Minor Projects on Water & Soil Analysis

OUTLINE

• Water distribution
• Physic-chemical parameters
• Instruments & accessories
• Analytical Procedures
• General methodology
• Type of research projects
• Proposed titles for research programme
• Major ion Chemistry (Modeling)

WATER DISTRIBUTION

Physic-chemical Parameters

pH, Temperature, Turbidity, Conductivity, DO, TDS, TSS, BOD
Alkalinity, Acidity, Hardness

Major ions
Cations: Ca, Mg, Na, K
Anions: SO\(_4^{2-}\), HCO\(_3^-\), Cl, CO\(_3^{2-}\)

Minor ions
Cations: Fe, Ba, Mn
Nutrients: NO\(_3^-\), NO\(_2^-\), NH\(_3\), PO\(_4^{3-}\), SiO\(_4^{4-}\)

Trace ions
Heavy metals (Hg, Cd, Pb, Zn, Cu)
minor projects on water & soil analysis

instruments & accessories

**field**

- GPS, High end Camera
- Portable Water Quality Analyser

- Bottles (normal type, DO Bottles, BOD Bottles)
- Bucket, Mug and funnel, Vials for microbiology, measuring tape, rope, filter papers, becchi disc

**lab**

- Bench type multiparameter analyser, Turbidimeter, Spectrophotometer, Flame photometer, Cadmium column, APHA (analytical manual)

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**gps (global positioning system)**

application: latitude (n) and longitude (e)

GPS is a space based satellite navigation system that provides location and time information in all weather, anywhere on earth, near the earth, where there is an unobstructed line of sight to four or more GPS satellites.

It is maintained by the DoD, United States Govt. and is freely accessible to anyone with a GPS receiver.

(24 satellites, fully operated in 1994)

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**portable water quality analyser**

applications: pH, temperature, conductivity, TDS, DO

ISE (Ion Selective Electrode)

- Make: 1. WTW 350i, German (Rs. 2.0-3.0 lakhs)
- 2. Thermo Orion, USA (1.0-1.75 lakhs)
- 3. Eutech, Singapore (1.0-1.75 lakhs)
- 4. Elico, India (0.3-0.5 lakhs)

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**bench type multiparameter analyser**

applications: same as above

- Make: 1. WTW German (Rs. 2.0 lakhs)
- 2. Thermo Orion, USA (1.00-2.25 lakhs)
- 3. Eutech (simultaneous analysis of 4 parameters)
  - Singapore (2.00 lakhs), Deluxe Model (0.70 lakhs)
- 4. Elico, India (0.75 lakhs)
Minor Projects on Water & Soil Analysis

**Flame photometer**
- Na & K
- Ca & Ba

**Spectrophotometer**
- Cations & anions
- Dyes
  (Colorimetry)

**Cadmium column**

**Turbidity meter**

**ANALYTICAL PROCEDURES**

**Insitu Analysis**
- Water temperature, pH, Electrical Conductivity & DO are measured insitu with water quality analyzer

**ALKALINITY**
- Alkalinity in natural waters are caused by OH⁻, CO₃²⁻ and HCO₃⁻
- Reagents- 0.02N H₂SO₄, mixed indicator (Methyl Orange + bromocresol green indicator)
- Procedure- It is estimated by titrating 25 ml sample with standard H₂SO₄ using mixed indicator. End point- colour change from blue to green.
- Alkalinity as mg/L of CO₃²⁻ = Titer value x 1000 / Vol. of spl
- Hence amount of HCO₃⁻ = amount of CO₃²⁻ x 1.22 mg/L
Minor Projects on Water & Soil Analysis

ACIDITY

- Acidity of water is its quantitative capacity to react with a strong base to a designated pH.
- Reagents - 0.02 NaOH, phenolphthalein indicator.
- Procedure - It is estimated by titrating 25 ml sample with standard NaOH using phenolphthalein indicator. End point - colour change from pink to colourless.
- As each mL of 0.02 NaOH = 1 mg CaCO₃

Acidity as mg/L CaCO₃ = Titer value × 1000/Vol of spl

TOTAL HARDNESS

- Water hardness - measure of the capacity of water to precipitate soap.
- Reagents - 0.01 M EDTA, NH₄Cl-NH₄OH buffer, Eriochrome Black-T indicator.
- Procedure - It is estimated by titrating 50 ml sample with standard EDTA + 1 ml buffer, using Eriochrome Black-T indicator. End point - colour change from wine red to blue.

