www.gondwanags.org.in
Research Article
ISSN : 2455-1953
JGSR
Journal of Geosciences Research
Vol. 9, No.2, July, 2024, pp. 123-131

Urban Environment and Water Quality: Insights from Karamana River Basin, Thiruvananthapuram, Kerala, India

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Abstract

This study mainly focuses on the water quality and urban influence in parts of the Karamana River. The water quality parameters of six selected sites within the urban area were considered. Physico-chemical and biological parameters of water quality were analysed for 2019 (pre-monsoon, monsoon, and post-monsoon). Results have shown a distinct variation of parameters in the less built-up areas than that of the more built-up areas. The indication of the effect of urbanization on water resources has been demonstrated. The pH at Thiruvallom was 5.8, which is located at downstream. The conductivity values range from 69.38 µs/s to 605 µS/cm and from 46.5 µS/cm to 615 µS/cm, and from 76.25 µS/cm to 559.6 µS/cm during pre-monsoon, monsoon and post-monsoon seasons. Ca > Na > Mg > K was the order of cation abundance for the study area. The TC value was 43100 cfu/100ml in Moonnattumukk station. The DO was very low in locations at Moonnattumukk, Thiruvallom and Pallathukadav. Though the deterioration of water quality was limited to a few localized zones, the trend of the quality change was distinct.

Keywords: Land Use/Land Cover, Urbanization, Water Quality, Physico-Chemical and Biological Parameters.

Introduction

The gradual increase in the human population has an effect in the change of both spatial and demographic characteristics (Davis, 1965). The main consequence of urbanization is the spatial expansion of the cities into their intermediate surroundings to house the rising urban population (Mosammam *et al.*, 2016). This affects the elementary amenities and facilities in the urban environment like housing, sanitation, water supply, transport, *etc*.

Contamination of groundwater and surface resources occurs mainly through two ways: diffuse and point sources (Sudhakar and Mamatha, 2004). Pollutions from point sources mainly include the effluents from industries, untreated domestic sewage and waste from sewage treatment plants. The source of diffuse pollution is from anthropogenic activities, like the usage of fertilizers and pesticides in agricultural fields, or from natural geogenic contamination of groundwater sources. The availability of proper sanitation facilities reduces and the direct discharge of wastes in surface water increases the contamination (Subhendu, 2000). But the seepage of waste into the groundwater from faulty pit latrines or septic tanks along with the surface run off and infiltration affect the groundwater quality (Floehr *et al.*, 2013). Characterization of water quality is very essential for identifying the problems for the optimal uses (Chang, 2005; Steven, 2008; Lalitha and Mohammed-Aslam, 2018; Raj *et al.*, 2018; Rizvi and Mohammed-Aslam, 2019; Mohammed-Aslam and Rizvi, 2020; Mohammed-Aslam *et al.*, 2020; Anju *et al.*, 2024; Mohammed-Aslam *et al.*, 2024). As far as urbanization is concerned, parameters such as dissolved oxygen, biological oxygen demand, total coliform and fecal coliform have got direct influence from the urban pollutants (Shanmugasundharam *et al.*, 2023).

It has been documented that, there exist such relation of LULC with water quality variables like nutrients and dissolved constituents (Smart, 1998; Turner and Rabalais, 2003; Ahearn *et al.*, 2005). Among the LULC classes, agricultural activities were found to be dominantly affecting the water quality in terms of its nitrogen concentration (Johnson *et al.*, 1997; Ahearn *et al.*, 2005). The nutrients in water environment are influenced by urban characteristics (Sliva *et al.*, 2001).

Remote sensing techniques are useful in land cover studies (Mohammed-Aslam *et al.*, 2006; Mohammed-Aslam *et al.*, 2010; Kumar and Kumar, 2012; Mohammed-Aslam *et al.*, 2020). Urban growth patterns and physical expressions on the landscape can be spotted, mapped and assessed through these techniques (Angel *et al.*, 2005). Combining spatial information and logical strategies help the stake holders and decision-makers in their activities (Herold *et al.*, 2003). Around 70% of the rivers in India are polluted (Rao and Mamatha, 2004).

In this study an attempt has been made to find out the quality characteristics of surface water in Thiruvananthapuram city covering the parts of Karamana River Basin and the possible influence of urbanisation on seasonal basis.

