PHYSICOCHEMICAL ANALYSIS OF WATER AND SOIL SAMPLES AS INDICATORS FOR URBAN ECO-RESTORATION PROCESS

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Abstract

Physicochemical analysis of water and soil samples was obtained from various parts of Thiruvananthapuram and Cochin in Kerala, India. The major physicochemical parameters of water, such as pH, electrical conductivity, TDS, BOD, hardness, nitrates, chlorides, fluorides, sodium, potassium, phosphate, and sulfate were measured from January 2019 to September 2022. Microbial and organic compounds were analyzed in soil samples obtained from various places of waste disposal areas in Thiruvananthapuram. The experimental results indicated that the water quality is deteriorated in most of the places. The poor water quality indicated that the freshwater system is contaminated by the untreated discharge of domestic wastewater and geological influences. Soil sample analysis revealed that microbial and organic contamination increased over some time. The physicochemical analysis of water and soil sample results is important for monitoring pollution and prompting the authorities and local communities to mitigate or prevent pollution.

Keywords: Physicochemical analysis, water quality, microbial content, organic contamination, soil quality

1. Introduction

Urban wetlands and other urban ecosystems are considered as valuable as they rely on the sustainability of civilization and agricultural activities. Regrettably, natural resources such as lakes, and ponds are continuously over-exploited and extremely polluted due to natural calamities, anthropogenic activities, and urbanization (Elmqvist et al., 2021; Huang et al., 2013; Maximillian et al., 2019). The pollution in urban ecosystems has serious threats and side effects on plant, animal, and human health. Climatic change and human activities have extensively changed the health of the ecosystem for more than 5 decades. The restoration of habitat is one of the most important and feasible ways to achieve the world's conservation objectives. According to others, human action is now necessary to prevent or lessen any additional effects and improve ecosystem function in these degraded urban ecosystems (Clewell and Aronson, 2007). At all scales of environmental policy, from local to international, ecological restoration has emerged as one of the most popular strategies (Wortley et. al., 2013, Tolvanen& Aronson 2016). Successful urban eco-restoration is thought to depend on having a thorough awareness of the larger social-ecological environment related to degraded ecosystems.

Fresh water is essential for mankind and access to it is a fundamental right in almost every facet of sustainable development. Water acts as a bridge between environmental and climate changes, it prevents impediments caused by climate changes (Duran-Encalada et al 2017).Poor water management results in various water-related crises in domestic water supply, agriculture, and other industrial sectors. Rapid population growth, industrialization, and energy sectors are the prime reasons for the increase in demand for water. Urbanization, natural calamity, and anthropogenic activities alter the change of chemical and physical composition of water. In addition, more than 80% of used water is being discharged back to the environment without even being treated or recycled(Zamora-Ledezma et al., 2021). Heavy metals and organic pollutants are the most common in water which alter the physicochemical parameters which eventually affects the quality of aquatic and human life. The pollutants belonging to the non-biodegradable category accumulate in various parts of the ecosystem. In addition to the heavy metals, inorganic and microbial contaminants also need to be studied(Maity et al., 2020). Discussions about their sources are also essential to prevent pollution. It is the prime responsibility of every individual to monitor the inorganic, organic, and microbial pollution as they are harmful to the life of aquatic as well as human. For example, heavy metals such as arsenic can be found in the environment as a result of anthropogenic activities and the interaction of soil and aqueous systems (Deb et al., 2020). These contaminants enter our body through the food chain, consequently, they pose various health issues such as skin cancer, and renal, respiratory, and hematological illness(Gupta & Sharma, 2019). High concentration of these contaminants also affects the kidneys, lungs, and liver(Edokpayi et al., 2018). Nickel contamination is mainly due to smelting, industrial refining, and electrolysis processes. The Nickel when entered into plants in a particular region, affects the entire ecosystem. The side effects of nickelinclude pulmonary fibrosis, and lung and pancreatic cancer(Vig et al., 2022). Sometimes the pH of water is found to be very high which is due to the presence of amphoteric aluminium ions. Microbial and organic contaminant arises due to anthropogenic and modern agricultural practices. The microbial and organic contaminated water poses a serious threat to mankind. Organic pollutants are wide in variety with a huge range of toxicity. Among the list of organic pollutants such as pharmaceutical waste, dyes, petrochemical waste, personnel care products, etc. A group of chemicals referred to as endocrine disruptive chemicals (EDC) also belong to organic pollutants. EDC is interfered with hormonal activities, thus affecting normal homeostatic reproduction, and developmental behavior(Colborn et al., 1993; Jeng, 2014). Dyes are used in large amounts in textile and dyeing industries for various product development. Many textile and dyeing industries are discharging into the water bodies without prior treatment. Thus, it affects the biotic component depending on water sources. The dyes present in water impede sunlight penetration into the water and reduce the dissolved oxygen content, thus leading to the death of photosynthetic organisms and other living organisms within the aquatic environment. Humans are also exposed to dye when ingested contaminated vegetables and other foods. Dyes are important but at the same time, it is carcinogens if it not effectively treated before discharge into the ground. Proteobacteria were considered an important species for restoring the constructed wetland system as the bacterial community removes pollutants effectively without altering the structure of wetland biodiversity.

