

Assessment of Water Quality Status of Guruvayur Municipality

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Abstract

Groundwater is an essential and vital component of our life support system. The deterioration in the groundwater quality due to geogenic and anthropogenic activities has drawn great attention as it is the major alternate source of domestic and drinking water supply. Groundwater and surface water samples collected from various locations in Guruvayur were analysed for selected physico-chemical and bacteriological parameters by adopting APHA standard methods. The results of the analysis indicated the chemical and bacteriological contamination due to the disposal of solid, organic and septic wastes in the surface water samples of Chakkamkandam, Palayur and Edappally which are the various locations in Guruvayur. Also the groundwater samples of Guruvayur were contaminated. The study revealed that, the water samples examined were found to be above the permissible limits of Bureau of Indian Standards (BIS). The sewage inlets that open directly to the water body are the major source of pollutants. The monitoring of various water bodies indicates the importance of taking appropriate measures to treat the water resources before either discharged to wetlands or consumed by human beings. It is also recommended to continue the monitoring periodically to assess the pollution status of the area.

Keywords

Water Quality, Chakkamkandam, Palayur, Edappully, Guruvayur

1. Introduction

All the 44 rivers originating from the Western Ghats of Southern district of Kerala, India are facing slow ecological death and losing their natural flow pattern due to combined impact of various interventions in the catchments and inside the river channel including deforestation of the catchment areas, forest fragmentation, blocking the flows by dams, encroachment and massive mining of

hills [1]. Water quality is a critical factor that controls human health; and human activities are the major cause of surface and groundwater pollution [2]. As Earth's population continues to grow, people are putting ever-increasing pressure on the planet's water resources. In a sense, our oceans, rivers, and other inland waters are being "squeezed" by human activities—not so they take up less room, but so their quality is reduced. It has been suggested that water pollution is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily [3]. Protection of groundwater is a major environmental issue since the importance of water quality on human health has attracted a great deal of interest in recent years [4].

Kerala, a southern State of India, is one among the most thickly populated region in the world and the population is increasing at a rate of 14% per decade. As a result of the measures to satisfy the needs of the huge population, the rivers of Kerala have been increasingly polluted from the industrial and domestic waste and from the pesticides and fertilizer in agriculture. Industries discharge hazardous pollutants like phosphates, sulphides, ammonia, fluorides, heavy metals and insecticides into the downstream reaches of the river. A study was reported [5] on the measurement of the impact of a municipal solid waste landfill on groundwater quality around Njelianparamba, a solid waste dumping site in Kozhikode district, Kerala state, India. One of the major problems associated with dumping of municipal solid waste landfill is the release of leachate and its impact on surrounding groundwater

Guruvayur or Gurupavanapuri is a municipal town in Thrissur district, of Kerala state in India. It houses the Guruvayur Sree Krishna Temple, the fourth largest temple in India in terms of the number of devotees visiting per day. Guruvayoor is a Grade-1 Municipality. The Municipality has a total population of 20,216 with a population density of 31, 14 per km². Guruvayur assembly constituency is part of Trissur. Guruvayur Sree Krishna Temple attracts millions of devotees from all over India and abroad every year. The small township has become the No.1 destination not only for the devotees of Lord Krishna but also for foreigners coming to India.

Presently, Guruvayur municipality faces many problems of water pollution. The discharge of untreated domestic and commercial effluents in to the backwater has resulted in severe environmental problems such as deteriorated water quality and health and livelihood related issues in the neighbouring villages. Chakkamkandam is a village adjacent to the great temple town of Guruvayur in Kerala. The residents of this village are agriculturists, coir workers, and fishermen. Guruvayur Township is situated in their serene landscape depriving them the use of fresh water, clean air and unpolluted land. There are 3000 families living around Chakkamkandam. The canal from Guruvayur to Chakkamkandam (Valiyathodu) is now an open sewer line with human excreta and all forms of water being carried through this to the village. The canal runs through the municipal area for almost two kilometres and then enters Thykad panchayat, where it travels two more kilometres, before reaching the Chakkamkandam backwater.