(Received : 30 November 2023 ; Revised Form Accepted : 30 May 2024)
https://doi.org/10.56153/g19088-023-0190-56

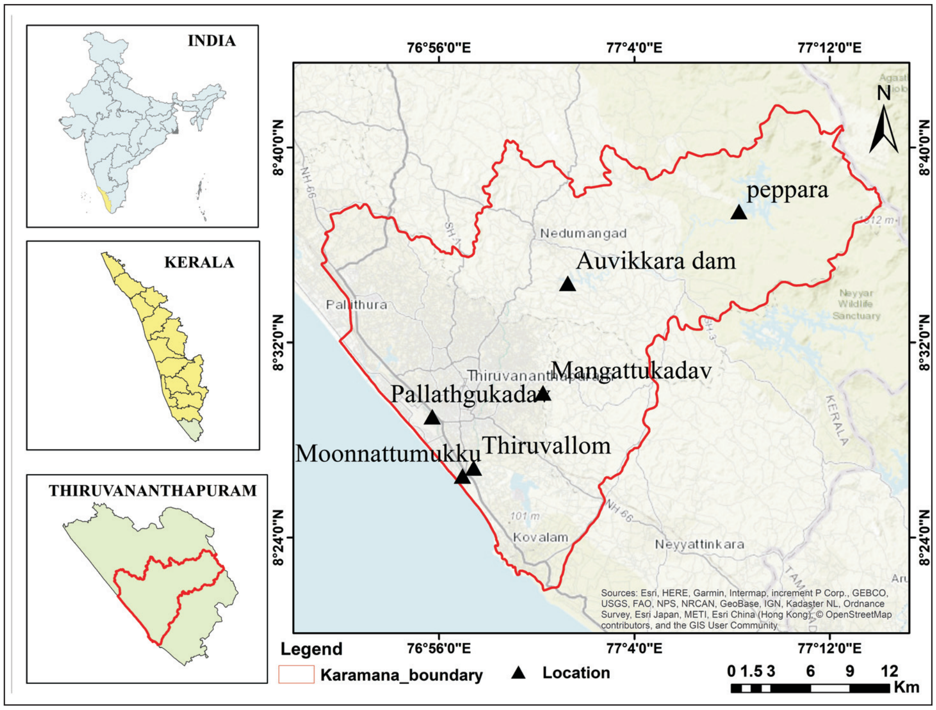

Fig 1. Location of study area

Study Area

Thiruvananthapuram is the capital city of Kerala State in India. It is the largest and the most populous city in Kerala. The population of the Thiruvananthapuram district is 3,307,284 (Census of India, 2011). It is having a population density of 1506 persons/sq.km. The population density is very high in the low land portion of the district, where Thiruvananthapuram city is located (Table 1). The overall growth rate of population for the 40 years until 2011 has revealed almost similar growth rates for both the midland and lowland zones.

The study area includes the parts of Karamana River Basin, which is situated between north latitudes 8° 05' and 8° 45' and east longitudes 76° 45' and 77° 15' (Fig. 1). The focus of the present study was limited to mainly on the built-up area. The catchment of the Karamana River is having an area of about 702 km^2, and the total length of the main channel is about 68 km. This river originates from the Western Ghats and confluences into the Arabian Sea.

Data and Methodology

To analyze the characteristics of river water quality parameters, the data maintained by the State Water Monitoring Programme (SWMP) of Kerala State Pollution Control Board (KSPCB) was taken for the year 2019 (data was accessed from keralapcb.nic.in). The data was compiled by the River Rejuvenation Committee (RRC) of Kerala State Pollution Control Board in a monthly format and the same has been given in the website. In the present study, these monthly data were classified into seasonal basis as pre-monsoon (February, March, April, and May), monsoon (June, July, August and September) and post-monsoon (October, November, December and January) by taking the average values for the considered months. The mean values of all parameters were calculated based on these seasons (Table 2) to represent the quality range in the map. Water quality data were utilized from the stations at Peppara dam (station 1), Aruvikkara (station 2), Mangattukadavu (station 3), Pallathukadavu (station 4), Thiruvallom (station 5), and Moonnattumukk (station 6). Water quality parameters such as temperature, pH, turbidity, biological oxygen demand (BOD), free ammonia, electrical conductivity (EC), dissolved oxygen (DO), total hardness, alkalinity, calcium, magnesium, sodium, potassium, boron, chloride, sodium adsorption ratio (SAR), total coliform (TC), fecal coliform (FC), ammonia nitrogen (NH_3-N), nitrate, phosphate and sulphate were considered for the assessment.

Table 1: Population growth rate in percentage (Charutha and Anilkumar, 2015)

Physiographic Division	1971	1981	1991	2001	2011
	Population in Percentage				
Low land	54.82	55.42	54.85	51.89	55.25
Mid land	38.58	39.21	39.94	43.09	40.05
Highland	6.58	5.35	5.20	5.01	4.69

The designated best use of water quality criteria compiled by the Central Pollution Control Board (CPCB) has been used in this study to characterise the water quality (https://cpcb.nic.in/wqm/Designated_Best_Use_Water_Quality_Criteria.pdf). The river water quality has been characterised based on the criteria prescribed by CPCB (Table 3).

A buffer zone of 5km was created from the sampling locations and Normalized Difference Built-up Index (NDBI) was generated using Sentinel 2A images retrieved in February, 2019 using ERDAS Imagine software. The satellite data was downloaded from the website of USGS (United States Geological Survey) Earth Explorer. This 5 km radius was considered based on the coverage of at least 50% of the sample point area in the buffer zone, especially in the coastal areas. The equation used to derive NDBI from Sentinel 2A is given as Eq.1.