Total hardness (as CaCO₃ mg/L) = Titer value × 1000/vol spl

CALCIUM HARDNESS AND MAGNESIUM HARDNESS

- Reagents - 0.01 M EDTA, 1N NaOH as buffer, Murexide indicator.
- Procedure for Ca hardness - It is estimated by titrating 50 ml sample with standard EDTA + 1 ml buffer, using Murexide indicator. End point - colour change from pink colour to purple.

Calcium hardness as CaCO₃ (mg/L) = Titer value × 1000/vol spl

- Magnesium - determined by calculating the difference between total hardness and calcium hardness of sample.

CHLORINITY

- Chloride in aqueous solution is not stable and the chlorine content of the sample decreases rapidly.
- Estimated by Argentometric method.
- Reagents - 0.01N AgNO₃, K₂CrO₄ indicator.
- Procedure - It is estimated by titrating 50 ml sample + 3 drops of K₂CrO₄ indicator using standard AgNO₃. End point - colour change from yellow colour to dirty orange.
- Amount of chlorine = NAgNO₃ × Titer value × 1000/vol spl
**SULPHATE**

- The sulphate ion is one of the major anions occurring in natural waters.
- It is estimated by turbidimetric methods.
- Reagents – Barium chloride crystals
- Procedure- 25ml sample + few barium chloride crystals- shake well- light absorbance of $\text{BaSO}_4$ measured spectrophotometrically at 420nm.

**Na and K**

- Na and K estimation- based on emission spectroscopy.
- Trace amounts of Na and K can be determined by flame emission photometry.
- Intensity of light measured by photodetector.

**SILICATE**

It is estimated by colorimetric methods.

- Reagents – ammonium molybdate, 10% $\text{H}_2\text{C}_2\text{O}_4$ and ascorbic acid solution
- Procedure- 20ml sample + 1 mL ammonium molybdate + 1ml 10% $\text{H}_2\text{C}_2\text{O}_4$ + 0.5 mL ascorbic acid solution. Blue color developed- measured spectrophotometrically at 810nm.

**IRON**

- It is estimated by colorimetric methods.
- Reagents – 1:1 HCl, hydroxyl amine hydrochloride, ammonium acetate buffer and 1,10- phenanthrline.
- Procedure- 50ml sample + 1mL 1:1 HCl +1mL hydroxyl amine hydrochloride- reduced to 20 ml, add 5ml ammonium acetate buffer + 5ml 1,10- phenanthrline. Light orange colour developed- measured spectrophotometrically at 510nm.
- Amount of iron in mg/L=Absorbance x S

**Calculation**

For the three standards, the concentrations are 25, 50 & 75 µg/mL, which is $C_1$, $C_2$, $C_3$

$F = \text{Concn}/\text{Abs}$

$\xi_i = C_i/\text{Abs}$, $\xi_2 = C_2/\text{Abs}$ and so on

$F = \xi_1 + \xi_2 + \xi_3$, $S = F \times 1000/\text{vol spl}$

If it is diluted, a dilution factor is also multiplied

Amount of silicate = Abs x S
Minor Projects on Water & Soil Analysis

NITRITE - NITROGEN

- Nitrite is found in waters by oxidation of ammonia compounds or by reduction of nitrate.
- It is estimated by colorimetric methods.
- Reagents – Sulphanilamide, NNED.
- Procedure: 20 ml sample + 0.5 ml Sulphanilamide + 0.5 ml NNED. Pink colour developed- measured spectrophotometrically at 540nm.
- Amount of NO$_2$-N in µg/L = Absorbance x S