Several research studies have been carried out around the globe. Recently, (Choi et al., 2022) Choi and their team evaluated the effectiveness of bacterial communities for water treatment polluted by various sources. To assess the association between inflow pollutants and the bacterial population, four built wetlands handling secondary livestock wastewater, agricultural runoff, and urban stormwater were explored in this study. According to the data, the 20 main bacterial species found in water samples taken from the livestock area made up 98.5% to 99.7% of the overall bacterial population. The 20 most prevalent bacterial species represented 99.7% to 99.8% of the overall bacterial population in agricultural regions. Similarly, the 20 leading bacterial species detected in soil samples from livestock and agricultural regions accounted for 97.2% to 98.7% of the entire bacterial population and 99.1% to 99.6% of the total bacterial population, respectively. In general, the variety of bacteria in soil was greater than in water. When developing a wetland ecosystem, it is critical to establish a specific bacterial habitat for optimal ecological functions.

Prakash and his co-workers assessed the temporal variation of physical and chemical parameters of river (Krishna River, India) water. The study period was from 2007 to 2012 and compared the river water quality at different places. The study concluded that the water quality was severely affected by the discharge of waste water originating from industries and municipal waste(Kengnal et al., 2015).

Ganga canal is being used for ritual baths, irrigation, and domestic needs. However, the water quality is being degraded day by day. Kamboj and the team studied the physicochemical characteristics (TDS, pH, hardness, turbidity, alkalinity, chloride, sulfate, fluoride, sodium, potassium, calcium, magnesium, nitrate) of Ganga canal water, Haridwar. The study was conducted between March 2014 to August 2014. The results indicated that the water quality such as sodium, magnesium, turbidity, and fluoride content is not within the limit as prescribed by the Bureau of Indian Standards (BIS)(Kamboj et al., 2018).

Karthick and his team evaluated the quality of drinking water samples obtained from Alappuzha and Palakkad, Kerala. The study reported that the water was highly contaminated and physicochemical parameters and bacterial content were above the permissible limits prescribed by BIS. The contamination was mainly due to a lack of community hygiene and ineffective treatment of water discharge(Karthick et al., 2010).

In this study, we have analyzed the physicochemical parameters of water and soil samples obtained from various places in the economically important cities of Kerala state in India.

2. Materials and methods:

2.1 Study area

Trivandrum and Kochi are the important industrial cities in the state of Kerala. The following areas with distinct topographical features were selected for the analysis.

(a) Study area for determination of BOD and other physicochemical parameters of water sample: Sampling site at Trivandrum:-Karamana River (KR1), Jagathi River (JR2), Amayizhanchan River (AR3), Killi River (KR4). Sampling site at Kochi:-Periyar (Manakkakdavu) MK1, Chithirapuzha (CP2), Kadubrayer (KB3), Unthithode (UT4).

(b) Study area for determination of Microbial and organic contaminants in soil, Trivandrum: Vilappilsala, Pazhavaugachi, Kunchalammoodu, and Kochi (Municipal waste disposal area)

2.2 General characteristics of the study area

Trivandrum and Kochi are located in the state of Kerala, India, the two main cities in the state are a technology hub and, an innovation cluster. The cities are fast-growing metropolis in the country teaming with restaurants, parks, Industries, amusement parks, and other necessities of modern lifestyle.