Table 2: Water quality parameters of Karamana River

Parameter	BIS (2012) Standard	WHO (2011) Standard	Location	Pre-monsoon	Monsoon	Post monsoon	Annual Average
Temperature	–	–	Peppara	32.25	32.4	28.8	31.15
			Aruvikkara	33.25	31.78	30	31.677
			Mangattukadavu	32.78	32.58	29.83	31.73
			Pallathukadavu	32.45	32.35	30.175	31.658
			Thiruvallom	33	31.25	29.75	31.333
			Moonnattumukk	33.25	31.25	30	31.5
pH	6.5-8.5	–	Peppara	6.48	6.61	6.89	6.66
			Aruvikkara	6.25	6.65	6.83	6.577
			Mangattukadavu	6.35	6.47	6.62	6.48
			Pallathukadavu	6.8	6.74	6.82	6.787
			Thiruvallom	6.65	6.83	5.88	6.453
			Moonnattumukk	6.65	6.85	6.58	6.693
Turbidity (NTU)	–	–	Peppara	0.45	0.6	1.98	1.01
			Aruvikkara	2.98	1.3	3.83	2.703
			Mangattukadavu	0.2	3.7	3.2	2.367
			Pallathukadavu	6.6	4.43	7.08	6.037
			Thiruvallom	5.68	3.73	5.58	4.997
			Moonnattumukk	29	7.63	3	13.21
EC (πS/cm)	500	–	Peppara	69.38	46.5	76.25	64.043
			Aruvikkara	109.25	114.5	94.75	106.167
			Mangattukadavu	80.25	56	92	76.083
			Pallathukadavu	99.5	126.25	83.5	103.083
			Thiruvallom	311.75	388.25	265	321.667
			Moonnattumukk	605	615	559.5	593.167
DO (mg/L)	–	>4	Peppara	5.83	5.7	6.65	6.1
			Aruvikkara	6.1	6.28	6.85	6.4
			Mangattukadavu	5.6	5.63	6.2	5.8
			Pallathukadavu	4.6	1.78	4.43	3.6
			Thiruvallom	1.73	1.1	0.6	1.1
			Moonnattumukk	0.85	1.03	0.43	0.8
BOD (mg/L)	–	<3	Peppara	2.48	2.65	2.35	2.493
			Aruvikkara	2.6	3.23	2.13	2.653
			Mangattukadavu	2.4	2.55	3.73	2.893
			Pallathukadavu	4.08	1.8	2.4	2.76
			Thiruvallom	7.8	4.83	11.58	8.07
			Moonnattumukk	6.93	5.28	6.73	6.313
Free Ammonia (mmoles/L)	–	–	Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	BDL	BDL	BDL	BDL
			Moonnattumukk	BDL	BDL	BDL	BDL
Chloride (mg/L)	250	–	Peppara	46.5	22	29	32.5
			Aruvikkara	17.25	30	18.25	21.833
			Mangattukadavu	41.5	36.5	45	41
			Pallathukadavu	276	347	87.5	236.833
			Thiruvallom	72	73.75	56.5	67.417
			Moonnattumukk	117.25	106	101	108.083
Total Alkalinity (mg/L)	500	–	Peppara	44	36.75	46.75	42.5
			Aruvikkara	24	28	21.5	24.5
			Mangattukadavu	54.5	62	65.75	60.75
			Pallathukadavu	170.25	121.5	145	145.583
			Thiruvallom	25.73	58.88	43.5	42.703
			Moonnattumukk	55	78	81.5	71.5
Total Hardness (mg/L)	–	–	Peppara	30.25	5.75	16.75	17.583
			Aruvikkara	36.5	33	28.25	32.583
			Mangattukadavu	50.25	26.5	32.5	36.417
			Pallathukadavu	196.5	113.5	70	126.667
			Thiruvallom	100	108.75	76.25	95
			Moonnattumukk	179.25	100.5	141	140.25
Calcium (mg/L)	–	75	Peppara	20.5	3.25	11.5	11.75
			Aruvikkara	22.75	24.75	20.25	22.583
			Mangattukadavu	33.75	18.5	20.5	24.25
			Pallathukadavu	109.75	86	46	80.583
			Thiruvallom	55.75	69.75	50.75	58.75
			Moonnattumukk	116	78.5	102.25	98.917

