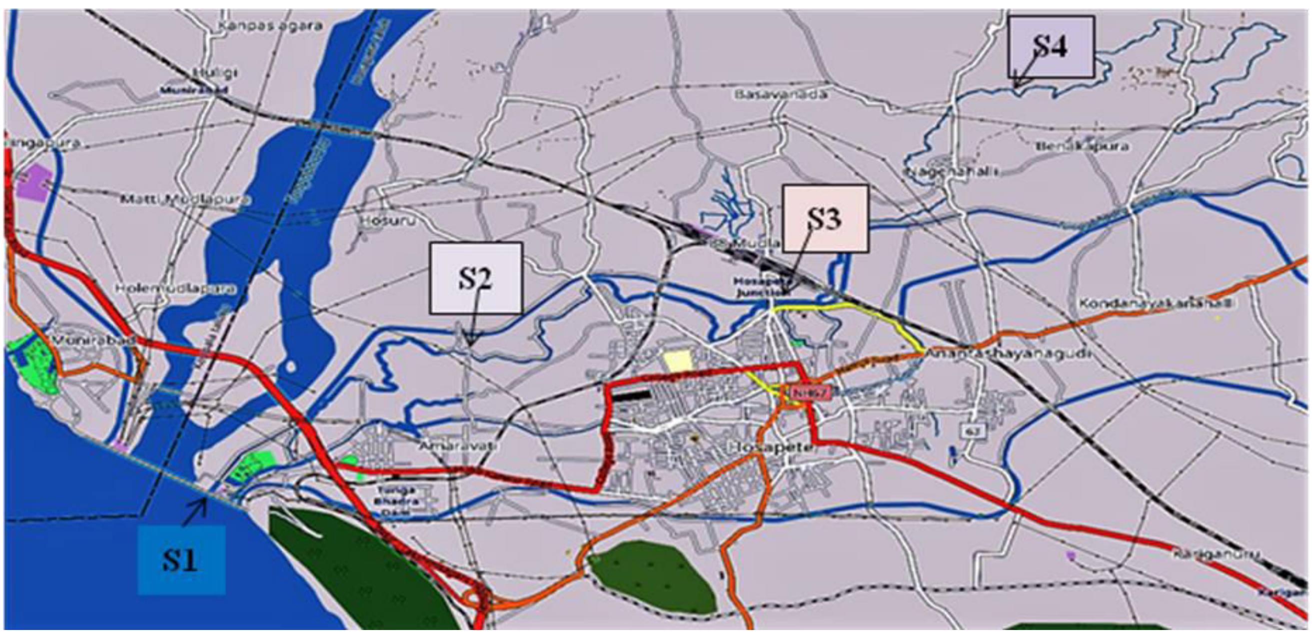


Fig. 2: Location map of surface water sampling stations of Raya Canal

3. RESULTS AND DISCUSSION

Seasonal variations in the values of physicochemical parameters, *viz.*, pH, Electrical Conductivity (EC), temperature (°C), Total Hardness (TH), Total Alkalinity (TA), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD), Chloride, Nitrate, Phosphate and Dissolved Oxygen (DO) were studied. It was noticed that throughout the study period, the seasonal behaviors of physico-chemical parameters of canal water were more or less similar at all the sample stations and values were gradually either increased or decreased with some exception, from sample station 1 to 4. This was due to Raya canal passing through Municipal area of Hospet town and the canal water was polluted gradually after the sample station 1 to 4 by the disposal of untreated sewage, seepage of agricultural wastes, anthropogenic activities, and excessive usage of detergents by the people for washing of cattle's, vehicles, cloths and utensils and also microbial activities [17].

3.1. Temperature of water at sample station S1 to S4

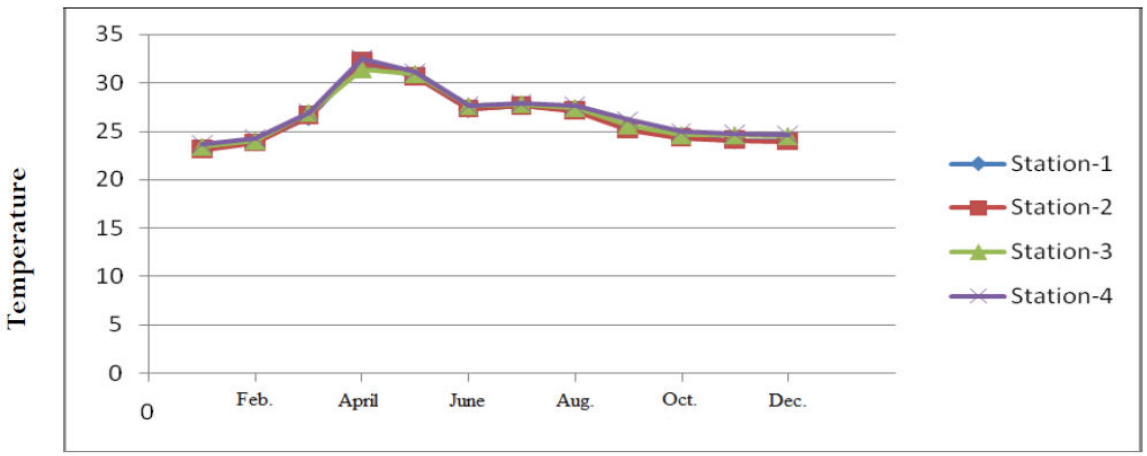
Temperature plays an important role on physical, chemical and biological parameters of water like the solubility of different gases, extent of chemical reaction and toxicity, and microbial activity [18]. Increase in water temperature decreases the extent of solubility of dissolved oxygen in water [19], thus its availability to aquatic organisms which may have an influence on their metabolism, behavior, growth, food and feeding habits, geographical distribution, reproduction, life histories, community structure, movements, migrations, tolerance to parasites, diseases and pollution. Long-term temperature increase can impact aquatic biodiversity, biological productivity, and the cycling of contaminants through the ecosystem. In the present study temperature of Raya canal was found ranging between 23.1°C to 32.5°C during the year as indicated in Table 2 and Fig.3A. The limit of temperature value for irrigation water is specified BIS limits [20] maximum as 40°C. All samples were in desirable limit as prescribed for irrigation water standard. The maximum value of temperature i.e. 32.5°C was recorded at sample station 4 during summer, whereas minimum 23.1°C was recorded at sample station 1 during winter. The temperature of water showed an increasing trend from winter to summer followed by a decreasing trend with some exception from monsoon to post monsoon.