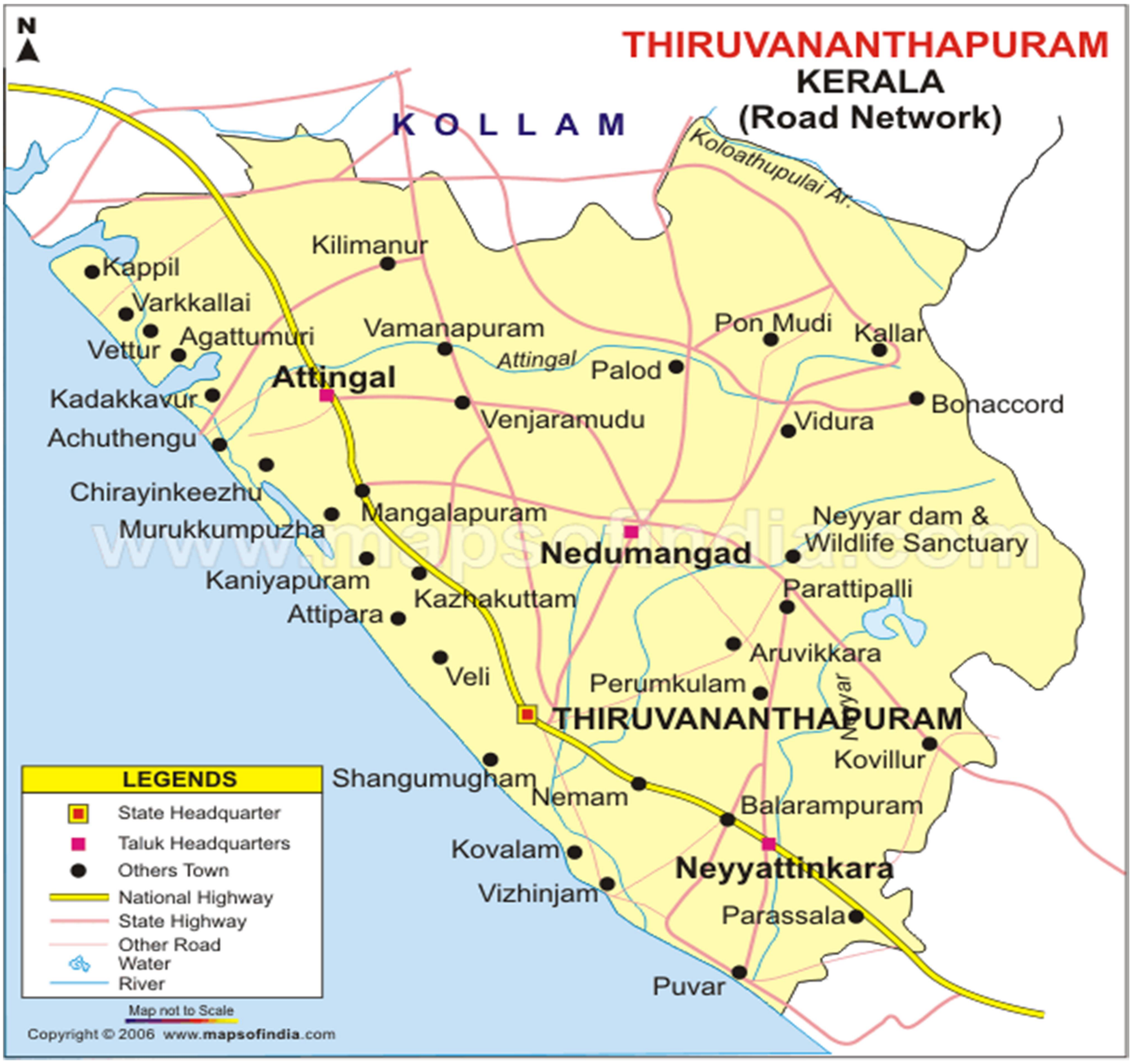

Figure2.1: Thiruvananthapuram district map

The geographical of Thiruvananthapuram district is separated into highland, midland, and lowland. The cities and sub-urban areas have mineral sources that produce minerals for various activities. Reserve forest – 495.14 sq km, vested forest area – 3.53 sq. km, spreading to Kulathupuzha, Palode in the middle, and Paruthipalli in the north. The city acts as an education hub where prime educational institutions are located in the district. The city involves industrial activity, agro-food-based industries, cotton textile, soda/water packed, garments, paper, rubber, mineral, and leather-based products.

2.3 Sampling Period

The sampling and analysis of physicochemical parameters for the present study were carried out from January 2019 to September 2022. The samples were collected according to the Meteorological department and as follows, 1. Winter – January to February, 2. Pre-Monsoon – March, April and May. 3. Monsoon: June, July, August, September. 4. Post Monsoon Season: October, November and December.

Table 1: Sampling coordinates of water sample

Sampling site	Latitude	Longitude
Trivandrum, Sampling site		
Karamana river (KR1)	8° 28' 44.7492"	76° 57' 56.6856
Jagathi River (JR2)	8.4964942	76.9670495
Amayizhanchan River (AR3)	8.5146683	76.9183945608
Killi river (KR4)	8.5381357	76.9758864559
Kochi, Sampling site		
Periyar (Manakkakdavu) (MK1)	10.0283098	76.3862078321
Chithirapuzha (CP2)	10.01668299	76.3456956208
Kadubrayer (KB3)	9.9972° N,	76.3679° E
Unthithode (UT4)	*9.931233*	76.267303