This canal carries tonnes and tonnes of disintegrated waste polluting the back-water and Guruvayur area as a whole.

Most commercial establishments and apartments do not have properly functional septic tanks and discharge the raw sewage directly into open drains. The drains, Valiyathod and Cheriyaathod flow three kilometres through the town before joining the back waters of Chakkamkandam. The discharge of untreated domestic and commercial effluents in to the backwater has resulted in severe environmental problems such as deteriorated water quality, health and livelihood related issues in the neighbouring villages.

According to the estimates of Guruvayur municipality, over 3.5 crore devotees visit Guruvayur every year. The people of Chakkamkandam are forced to live with a substantial portion of the bio-waste of these visitors. The situation worsens during the rainy season. When it rains, the entire area gets flooded. The canal overflows and black filth gets deposited in courtyard.

The people of Chakkamkandam used to cultivate Pokkali rice (a salinity-resistant rice variety raised in water-logged fields) on both sides of the lake. The banks of the lake were then dotted with coir looms. The scene changed some 25 years ago with the mushrooming of lodges and hotels in Guruvayur to cater to the needs of the rapidly increasing number of pilgrims. High levels of contamination have made farming impossible. Skin diseases and allergy conditions are common among residents of the village. The fish resources are also fast depleting. Valiyathodu (the canal leading to the backwaters) has become a breeding centre for mosquitoes and the putrefaction of wastes takes place all along the course of the canal. Chakkamkandam backwaters have been partially filled with the sludge from the decomposition of the night soil.

Another issue that found in Guruvayur is the dumping of municipality wastes at Choolpuram nearby locality in Guruvayur City. Guruvayur over decades is posing a grave threat to people's lives. The environment is highly polluted and there is a stinking smell all over. The drinking water in all the wells is seriously contaminated because of the pollution and it is not drinkable even after boiling due to large presence of bacteria.

2. Methodology

Study Area

Guruvayur is a municipal town in Thrissur District, of Kerala State in India. Water pollution is one of the major environmental problems faced by that township. Chakkamkandam canal (a canal from Guruvayur to Chakkamkandam), Valiyathod and many water bodies in Guruvayur are polluted by the presence of sewage and human excreta, organic wastes, etc. To assess the water quality, thirteen water samples were collected from Guruvayur municipality in which 7 samples were groundwater, 2 samples were public water and 4 samples from surface water bodies. The water sampling locations are depicted in **Figure 1** and **Figure 2**. One of the surface water samples was collected from Guruvayur temple pond and other 3 samples were collected from Chakkamkandam canal,