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Parameter	BIS (2012) Standard	WHO (2011) Standard	Location	Pre-monsoon	Monsoon	Post monsoon	Annual Average
Magnesium (mg/L)	30	–	Peppara	9.75	2.5	5.25	5.833
			Aruvikkara	13.75	8.25	8	10
			Mangattukadavu	16.5	8	12	12.167
			Pallathukadavu	86.75	27.5	24	46.083
			Thiruvallom	44.25	39	25.5	36.25
			Moonnattumukk	63.25	22	39.25	41.5
Sodium (mg/L)	200	–	Peppara	0.88	0.95	6.28	2.703
			Aruvikkara	7.9	11.03	5.15	8.027
			Mangattukadavu	4.3	8.6	10.13	7.677
			Pallathukadavu	20.03	73.63	9.1	34.253
			Thiruvallom	23.63	29.25	18.63	23.837
			Moonnattumukk	37.38	57.13	45.48	46.663
Pottassium (mg/L)	-	-	Peppara	1.25	1.28	1.78	1.437
			Aruvikkara	1.15	4.18	1.6	2.31
			Mangattukadavu	2.75	2.45	4.25	3.15
			Pallathukadavu	4.075	7.76	10.3	7.378
			Thiruvallom	13.6	6.35	5.6	8.517
			Moonnattumukk	9.83	30	9.45	16.427
Boron (mg/L)	-	-	Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	BDL	BDL	BDL	BDL
			Moonnattumukk	BDL	BDL	BDL	BDL
SAR (mmoles/L)		10	Peppara	0	0.07	0.53	0.2
			Aruvikkara	0	0.3	0.21	0.17
			Mangattukadavu	0	9.9	0.58	3.493
			Pallathukadavu	0	15.54	0.27	5.27
			Thiruvallom	0	0.4	0.43	0.277
			Moonnattumukk	0	0.58	0.89	0.49
TC (CFU/100ml)	200		Peppara	400	200	250	283.333
			Aruvikkara	217.5	400	360	325.833
			Mangattukadavu	1625	875	1200	1233.333
			Pallathukadavu	2275	1150	1250	1558.333
			Thiruvallom	4400	7825	4600	5608.333
			Moonnattumukk	43100	20150	19250	27500
FC (cfu/100ml)	100		Peppara	125	95	100	106.667
			Aruvikkara	92.5	200	125	139.167
			Mangattukadavu	500	275	450	408.333
			Pallathukadavu	1325	575	700	866.667
			Thiruvallom	2425	2075	1075	1858.333
			Moonnattumukk	14000	5775	7650	9141.667
Ammonia nitrogen (mg/L)		20	Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	BDL	BDL	BDL	BDL
			Moonnattumukk	BDL	BDL	BDL	BDL
Nitrate (mg/L)	45		Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	BDL	BDL	BDL	BDL
			Moonnattumukk	0.85	1.325	1.25	1.1416
Phosphate (ppm)	0.1		Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	BDL	BDL	BDL	BDL
			Moonnattumukk	BDL	BDL	BDL	BDL
Sulphate (mg/L)	250		Peppara	BDL	BDL	BDL	BDL
			Aruvikkara	BDL	BDL	BDL	BDL
			Mangattukadavu	BDL	BDL	BDL	BDL
			Pallathukadavu	BDL	BDL	BDL	BDL
			Thiruvallom	0.85	0.625	0.975	0.825
			Moonnattumukk	32	33.75	26.75	30.83

Table 3: Classification of samples in the study area and designated best use water quality criteria as per CPCB Designated best use water quality criteria as per CPCB Water quality class of sampling locations (https://cpcb.nic.in/wqstandards)

Designated-Best Use	Class of water	Criteria	Water quality class of sampling locations
Drinking-Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less; pH between 6.5 and 8.5; Dissolved Oxygen 6mg/L or more; Biochemical Oxygen Demand 5 days 200C 2mg/L or less;	None of the stations listed as Class A
Outdoor bathing (Organised)	B	Total Coliforms Organism MPN/100ml shall be 500 or less; pH between 6.5 and 8.5; Dissolved Oxygen 5mg/L or more; Biochemical Oxygen Demand 5 days 200C 3mg/L or less	Peppara and Aruvikkara stations are classified as Class B
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less; pH between 6 to 9; Dissolved Oxygen 4mg/L or more; Biochemical Oxygen Demand 5 days 200C 3mg/L or less;	Mangattukadavu is classified as Class C
Propagation of Wildlife and Fisheries	D	pH between 6.5 to 8.5; Dissolved Oxygen 4mg/L or more; Free Ammonia (as N) 1.2 mg/L or less;	Pallathukadavu during pre-monsoon and post monsoon seasons classified as Class D
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5; Electrical Conductivity at 250C micro mhos/cm Max.2250; Sodium absorption Ratio Max. 26; Boron Max. 2mg/L	Thiruvallom and Moonnattumukk stations are classified as Class E

$$\mathrm{NDBI} = \frac{\mathrm{SWIR-NIR}}{\mathrm{SWIR+NIR}} \tag{1}$$

Results and Discussion

The highest value of temperature was 33.25°C is in Aruvikkara and Moonnattumukk and the lowest temperature value was 28.8°C in the source region at Peppara dam (Fig. 2). Except for Thiruvallom (pH of 5.8) in the post-monsoon season (Table 2), the pH of all other stations was within the tolerable limit (Table 2). The reason for the low pH value in Thiruvallom region may be due to the highly concentrated wastes in the effluent water (Beegom and Binoj Kumar, 2011; Shanmugasundharam *et al.*, 2023). The conductivity range of the samples from the study area was from 69.38 µs/s to 605 µS/cm and from 46.5 µS/cm to 615 µS/cm, and 76.25 µS/cm to 559.6 µS/cm during pre-monsoon, monsoon and post-monsoon seasons respectively (Table 2). The slightly high conductivity was observed in Moonnattumukk station (Fig. 2) in all the three seasons