3.2. pH values of water collected at study sites

The change in pH value alters the concentration of other substances in water to become a more toxic form. Lower value of pH indicates acidic and corrosive properties of water and higher pH values indicate alkaline properties. The values of pH for all collected water samples are within the admissible limits of (7.1 to 8.1) specified by WHO [21] and ISI [22] standards for drinking water and BIS [20] for irrigation purpose. As heavy metals can be removed by carbonate or bi-carbonate precipitation [23] a slight alkaline pH is acceptable in water. It was noticed along the course of the study that pH values gradually increased with some exception from the sample station 1 to 4 in all seasons. This is due to the Raya canal runs along Municipal area of Hospet town and the canal water was polluted gradually after the sample station 1 to 4. The high alkaline pH of Raya canal may be due to the excessive usage of detergents by the people for washing of vehicles, cloths, cattle's and utensils and also microbial activities [24]. The regional and seasonal variation of pH values in Raya canal is given in Table 2 and Fig. 3B with some exception, the results of pH values revealed slight variations in its values. Higher pH values of studied Raya canal during summer and winter could be ascribed to increased photo synthetic assimilation of dissolved inorganic carbon by planktons [25]. A similar effect could also be produced by water evaporation through the loss of half bound CO_2 and precipitation of mono-carbonate [26]. Lower pH values during rainy season were due to increase in the volume of canal water by rain. This study was in close conformity with the research finding [27].

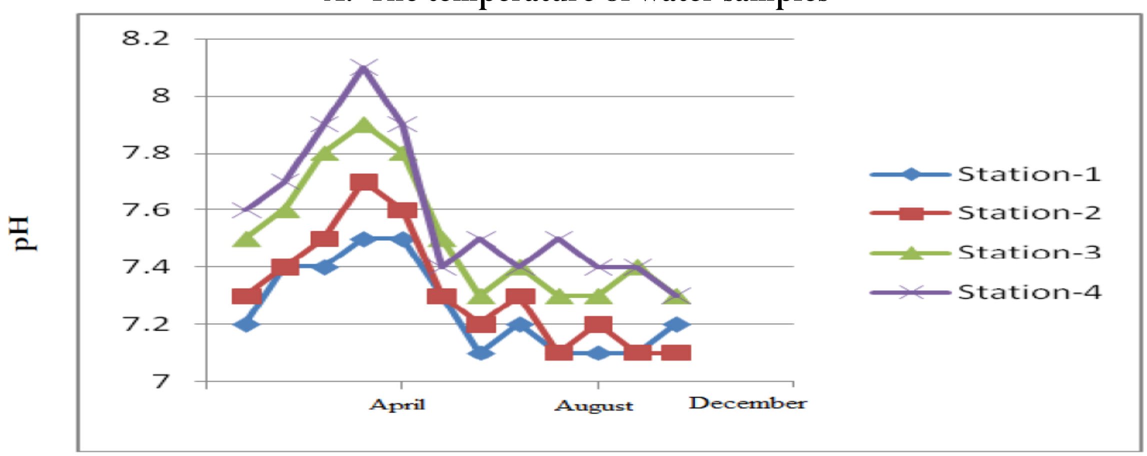
3.3. Electrical Conductivity

To check the suitability of water resources for irrigation purpose, the electrical conductivity (EC) has long been used as an important parameter. It represent as an index for total concentration of soluble salts in water [28]. EC is an estimate of total dissolved salts in water [29] and water with EC values between 2500 and 10000 μmho/cm was not recommended for human consumption and also not suitable for irrigation [30], except for high salt tolerant crops with special management techniques. The Electrical conductivity limit of value for irrigation water is specified BIS limits [20] as 3000 (μ mho/cm). At water discharged point (sample stations 1) of the T.B. Dam EC values were very low. As we move far away from the T.B. Dam, along the course of Raya canal (S1 to S4) with some exception, the EC values gradually increased in all seasons. This is due to the Raya canal runs along the Municipal area of Hospet town and the canal water pollution gradually increases after the sample station 1 to sample station 4 by disposal of untreated sewage, seepage of agricultural wastes, anthropogenic activities, washing activities, storm water drainage, cattle farming wastes and dumping of liquid & solid wastes along the course. The EC values of the Raya canal at sample stations S1, S2 and S4 in the month of May were highest (942.13μ mho/cm, 1176.33 μ mho/cm and 1801.32 μ mho/cm) and lowest in the month of January (475.4 μ mho/cm, 613.55 μ mho/cm and 1212.22 μ mho/cm) respectively. EC value of sample station 3 was recorded highest in month of April (1598.12 μ mho/cm) and lowest in month of January (1035.76 μ mho/cm). All samples (Table 2 and Fig. 3C) were within the desirable limit as prescribed for irrigation water standard. In the present study, it was observed that EC values were higher during the summer and rainy season in all sample stations than during the winter season. This supports the observation of research finding [31]. In summer season higher EC values indicates water with higher electrolyte concentration may be due to evaporation. Higher EC values in rainy season also due to floods and rains, which contains more electrolytes.