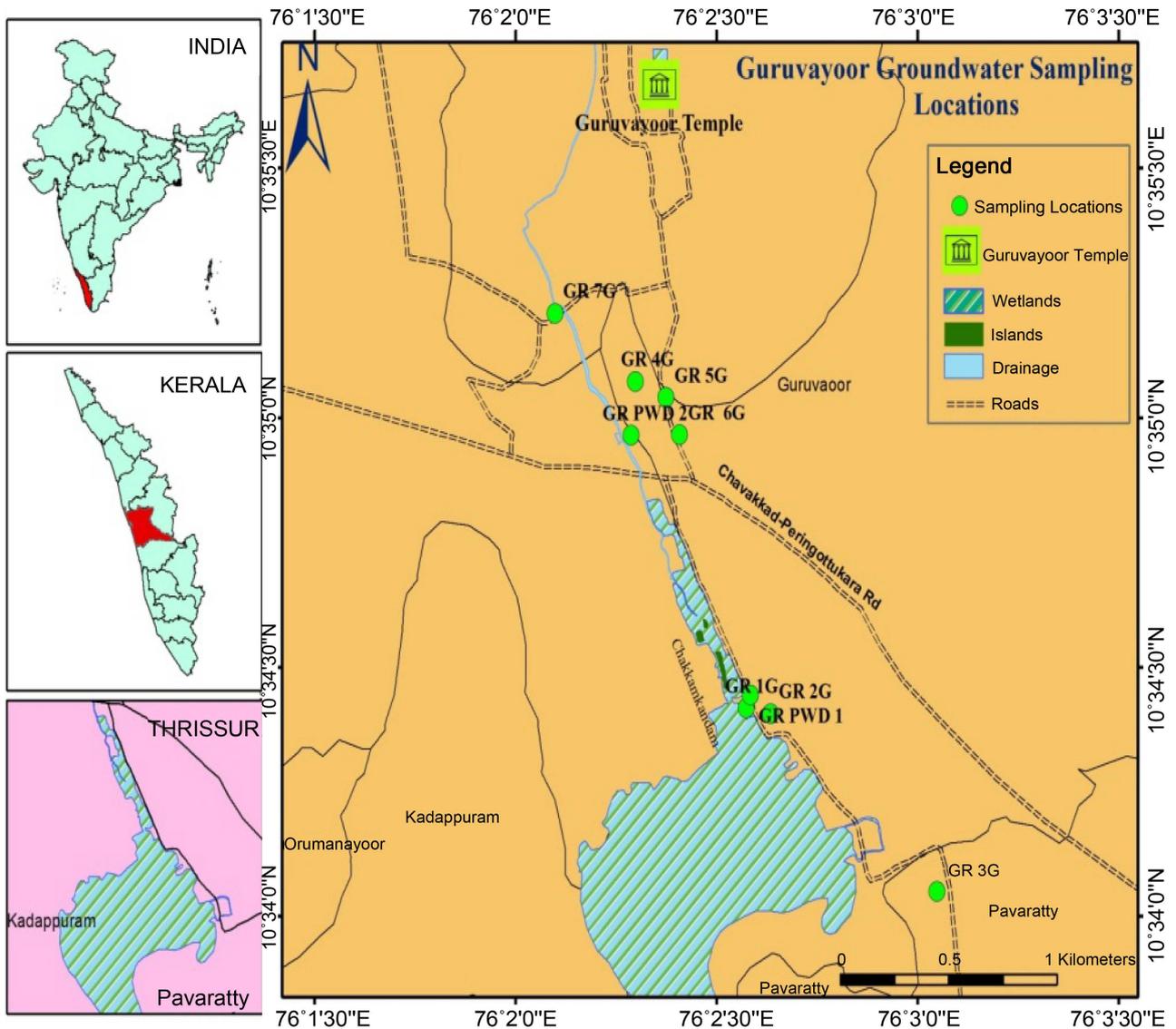


Figure 1. Map showing groundwater sampling location of Guruvayur.

Cheriyathodu and Angadithazham respectively. Seven groundwater samples collected from mainly 3 wards of Guruvayur municipality (Chakkamkandam, Palayur and Edappully).

As a part of the water quality assessment of Guruvayur, a total of 13 samples were collected from different areas of Guruvayur. Random sampling method was done. The containers used for sampling were pre cleaned, non-reactive plastic bottles (1 liter) and sterilized bottles (100 ml) for physico-chemical and bacteriological analysis respectively. Some parameters like pH, temperature, electrical conductivity, TDS, salinity were measured in sites. The samples collected from Guruvayur were analyzed for most of the parameters including physico-chemical and biological parameters as per the standard procedure given in the standard methods for the examination of Water and Wastewater [6].