NITRATE - NITROGEN

- Nitrate in water is reduced to nitrite by passing through reduction column.
- Reagents – NH$_4$Cl buffer, Sulphanilamide, NNED.
- Procedure: 50 ml sample + 50 ml buffer - passed through cadmium column. Last 20 ml of reduced sample collected + 0.5 ml Sulphanilamide + 0.5 ml NNED. Pink colour developed- measured spectrophotometrically at 540nm.
- Amount of NO$_3$-N in µg/L = Absorbance x S

INORGANIC PHOSPHATE

- Phosphorus occurring as orthophosphate can be measured colorimetrically.
- Reagents – mixed reagent (ammonium molybdate + 9N H$_2$SO$_4$) and ascorbic acid solution
- Procedure: 20 ml sample + 0.5 mL mixed reagent + 0.5 mL ascorbic acid solution. Blue color developed- measured spectrophotometrically at 880nm.
- Amount of PO$_4^{3-}$ in µg/L = Absorbance x S

FLUORIDE

- Fluoride is more common in ground water than in surface water. It is estimated by colorimetric methods.
- Reagents – mixed reagent (equal volumes of SPADNS solution and zirconyl acid reagent mixed together).
- Procedure: 90 ml sample + 10 ml of mixed reagent. Deep red color developed- measured spectrophotometrically at 570nm.
- Amount of F$^{-}$ in µg/L = Absorbance x S
Minor Projects on Water & Soil Analysis

**Rock/Sediment/Soil - Analysis**

- Texture, Particle Size, nutrients/metal constituents
- X-RD (Rs. 200/- sample) Metal oxides
- X-RF (Rs. 200/- sample) Major (Si, Ti, Mn, Fe Ca, Mg, Na, K, P etc) and minor elements (V, Cr, Co, Ni, Cd, Pb, Zn, La, Ba, Ce, Th, Sr etc)

**General Methodology**

**FIELD WORK**

- System Identification (Riverine based, Marine Based)
- Study Area: Locating & Mapping
- Land use & Physical processes
- Sampling (water & soil)
- In situ and naked eye analysis
- Lab analysis
- Data Processing
- Evaluation of Data
- Modeling and Interpretation

**GPSE Locate and Map (GIS-Geographic Information System)**

**Field Data Sheet (Freshwater)**

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<td>Conductivity, µS/cm</td>
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<td>DO, mg/L</td>
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<td>DO, %</td>
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<td>Temperature, °C</td>
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Field Data Sheet for Fresh Water Sampling

- Lat. & Long.: 
- Panchayat: 
- Block: 
- District: 
- River basin: 
- Physiography: Lowland/Midland/ High land 
- Geology: Khondalite /Granitic /Charnockite 
- Geomorphology: Plateau/valley fills/Costal 
- Soil type: Laterite, Clay, Sandy clay, Silty clay etc 
- Nature of Pond: With lateritic exposures inside, eutrophic 
- Type: Perennial 
- Storage structure/structural protection if any: protected 
- Land use: Mixed/ cultivated/irrigated 
- Present usage: Bathing, washing & agricultural purposes
Field Data Sheet (Marine)

Land Use & Physical Processes

Visual Observation:
- Type of agricultural activities, industries (local/small scale/etc)
- Presence of Road/bridges/etc
- In general, manmade activities
- Natural observations
  - Heavy rain, Strong wind, Geomorphology, Geology

Sampling

- Niskin Water Sampler (Deep Water), Bottom Sampler (just 2/3 m)
- Simple pot (surface water sampling, bucket)
- Floating particulates should be removed during sampling
- Labelling most important (including date and time of collection)
- Normally, 2 L of water sample is required for Major ions and nutrient analysis (1 L each)
  - 1 L for Heavy metals (fixed using conc. HNO3, pH < 2.0)
  - 1 L for major ions and nutrients
- But for DO and BOD, separate bottles (250 mL and 300 mL, respectively)
- Preserving Temp. for all samples: < 5.0°C
- DO – fix using Winkler A & B