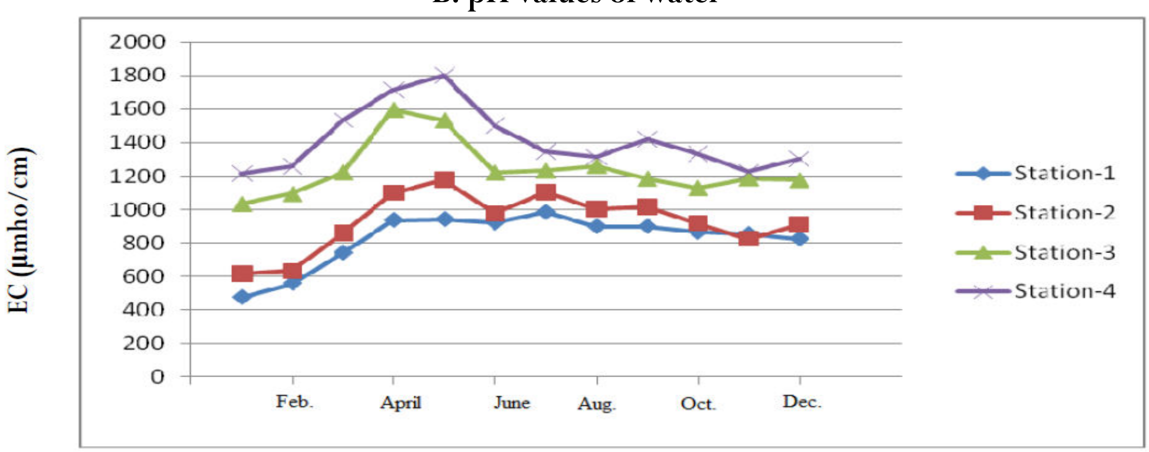
Month

A: The temperature of water samples



Month

B: pH values of water



Month

C: Electrical conductivities of water

Fig. 3 A: The temperature, B: pH and C: Electrical conductivities of water at sites S1 to S4 from Jan. 2021 to Dec. 2021

Table 2: The temperature (°C), pH and Electrical Conductivity (μmho/cm) values of water samples at different study areas

Season	Month	Station-1			Station-2			Station-3			Station-4		
		Temp	pH	EC	Temp	pH	EC	Temp	pH	EC	Temp	pH	EC
Winter	Jan-21	23.2	7.2	475.4	23.1	7.3	613.6	23.4	7.5	1035.8	23.6	7.6	1212.2
	Feb-21	23.9	7.4	559.0	23.8	7.4	630.3	24	7.6	1096.3	24.2	7.7	1256.1
Summer	Mar-21	26.5	7.4	741.6	26.6	7.5	856.8	26.9	7.8	1223.9	26.9	7.9	1534.2
	Apr-21	32.1	7.5	937.2	32.2	7.7	1097.7	31.4	7.9	1598.1	32.5	8.1	1714.3
	May-21	30.6	7.5	942.1	30.6	7.6	1176.3	30.9	7.8	1535.5	31.1	7.9	1801.3
Monsoon	Jun-21	27.3	7.3	920.5	27.3	7.3	973.7	27.6	7.5	1223.8	27.6	7.4	1501.0
	Jul-21	27.6	7.1	984.2	27.6	7.2	1099.4	27.8	7.3	1234.7	27.9	7.5	1345.2
	Aug-21	27.2	7.2	899.1	27.1	7.3	1000.3	27.4	7.4	1263.3	27.6	7.4	1310.9
	Sep-21	25.3	7.1	899.7	25.1	7.1	1012.9	25.6	7.3	1187.5	26.1	7.5	1419.9
Post-monsoon	Oct-21	24.4	7.1	864.5	24.3	7.2	916.7	24.6	7.3	1132.1	24.9	7.4	1332.4
	Nov-21	24.1	7.1	853.2	24.1	7.1	822.4	24.6	7.4	1188.8	24.7	7.4	1223.8
	Dce-21	24.1	7.2	825.2	23.9	7.1	909.1	24.5	7.3	1177.7	24.6	7.3	1299.9

3.4. Total Hardness (TH)

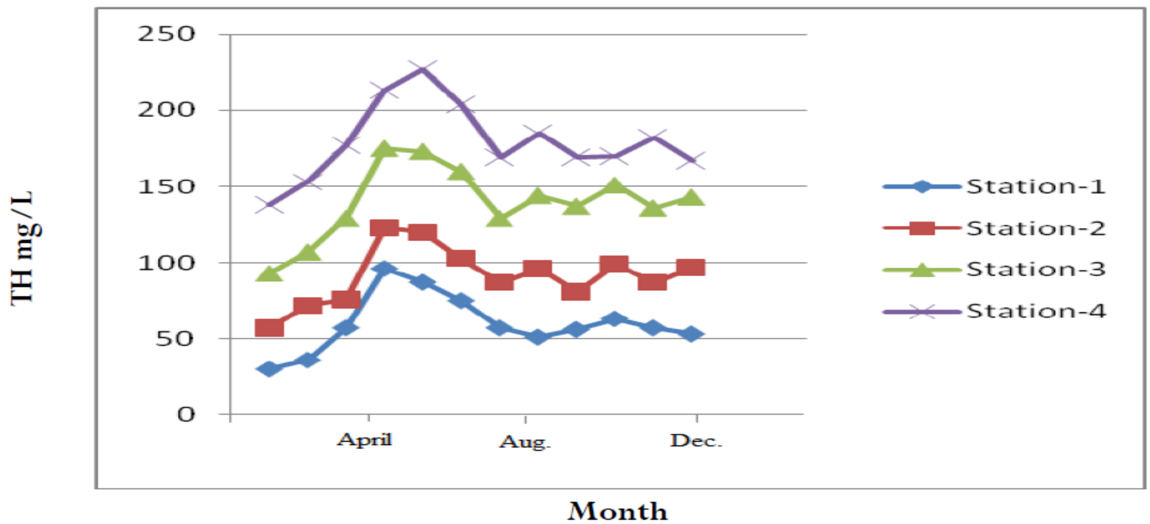
The total hardness of the surface water is dependent on the presence of Ca and Mg contents that enter the water bodies through residues of soaps, detergents and parent bed rock materials made up of Ca, Mg and other metal ions [32]. The untreated domestic sewage and industrial wastes are considered to be important source of calcium and magnesium [33] and is responsible for hardness of water. Hardness of Raya canal water sample stations S1, S2 and S3 in the month of April were highest (96 mg/L, 123 mg/L and 175 mg/L) and lowest in the month of January (30 mg/L, 57 mg/L and 93 mg/L) respectively. Hardness of sample station 4 was recorded highest in the month of May (227 mg/L) and lowest in the month of January (138 mg/L). All samples (Table 3 and Fig. 4A) were within the desirable limit as prescribed for irrigation water standard. The seasonal water hardness of all sample stations indicates that hardness were high in summer and rainy season than in winter season. High values in hardness in summer season due to the disposal of sewage and detergents [34] into the canal and reduced inflow' and high evaporation [35]. The lowest total hardness was observed in winter season due to the low volume of water and high rate of vegetation [36]. This seasonal trend was in close conformity with the research findings [37, 38].