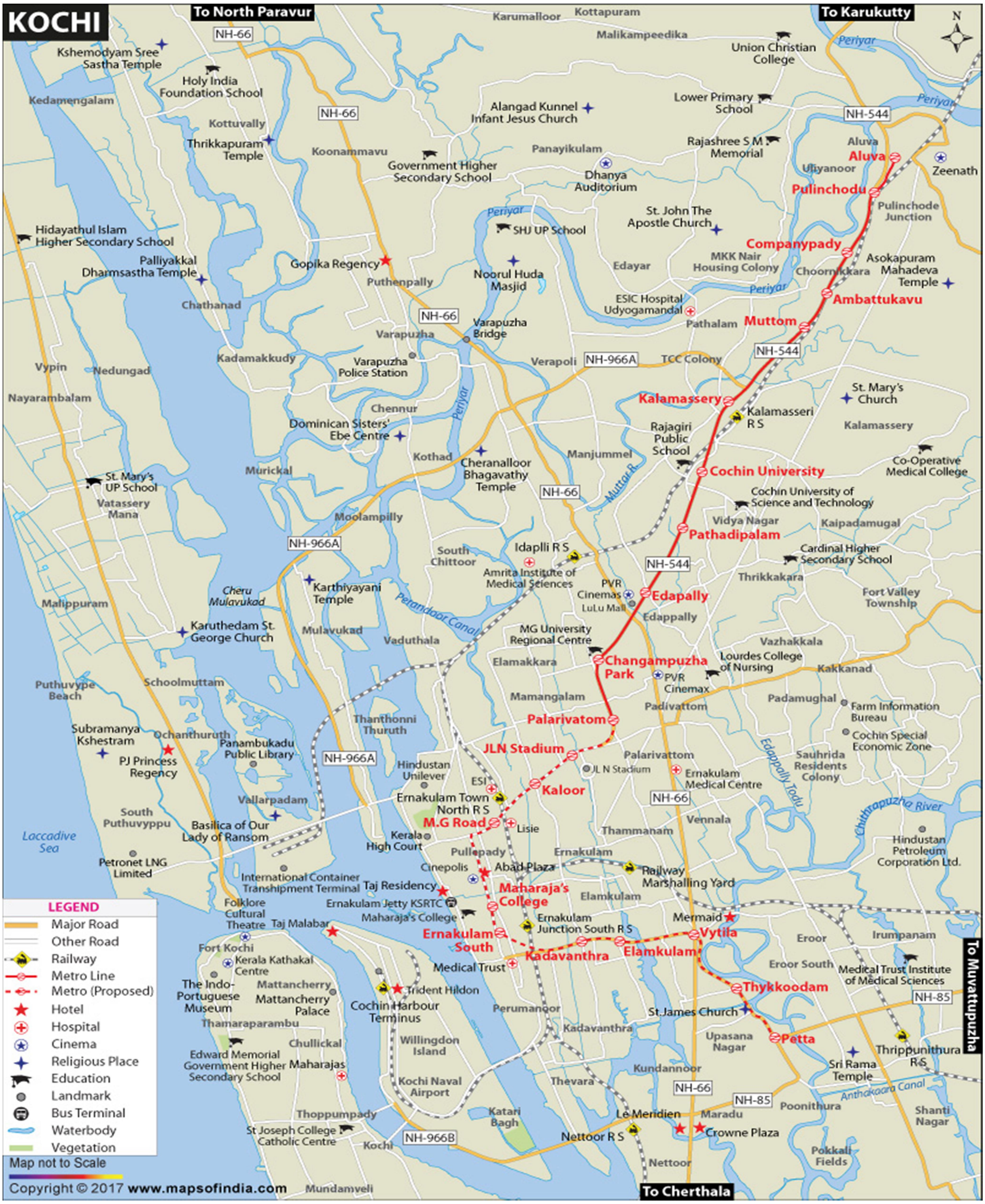

Figure 2.2: Geographical of Kochi - Study Area

2.4 Water Sampling

Testing water samples were collected from different areas of Trivandrum and Cochin. The samples were collected from different points, inner, center, and outer lakes to assess the quality of water samples. The samples were collected in a clean glass vial and brought to the laboratory where subjected to physicochemical analysis. Field parameters such as pH, turbidity, total dissolved solids, and dissolved oxygen were tested in the field and tabulated. APHA 2015 procedure was followed to test the samples.

2.5Isolation and Identification of Microbes: Different color and shaped bacteria and fungi colonies were picked and purified with the help of nutrient agar and incubated at 37 ºC for 24 hours to get pure culture. The bacterial strain was identified as per the classification scheme published in Bergey's Manual of Systematic Bacteriology (Madigon, &Martinko, 2006 Krieg, & Holt, 1984. The isolates of different fungi and bacteria were identified based on color, shape by gram staining, and other characteristics as described.

2.6 Biochemical Characterization of Bacterial Strain: Isolated bacteria were characterized using biochemical tests viz. Vogesproskauer (MRVP), Indole test, coagulase test, and triple sugar iron agar test (TSI), as described by various authors [Ogbulie, 1998 and Cheesbrough, 1999].

2.7 Procedure for Determination of Microplastics in Water and Soil Samples

Water sample: Sediment samples were collected using (the Van Veen grab sediment water sampling instrument) in the selected study area. The sampling protocol was followed as per the procedure reported by the National Oceanic and Atmospheric Administration (NOAA) (Masura et al., 2015). The collected water samples were sieved through 5 mm mesh to remove macro plastics and other debris. The samples were then air-dried and treated with H_2O_2 (30%) to get organic matter digested in the samples. The H_2O_2 treated samples were then subjected to salt water density separation) using NaCl (d ¼ 1.3 g ml^{-1}) to separate microparticles through floatation. Then the samples were dried in air and the microplastics were through a microscope with 10 x resolution.

Soil sample: The sampling procedure was adhered to according to ISO 11464. The soil samples obtained from the study area were dried at 40 ºC for 72 hours. The samples were then homogenized manually and the fine soil samples were sieved ≤5 mm mesh. The sieved samples underwent density separation using NaCl salt solution to separate microplastic from soil, subsequently, the microplastics were isolated and subjected to analysis. Qualitative determination of plastics was identified using Raman spectroscopy and quantification was done by optical microscopy with 10 x magnification.

2.8 Data Analysis

The collected data underwent analysis using Excel (Microsoft Office 2021, Microsoft Corporation, Washington, DC, USA).

3. Results and Discussion

3.1 Physicochemical Analysis of Water

3.1.1 Sampling Site-Thiruvananthapuram: KaramanaRiver (KR1), Jagathi River (JR2), Amayizhanchan River (AR3), Killiriver (KR4). The mean values of analyzed various physicochemical parameters of water samples collected from various sampling sites are presented in the following section.