The groundwater samples, public water samples and surface water sample collected from temple pond were analyzed for the physic-chemical parameters

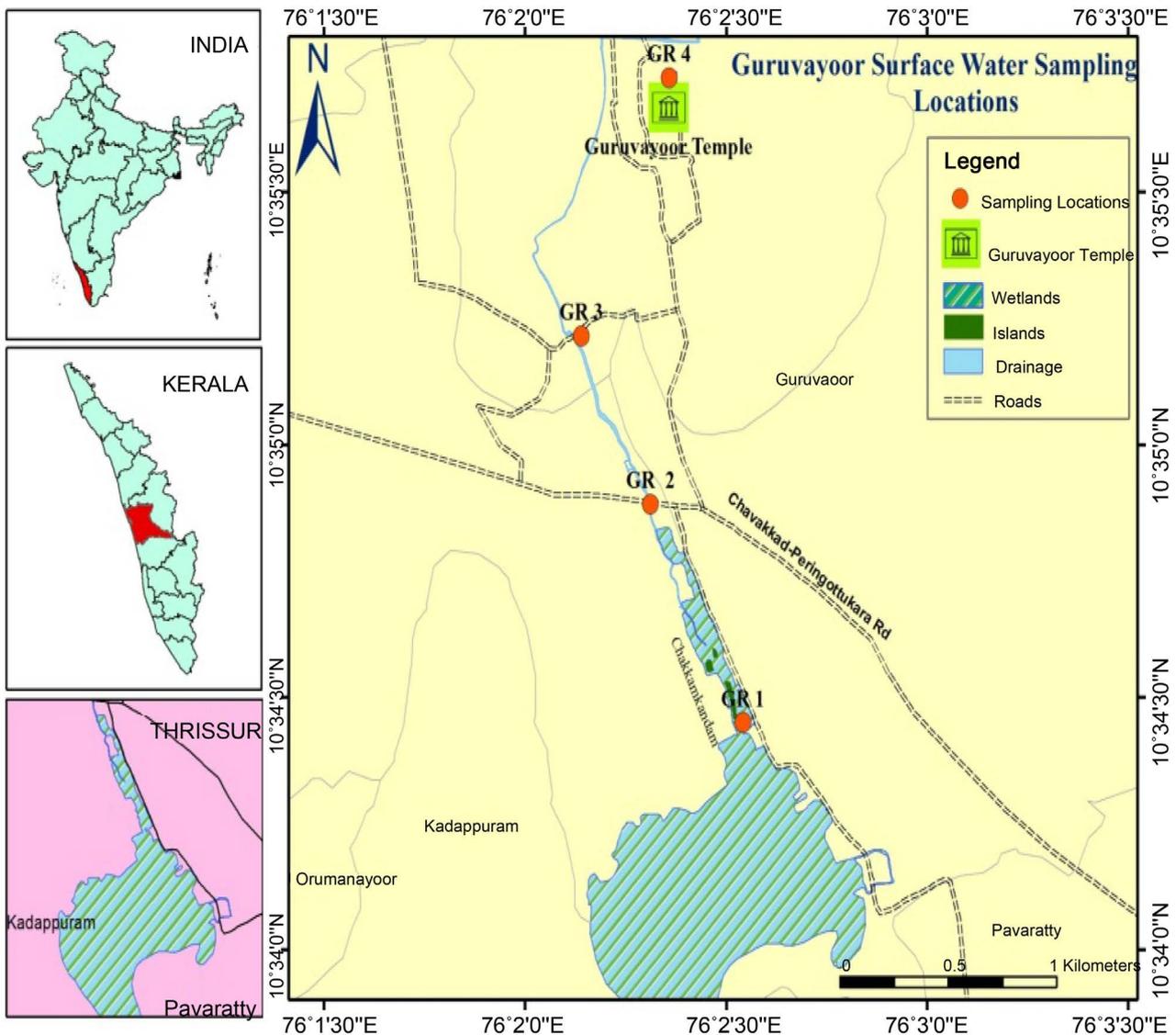


Figure 2. Map showing surface water sampling location of Guruvayur.

