# Chemical analysis of ground and surface water collected from the coastal area in Kollam district

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## I. INTRODUCTION

Water is the most abundant and indispensable natural resource on Earth, playing a fundamental role in sustaining life, regulating climate, and supporting socio-economic development. As a universal solvent, water possesses a unique ability to dissolve, transport, and transform a wide variety of inorganic and organic substances, thereby controlling geochemical and biochemical processes in natural systems. Approximately 71% of the Earth's surface is covered by water; however, nearly 97% of this is saline and unsuitable for direct human consumption, leaving only a small fraction available as freshwater resources in the form of groundwater, glaciers, ice caps, and surface water bodies. Among these, groundwater constitutes the most reliable and widely used source of drinking water, particularly in developing countries and coastal regions where surface water availability is often limited or seasonal [1–3].

Water quality is defined by its physical, chemical, and biological characteristics in relation to its intended use, such as drinking, irrigation, industrial processing, and ecosystem sustainability. Deterioration in water quality poses serious threats to public health, aquatic life, and environmental integrity. According to the World Health Organization, more than two billion people globally consume drinking water contaminated with fecal matter, and by 2025 nearly half of the world's population is projected to experience water stress due to population growth, urbanization, industrialization, and climate variability [4,5]. These challenges highlight the growing need for systematic monitoring, assessment, and management of water resources.

Groundwater quality is influenced by a complex interaction of natural processes and anthropogenic activities. Natural factors include lithology, mineral composition of aquifers, residence time of water, depth from the surface, permeability of sediments, climatic conditions, and seawater intrusion in coastal areas [6–8]. Anthropogenic influences such as industrial effluents, agricultural runoff, excessive use of fertilizers and pesticides, improper waste disposal, landfill leachates, urban sewage, and over-extraction of groundwater significantly accelerate water quality degradation [9–11]. Unlike surface water, groundwater contamination is often irreversible or extremely slow to remediate, making prevention and early detection critically important [12].

Among the various hydrochemical processes affecting groundwater quality, salinization and seawater intrusion are of particular concern in coastal aquifers. Excessive withdrawal of groundwater disrupts the natural hydraulic balance between freshwater and seawater, leading to inland migration of saline water and deterioration of potable water sources [13–15]. Elevated concentrations of total dissolved solids (TDS), electrical conductivity (EC), chloride, sodium, and hardness are commonly observed indicators of salinity intrusion, adversely affecting drinking water quality, agricultural productivity, and industrial usage [16].Water quality assessment typically involves the analysis of key physicochemical and biological parameters such as pH, temperature, turbidity, EC, TDS, total hardness, alkalinity, major cations ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$), major anions ($Cl^{-}$, $SO_4^{2-}$, $NO_3^{-}$, $PO_4^{3-}$), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and trace metal concentrations [17–19]. Among these, pH controls chemical speciation and metal solubility, EC and TDS reflect the ionic strength and mineralization of water, while hardness and alkalinity influence domestic usability and scaling tendencies. Biological parameters such as DO, BOD, and COD provide insight into organic pollution and microbial activity [20].

Trace metals including iron, copper, zinc, cadmium, lead, chromium, and manganese, though present at low concentrations, are of significant environmental and health concern due to their toxicity, persistence, and bioaccumulation potential. Advanced analytical techniques such as Flame Emission Spectroscopy (FES) and Atomic Absorption Spectrometry (AAS) are widely employed for the accurate determination of metal ions in water samples [21–23]. Regulatory bodies such as the Bureau of Indian Standards (BIS) and the World Health Organization (WHO) have established guideline values to ensure the safety and suitability of drinking water, emphasizing the importance of continuous monitoring and compliance [24,25].Coastal regions of India, particularly along the southwest coast, are increasingly vulnerable to groundwater quality deterioration due to high population density, rapid urban expansion, industrial development, and dependence on shallow aquifers. Kollam, located along the Arabian Sea coast of Kerala, represents a typical low-lying coastal environment characterized by tropical monsoon climate, high annual rainfall, and extensive mineral sand deposits. Despite substantial rainfall, the region frequently experiences groundwater quality issues such as salinity, hardness, and elevated ion concentrations, especially in areas influenced by seawater intrusion and urban activities [26–28].In this context, systematic hydrochemical characterization of groundwater is essential for evaluating its suitability for drinking and other domestic purposes, identifying dominant geochemical processes, and assessing the extent of anthropogenic impact. The present study aims to evaluate the physicochemical, biological, and metal ion characteristics of groundwater samples collected from coastal and urban regions of Kollam, Kerala. The findings are expected to contribute valuable baseline data for sustainable groundwater management and provide scientific support for water quality protection strategies in vulnerable coastal environments.