The pH of water samples collected from various sampling sites ranged from 7.5 to 8.9. According to IS: 2296-1982, the permissible limit of pH for water samples ranges from 6.5 to 8.5. The pH value of water samples is below 7 due to photosynthesis, respiration, and nitrogen assimilation. The effect of photosynthesis and respiration depends on carbonate, bicarbonate, and carbon dioxide equilibrium. Most of the waters in the study area are slightly alkaline due to the presence of carbonates and bicarbonates. Generally, the pH of water is influenced by the geology of the catchment area and the buffering capacity of water. The electrical conductivity of the water sample is one of the important physical parameters that determines the water quality. The prescribed electrical conductivity value for surface water is 2250µmohs/cm (IS: 2296-1982). The mean value of electrical conductivity was recorded as 944.6 µmohs/cm and the standard deviation value was 334.3 µmohs/cm.

Turbidity measurement is an important parameter that determines how much water is cloudy. The turbidity is due to suspended solid particles colloidal matters including clay, silt, and finely divided organic and inorganic matter, plankton, and other microscopic organisms (APHA, 2005).

Technically turbidity is measured by the amount of light scattered by suspended particles present in water.

The study area wetlands had dense vegetation (Figure 4.8) and a gradual slope in most wetlands which results in suspended particles being more readily deposited making water clear.

Inorganic and other dissolved salts in the water are known as total dissolved solids (TDS). The mean value and standard deviation of TDS value in different places are found to be 577.56 and 112.66 respectively. High values of total dissolved solids may be due to urban and agricultural runoff, and municipal and industrial wastewater. Biological oxygen demand refers to the amount of oxygen required by the bacteria while stabilizing the decomposable organic matter under aerated conditions. The mean value of BOD ranges from 16 to 67 mg/L. The mean value and std deviation are found to be 34.31 and 20.06 mg/l respectively. It is observed that the sample obtained from Killi River exceeded the BOD tolerance limits as prescribed by general standards for discharge of environmental pollutants (inland surface water), EPA rules, 1986 tolerance limit of BOD is 30mg/L. Nitrates and phosphates in waterbody can contribute to high BOD levels, and due to organic matter which may include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants; failing septic systems; and urban stormwater runoff. The presence of wetland plants is a source of BOD and decomposes the organic matter. Wetland decreases the BOD through the decomposition of organic matter during aerobic bacterial respiration.

Chemical oxygen demand (COD) is the measure of oxygen equivalent to the organic constituent inclined to oxidation. COD is the oxygen required by organic pollutants to be oxidized by a chemical oxidizing agent. The COD level varied from 27 to 157 mg/L and the mean value was found to be 82.56mg/L. The standard deviation is found to be 53.61 mg/L. The Amayizhanchan River water sample shows a high COD content due to the discharge of untreated waste water. Dissolved oxygen is the measure of oxygen content dissolved in water. It is an important parameter for the survival of plants and other aquatic species. The DO range is between 2.9 to 7.3 mg/L. The Karamana river water sample shows the minimum value of DO whereas the Amayizhanchan River water sample indicates the highest DO value. The high DO value indicates the warning sign for pollution index load. The measure of the total hardness of the water sample is an important parameter. The hardness was measured in terms of $CaCO_3$

chemical equivalent. The hardness of different water samples varied ranging from 76 to 342mg/L. The high hardness value was observed in KR1 water sample indicating the load of a pollution index. Total hardness in the water was reduced may be due to the filtration of minerals by the wetland vegetation. The high level of hardness of water may be due to the discharge of detergent waste, and minerals waste.

The mean value and std deviation of chlorides in water samples ranged between 165.13 to 61.88 mg/L. The Jagathi River water sample indicated the pollution load index. The chloride content may be salts of magnesium and calcium. The reduced chloride observed in the study area wetlands may be due to photo degradation and reaction with organic and inorganic materials in water. The mean value and std deviation of fluoride in water samples ranged between 0.35 and 0.16 mg/L respectively. KR4 water sample indicated an increase in pollution load index. The fluoride content may be salts of magnesium and calcium. The reduced chloride observed in the study area wetlands may be due to photo degradation and reaction with organic and inorganic materials in water. Nitrates are also an important nutrient for plant and algal growth. Sources of nitrogen in a lake are varied, ranging from fertilizer and animal wastes to human waste from sewage treatment plants or failing septic systems, to groundwater, air, and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. The mean value and std deviation of Nitrates in the water sample ranged between 24.14 and 7.69 mg/L respectively. AR3 water sample indicated an increase in pollution load index.

The mean value and standard deviation of sodium are found to be 21.45 and 3.40 mgL^{-1} respectively. The sodium source of pollution is due to surface run off and agricultural field discharge. The mean value and standard deviation of potassium are found to be 19.64 and 3.71 mgL^{-1} respectively. The potassium source of pollution is due to surface run off and agricultural field discharge. The mean value and standard deviation of phosphate are found to be 6.15 and 4.26 mgL^{-1} respectively. The water samples were obtained from the sampling site JR2, AR3, KR4 where the phosphate was found to be exceeding the prescribed limit (IS:2296-1982). External sources of phosphorus enter a river through point sources like storm water pipes and wastewater discharge and nonpoint runoff like overland water flow. This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems, or impervious surfaces before it empties into the lake. Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. The mean value and standard deviation of sulfate are found to be 69.53 and 86.41 mgL^{-1} respectively. The sulfate source of pollution is due to surface run off and agricultural field discharge.