such as pH, EC (micro siemens/cm), Temperature ($^{\circ}\text{C}$), Colour (Hazen), Turbidity (NTU), Total alkalinity (mg/l), TDS (mg/l), Salinity (ppt), Total Hardness(mg/l), Ca (mg/l), Mg (mg/l), Iron (mg/l), Mn(mg/l), Na (mg/l), K (mg/l), Chloride (mg/l), Sulphate (mg/l), Nitrate-N (mg/l), Phosphate-P (mg/l) Total Coliform (MPN/100), *Faecal coliform*, *E. coli*. Water quality parameters such as pH, EC, TDS, salinity, temperature of the samples were detected using Eu Tech multiparameter analysis meter. The values of turbidity and sulphate were detected using Nephelo turbidity meter. Colour of the samples was determined by visual comparison method. Total alkalinity of the samples was measured by acid-base titration. Total hardness, Ca and Mg concentrations of the samples were determined by complexometric titration. Concentration of chloride of the samples was determined by Argentometric titration method. The values of iron, phosphate and nitrate of the collected samples were determined by UV-Visible spectrophotometer. Concentrations of sodium and potassium of the sample were

detected by flame photometer. The amount of manganese was measured by atomic absorption spectrophotometry.

The surface water samples, collected from Guruvayur municipality were analyzed for DO, BOD, COD, TSS and Oil and grease in addition to other physico-chemical and bacteriological parameters such as total coliform, faecal coliform and *E. coli* of the samples were analyzed by Multiple Tube Dilution Techniques (MTD Techniques).

3. Results and Discussion

The results of the physico-chemical characteristics of the groundwater samples are given in **Table 1**.

The results of the samples were compared with Bureau of Indian Standards for drinking water quality guidelines (**Table 2**). pH of the groundwater samples ranged from 6.24 to 8.55 which indicates that samples were in the acceptable limit as per BIS for drinking water. Most of the groundwater samples have high values of EC especially, water samples taken from Chakkamkandam and Palayur

Table 1. Physicochemical and bacteriological characteristics of groundwater samples.

Parameters	GR 1G	GR 2G	GR 3G	GR 4G	GR 5G	GR 6G	GR 7G	GR PWD1	GR PWD2
pH	6.24	6.53	6.27	6.61	6.66	6.81	8.55	7.30	7.34
EC ($\mu\text{s}/\text{cm}$)	1622	945	630	2420	2310	757	665	427	428
Temperature ($^{\circ}\text{C}$)	28.4	29.5	28.8	31.7	28.7	29.1	29.5	32.9	32.2
Colour (Hazen)	1	3	2.8	5	9.3	3.6	BDL	1	1
Turbidity (NTU)	0.5	2.5	1.6	3.5	5.5	2.4	BDL	0.4	0.5
Total alkalinity (mg/l)	131.92	131.92	89.24	190.12	267.72	131.92	97	89.24	89.24
TDS (mg/l)	1150	661.5	447	1710	1560	537	472	303	304
Salinity (ppt)	0.476	0.281	0.190	0.731	0.690	0.228	0.200	0.129	0.130
Total Hardness (mg/l)	265.2	122.4	106.8	550.8	306	114.24	110.16	93.84	89.76
Calcium (mg/l)	73.44	40.8	29.38	122.4	48.96	27.74	32.64	22.85	22.85
Magnesium(mg/l)	19.83	4.96	7.93	59.49	44.61	10.91	6.94	8.92	7.93
Iron (mg/l)	BDL	0.4	BDL	0.7	2.1	0.2	BDL	BDL	BDL
Manganese (mg/l)	0.01	BDL	BDL	0.01	BDL	BDL	BDL	BDL	BDL
Sodium (mg/l)	204.8	113.2	42.15	422.2	340	84	42.31	20.39	19.49
Potassium (mg/l)	8.5	8.5	3.67	46	16	7.6	13.24	2.83	2.82
Chloride (mg/l)	328.20	153.42	62.14	901.09	514.44	77.72	66.62	29.61	29.61
Sulphate (mg/l)	146	43.2	27.96	242.4	95.2	4.88	20.72	2.64	2.88
Nitrate-N (mg/l)	0.38	0.36	0.09	0.85	1.41	0.58	0.07	0.16	0.17
Phosphate-P (mg/l)	0.04	BDL	0.21	0.01	0.14	0.12	0.04	0.02	0.08
Total Coliform (MPN/100)	≥ 2400	≥ 2400	≥ 2400	≥ 2400	1100	≥ 2400	1100	460	460
<i>Faecal coliform</i>	≥ 2400	≥ 2400	≥ 2400	≥ 2400	210	1100	1100	210	240
<i>E. coli</i>	Present	Present	Present	Present	Present	Present	Present	Present	Present