## II. MATERIALS AND METHODS

### 2.1 Study Area and Sample Collection

Groundwater quality assessment was carried out in coastal and urban regions of Kollam, located along the southwest coast of India adjacent to the Arabian Sea. The region is characterized by low-lying coastal terrain, tropical monsoon climate, high annual rainfall, and extensive dependence on groundwater for domestic use.A total of 25 groundwater samples were collected from beach-side and corporation areas to represent varying hydrogeological and anthropogenic conditions. Samples were collected from open wells and bore wells during the pre-monsoon season. Clean polyethylene containers (2 L capacity) were pre-washed with dilute nitric acid, rinsed with distilled water, and finally rinsed with sample water prior to collection. Samples were preserved at 4 °C and transported to the laboratory for analysis.Field parameters including pH, electrical conductivity (EC), salinity, and total dissolved solids (TDS) were measured in situ to minimize physicochemical alterations.

### 2.2 Measurement of Physicochemical Parameters

pH was measured using a calibrated digital pH meter. Calibration was performed using standard buffer solutions of pH 4.0, 7.0, and 9.2. pH values were used to assess the acidic or alkaline nature of groundwater and its influence on geochemical reactions.Electrical conductivity was measured using a portable EC meter in the field and cross-verified in the laboratory using a Systronics Water Analyzer (Model 371). Calibration was performed using 0.01 M KCl solution. EC values were expressed in $\mu S\ cm^{-1}$.TDS was determined using the Systronics Water Analyzer. TDS values indicate the degree of mineralization and salinity of groundwater.

### 2.3. Total, Calcium, and Magnesium HardnessTotal Alkalinity

Total hardness and calcium hardness were determined by complexometric titration using standard EDTA solution. Eriochrome Black-T was used as indicator for total hardness, while murexide indicator was employed for calcium hardness determination. Magnesium hardness was calculated as the difference between total hardness and calcium hardness. Results were expressed as mg $L^{-1}$ $CaCO_3$.Total alkalinity (carbonate and bicarbonate) was determined by titration with standard 0.02 N $H_2SO_4$ using phenolphthalein and methyl orange indicators. Alkalinity values were expressed as mg $L^{-1}$ $CaCO_3$.

### 2.4 Determination of Major Anions

Chloride concentration was determined by argentometric titration using standard $AgNO_3$ solution with potassium chromate as indicator. Results were expressed in mg $L^{-1}$.Sulphate concentration was determined by the turbidimetric method using barium chloride. Absorbance was measured at 420 nm using a UV–Visible spectrophotometer, and concentrations were obtained from a standard calibration curve.Phosphate was analyzed by the ascorbic acid–molybdate method. The blue-coloredphosphomolybdenum complex formed was measured at 880 nm using a UV–Visible spectrophotometer.Nitrate concentration was determined spectrophotometrically after reduction to nitrite using hydrazine sulphate. The resulting azo dye was measured at 543 nm. Nitrite present initially was analyzed separately, and nitrate concentration was obtained by difference.

2.5. Determination of Major Cations

Calcium concentration was determined by EDTA titration at pH ≈ 12 using Patton and Reader indicator. Magnesium concentration was calculated from the difference between total hardness and calcium hardness.Sodium and potassium concentrations were determined using a flame emission photometer (ESICO Digital Clinical Flame Photometer). Calibration was performed using mixed $Na^+$ and $K^+$ standard solutions prepared from analytical-grade salts. Results were expressed in mg $L^{-1}$.