Research Project Type: 1

- Focus on River basin
  - Eg: Neyyar Basin
  - System: five Ponds, Five Well water, Five river water samples
    - (Total 15 sampling points)
  - GPS Lat (N) and Long (E)
  - For each sampling point cover the land use
  - Water & Soil Samples – Initial observation
Minor Projects on Water & Soil Analysis

STUDY AREA

<table>
<thead>
<tr>
<th>Location: Noyar Bank, Sampling Stations</th>
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<tbody>
<tr>
<td>Block: Perumkadavila</td>
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<tr>
<td>Lat. &amp; long. : N 8 23' 8'' E 77 06' 18.2''</td>
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<tr>
<td>Panchayat: Chenkal</td>
<td>Municipality: Neyyattinkara, Ward E 30</td>
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<td>Land use: Mixed crops; dominance of coconut</td>
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<td>Storage structure/structural protection if any: Well protected</td>
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</table>
Minor Projects on Water & Soil Analysis

Research Project Type: 2

Focus on Springs

Springs at a glance

- Controlling factors
- Water potential & quality
- Importance

Types

Spring

Study Area

The study area consists of three districts - Pathanamthitta, Kottayam and Idukki, covers an aerial extent of nearly 9995 km².

Types of Springs identified

- Contact spring
- Joint spring
- Fracture spring
- Rheocrene
- Helocrene
- Limnocrene
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Spring classes identified:

- **Contact spring**: Water discharges where the contact zone between the strata intersects the land surface
- **Joint Spring**: Occurs along joints, fractures or faults where they intersect the land surface
- **Fracture spring**: The fracture zone between two opposing rock strata provides a flow path for groundwater to discharge

- **Spring typology**:
  - **Rheocrene**: Spring’s discharges form a flowing stream
  - **Helocrene**: Small springs (seepages) form a spring-fed marsh
  - **Limnocrene**: Spring discharges through the bed of a pond or lake

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Direct method  
Pumping

Major Ions

- **Ca²⁺ and Na⁺** are dominating cations
- **Cl⁻ and HCO₃⁻** are dominating anions

Schollinger diagram

Heavy metals

- Zn: 0.006 - 4.432
- Pb: 0.066 - 0.184
- Cd: 0.002 - 0.022
- Cu: 0.002 - 0.887
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Quality comparison with BIS & WHO

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<tr>
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<tr>
<td>Colour</td>
<td>5 HU</td>
<td>Pt.scale 5</td>
<td>&lt;2HU</td>
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<tr>
<td>Odour</td>
<td>Agreeable</td>
<td>Un objectionable</td>
<td>Agreeable</td>
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<td>pH</td>
<td>6.5-8.5</td>
<td>7.0-8.5</td>
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<td>10 NTU</td>
<td>2.5 JTU</td>
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<td>Magnesium</td>
<td>30 mg/l</td>
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<td>0.00-0.0729</td>
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Key Findings

- Lack of awareness among public
- Unscientific agricultural/developmental activities in spring head region
- Irrational land use changes curtails the ‘spring boils’
- Lack of proper approach pathway towards Spring region
- Insanitation is a common scene
- Lack of protective measures in spring fed catchment areas
- >20% of observed springs are on the verge of destruction

Conclusion

- Spring water is generally acidic (4.81-6.67) in nature
- EC ranges from 22.14 to 330.4 µS/cm with an average of 57.5 µS/cm indicating low range of dissolved salts
- TDS varies between 15.81 to 236 mg/l with an average of 41.06 mg/l
- Major ion concentration was lowest
- Low concentration of nutrients were noted
- Chemical quality satisfies BIS/WHO (Table 1) drinking water standards (except pH)
- Human settlements are associated with the surroundings of springs