Table 2. Acceptable limits for different drinking water quality parameters prescribed by BIS (IS 10500-2012).

Parameters	Acceptable limit
pH value	6.5 - 8.5
Colour (Hazen)	5
Turbidity, NTU	1
Total Dissolved Solids (TDS) (mg/l)	500
Total alkalinity (mg/l)	200
Total hardness (mg/l)	200
Calcium (mg/l)	75
Magnesium (mg/l)	30
Chloride (mg/l)	250
Sulphate (mg/l)	200
Nitrate (mg/l)	45
Iron (mg/l)	0.3
Total Coliform (MPN/100)	Absent
<i>Faecal coliform</i>	Absent
<i>E. coli</i>	Absent

region. The factors that influence the degree of conductivity of water are concentration and mobility of the ions and temperature of water. The concentration of ions like Na^+ and K^+ were higher in groundwater samples collected from Chakkamkandam and Palayur. It may be due to the presence of marine water adjacent to these locations.

High TDS values were observed in groundwater samples which were collected from Chakkamkandam and Palayur (GR-1G, GR-4G and GR-5G). Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source of water pollution discharge from sewage treatment plants and also higher concentration of sodium and potassium which can increase the TDS value of samples.

In most of the groundwater samples, values of turbidity exceeded the acceptable limit. The colloidal size particles cause the liquid to appear turbid. Turbidity in open water may be caused by the growth of phytoplankton and also it may be caused by urbanized areas that contribute large amounts of turbidity to nearby waters, through storm water pollution from paved surfaces such as roads, bridges and parking lots.

In groundwater samples collected from Guruvayur municipality, only the value of colour of the sample GR-5G exceeded the safe limit. The colour of the sample was pale brown which indicated the presence of iron in water (insoluble ferric iron). The presence of iron is due to geological origin. The soluble ferrous iron will be oxidized to ferric iron when contact with air and will precipitate as brown or red deposits.

High value of total alkalinity was reported in groundwater sample GR-5G. It might have occurred due to the presence of calcium carbonate or other com-

pounds such as magnesium carbonate, that contribute carbonate ions to the buffering system. Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks (limestone) which are mostly CaCO_3 . If CaCO_3 actually accounts for most of the alkalinity, hardness in CaCO_3 is equal to alkalinity. The value of hardness of the sample GR-5G was also exceeded the safe limit. From this it can be understood that there was a direct relationship between alkalinity and hardness.

The two main cations that cause water hardness are Ca and Mg. Hard water contains dissolved Mg and Ca ions. These make it more difficult for the water to form lather with soap. Temporary hardness is caused by dissolved calcium hydrogen carbonate (which can be removed by boiling). Permanent hardness is caused by dissolved calcium sulfate (which cannot be removed by boiling). In the case of Guruvayur municipality the values of total hardness of samples GR-1G, GR-4G, exceeded the permissible limit.