3.5. Total Alkalinity (TA)

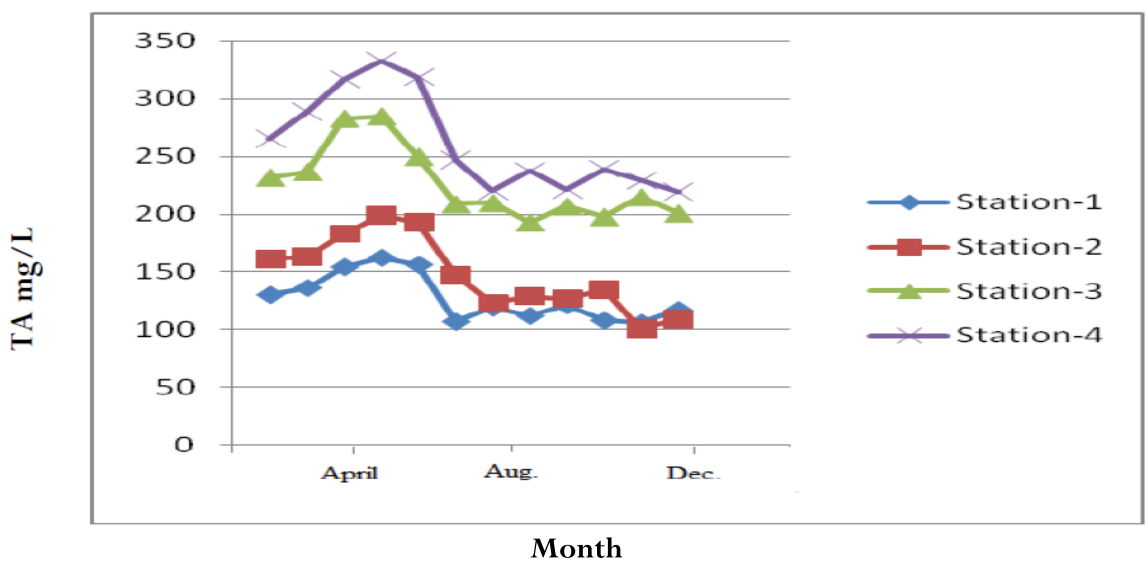
Total Alkalinity (TA) is the acid neutralizing tendency of water that generally imparted by the hydrolysis of salts such as carbonates, bicarbonates and hydroxides [39] but may also include contributions of other basic compounds. Sewage and wastewaters usually exhibit higher alkalinities either due to the presence of silicates and phosphates or to a concentration of the ions from natural waters. The TA values of the Raya canal at sample stations S1, S2, S3 and S4 were recorded highest in the month of April (162 mg/L, 199 mg/L, 285 mg/L and 333 mg/L). The lowest TA values at sample stations S1, S2, were recorded in the month of November (106 mg/L and 101 mg/L) and at S3 and S4 were recorded in the month of December (201 mg/L and 219 mg/L) respectively. Water of all sample sites were within the desirable limit as prescribed for irrigation water standard. In the present study, the seasonal variations of total alkalinity was observed maximum in summer and minimum in monsoon is in conformity with the research findings [31, 40-42] at all the sample stations (Table 3 and Fig. 4B) and was predominantly caused by bicarbonates. In summer, the higher alkalinity is due to the increased rate of photosynthesis which leads to higher utilization of CO_2, discarding dead bodies of animals, cloth washing station and urban excrete through open drains to the canal.

3.6. Biochemical Oxygen Demand (BOD)

Aquatic eco-system has a capacity to reduce organic wastes and gradually regains normal conditions. When the quantity of biodegradable pollutants exceeds in the system, the microorganisms present in the system, in turn use excessive oxygen to reduce the organic load. This leads to decrease in oxygen concentration. The depletion of oxygen seriously affects life of the aquatic animals and lead disastrous consequences. The value of BOD is a measure of the quantity of organic pollution in water. According to report [43] the BOD values of river water up to 5 mg/L, higher than 10 mg/L and more than 20 mg/L were treated as unpolluted, polluted moderately and highly polluted respectively. BOD values of the Raya canal at sample stations S1, S2, S3 and S4 were recorded highest in the month of April i.e. 8.7 mg/L, 37 mg/L, 74 mg/L and 100 mg/L respectively. The lowest BOD values at sample station S1 were recorded in August (3.9 mg/L) and at S3 in November (46 mg/L) and at S2 and S4 were recorded in December (17 mg/L) and October (66 mg/L) respectively. The data (Table 4 and Fig.5A) shows that the values of BOD at sample station S1 was within the desirable limit as prescribed for irrigation water standard and the BOD values at sample stations S2, S3 and S4 were substantially higher than the prescribed levels. These results show a high level of pollution along the course of Raya canal. In the present investigation, the seasonal variations of values BOD was observed maximum in summer due to lesser quantity of water and saturation of impurities in the canal water at all the sample stations. The similar seasonal trend was also observed in accordance with the research findings [31, 44-47].



A: Graph of Total Hardness (TH) values (mg/L)



B: Graph of Total Alkalinity (TA) values (mg/L)

Fig. 4: Graph of A: Total Hardness (TH) values (mg/L) and B: Total Alkalinity values (mg/L) of water samples at sites S1 to S4 from Jan.2021 to Dec.2021

Table 3: Total Hardness (TH mg/L) and Total Alkalinity (TA mg/L) values of water samples at sites S1 to S4 from Jan.2021 to Dec.2021