The mean value of hardness of the water sample was found to 189.76 mg/L, the excess of hardness in the water sample is attributed to the following reason. (i) Agricultural run–off during the rainy season, (ii) uncontrolled discharge of effluent from households as well as industries. Other ions such as fluorides, phosphate, and nitrate are found to be within the permissible limits.

The water samples show the positive results of the coli form. BSI Drinking Water Specification: IS: 10500, (Reaffirmed 1993) suggests that coliform organisms should not be more than 10 per 100 ml in any sample. According to the above-mentioned legislation about 67.44 % of samples are above permissible level.

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Table 2: Analytical Results Of Physical- Chemical Analysis Of River Water Samples

Parameters		**KR1**				**JR2**				**AR3**				**KR4**			
	IS: 2296-1982	**Nov-19**	**May-20**	**Jul-21**	**Aug-22**	**Nov-19**	**May-20**	**Jul-21**	**Aug-22**	**Nov-19**	**May-20**	**Jul-21**	**Aug-22**	**Nov-19**	**May-20**	**Jul-21**	**Aug-22**
pH	-	7.9	8.2	8.1	7.9	7.5	7.3	7.6	7.7	7.5	7.3	7.2	7.5	7.6	7.5	7.9	8.1
Electrical conductivity	-	742	672	676	714	1320	380	423	1221	1320	880	890	1121	1120	1123	1121	1120
Turbidity	-	0.52	0.62	0.64	0.54	2.17	2.22	2.83	2.34	17.12	16.26	16.12	17.12	6.23	5.23	6.2	6.1
Total dissolved solids	500	410	473	478	489	520	562	521	511	580	594	543	561	760	782	734	723
Biochemical Oxygen Demand	30	28	27	26	25	29	26	25	24	18	17	19	16	65	71	66	67
Chemical Oxygen Demand	_	75	78	79	81	56	54	56	58	156	167	171	174	32	29	27	28
Dissolved oxygen	>4	3.2	2.9	3.1	3.2	4.1	4.6	4.1	4.4	6.2	6.9	6.7	6.4	7.2	6.7	7.3	6.8
Total Hardness as $CaCO_3$	300	328	334	338	342	156	172	162	165	76	81	85	82	152	146	154	153
Chlorides	250	167	178	181	183	253	257	254	252	139	142	138	136	89	92	90	91
Fluorides	1.5	0.2	0.24	0.21	0.23	0.31	0.35	0.34	0.32	0.23	0.26	0.24	0.23	0.63	0.64	0.59	0.61
Nitrate as NO_3	20	20	19.8	19.1	19.2	21.2	21.3	20.3	20.6	36.3	37.1	37.1	37.2	17.2	19.3	20.1	20.4
Sodium	_	23.4	21.2	20.3	20.8	18.3	18.1	18.3	18.5	26.3	26.2	27.1	27.4	19.2	19.7	19.8	19.4
Potassium	_	17.2	16.9	17.5	17.4	21.2	20.7	21.2	21.3	15.4	15	15.6	15.9	24.3	25.2	24.6	24.9
Phosphat	5	1.2	1.8	1.3	1.4	5.8	6.1	6.2	6.3	4.8	4.9	15.7	15.4	7.2	6.8	6.8	6.7

e																	
Sulphate	400	32	43	41	42	45	42	41	43	38	39	40	41	72	75	73	75
E.Coli (MPN/100),	No Relaxation	326	339	289	321	189	192	329	186	192	293	394	401	372	348	182	210

*Note: All values are in mg/L; except pH, EC (µmhos/cm), Turbidity (NTU), % R – Percent Removal of Pollutant, 1As per general standards for discharge of environmental pollutants (inland surface water).

Table 2 shows the analytical results of physicochemical analysis of water samples obtained from different places of Thiruvananthapuram and Kerala. Table 3 shows the Mean values and standard deviation of physicochemical analysis of lake water samples obtained in various places. From place to place the values are varied. The pH ranged mean value is found to be 7.67. However, the pH of the water sample in some places shows alkaline as well as an acidic nature. This should be minimized by proper sewage disposal near the freshwater stream. The mean value of electrical conductivity is found to be 927.68(µmhos/cm). The normal range is expected between 50 and 1500µmhos/cm. The higher conductivity values are attributed to enter of agricultural run-off. The low conductivity value might be attributed to the settle down of salts and uptake by plant species.

Table 3: Mean values and standard deviation of Physicochemical analysis of lake water

Parameters	**Mean value (mg/L)**	**Standard deviation**	**IS: 2296-1982**
pH	7.67	0.31	6-8.5
Electrical conductivity	927.68	299.77	2296-1982
Turbidity	6.39	6.45	5
Total dissolved solids	573.00	110.70	500
Biochemical Oxygen Demand	34.06	19.45	30
Chemical Oxygen Demand	82.56	53.61	_
Dissolved oxygen	5.24	1.67	>4
Total Hardness as $CaCO_3$	189.76	97.91	300
Chlorides	170.12	63.35	250
Fluorides	0.42	0.32	1.5
Nitrate as NO_3	23.89	7.51	20
Sodium	21.50	3.40	_
Potassium	19.64	3.71	–
Phosphate	6.08	4.13	5
Sulphate	69.53	86.41	400
E. coli	285.19	80.55	Absent

3.2 Microbials And Organic Pollution In Soil

The following places Vilappilsala, Pazhavangadi, and Kunchalummoodu, in Kerala were selected for sampling. The samples were collected especially from Industrial and waste disposal areas and analyzed the microorganism content (Table 4). The corresponding sample code has been given. The direct dumping of organic and industrial waste is polluting the soil. The experimental results are presented in the following tables. The microorganisms varied with different localities. The increase in pollutants affects the microorganism growth and in some places, no fungal and bacterial species were detected. The bacterial strains varied from 445 to 1231.

