EXECUTIVE SUMMARY OF THE FINAL REPORT WORK DONE ON THE MAJOR RESEARCH PROJECT

1.	Title of the Project	**Identification of sources of Groundwater Salinization in parts of Nagapattinam and Karaikal coastal aquifers: a Geophysical, Hydrochemical and Isotopic approach**
2.	Name and Address of the Principal Investigator	**Dr.K.Srinivasamoorthy Associate Professor and PI, Department of Earth Sciences, School of Physical, Chemical and Applied Sciences, Pondicherry University, Puducherry – 605 014.**
3.	Name and Address of the Institution	**Pondicherry University, R.Venkatraman Nagar, Kalapet, Puducherry – 605 014.**
4.	UGC approval letter No. and Date	**41-1036/2012 (SR) dated.01.07.2012.**
5.	Date of Implementation	**01.07.2012.**
6.	Tenure of the Project	**3 Years from 01.07.2012 to 31.12.2015**
7.	Total Grant Allocated	**Rs.10,04,620/-**
8.	Total Grant Received	**Rs. 7,54,300/-**
9.	Final Expenditure	**Rs.9,59,502/-**
10.	Title of the Project	**"Identification of sources of Groundwater Salinization in parts of Nagapattinam and Karaikal coastal aquifers: a Geophysical, Hydrochemical and Isotopic approach".**

11. OBJECTIVES OF THE PROJECT:

- Identifying Groundwater flow pattern, characterization of aquifer systems, delineating and characterizing chemical behaviour of the aquifer systems in the study area.
- To identify the seasonal and temporal variations of groundwater in space and time to decipher the complex hydrogeochemical process activated in the study area.
- To identify the location of major pollutant sources (e.g.) landfill site, shrimp culture, agricultural or sewage disposal facility) delineation of saline water intrusion and migration of the pollutant in aquifer systems.
- Identification of groundwater potential and recharge zones as protection priorities.
- Isolating geochemical susceptibility zones based on the complexity of groundwater chemistry using geophysical, hydrochemical and isotopic significances.

12. WHETHER THE OBJECTIVES WERE ACHIEVED:

Yes the objectives were achieved.

The resistivity investigations demarcated a total of five layered curves. The dominant curve type represented is KHK. Higher resistivity values demarcated unpolluted nature of

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aquifer and lower resistivity values (<0.5 Ω m) indicated contaminated nature of the aquifers. Groundwater samples collected for four different seasons by considering natural geochemical processes and anthropogenic sources demarcates younger groundwater starting from Ca^{2+}-HCO_3 type to saline groundwater of Na^{+}-Cl^{-} type indicating water chemistry influenced by weathering, cation exchange and simple mixing. The REEs in groundwater found to be decreasing with increasing distance offshore indicating significant REE source to sea water end member. The $\delta^{18}O$ and $\delta^{2}H$ increases towards the sea suggesting enrichment attributed to the sea water influence. SEAWAT model predicts saline intrusion mainly due to groundwater withdrawal. Final sources of groundwater salinization were demarcated.

13. ACHIEVEMENTS FROM THE PROJECT

- Resistivity investigations were attempted and results were interpreted.
- Groundwater samples were collected for four different seasons and the sources for salinization were demarcated.
- The REEs and isotopes ($\delta^{18}O$ and $\delta^{2}H$) were used as tool to discriminate the saline sources.
- SEAWAT model predicted saline intrusion due to excess groundwater withdrawal.
- Final sources of groundwater salinization were demarcated along with suggestions to mitigate the same.
- One Ph.D awarded.
- Six publications out of the project.