Similar to hardness, the concentration of chloride in groundwater samples GR-1G, GR-4G and GR-5G exceeded the acceptable limit in drinking water. Chloride salts such as sodium chloride, potassium chloride, magnesium chloride are often soluble in water. Wastewater may sometimes contain chloride. Chloride may get into surface water from waste water from municipalities or from saline water bodies. Guruvayur, which is an area adjacent to Chavakkad coastal area, has a possibility to have high concentration of sodium and chloride. These samples collected from Guruvayur, reported to have chloride concentration beyond the permissible limit. Among these three samples, GR-4G has high concentration of chloride. The values of sodium and potassium in groundwater samples of GR-4G and GR-5G was high.

Sulfate is a constituent of TDS and may form salts with Na, K, Ca, Mg and other cations. In the case of GR-4G, values of Ca and Mg exceeded the acceptable limit and also the value of sulphate was high in GR-4G. A positive correlation was observed between Ca, Mg with sulphate.

Manganese, nitrate and phosphate values of groundwater samples of Guruvayur municipality were within the acceptable limit.

Groundwater samples collected from stations such as GR-2G, GR-3G, GR-6G, and GR-7G were used by the people for drinking, cooking and bathing purposes. But in those samples, only GR-3G was comparatively less contaminated when compared to other samples. The people of Chakkamkandam and Palayur were not using the well water for domestic purpose (*i.e.* samples GR-1G, GR-4G, and GR-5 G). Most of the people of Guruvayur depend on public (municipality) water for drinking and cooking purposes.

Two samples collected from Guruvayur public water supply scheme were found to be contaminated with coliform bacteria. Faecal coliform and *E. coli* was also present in the samples. A total of 4 surface water samples were collected from Chakkamkandam, Palayur, Edappully and Sree Krishna temple pond, Guruvayur. The results of analysis of samples collected from temple pond are shown in **Table 3**. Analysis of various water quality parameters were carried out

Table 3. Bacteriological and physico-chemical characteristics of Guruvayur-temple water.

Parameters	GR-4
pH	8.45
EC (micro siemens/cm)	1314
Temperature (°C)	34.2
Colour (Hazen)	4
Turbidity (NTU)	3
Total alkalinity (mg/l)	38.8
TDS (mg/l)	931
Salinity (ppt)	400
Total Hardness (mg/l)	383.52
Calcium (mg/l)	130.6
Magnesium (mg/l)	13.880
Iron (mg/l)	BDL
Manganese (mg/l)	0.017
Sodium (mg/l)	99.4
Potassium (mg/l)	31.8
Chloride (mg/l)	699.45
Sulphate (mg/l)	32.28
Nitrate-N (mg/l)	1.56
Phosphate-P (mg/l)	0.08
Total Coliform (MPN/100)	≥2400
<i>Faecal coliform</i>	≥2400
<i>E. coli</i>	Present
COD (mg/l)	80
DO (mg/l)	8.316
BOD (mg/l)	2.178
TSS (mg/l)	51
Oil and Grease (mg/l)	98

for the surface sample collected from Guruvayur. The pH of the sample was 8.45 which was within the acceptable limit set by Bureau of Indian Standards (BIS). (The acceptable limit for various parameters as per BIS is given in **Table 4**). The sample was green in colour (4 Hz). It may be due to the presence of algae in sample. In the case of temple pond water, the values of, nitrate, phosphate, Mg, iron, manganese, and alkalinity were within the acceptable limit. The concentrations of cations like calcium, sodium, potassium were high in temple pond. The high concentration of cations increases the value of TDS, EC, and Hardness of the sample. The value of turbidity exceeded the acceptable limit. The cause of turbidity is due to the suspended clay particles.

The water in the temple pond is used for bathing purpose only. The physico-chemical and bacteriological quality characteristics of water samples are shown in **Table 2**. According to CPCB (Central Pollution Control Board) out of

Table 4. Bacteriological and physico-chemical characteristics of surface water samples.