Table 4: Bacteria and fungi count in soil samples CFU/gm (x 10^4)

S.No	Name of sampling station	Sample code	No colonies of microorganisms	No of Bacteria	No of Fungi
1	Vilappilsala	V1	456	455	1
2	Vilappilsala	V2	1324	1324	0
3	Vilappilsala	V3	876	874	2
4	Vilappilsala	v4	1232	1231	1
5	Pazhavangadi	P1	1221	1219	2
6	Pazhavangadi	P2	786	782	4
7	Pazhavangadi	P3	891	885	6
8	Pazhavangadi	P4	532	527	5
9	Kunchalummoodu	K1	453	445	8
10	Kunchalummoodu	K2	654	645	9
11	Kunchalummoodu	K3	875	869	6
12	Kunchalummoodu	K4	743	735	8

Isolated bacteria from soil samples were observed that Pseudomonas aeruginosa, Salmonella sp., and Proteus species, tested positive for methyl red, citrate, indole and vogue Proskauer test, while Providenella species, Shigella species and Aspergillus showed negative to urea test. Although all the bacteria showed negative for gas production, the identified isolates bacteria were mostly represented by gram-negative bacteria which were found in soil samples from the waste disposal area..

Table 5: Showing Biochemical Characterization And Gram Reaction Of Isolated Bacteria And Fungi From The Waste Disposal Area

S. No	Name of sampling station	Sample code	Biochemical test					Shape	Gram stain	Colony characterization	Identified organism	
			MR	VP	Ctr	Ind	Tsi				Bacteria	Fungus
1	Vilappilsala	V1	-	-	-	-	-	Cocci	-ve	Spherical, smooth	Non identified	
			-	-	+	-	-	Bacilli	-ve	Spherical, smooth, filamentous	B.Subtilis	Penicillium Spp.
2	Vilappilsala	V2	-	-	+	-	-	Cocci	-ve	Lobate, countered, irregular	P.aerogino sp.	
			+	-	+	-	-	Bacilli	-ve	Concentric, round and spherical	non - identified	
			+	-	+	+	-	Bacilli	+ve	Smooth, irregular	Providenellaspc	No fungal detected
3	Vilappilsala	V3	+	+	+	-	-	Bacilli	-ve	Smooth, irregular	non - identified	
			+	+	+	-	-	Bacilli	+ve	Spherical, smooth	non - identified	
			+	-	-	-	-	Bacilli	+ve	Smooth, Concentric, Round	Salmonell a typhi / S.paratyphi	PenicilliumSpp
4	Vilappilsala	v4	+	+	-	-	-	Cocci	-ve	Smooth, filamentous, spherical	Non identified	
			+	+	+	-	-	Bacilli	+ve	Smooth, filamentous, spherical	Non identified	
			+	+	+	-	-	Bacilli	-ve	Round, wrinkled, Concentric	Non identified	No fungal detected
5	Pazhavangad i	P1	+	+	+	-	-	Cocci	+ve	Round, smooth, Concentric	Non identified	
			+	+	+	-	-	Cocci	-ve	Round, smooth, Concentric	Non identified	Aspergillusfumi gatus, Aspergillus spp.
			+	+	+	-	-	Bacilli	-ve	Round, smooth, Concentric	Non identified	
6	Pazhavangad i	P2	+	+	+	-	-	Cocci	-ve	Round, smooth, Concentric	Non identified	Aspergillusfumi gatus, Aspergillus spp.

			+	+	+	-	+	Bacilli	+ve	Round, smooth, Concentric	S.Typhi	Fumigatus, penicilliumAspe rgillusniger
			-	-	-	-	-	Bacilli	-ve	Irregular, wrinkled	Non identified	
7	Pazhavangad i	P3	+	+	-	-	-	Cocci	-ve	Smooth, filamentous, spherical	Non identified	Mostly Aspergillus spp.
			-	-	+	-	-	Bacilli	+ve	Smooth, spherical	S.aureus	
			-	-	-	-	-	Cocci	-ve	Smooth, spherical	Shigellaspc.	
8	Pazhavangad i	P4	+	-	-	-	-	Bacilli	-ve	Round, wrinkeled, Concentric	Non identified	Fusarium Green mold
			+	+	+	-	+	Cocci	-ve	Spherical, wrinkled	Non identified	
			-	-	-	-	-	Cocci	-ve	Spherical, wrinkled	Non identified	
9	Kunchalum moodu	K1	-	+	-	-	-	Mix	-ve	Irregular, wavy, concentric	Non identified	Mostly Aspergillus spp.
			-	+	-	-	-	Cocci	-ve	Irregular, lobate, wrinkled	Non identified	
			-	-	-	-	-	Cocci	-ve	Spherical, wrinkled	Non identified	
10	Kunchalum moodu	K2	+	+	+	-	-	Bacilli	+ve	Smooth, filamentous, spherical	Non identified	No fungal detected Mucor, mostly Aspergillus
			+	+	-	-	-	Cocci	-ve	Smooth, filamentous, spherical	Non identified	
			+	+	+	-	+	Cocci	-ve	Spherical, wrinkled	Non identified	
11	Kunchalum moodu	K3	+	-	+	-	-	Cocci	-ve	Irregular, wavy, concentric	S.aureus	Non identified
			-	+	-	-	-	Cocci	-ve	Irregular, lobate, wrinkled	Non identified	
			+	+	-	-	-	Cocci	-ve	Smooth, filamentous, spherical	Non identified	
12	Kunchalum moodu	K4	+	+	-	-	-	Cocci	-ve	Smooth, filamentous, spherical	Non identified	Non identified
			+	+	+	-	+	Cocci	-ve	Spherical, wrinkled	Non identified	
			-	+	-	-	-	Cocci	-ve	Irregular, lobate, wrinkled	Non identified	