2.6 Trace Metal Analysis

Trace metals including copper (Cu), zinc (Zn), cadmium (Cd), and iron (Fe) were determined using Atomic Absorption Spectrophotometry (AAS) with an air–acetylene flame. Instrumental parameters such as lamp current, wavelength, slit width, and flame conditions were optimized for each element. Metal concentrations were reported in mg $L^{-1}$ and compared with Bureau of Indian Standards (BIS) drinking water guidelines.

2.7 Quality Assurance and Data Analysis

All chemicals and reagents used were of analytical reagent grade, and double-distilled water was employed throughout the analysis. Calibration standards and reagent blanks were analyzed periodically to ensure accuracy and precision. Analytical results were statistically evaluated, tabulated, and compared with BIS drinking water standards to assess groundwater suitability for domestic use.

## III. RESULTS AND DISCUSSION

3.1 Overall Hydrochemical Characteristics

Groundwater samples collected from coastal and urban regions of Kollam show marked spatial variation in physicochemical characteristics. The integrated assessment of pH, hardness, major ions, nutrients, alkali metals, and heavy metals indicates that seawater intrusion, aquifer lithology, groundwater residence time, and anthropogenic activities are the dominant factors controlling groundwater chemistry. Similar hydrochemicalbehavior has been reported for several coastal aquifers worldwide [21–24].

3.2 pH Distribution and Acid–Base Characteristics

The pH values of the groundwater samples (Table 1) varied from 4.45 to 11.55, indicating substantial heterogeneity in acidbase conditions. The majority of samples exhibited pH values between 6.0 and 8.0, falling within the WHO recommended range (6.5–8.5) for drinking water

[25]. However, seven samples were outside this permissible range, suggesting localized geochemical imbalance.Highly alkaline conditions observed at Andamukkam (S20) and Ayathil (S19) can be attributed to dissolution of alkaline earth minerals, ion exchange reactions, and urban influences, which are typical of coastal aquifers affected by salinity ingress [26,27]. In contrast, acidic conditions at Karbala (S24) may result from organic matter decomposition, acidic leachates, or corrosion-related processes [28]. Extreme pH values significantly influence metal solubility and mobility, thereby affecting groundwater potability [29].

### 3.3 Total Hardness and Alkaline Earth Metals ($Ca^{2+}$ and $Mg^{2+}$)

Total hardness and associated calcium and magnesium concentrations are presented in Table 2. Total hardness ranged from 35.84 ppm to 2032.64 ppm, indicating wide variability in mineralization. Exceptionally high hardness recorded at the Kollam beach sample (S12) strongly suggests direct seawater intrusion, as marine water is enriched with calcium and magnesium salts [30].Coastal and near-coastal locations such as Kappil, Thangassery, Mayyanad, and Eravipuram exhibited hardness values approaching or exceeding 200 ppm, whereas inland areas including Ayathil (S19), Karbala (S24), and Puliyathumukku (S6) showed comparatively low hardness, likely due to reliance on treated municipal water. According to WHO classification [31], seven samples are soft, four are moderately hard, and the remaining samples are hard water. Persistent consumption of highly hard water reduces palatability and domestic suitability and may cause scaling problems [32].

### 3.4 Major Anions and Nutrient Chemistry

The distribution of major anions is summarized in Table 3. Chloride concentrations showed extreme variation, with exceptionally high values in S12, far exceeding the BIS desirable limit of 200 ppm [33]. Elevated chloride in coastal samples is a well-established indicator of marine water mixing and salinity intrusion [34].Bicarbonate alkalinity was detected in all samples, reflecting carbonate weathering and dissolution of $CO_2$ within the aquifer system. Sulphate concentrations were high in most samples, influenced by geological formations, soil characteristics, and anthropogenic inputs such as sewage and surface runoff [35]. Nitrate levels were generally within permissible limits, except for the beach sample, indicating organic contamination and marine influence. Phosphate, absent in several samples, exceeded the WHO guideline value (0.4 ppm) in five locations, suggesting contamination from detergents, fertilizers, or domestic wastewater [36]

### 3.5 Alkali Metals: Sodium and Potassium

Sodium and potassium concentrations (Table 4) showed a clear coastal gradient. Sodium ranged from 8 to 1017 ppm, while potassium ranged from 2 to 897 ppm, with the highest values recorded at Kollam beach (S12). Such elevated concentrations are characteristic of aquifers affected by seawater intrusion and ion exchange processes [37].Coastal locations generally exhibited sodium >60 ppm and potassium >40 ppm, whereas inland locations such as Ayathil

(S19) and Karbala (S24) recorded minimal concentrations. Although sodium and potassium are essential nutrients, excessive sodium intake may pose health risks, particularly for individuals with hypertension and renal disorders [38].