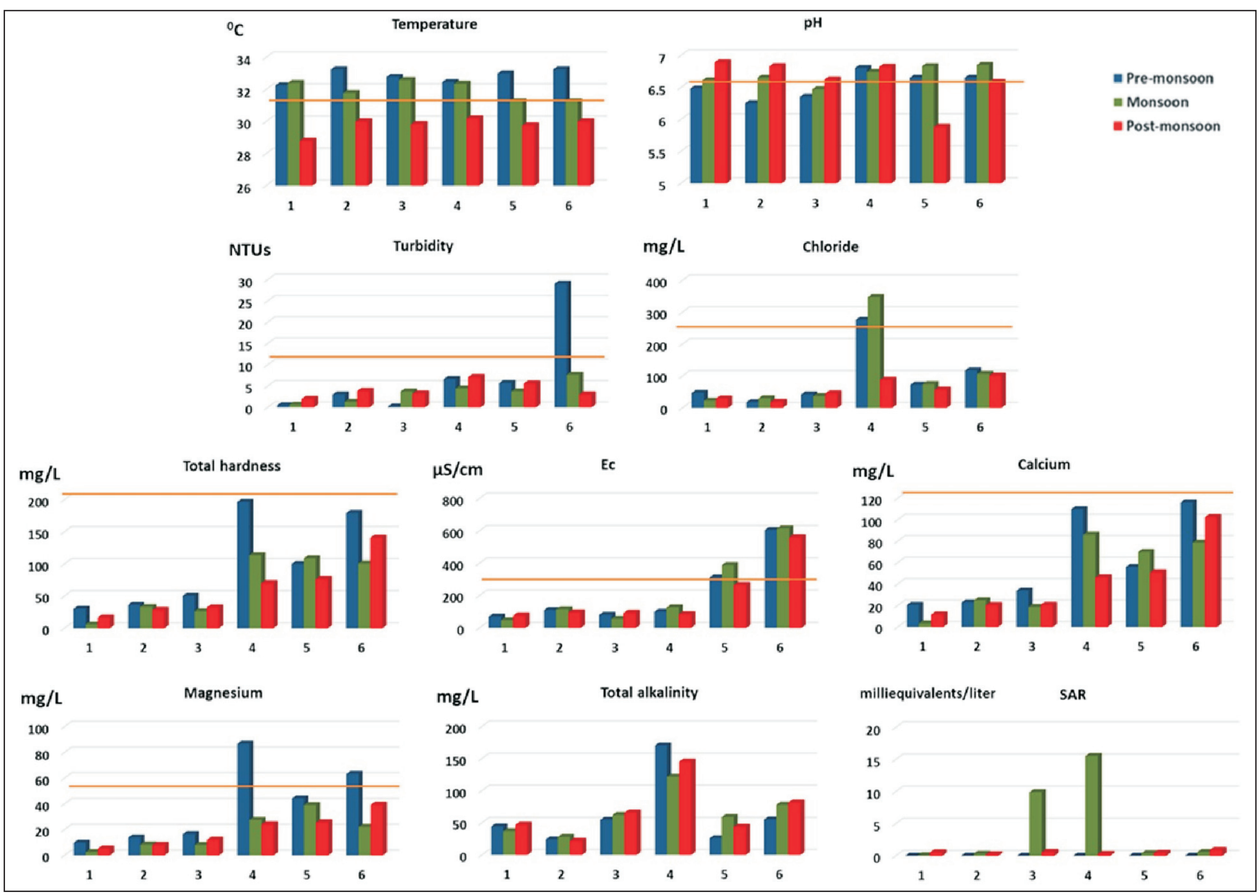

Fig.2. Water quality parameters of pre-monsoon (blue), monsoon (green), and post-monsoon (red)

which may be due to the seawater intrusion as the station is near the coastal zone. The low EC values in the other region suggest the limited mineralization, probably due to the relative inertness of the bedrock minerals (Sajinkumar *et al.*, 2017; Shanmugasundharam *et al.*, 2023). Except for Moonnattumukk (Station 6) in pre-monsoon, all other stations have recorded significantly less turbidity rate in all seasons. The high turbidity may be due to the growth of algae. The algal growth is typical in many parts of the river during the pre-monsoon time. Phosphorus from different sources can cause algal growth resulting in increased turbidity. The sources may include discharges of wastewater treatment plants and nutrient runoff from cropland (Sajinkumar *et al.*, 2017). Organic matter from sewage discharges can also contribute to turbidity (The total alkalinity value ranges from 24mg/L (Station 2) to 170.25 mg/L (Station 4) in pre-monsoon, 28 mg/L (Station 2) to 121.5 mg/L (Station 4) in monsoon and 21.5 mg/L (Station 2) to 145mg/L (Station 4) in post-monsoon (Fig. 2).