- Protected springs are mostly in association with temples having good water potential
- Highland and midland regions are enriched with springs and most of them are used by local people (using tubes and other pumping measures)
- The heavy metal contents (Zn, Cd, Pb and Cu) noticed in some springs may be an indication of pesticide impact
- Presence of coliforms, Faecal streptococci indicates anthropogenic source of contamination
- Chromobacterium violaceum species which is non ubiquitous in spring waters were identified in several samples point towards need of proper maintenance and management of spring resources
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5. Aaliyirakkam Spring (S1)

**Typology:** Contact Spring

**Location:** Arthanareeswara temple, Chilakkoor

**Lat. & Long:** N8˚43'12˝ E 76˚42'58˝

**Municipality:** Varkala, Ward-19

**Block:** Varkala

**District:** Thiruvananthapuram

**River Basin:** Ayiroor

**Physiography:** Coastal zone/lowland

**Geology:** Clay with lignite seams

**Geomorphology:** Coastal plain/lower lateritic plateau

**Soil Type:** Very deep well drained gravelly clay soil

**Nature of Spring:** Undeveloped, with thick natural vegetation.

**Genesis:** Perennial

**Storage structure/structural protection if any:** Nil storage/protection structure

**Spring Environment:** Beach/cliffs herbs and shrubs

**Flow rate (LPM):** 17

**Present usage:** > 400 people use for drinking, bathing, and washing.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
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<td>pH</td>
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<td>Conductivity, µS/cm</td>
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<td>Ca, mg/l</td>
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<td>TN, µg/l</td>
<td>1536</td>
<td>TSS, mg/l</td>
<td>3.7</td>
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Focus on coastal ocean

**Research Project Type:** 3

**Major Ion Chemistry**

- Water derives some of the dissolved chemicals such as HCO₃⁻, Na⁺, Ca²⁺, Mg²⁺, SO₄²⁻, Cl⁻, and several others due to chemical interaction between soil mineral matter, rocks below the soil and contributions from rain, moisture and air.
- The solute load of the water — TDS — affect the quality of water.
- Weathering plays an important role in buffering of surface and ground waters (soluble basic cations: Ca, Mg, K and Na).
- In General, Dissolved constituents in water indicates Geological Evolution, mode of origin with in the hydrological cycles, soil or rock mass influences, influence of flora and fauna, the extent of pollution.
Interpretation of Physic-chemical Data

- The Box Plot
- Stiff’s Diagram
- Piper (Trilinear) Diagram
- Durov Diagram

Softwares
AquaChem

The BOX Plot

- Simple visual method to interpret data
- The box plot uses the median, the approximate quartiles, and the lowest and highest data points to convey the level, spread, and symmetry of a distribution of data values
- The box plot is more than a substitute for a table
- It is a tool that can improve our reasoning about quantitative information

Box plots showing the distribution of major ions in the ground water samples. The box represents interquartile range and either end of the line indicates the minimum and maximum values. The major ionic concentration of the ground water shows the following general pattern as:

Well: Ca > Mg > Cl > Na > HCO₃ > SO₄ > K > NO₃

Box plots showing the distribution of major ions in the pond water samples. The box represents interquartile range and either end of the line indicates the minimum and maximum values. The major ionic concentration of the pond water shows the following general pattern as:

Pond: Ca > Mg > HCO₃ > Cl > Na > SO₄ > K > NO₃
Minor Projects on Water & Soil Analysis

Box plots showing the distribution of major ions in the river water samples. The box represents interquartile range and either end of the line indicates the minimum and maximum values. The major ionic concentration of the river water shows the following general pattern as:

River: Ca > Mg > HCO$_3$ > Cl > Na > SO$_4$ > K > NO$_3$  
Pond: Ca > Mg > HCO$_3$ > Cl > Na > SO$_4$ > K > NO$_3$  
River: Ca > Mg > HCO$_3$ > Cl > Na > SO$_4$ > K > NO$_3$

The Ca-Mg-HCO$_3$ & Cl type waters are dominating in the case of major ions in analyzed water sources of the study area. But the rainwater acts as a medium which brings the Cl & NO$_3$ to the shallow groundwater aquifers which indicate organic pollution and fertilizer input. Overall the studied water sources seem to have more lithologic affinity since HCO$_3$, Ca and Mg dominated because of rock-water/sediment-water interaction processes/feldspar dissolution leading to cation exchange processes.