### 3.6 Heavy Metal Distribution

Heavy metal concentrations (Table 5) indicate that iron, copper, zinc, and cadmium were present predominantly in trace concentrations. Approximately 90% of the samples complied with BIS drinking water standards [33]. Elevated concentrations observed in the beach sample may be attributed to marine sediments, mineral sand deposits, and anthropogenic activities along the coastline [39].Among the analyzed metals, zinc exhibited relatively higher concentrations, while cadmium, a highly toxic element, was detected only in trace amounts or below detection limits in most samples. Similar trends have been reported in other coastal groundwater studies [40]. Although current levels are largely within permissible limits, continuous monitoring is recommended due to the potential for bioaccumulation and long-term toxicity [41].

### 3.7 Integrated Groundwater Quality Assessment

Considering all physicochemical parameters, ionic constituents, nutrients, and metals together, groundwater quality in the coastal belt of Kollam is strongly influenced by seawater intrusion, resulting in elevated hardness, chloride, sulphate, sodium, and metal concentrations. Inland and corporation-supplied areas exhibit comparatively better water quality. These findings highlight the vulnerability of coastal aquifers and the necessity for regulated groundwater extraction, artificial recharge, and periodic monitoring to ensure sustainable potable water resources.

## IV. CONCLUSION

The present investigation provides a comprehensive assessment of groundwater quality in coastal and urban regions of Kollam, with particular emphasis on physicochemical parameters, major ions, alkali metals, and trace/heavy metals. The study clearly demonstrates that groundwater quality deteriorates significantly toward the coastal belt, primarily due to seawater intrusion, aquifer lithology, and anthropogenic influences.A substantial proportion of the coastal samples exhibited total hardness values exceeding the desirable limits prescribed by BIS and WHO, rendering the water unsuitable for direct domestic consumption. Approximately 72% of the samples showed pH values within the WHO recommended range (6.5–8.5), while the remaining samples displayed either acidic or highly alkaline conditions, which may adversely affect water palatability and metal mobility [25]. Elevated hardness, salinity, and alkalinity in coastal locations are consistent with marine salt dissolution and ion exchange processes, commonly reported in coastal aquifers worldwide [30,34].The analysis of major anions revealed exceptionally high chloride concentrations in the beach sample, far exceeding permissible limits, confirming the dominant influence of saltwater intrusion. Sulphate and bicarbonate concentrations were also relatively high in several coastal and near-coastal locations, influenced by geological formations and anthropogenic inputs. Although nitrate and phosphate levels were generally within acceptable limits, localized exceedances indicate nutrient enrichment from domestic wastewater, detergents, and surface runoff, which could pose long-term ecological and public health concerns [35,36].Alkali metals (sodium and potassium) exhibited a pronounced coastal gradient, with extremely high concentrations in the beach sample, further substantiating seawater mixing. While most inland samples complied with BIS limits, excessive sodium concentrations in coastal water may increase health risks for vulnerable populations, particularly individuals with cardiovascular and renal disorders [38].

Trace and heavy metal analysis using AAS and FES techniques showed that iron, copper, zinc, and cadmium were mostly present in trace concentrations, and nearly 90% of the samples complied with BIS drinking water standards [33]. However, relatively higher metal concentrations in coastal samples highlight the role of marine sediments, mineral sand deposits, and anthropogenic activities. Although current concentrations are largely within permissible limits, continuous monitoring is essential due to the potential for bioaccumulation and chronic toxicity [41].The findings underscore the acute vulnerability of coastal groundwater resources. Due to poor water quality, residents in shoreline regions are increasingly dependent on municipal and public water supply systems to meet their daily needs, reflecting a growing socio-environmental challenge. Given that a significant portion of India's population still lacks access to safe drinking water, the results emphasize the urgent need for regulated groundwater extraction, artificial recharge measures, protection of coastal aquifers, and routine water quality monitoring. Sustainable water resource management is imperative to prevent further degradation and to ensure long-term availability of safe drinking water in coastal regions.