Ca > Na > Mg > K is the order of cation abundance for the study area. The highest value of calcium was observed in Moonnattumukk (Station 6) as 102.25 mg/L in post-monsoon season and the lowest was in Peppara as 3 .25 mg/L in monsoon season. Only at Moonnattumukk station during pre-monsoon and post-monsoon the value exceeded 100 mg/L. In all the other stations the recorded values were below 80 mg/L (Table 2) except at Pallathukadavu during pre-monsoon (Fig. 2). The highest value of sodium was in Pallathukadavu (station 4) with a value of 73.63 mg/L in the monsoon season and the lowest in the Peppara dam (0.88 mg/L). The sodium level in Peppara dam and Aruvikkara station was less compared with the other sampling stations (Table 2). In the case of magnesium, except atstation 4 with a value of 86mg/L (Pallathukadavu) and station 6 with value of 63 mg/L (Moonnattumukk) in pre-monsoon time, all the other samples were with less concentration in all the seasons (Table 2). The highest level of potassium was in Thiruvallom (13.6 mg/L) during pre-monsoon season and the lowest was in Aruvikkara station (1.15 mg/L) during pre-monsoon season (Table 2).

Boron, phosphate, sulphate and ammonia nitrogen presence were below the detection level in all the stations. Only station 4 (Pallathukadavu) showed the higher chloride content in pre-monsoon and monsoon seasons (276 mg/L and 347 mg/L). High chloride concentration in monsoon may be due to the sewage runoff near the station. The highest value of SAR was noticed in the monsoon season, with a value of 15.54 at Pallathukadavu station (Table 2). Sulphate and nitrate presence identified in Moonnattumukk station only within permissible limit (Arun *et al.*, 2024).

Except for stations 5 and 6 (Thiruvallom and Moonna-ttumukk), all other stations have relatively higher DO content in all the seasons (Fig. 3). The highest DO content was in Aruvikkara (Station 2) water sample. The high DO content in most of the areas may be due to the open exposure and the dissolution of the high amount of atmospheric oxygen in the water. The two stations which recorded the low DO may be due to the higher BOD level. The DO and BOD are inversely related. If BOD level is high, then DO will be less and vice versa (Sujitha *et al.*, 2012). The BOD level in stations 5 and 6 (Thiruvallom and Moonnattumukk) is high (Table 3). If the BOD level increases, the dissolved oxygen level decreases thereby preventing the aquatic organisms to grow (Sheela *et al.*, 2011). The highest level of BOD was observed in Thiruvallom station, with value of 11.5mg/L in the post-monsoon season (Table 2; Fig. 3).