Stiff’s Diagram

• Stiff’s Diagram is a sophisticated method for demonstrating vertical changes in the chemical composition of water.
• The basic of Stiff’s diagram is a vertical line which has two functions.
• It is both a depth scale of aquifers and vertical zero axes from which the concentrations of ions are plotted on four parallel horizontal axes extending on each side. Each different pattern represents a different type of water.
• The Stiff system is a relatively distinctive method of showing differences or similarities in waters and changes in water composition with depth.
• It is useful especially for illustrating chemical composition in hydrogeologic cross sections.
• It can be used also for classification purposes, and is useful as a symbol on a map.
Piper (Trilinear) Diagram

- Piper diagram is an excellent tool for hydrochemical analysis using a series of water quality analyses into a spatial context.
- Understanding and describing the chemical evolution of groundwater which depends on pattern recognition techniques and permits the classification of waters (seven types).
- It can also define the patterns of spatial change in the water chemistry among geological units, along a line of section or along a path line.
- In understanding the water flow and water quality and the changes in water types and mixing relationships based on the relative proportions of major ions rather than the bulk concentrations.
- Method for the delineation of hydrochemical evolution and identification of the dominant processes that control water chemistry.

Finally, this diagram was modified by Back and Hanshaw to segregate the water type categories (hydrochemical facies) that form the basis for one common classification scheme for natural waters.

Durov Diagram

- Durov diagram is based on the percentage of the major ions in meq/L.
- Both the positive and the negative percentages total 100%.
- The values of the cations and the anions are plotted in the appropriate triangular and projected into the square of the main field.
- The advantage of this diagram is that it displays some possible geochemical processes that could affect the water genesis.
- Durov diagram for the major cations and anions plotted by Aquachem software (version: 4.9).
- The fields and lines on the diagram show the classifications of Lloyd and Heathcote (1985).
Minor Projects on Water & Soil Analysis

PROPOSED TITLES

1. Major ion chemistry in selected well water resources
2. Nutrient flux in Pamba River at Pamba (your place), Kerala, India
3. Appraisal of physico-chemical characteristics of various water resources from Karamana river surroundings at Vilappilsala (at your place), Trivandrum
4. Hydrological studies on the coastal spring water along the southwest coast of India in Kollam district of Kerala.
5. Hydrography of Temple Ponds in Chempazhanthy rural area (at your place) of Trivandrum district, Southern Kerala
6. Modeling of groundwater chemistry of Palakkad urban area (at your place) using statistical tools
7. Physico-chemical aspects of well water resources in coastal areas of Neendakara, Kollam district

CONTINUED

1. geochemical characterization of recently deposited sediments of ashtamudi estuary, kollam, southwestern india
   - hydrochemical framework of killi ar, a major tributary of karamana river, thruvananthapuram, southern kerala
   - major ion chemistry and compositional structure of selected groundwater sources of karamana river basin, southern kerala
   - hydrochemistry of peppara and aruvikkara reservoirs with special reference to drinking water quality
   - the dynamics of phosphorus in an urban-fringe estuarine system: an example from cochin, sw coast of india
   - “mercury geochemistry of recent sedimentary environs of the river dominated mixing zone in a tropical coastal estuarine system”, sw india

CONTACT DETAILS

Dr. K. ANOOP KRISHNAN
Scientist
Chemical Sciences Division, Centre for Earth Science Studies (CESS)
P.B. No. 7250, Akkulam, Trivandrum-31, Kerala, India
Ph: +91-(0)471 2511690 (off), +91-(0)471 2442280 (fax), +91-(0)9447402468 (cell)
E-mail: sreeanoop@rediffmail.com, sreeanoop@yahoo.com, sreeanoop@cess.res.in
URL: http://cess.res.in/people/dr-anoop-krishnan-k/profile.html
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