Sample code	GR-1	GR-2	GR-3
pH	7.78	7.34	7.09
TDS (mg/l)	4550	931	4870
Salinity (ppt)	2.07	2.23	2.07
EC ($\mu\text{s}/\text{cm}$)	6170	6720	6890
COD (mg/l)	3600	1720	920
DO (mg/l)	6.138	Nil	Nil
BOD (mg/l)	132	145.2	66
TSS (mg/l)	320	244	104
Oil and Grease (mg/l)	146.8	149.6	112.4
Total coliform (MPN/100)	≥ 2400	≥ 2400	≥ 2400
<i>Faecal coliform</i>	≥ 2400	≥ 2400	≥ 2400
<i>E. coli</i>	Present	Present	Present

the several uses of water of a particular body, the use which demands highest quality is termed its designated best use. One of the five designated best uses identified by CPCB was water for bathing (class B). The bathing water quality of Guruvayur temple pond was determined by comparing the CPCB guidelines. According to CPCB, the amount of dissolved oxygen shall be 5 mg/l or more in bathing water. In temple pond, dissolved oxygen was 8.316 mg/l. The safe limit of biological oxygen demand is 3 mg/l or less. In sample GR-4, the value of BOD was 2.178 mg/l which is within the acceptable limit. But the total coliform content of the sample was more than 2400 which exceeded the safe limit (500 MPN/100) and also the sample was contaminated by *E. coli*. TSS value of sample was 51 mg/l. The value of oil and grease present in sample was 98 mg/l which is higher than the acceptable limit.

4. Surface Water Analysis Report

Three surface water samples were collected from Chakkamkandam canal, near Chakkamkandam Lake, Palayur and Edappully. The analytical reports of the 3 samples are shown in Table 4. The results are shown in table. The pH of the surface water samples were within the acceptable limit. The sample GR-1 and GR-2 collected from wetland receives the effluent from the drainage. The sample GR-3 was collected from drainage. The values of electrical conductivity, TDS, salinity of the surface water sample exceeded the permissible limit. The sample GR-1 has high value of COD and the values of COD of all other samples exceeded the permissible limit set by CPCB. The high value of COD in surface sample may be due to the presence organic pollutants or wastes and also the value of oil and grease of the samples were found to be beyond the limit. The surface water of Guruvayur was contaminated by *E. coli*. It may be due to the discharge of untreated domestic, commercial effluents, excreta, human and non-human organic waste from 110 old lodges and a number of marriage audi-

toriums, restaurants, into the drainage, which flows from Guruvayur. Because of this TSS values of the samples were also higher than the permissible limit.

In surface water sample GR-1 the value of dissolved oxygen was 6.14 mg/l, which is within the limit. But dissolved oxygen was absent in sample GR-2 and GR-3. Low dissolved oxygen (DO) may be the results of excessive algae growth caused by phosphorus and nitrogen. Die-off and decomposition of submerged plants also contributes to low dissolved oxygen. Sources of phosphorus include discharges from municipal and private wastewater treatment. Direct discharge of pollutants from point source and nonpoint sources into water bodies decrease DO below acceptable concentrations.

The values of BOD of sample GR-1 was maximum and all other samples have the BOD value above the permissible limit. Natural organic detritus and organic waste from waste water treatment plants, failing septic systems and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the DO present for fish. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic condition. Thus the high value of BOD of sample may be due to the presence of high amount of pollutants in samples.

5. Conclusion

The results of the current study indicated the chemical and bacteriological contamination due to the disposal of solid, organic and septic wastes in the surface water samples of Chakkamkandam, Palayur and Edappally which are the various locations in Guruvayur. The sewage inlets that open directly to the water body are the major source of pollutants. There are both point and non-point sources of pollution which are leading to pollution of various water bodies of Guruvayur. Also the groundwater samples of Guruvayur were contaminated. The study revealed that, the characteristics of water samples examined were not within the limits prescribed by BIS. The monitoring of various water bodies indicates the importance of taking appropriate measures to treat the water resources before either discharged to wetlands or consumed by human beings. It is also recommended to continue the monitoring periodically to assess the pollution status of the area.

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