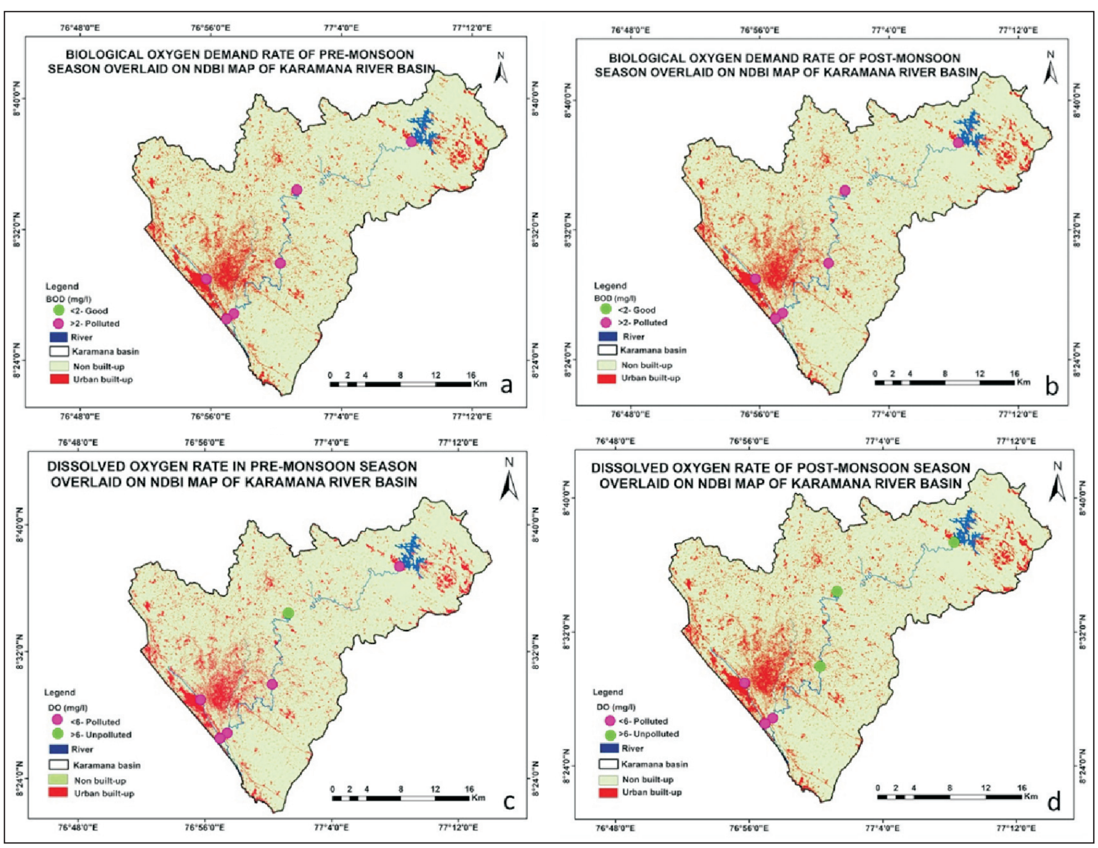

Fig.3. (a-d) Dissolved Oxygen and Biological Oxygen Demand of pre-monsoon and post-monsoon of Karamana Basin

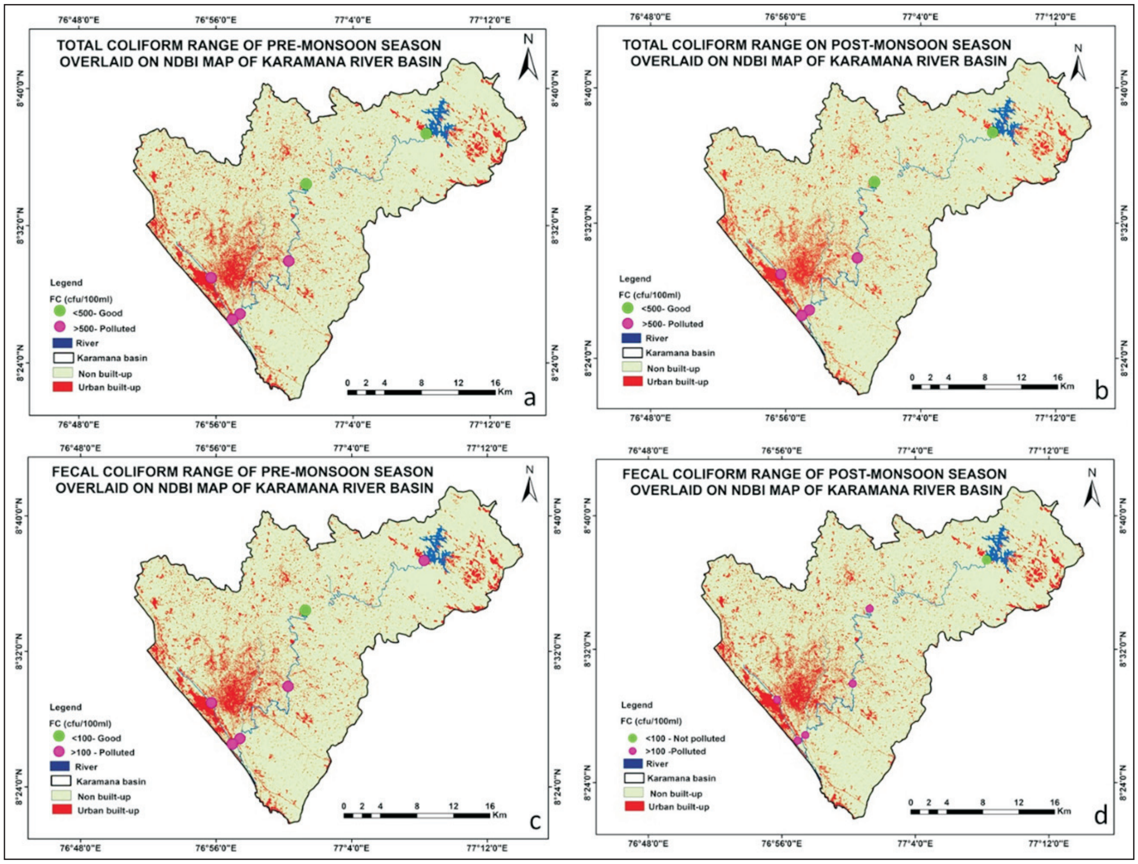

Fig.4. (a-d) Total Coliform and Fecal Coliform of pre-monsoon and post-monsoon of Karamana Basin

The presence of total coliform bacteria indicates that water is contaminated with feces or sewage (Sheela *et al.*, 2011). The stations Pallathukadavu, Thiruvallom and Moonnattumukk have also showed higher amount of TC in the water samples (Table 2). The TC value was 43100 cfu/100ml in Moonnattumukk station in pre-monsoon time was the highest value obtained in the whole period of analysis. In all the seasons, the rate of TC was comparatively very high in this station. Peppara dam was showing the lowest values. It is very clear that the reason behind the increase in the rate of TC in the river is probably due to the discharges from the households due to urbanization (Fig. 4). Fecal coliform bacteria were detected in all the stations, but the higher rate was noticed in three stations (Pallathukadavu, Thiruvallom, and Moonnattumukk). The reason behind this may be the higher quantity of discharge of the sewage from the households to the river water (Sukanya and Joseph, 2020; Harikumar, 2017; Mahadevan *et al.*, 2020; Fig. 4).