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Table No :1 pH Study

| sl no | Code | Place | pH |
|---|---|---|---|
| 1 | S1 | Kappil | 7.16 |
| 2 | S2 | Thangassery | 7.14 |
| 3 | S3 | Valiyavila | 6.9 |
| 4 | S4 | Mayyanad | 6.87 |
| 5 | S5 | Thanni | 6.6 |
| 6 | S6 | Puliyathumukku | 6.9 |

| | | | |
|---|---|---|---|
| 7 | S7 | Karikuzhi | 7.1 |
| 8 | S8 | Madannada | 7.3 |
| 9 | S9 | Kadavoor | 7.5 |
| 10 | S10 | Ammanada | 7.8 |
| 11 | S11 | Mundackal | 8.4 |
| 12 | S12 | Kollam beach | 7.9 |
| 13 | S13 | Polayathodu | 7.6 |
| 14 | S14 | Muncipal Colony | 7.7 |
| 15 | S15 | Paravoor | 7.5 |
| 16 | S16 | Kochupilammodu | 6.5 |
| 17 | S17 | Pattathanam | 5.9 |
| 18 | S18 | Mathilil | 6.3 |
| 19 | S19 | Ayathil | 8.8 |
| 20 | S20 | Andamukkam | 11.55 |
| 21 | S21 | Chemmamukku | 8.9 |
| 22 | S22 | Kappalandimukku | 6.2 |
| 23 | S23 | Powerhouse junction | 7.4 |
| 24 | S24 | Karbala | 4.45 |
| 25 | S25 | Eravipuram | 6.65 |

Table No: 2 Hardness and Concentration of Cations

| sl no | Code | Place | Total Hardness, ppm | Ca hardness, ppm | Mg hardness, ppm | Ca conc, ppm | Mg conc, ppm |
|---|---|---|---|---|---|---|---|
| 1 | S1 | Kappil | 266.24 | 158.72 | 107.52 | 63.488 | 26.12736 |
| 2 | S2 | Thangassery | 256 | 148.48 | 107.52 | 59.392 | 26.12736 |
| 3 | S3 | Valiyavila | 66.56 | 30.72 | 35.84 | 12.288 | 8.70912 |
| 4 | S4 | Mayyanad | 250.88 | 148.48 | 102.4 | 59.392 | 24.8832 |
| 5 | S5 | Thanni | 174.08 | 102.4 | 71.68 | 40.96 | 17.41824 |
| 6 | S6 | Puliyathumukku | 46.08 | 20.48 | 25.6 | 8.192 | 6.2208 |
| 7 | S7 | Karikuzhi | 179.2 | 92.16 | 87.04 | 36.864 | 21.15072 |
| 8 | S8 | Madannada | 184.32 | 97.28 | 87.04 | 38.912 | 21.1507 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | 2 |
| 9 | S9 | Kadavoor | 143.36 | 81.92 | 61.44 | 32.768 | 14.92992 |
| 10 | S10 | Ammanada | 112.64 | 51.2 | 61.44 | 20.48 | 14.92992 |
| 11 | S11 | Mundackal | 153.6 | 56.32 | 97.28 | 22.528 | 23.63904 |
| 12 | S12 | Kollam beach | 2032.64 | 1167.36 | 865.28 | 466.944 | 210.263 |
| 13 | S13 | Polayathodu | 194.56 | 97.28 | 97.28 | 38.912 | 23.63904 |
| 14 | S14 | Muncipal Colony | 199.68 | 102.4 | 97.28 | 40.96 | 23.63904 |
| 15 | S15 | Paravoor | 194.56 | 87.04 | 107.52 | 34.816 | 26.12736 |
| 16 | S16 | Kochupilammodu | 87.04 | 46.08 | 40.96 | 18.432 | 9.95328 |
| 17 | S17 | Pattathanam | 66.56 | 35.84 | 30.72 | 14.336 | 7.46496 |
| 18 | S18 | Mathilil | 117.76 | 56.32 | 61.44 | 22.528 | 14.92992 |
| 19 | S19 | Ayathil | 35.84 | 15.36 | 20.48 | 6.144 | 4.97664 |
| 20 | S20 | Andamukkam | 158.72 | 102.4 | 56.32 | 40.96 | 13.68576 |
| 21 | S21 | Chemmamukku | 71.68 | 46.08 | 25.6 | 18.432 | 6.2208 |
| 22 | S22 | Kappalandimukku | 66.56 | 30.72 | 35.84 | 12.288 | 8.70912 |
| 23 | S23 | Powerhouse junction | 163.84 | 76.8 | 87.04 | 30.72 | 21.15072 |
| 24 | S24 | Karbala | 40.96 | 25.6 | 15.36 | 10.24 | 3.73248 |
| 25 | S25 | Eravipuram | 189.44 | 107.52 | 81.92 | 43.008 | 19.90656 |