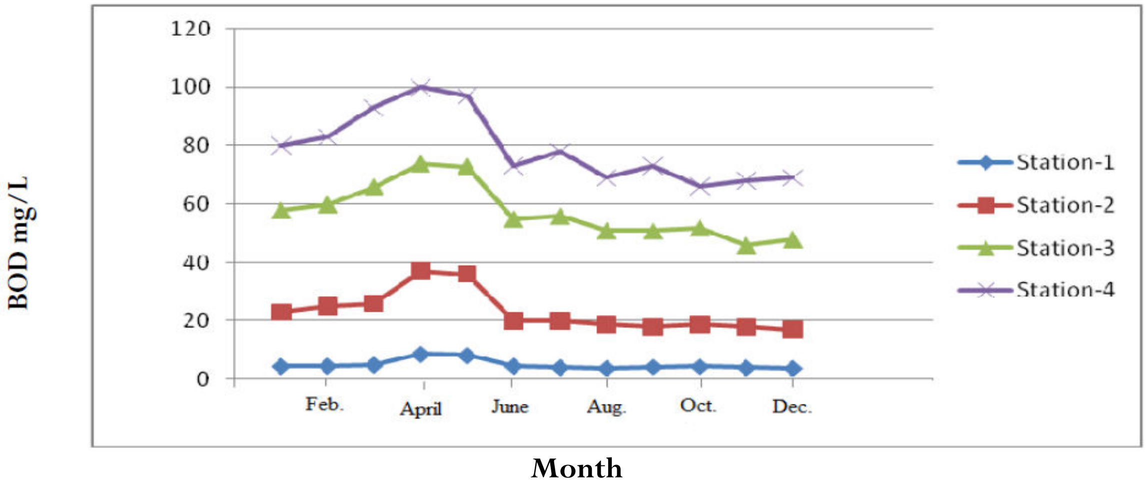
Season	Month	Station-1		Station-2		Station-3		Station-4	
		TH	TA	TH	TA	T H	T A	TH	T A
Winter	Jan-21	30	130	57	161	93	232	138	265
	Feb-21	36	136	72	163	107	237	153	289
Summer	Mar-21	57	154	76	183	129	283	177	317
	Apr-21	96	162	123	199	175	285	213	333
	May-21	87	156	120	193	173	250	227	319
Monsoon	Jun-21	75	107	103	147	160	209	204	247
	Jul-21	57	119	87	123	129	210	169	220
	Aug-21	51	112	96	129	144	193	185	237
	Sep-21	56	121	81	127	137	207	169	221
Post-monsoon	Oct-21	63	108	99	135	151	198	170	239
	Nov-21	57	106	87	101	136	215	182	229
	Dce-21	53	117	97	109	143	201	167	219

3.7. Chemical Oxygen Demand (COD)

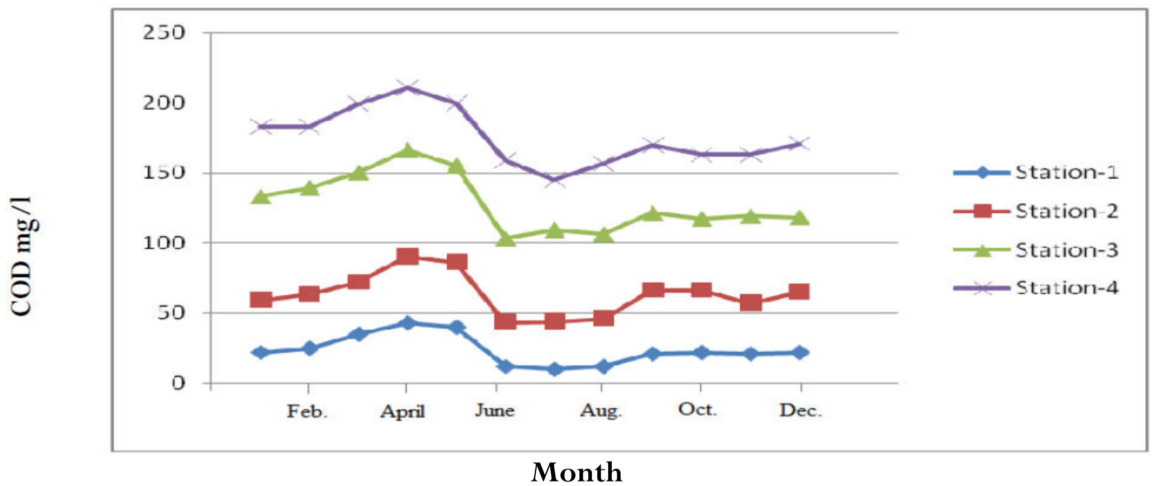
In water quality assessment COD is employed for estimating the organic pollution of water. It is widely used as a measure of the susceptibility for the oxidation of both organic as well as inorganic materials present in water bodies. It determines the quantity of O_2 consumed in the chemical oxidation of chemical compounds using a strong chemical oxidant ($K_2Cr_2O_7$ or $KMnO_4$) under reflux conditions [48]. If COD values are more, there is high organic pollution leading to a depletion of dissolved O_2. COD value is an indicator of organic pollution in surface water and also danger to aquatic ecosystem. The COD values recorded in the entire sampling sites crossed the limit prescribed by the WHO guidelines (10 mg/L) for drinking water quality criteria [21]. The elevated level of COD lowers the quantity of dissolved O_2 in a water body which causes a bad water quality and stress to the resident aquatic life [49]. The COD values of the Raya canal at sample stations S1, S2, S3 and S4 were recorded highest in the month of April (43 mg/L, 90 mg/L, 166 mg/L and 211 mg/L) respectively. The lowest COD values at sample stations S1, and S4 were recorded in the month of July (10 mg/L), 145 mg/L) and at S2 and S3 were recorded in the month of June (43 mg/L, 103 mg/L) respectively. The above data (Table 4 and Fig. 5B) shows that COD at all the sampling stations were substantially higher than the prescribed levels. This shows a high level of pollution along the course of Raya canal. In the present investigation, the seasonal variation of COD was observed maximum in summer due to the lower levels of water and saturation of impurities. It was minimum in rainy season at all the sample stations. The similar seasonal trend was also recorded in water by researchers [47].