The NDBI map revealed that the intensity of urbanization is more at Pallathukadavu, followed by Moonnattumukk, Thiruvallam, Mangattukadv, Aruvikkara and then Peppara (Fig. 5). This intensity of urbanization was found to be exactly matching with the concentration of DO (Table 4). In the places of low DO levels, higher BOD levels had been observed. Similar observations were recorded for these locations in terms of the Total coliform and E coliform bacteria presence in the water samples.

From the analysis it is evident that the river was polluted mostly from anthropogenic sources. All the sampling stations were located in the urban zone except the Peppara dam station. The

Table 4: Urban, non-urban and urban area percentage distribution in 5km buffer zone of sampling location

Station	Urban (km^2)	Non-urban (km^2)	Total area (km^2)	Urban %
Peppara	5.6322	71.6406	77.2728	7.28872255
Aruvukkara	8.052	70.47348	78.52548	10.2539965
Moonnattumukk	14.07374	40.56472	54.63846	25.7579368
Pallathukadav	24.4619	31.4764	55.9383	43.7301455
Mangattukadv	14.4976	64.033	78.5306	18.461084
Thiruvallom	11.4158	33.4165	44.8323	25.4633378

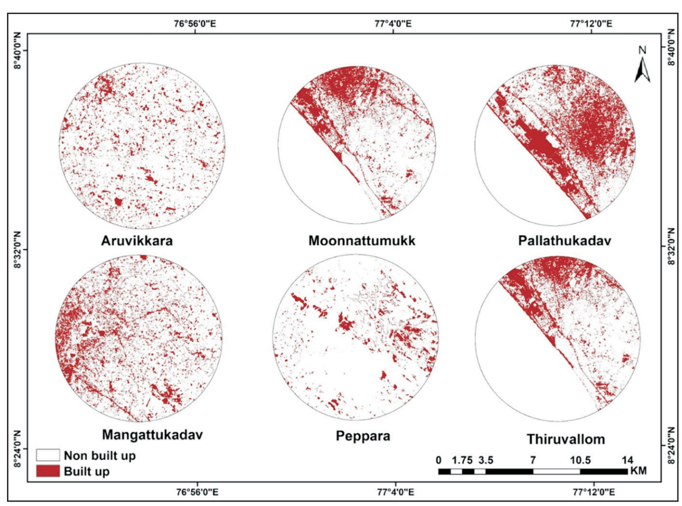

Fig.5. Urban intensity in 5km buffer zone of sampling locations

Peppara dam is away from the Thiruvananthapuram city in the Karamana River Basin, where all the water quality parameters were relatively better. Highly polluted zones are located in the downstream urbanized area. Due to the high-level anthropogenic stress, all the sewage waste materials from the above sources are mixed directly into the surface water.

Conclusions

Study revealed that, there exist a significant relationship between water quality of surface water and the process of urbanization. The DO value in the Thiruvallom, Pallathukadav and the Moonnattumukk region were low and high BOD level signified the impact of urbanization in the quality of surface water. The high BOD in those regions resulted in lesser growth rate of the aquatic organisms. Both fecal coliform and total coliform counts were very high at Pallathukadavu, Thiruvallom, and Moonnattumukk. The results obtained from the study showed the localized mode of pollution was mostly found occurring in the river.

An efficient urban water management practice is required to minimize the impact on the quality of water in an urbanized area of Thiruvananthapuram. Such practice will not only preserve the natural areas but also improve the quality of water. Frequent water quality checks are required to be carried out to identify the water pollution and its source. Proper mechanisms must be in place in the urban zones to stop the direct dumping of wastes from households. Appropriate sewage system should be developed to avoid the direct discharge of sewage waste to the surface water bodies.

Authors' Contributions

MA: Conceptualization, Supervision, Reviewing and Editing. **RSR**: Investigation, Writing-Original Draft, Formal Analysis.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors thank Central University of Karnataka for the facilities provided for the preparation of the manuscript. The authors are also thankful to the Kerala State Pollution Control Board (KSPCB) for the free access of water quality data. They wish to thank Dr. Sheela A.M, Member secretary, Head office, KSPCB, Thiruvananthapuram, for her valuable help and support. The authors also thank USGS Earth Explorer (https://earthexplorer.usgs.gov) for providing access to the satellite data used in this manuscript.

Data Availability Statement

The data used in this article can be found online at *keralapcb.nic.in*.

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