Abbreviations: +VE = Positive; -VE = Negative; MR = Methyl Red; VP = Vogue's Poaskauer; Ctr =Citrate; Ind = Indole; TSI= Triple-Sugar Iron Agar Test

As observed from Table 5, the high bacteria and fungi populations in the soil samples compared with other soil samples in 2km and 5km away from the waste disposal area were found in increasing order. This could be because of less soil pollution due to organic and inorganic waste. The increase in microbial diversity and population moved away from the factory site. Soil pollution is defined as the increase in concentration of persistent toxic components, organic, or disease-causing agents which leads to affect the health of plants and animals. The soil consists of organic and inorganic portions, where the organic portion is formed by changes in physical and chemical weathering of bedrock, and the inorganic portion is mainly from rock fragments. The soil contamination occurred variously including seepage of solid waste, contaminated water percolation, modern agricultural practices, and discharge of untreated industrial waste.

Organic pesticides: Pesticides are quite frequently used to -control several types of pests nowadays. Pesticides may exert harmful effects on micro-organisms, as a result of which plant growth may be affected. Pesticides that are not rapidly decomposed may create such problems. Accumulation is residues of pesticides in higher concentrations are toxic. Pesticides' persistence in soil and movement into water streams may also lead to their entry into foods and create health hazards. Pesticides particularly aromatic organic compounds are not degraded rapidly and therefore, have a long persistence time. Organic compound analysis data (Table 6) showed a gradual decrease in organic carbon content from 5.33 % to 3.79% in the soil in accordance with to waste disposal area

Table 6: Organic Compounds In Various Sampling Sites

S.No	Name of sampling station	Sample code	Organic Compound (%)
1	Vilappilsala	V1	5.32
2	Vilappilsala	V2	5.12
3	Vilappilsala	V3	5.08
4	Vilappilsala	v4	5.33
5	Pazhavangadi	P1	4.84
6	Pazhavangadi	P2	4.63
7	Pazhavangadi	P3	4.21
8	Pazhavangadi	P4	4.81
9	Kunchalummoodu	K1	3.9
10	Kunchalummoodu	K2	3.81
11	Kunchalummoodu	K3	3.79
12	Kunchalummoodu	K4	3.81

4. Conclusion

The place KR1 and KR2 where the pH is found to be greater than 7.5 may be due to carbonate, bicarbonate, and carbon dioxide dissolution. The water samples collected during 2019 in all the places show within the pH range and exceeded pH 7.6 which indicates dissolution of carbonate, bicarbonate, and carbon dioxide dissolution during 2020 and 2021. In water samples collected during 2022, the pH started to decline due to the geology of the catchment area and the buffering capacity of the water. The turbidity level may be due to the discharge of agricultural run-off and the discharge of untreated industrial effluents. BOD and other physicochemical parameters are initially within the range and increased in the water sample collected in subsequent years. Waste water inflow was observed during 2019, 2020, and 2021 in all study areas. However, in some places the physicochemical parameter shows within the range in water samples collected during 2022. Most importantly, the significant increase in BOD, COD, alkalinity, hardness, and EC values indicates that the water quality is bad and immediate restoration action is highly recommended. Similarly, soil samples collected from various places in Trivandrum show a low microorganism population which indicates that the municipal solid waste degrades the soil quality and fertility. Thus, pollution control and waste management should be strictly followed.

The water samples were analyzed for the presence of E.Coli form to determine their potability. Experimental results indicate that the water is not suitable for drinking purposes. The quality of water in Thiruvananthapuram is not desirable limits as prescribed by the Bureau of Indian Standards Drinking Water Specification: IS 10500. The freshwater ecosystem is very unhygienic in condition. A water purifier such as reverse osmosis is suggested to purify water for drinking and cooking purposes. Generally, community-owned revere osmosis could be installed for water purification. Rain water harvesting programs should be promoted to increase the water level. The poor quality of water is attributed mainly due to contamination by point sources and non point sources. Further, the mismanagement of solid and liquid waste is another reason for the water contamination. The current scientific solution is chlorination. However, in most cases, chlorination is not killing all the bacteria.

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