3.8. Dissolved Oxygen (DO)

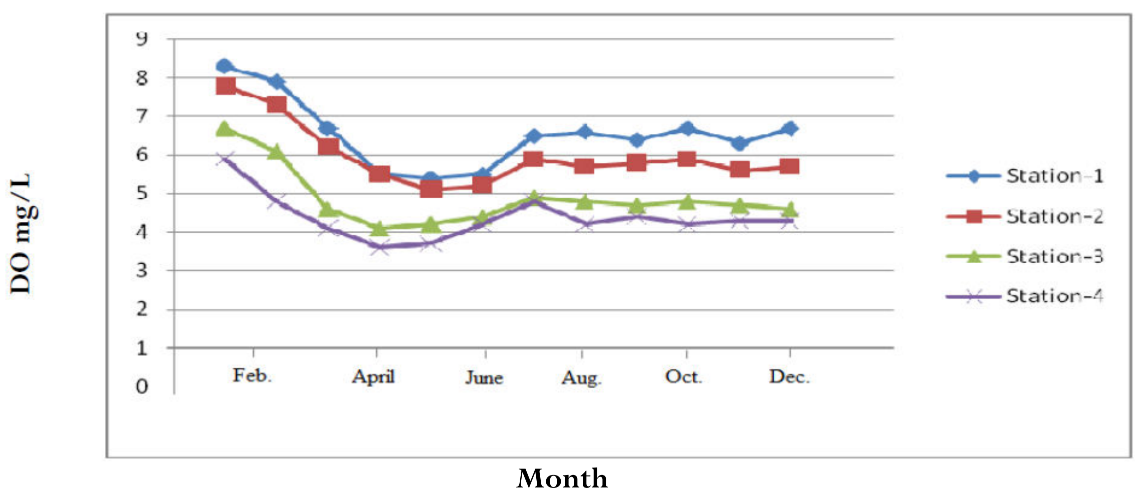
Dissolved oxygen (DO) is required for living organisms to maintain their biochemical process and it plays a major role for supporting aquatic life. Dissolved oxygen is the amount of life-sustaining oxygen dissolved in water. Depletion of DO in water is due to high temperature or added materials, either organic or inorganic would increase microbial activity [50]. For normal healthy aquatic life it requires a concentration of at least 5 mg/L of dissolved oxygen. Less than 5 mg/L indicates water pollution [51]. The DO values of the Raya canal at sample stations S1, S2, S3 and S4 were recorded highest in the month of January (8.3 mg/L, 7.8 mg/L, 6.7 mg/L and 5.9 mg/L) respectively. The lowest DO values at sample stations S1 and S2 were recorded in May (5.4 mg/L and 5.1 mg/L) and at sample stations S3 and S4 were recorded in the month of April (4.1 mg/L and 3.6 mg/L) respectively. The seasonal variation in the quantity of DO was due to industrial, human and thermal activities. It was observed that the DO was maximum during winter as compared that in summer (Table 4 and Fig.5C). The lower DO values at S3 and S4 sampling stations have been observed as compared to S1 and S2, because of higher pollution at these sites due to anthropogenic activity, disposal of sewage from the surrounding area, agricultural seepage and effluents from small industrial units. Increased DO level during monsoon was in accordance with the research findings [31, 52-54]. Increased value of DO during monsoon was attributed to the addition of freshwater in rainy days.



A: Graph of BOD values (mg/L)



B: Graph of COD values (mg/L)



C: Graphical representation of Dissolved Oxygen (mg/L)

Fig. 5: The graphical representation of The BOD, COD and DO values (mg/L) at studied sites in the month of Jan-2021 to Dec-2021

Table 4: The BOD, COD and DO values (mg/L) at studied sites in the month of Jan-2021 to Dec-2021

Season	Month	Station-1			Station-2			Station-3			Station-4		
		BOD	COD	DO	BOD	COD	DO	BOD	COD	DO	BOD	COD	DO
Winter	Jan-21	4.6	22	8.3	23	59	7.8	58	133	6.7	80	183	5.9
	Feb-21	4.7	25	7.9	25	63	7.3	60	139	6.1	83	183	4.8
Summer	Mar-21	5.1	35	6.7	26	72	6.2	66	150	4.6	93	199	4.1
	Apr-21	8.7	43	5.5	37	90	5.5	74	166	4.1	100	211	3.6
	May-21	8.3	40	5.4	36	86	5.1	73	155	4.2	97	200	3.7
Monsoon	Jun-21	4.7	12	5.5	20	43	5.2	55	103	4.4	73	159	4.2
	Jul-21	4.2	10	6.5	20	44	5.9	56	109	4.9	78	145	4.8
	Aug-21	3.9	12	6.6	19	46	5.7	51	106	4.8	69	157	4.2
	Sep-21	4.4	21	6.4	18	66	5.8	51	121	4.7	73	170	4.4
Post-monsoon	Oct-21	4.5	22	6.7	19	66	5.9	52	117	4.8	66	163	4.2
	Nov-21	4.1	21	6.3	18	57	5.6	46	119	4.7	68	163	4.3
	Dce-21	4.0	22	6.7	17	65	5.7	48	118	4.6	69	171	4.3

3.9. Chloride (Cl^-)

In domestic water supply, Chloride is added as a bleaching agent to kill microorganisms. It is highly soluble therefore found in almost all water bodies. The acceptable limit of chlorides in water was 250mg/L. High concentration of chloride is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. High values of chloride are troublesome in irrigation water and also harmful to aquatic life [17]. The chloride values of the Raya canal at sample stations S1 and S3 were recorded highest in the month of April (83 mg/L and 152 mg/L) and at sample stations S2 and S4 were recorded highest in the month of May (118 mg/L and 175 mg/L) respectively. The lowest chloride values at sample station S1 were recorded in the month of September (31 mg/L) and at S2, S3 and S4 were recorded in the month of July (55 mg/l, 88 mg/l and 111 mg/l) respectively. High values of Chloride at all sample stations (Table 5 and Fig. 6A) in summer season may be associated with high temperature which enhances the evaporation and reducing the quantity of water, discharge of small industrial effluents, irrigation drains or contamination with sewage [55, 56]. Low concentration of chloride at all the sample stations in rainy season was due to increase in water level by rain. This observation was in agreement with the research finding [57-59].

3.10. Nitrate (NO_3^-)

All organisms require nitrogen to synthesize protein required for growth and reproduction. In water if nitrate is present it indicates some bacterial action and bacterial growth. Nitrate in surface water is an important parameter for water quality assessment [60]. It is used to find out the water pollution status and anthropogenic load in the canal water. It is highly oxidized form of nitrogenous compounds and will present in surface water as it is the end product of aerobic decomposition of organic nitrogenous matter present in animal waste. Its concentration depends on the nitrification and denitrification activities of microorganisms. Non polluted, pure natural water contain a minute amount of NO_3^- [61]. The excessive use of fertilizers in agriculture [62], atmospheric deposition and urban activities are a major source of elevated NO_3^- concentration in freshwater [63]. It causes a diverse problems in aquatic systems and in drinking water are linked to health problems in human beings [64] and toxic effects on livestock [65]. The nitrate values of the Raya canal (Table 5 and Fig. 6B) at sample stations S2 and S3 were recorded highest in the month of June (2.74 mg/L and 3.31 mg/L) and at sample stations S1 and S4 were recorded highest in the month of July (1.98 mg/L and 3.88 mg/L) respectively. The lowest nitrate values at sample stations S1, S2, S3 and S4 were recorded in the month of April (0.83 mg/L, 1.37 mg/L, 2.07 mg/L and 2.35 mg/L) respectively. In the present investigation, the seasonal variations of nitrate was observed maximum in monsoon due to the excessive entry of water from agricultural field, animal matter, decayed vegetables, sewage or sludge disposal, domestic effluents and leachable from refuse dumps, atmospheric washout and precipitation that enrich canal water with nitrogen compounds. The minimum amount of nitrate in water was observed in summer due to the utilization by plankton and aquatic plants for metabolic activities. According to WHO [21], the value of nitrate for drinking purpose is 50 mg/L and in the respect, NO_3^- was found under the permissible limit.