Table No: 3 Presence of anions

| Sl no | Code | Place | Chloride, ppm | Alkalinity (Bicarbonate), ppm | Sulphate, ppm | Nitrate, ppm | Phosphate, ppm |
|---|---|---|---|---|---|---|---|
| 1 | S1 | Kappil | 159.75 | 124 | 450.5 | 35.9 | 1.8 |
| 2 | S2 | Thangassery | 168.625 | 104 | 426.8 | 32.8 | 1.6 |
| 3 | S3 | Valiyavila | 177.5 | 12 | 98.9 | 8.7 | Nil |
| 4 | S4 | Mayyanad | 150.875 | 120 | 409.13 | 30.7 | 1.4 |
| 5 | S5 | Thanni | 142 | 56 | 369.6 | 21.7 | 0.006 |
| 6 | S6 | Puliyathumukku | 44.375 | 20 | 91.9 | 8.1 | Nil |
| 7 | S7 | Karikuzhi | 97.625 | 100 | 379.4 | 24.7 | 0.007 |
| 8 | S8 | Madannada | 230.75 | 72 | 380.88 | 24.1 | 0.007 |
| 9 | S9 | Kadavoor | 97.625 | 44 | 335.5 | 17.12 | 0.003 |
| 10 | S10 | Ammanada | 204.125 | 64 | 298.9 | 13.8 | 0.001 |
| 11 | S11 | Mundackal | 71 | 68 | 352.73 | 20.5 | 0.005 |
| 12 | S12 | Kollam beach | 363875 | 224 | 984.66 | 78.4 | 8.3 |
| 13 | S13 | Polayathodu | 257.375 | 60 | 392.9 | 29.3 | 1.4 |
| 14 | S14 | Muncipal Colony | 301.75 | 76 | 398.1 | 27.9 | 0.18 |
| 15 | S15 | Paravoor | 62.125 | 92 | 390.3 | 27.2 | 0.15 |
| 16 | S16 | Kochupilammodu | 301.75 | 12 | 101.6 | 9.2 | Nil |
| 17 | S17 | Pattathanam | 443.75 | 24 | 99.87 | 8.8 | Nil |
| 18 | S18 | Mathilil | 79.875 | 64 | 301.12 | 14.6 | 0.002 |
| 19 | S19 | Ayathil | 177.5 | 4 | 79 | 7.2 | Nil |
| 20 | S20 | Andamukkam | 159.75 | 44 | 354.19 | 20.6 | 0.005 |
| 21 | S21 | Chemmamukku | 150.875 | 4 | 99.2 | 8.8 | Nil |
| 22 | S22 | Kappalandimukku | 177.5 | 12 | 97.9 | 8.4 | Nil |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | S23 | Powerhouse junction | 186.375 | 40 | 359.2 | 21.4 | 0.006 |
| 24 | S24 | Karbala | 239.625 | 12 | 86.01 | 7.8 | Nil |
| 25 | S25 | Eravipuram | 301.75 | 56 | 385.8 | 25.6 | 0.008 |