3.11. Phosphate (PO_4^{3-})

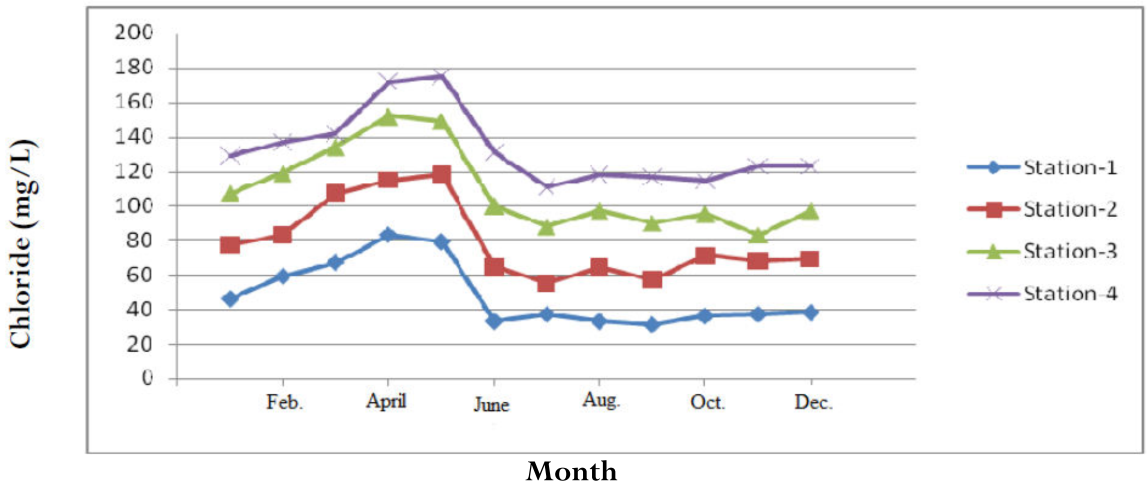
Phosphate (PO_4^{3-}) was the first limiting nutrient for plant growth in freshwater system [66] and also used as an important parameter to assess the quality of water. Both organic and inorganic forms of phosphorus are utilized by organisms but inorganic phosphorus seems to be more appreciated by plants. PO_4^{3-} is an essential component of the geochemical cycle in water bodies, thus PO_4^{3-} is often included in basic water quality surveys. The phosphate values of the Raya canal (Table 5 and Fig. 6C) at sample stations S1, S2 and S4 were recorded highest in the month of July (1.79 mg/L, 2.27 mg/L and 3.45 mg/L) and in the month of June sample station S3 was recorded (2.77 mg/L). The lowest phosphate values at sample stations S1, S3 and S4 were recorded in the month of April (0.61 mg/L, 1.59 mg/L and 2.01 mg/L) and at sample station S2 was recorded in the month of March (1.07 mg/L) respectively. In the present investigation, the seasonal variations of PO_4^{3-} have been observed maximum in monsoon because of excessive entry of effluent discharge from sewage treatment plants, domestic wastewater, runoff from agricultural fields sprayed with phosphate fertilizers, phosphate additives used in detergents. The minimum amount of PO_4^{3-} in canal water was observed in summer because of the utilization of phosphate as nutrients by algae and other aquatic plants.

Table 5: Chloride (Cl^-), Nitrate (NO_3^-) and Phosphate (PO_4^{3-}) values (mg/L) of water samples at stations S1 to S4 from Jan. 2021 to Dec. 2021

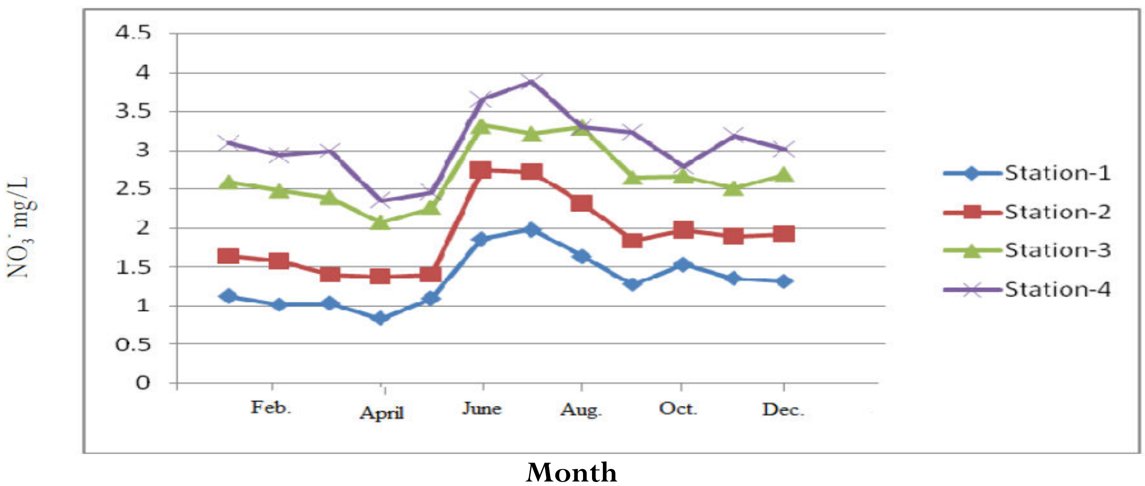
Season	Month	Station-1			Station-2			Station-3			Station-4		
		Cl^-	NO_3^-	PO_4^{3-}	Cl^-	NO_3^-	PO_4^{3-}	Cl^-	NO_3^-	PO_4^{3-}	Cl^-	NO_3^-	PO_4^{3-}
Winter	Jan-21	46	1.12	0.71	77	1.63	1.23	107	2.59	1.75	129	3.09	2.12
	Feb-21	59	1.01	0.69	83	1.57	1.12	119	2.48	1.66	137	2.93	2.17
Summer	Mar-21	67	1.03	0.64	107	1.39	1.07	134	2.39	1.61	142	2.99	2.09
	Apr-21	83	0.83	0.61	115	1.37	1.19	152	2.07	1.59	172	2.35	2.01
	May-21	79	1.09	0.91	118	1.39	1.36	149	2.26	2.01	175	2.46	2.66
Monsoon	Jun-21	33	1.86	1.73	65	2.74	2.12	100	3.31	2.77	131	3.65	3.23
	Jul-21	37	1.98	1.79	55	2.72	2.27	88	3.21	2.68	111	3.88	3.45
	Aug-21	33	1.63	1.23	64	2.31	1.81	97	3.29	2.41	118	3.29	2.79
	Sep-21	31	1.27	1.37	57	1.83	1.87	90	2.65	2.62	117	3.23	3.09
Post-monsoon	Oct-21	36	1.53	1.19	71	1.97	1.77	95	2.67	2.46	115	2.79	2.91
	Nov-21	37	1.35	1.19	68	1.89	1.83	83	2.51	2.22	123	3.19	3.01
	Dce-21	38	1.31	1.21	69	1.92	1.64	97	2.69	2.35	123	3.01	3.01

Table 6: Comparison of studied water quality parameters with the standards for drinking and irrigation limits provided by WHO (2004), ISI (1983) and BIS (1991)

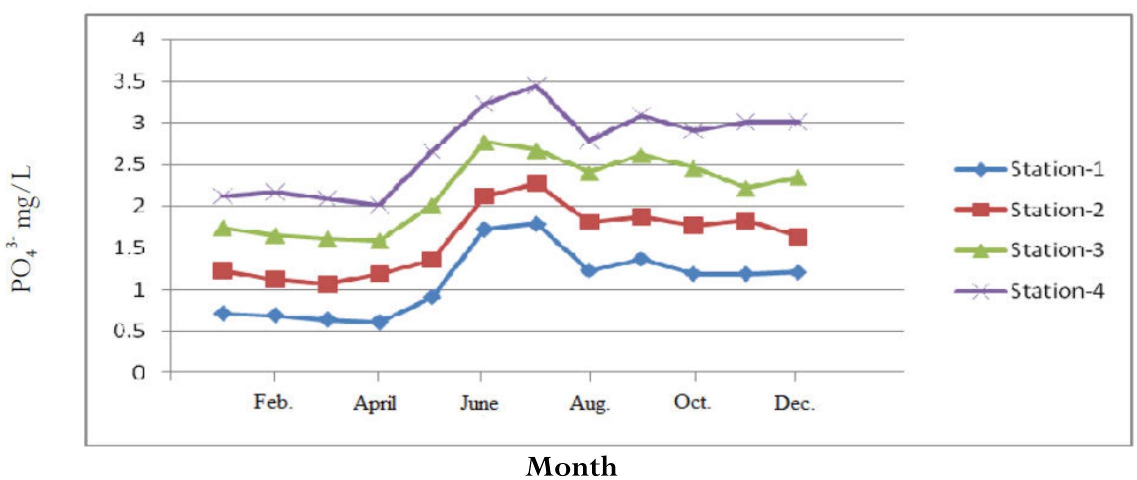
Parameter	WHO (2004)	ISI (10500, 1983)	BIS (10500-1991)	Range in the Study Area
pH	6.5 – 8.5	6.5 – 8.5	6.5-8.4	7.1-8.1
EC	1400	1400	1164-1986	475.1-1801.3
BOD	5.0	5.0	-	3.9-100
COD	10.0	10.0	-	10-211
DO	5.0	5.0	-	3.6-8.3
TA	120	200	200	106-333
TH	300	300	300	30-227
Chloride	250	250	250-1000	31-175
Nitrate	40-100	40-100	0-10	0.83-3.88
Phosphate	-	-	0-2	0.61-3.45
Odour	Unobjectionable	Unobjectionable	Unobjectionable	objectionable



A: Chloride (Cl^-) values (mg/L) of water at sites S1 to S4 *vs* different months



B: Nitrate (NO_3^-)values (mg/L) of water at sites S1 to S4 at different Months



C: Phosphate (PO_4^{3-}) (mg/L) of water at sites S1 to S4 at different months

Fig. 6: Graphical representation of Cl^-, NO_3^- and PO_4^{3-} values (mg/L) of water at sites S1 to S4 *vs* months from Jan. 2021 to Dec. 2021

4. CONCLUSION

The present research was undertaken to examine the quality of Raya canal water which changes due to the addition of human wastes, agricultural wastes, domestic wastes, cattle farming wastes and liquid & solid wastes into canal water. It was revealed that some of the physicochemical parameters like total alkalinity, dissolved oxygen, chemical oxygen demand and biological oxygen demand exceeding the permissible limits as prescribed by Indian standards and WHO. The parameters such as temperature, electrical conductivity, total hardness, nitrate, phosphate and chloride, values are within permissible limits with some seasonal exceptions. Seasonal variations indicated that the most of the physico-chemical parameters such as Temp, pH, EC, TH, and TA, BOD, COD and chlorides were present in higher concentrations at summer and the parameters like pH, TA, BOD, COD and chlorides showed lower concentrations at monsoon and Temp, EC and TH showed lower concentrations at winter. The other physico-chemical parameters like nitrates and phosphates were more at monsoon followed by post-monsoon and lower at summer. DO showed higher concentration at winter followed by monsoon and lower at summer. The quality of canal water is neither in safe limit now nor good for domestic purposes. The situation is alarming and degradation is in continuous process. The continuous monitoring of the pollution level is necessary and immediate action is required for the improvement of quality of canal water.

5. ACKNOWLEDGEMENT

The author[1] would like to thank Government First Grade College, Koppal, for providing instrumental and infrastructure facilities. Author[2] is grateful for Maharani's Science College for Women, Palace Road, Bangalore (DST- FIST, STAR-DBT, UGC-CPE Facilities).

Conflict of interest

None declared

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