TABLE NO: 4. Presence of metals

| Sl no | Code | Place | Sodium (ppm) | Potassium(ppm) |
|---|---|---|---|---|
| 1 | S1 | Kappil | 96 | 80 |
| 2 | S2 | Thangassery | 93 | 76 |
| 3 | S3 | Valiyavila | 19 | 7 |
| 4 | S4 | Mayyanad | 90 | 71 |
| 5 | S5 | Thanni | 70 | 54 |
| 6 | S6 | Puliyathumukku | 10 | 4 |
| 7 | S7 | Karikuzhi | 72 | 56 |
| 8 | S8 | Madannada | 79 | 60 |
| 9 | S9 | Kadavoor | 60 | 41 |
| 10 | S10 | Ammanada | 41 | 28 |
| 11 | S11 | Mundackal | 65 | 44 |
| 12 | S12 | Kollam beach | 1017 | 897 |
| 13 | S13 | Polayathodu | 82 | 65 |
| 14 | S14 | Muncipal Colony | 84 | 68 |
| 15 | S15 | Paravoor | 82 | 66 |
| 16 | S16 | Kochupilammodu | 29 | 17 |
| 17 | S17 | Pattathanam | 18 | 7 |
| 18 | S18 | Mathilil | 43 | 30 |
| 19 | S19 | Ayathil | 8 | 2 |
| 20 | S20 | Andamukkam | 67 | 49 |
| 21 | S21 | Chemmamukku | 22 | 9 |
| 22 | S22 | Kappalandimukku | 20 | 8 |
| 23 | S23 | Powerhouse junction | 69 | 50 |
| 24 | S24 | Karbala | 9 | 3 |
| 25 | S25 | Eravipuram | 80 | 62 |

TABLE NO: 5 Presences of heavy metals

| Sl no | Code | Place | Iron (ppm) | Copper(ppm) | Zinc(ppm) | Cadmium(ppm) |
|---|---|---|---|---|---|---|
| 1 | S1 | Kappil | 0.18 | 0.07 | 2.95 | 0.0022 |
| 2 | S2 | Thangassery | 0.17 | 0.069 | 2.89 | 0.0024 |
| 3 | S3 | Valiyavila | 0.0008 | 0.003 | 0.89 | 0.0019 |
| 4 | S4 | Mayyanad | 0.15 | 0.067 | 2.98 | 0.0001 |
| 5 | S5 | Thanni | 0.078 | 0.03 | 1.78 | 0.0018 |
| 6 | S6 | Puliyathumukku | 0.0001 | 0.0055 | 0.8 | Nil |
| 7 | S7 | Karikuzhi | 0.06 | 0.04 | 1.88 | 0.0004 |
| 8 | S8 | Madannada | 0.09 | 0.06 | 1.98 | 0.0008 |
| 9 | S9 | Kadavoor | 0.033 | 0.009 | 1.22 | 0.0002 |
| 10 | S10 | Ammanada | 0.0081 | 0.006 | 1.08 | 0.0003 |
| 11 | S11 | Mundackal | 0.046 | 0.01 | 1.32 | 0.0006 |
| 12 | S12 | Kollam beach | 3 | 0.339 | 4.9 | 0.003 |
| 13 | S13 | Polayathodu | 0.11 | 0.03 | 2.03 | 0.0014 |
| 14 | S14 | Muncipal Colony | 0.13 | 0.06 | 2.11 | 0.0019 |
| 15 | S15 | Paravoor | 0.09 | 0.05 | 2.09 | 0.0009 |
| 16 | S16 | Kochupilammodu | 0.0009 | Nil | 1.001 | 0.0001 |
| 17 | S17 | Pattathanam | 0.0006 | 0.0045 | 0.99 | 0.0001 |
| 18 | S18 | Mathilil | 0.009 | 0.0078 | 1.16 | 0.0003 |
| 19 | S19 | Ayathil | Nil | Nil | 0.4 | Nil |
| 20 | S20 | Andamukkam | 0.045 | 0.015 | 1.38 | 0.0001 |
| 21 | S21 | Chemmamukku | 0.005 | 0.0048 | 0.99 | Nil |
| 22 | S22 | Kappalandimukku | 0.007 | 0.0034 | 0.91 | 0.0005 |
| 23 | S23 | Powerhouse junction | 0.04 | 0.022 | 1.6 | 0.0004 |
| 24 | S24 | Karbala | Nil | 0.001 | 0.6 | Nil |
| 25 | S25 | Eravipuram | 0.06 | 0.05 | 1.8 | 0.0009 |