14. SUMMARY OF THE FINDINGS (500 words)

The study area receives major rainfall from Northeast monsoon. The area is underlined by sedimentary formations ranging in age from Miocene to Quaternary with major observed soil type as Clay, clayey loam, silty clay, sandy clay, loam, sandy loam and sand. The main aquifers noted in the area were the lower Miocene deeper aquifers and Pliocene – Quaternary shallow aquifers. Majority of groundwater resources used for different utilities in the study area are mainly from shallow Pliocene quaternary shallow aquifers. Peizometric head varies between 4.43 to 12.25m BGL during PRM and 2.10 – 10.20 m BGL during POM season. Resistivity survey demarcated a total of five layers. The curves suggest unconsolidated nature of the formations characterized by sands and clay/shale formations. The resistivity pseudo cross section demarcated sea water intrusion at a depth of 30 m with a lateral extent of 7 to 10

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Km along the western parts of the study area. Higher EC observed during SWM along eastern part of the study area. Silica higher during SUM suggests sources from silicate minerals and cation exchange reactions. Sodium in groundwater and surface water suggests sources from feldspar weathering and sea water intrusion. Higher Br during NEM indicates influence of sea water intrusion along north-eastern parts of the study area. Ionic ratio plots suggest sources from sea water intrusion, ionic exchange process, reverse ion exchange, agricultural and domestic influences. Saline water ratio suggests salinization prominent along eastern and southern parts of the study area. Prominences of other sources for salinization were isolated along the western and southern parts of the study area. The sodium adsorption ratio suggests majority of groundwater samples exhibit excellent to good for irrigation utilities. The residual sodium carbonate suggests majority of water samples not suitable for irrigation purposes. The factor score isolated three prominent saline sources in groundwater as sea water intrusion noted along western and southern parts of the study area, rock weathering/ion exchange noted along central and western parts of the study area, agricultural and domestic influences along the central parts of the study area. Trace and rare elements suggest influences of anthropogenic and seawater intrusion. The $\delta^{18}O$ and $\delta^{2}H$ values increase towards sea suggesting influence from sea water. SEAWAT modelling attempted isolates saline intrusion along the western parts of the study area and model stimulation suggests the condition to worsen further by considering the present pumping scenario. Comparison of groundwater salinization sources suggests sea water intrusion up to 5 km inland and vertically up to 5 to 10 km inland. Water quality index calculated for the water samples confirms different sources of salinization. Comparison of saline sources with trace elements and REEs suggest sea water intrusion, rock water/ion exchange and agricultural influences already demarcated were in good correlation. The increase of $\delta^{18}O$ and $\delta^{2}H$ value towards sea suggests sources of sea water intrusion.

15. CONTRIBUTION TO THE SOCIETY (Give Details)

The study demarcated multiple sources of salinization that influences and destroys agricultural yield and lands, Jeopardize livelihoods by making water unfit for human consumption and increase in costs of industrial processes. All this factors depend on how effectively the available groundwater is utilized to meet the future demand. In order to manage groundwater salinization, policy makers, scientists and stake holders should be informed about the severity of present scenario of salinization. This study will contribute to provide such essential information to the peoples to promote and enhance their understanding about the sources and pathways of groundwater salinity. The study also gives information

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about the present status of salinization and its influence on the public so as to develop proper measures to mitigate or adapt to groundwater salinity.

16. WHETHER ANY PH.D ENROLLED/PRODUCED OUT OF THE PROJECT

Yes, Dr.S.Gopinath has been awarded Ph.D by using the data sets generated from the project.

17. NO. OF PUBLICATIONS OUT OF THE PROJECT.

1. Gopinath.S and Srinivasamoorthy.K., (2014) Geophysical VES approach for seawater intrusion assessment in Nagapattinam and Karaikal coastal aquifers, India. Coastal Resource Management Strategies and Spatial Technology, 13(14):50–56.

2. Gopinath S, Srinivasamoorthy K (2015) Application of Geophysical and Hydrogeochemical Tracers to investigate Salinisation Sources In Nagapatinam and Karaikal Coastal Aquifers, South India (2015)., Aquatic Procedia 4 (2015) 65 – 71.

3. S. Gopinath, K. Srinivasamoorthy, M, Vasanthavigar, K. Saravanan, R. Prakash, C. S. Suma & D. Senthilnathan (2015), "Hydrochemical characteristics and salinity of groundwater in parts of Nagapattinam district of Tamil Nadu and the Union Territory of Puducherry, India, Carbonates Evaporites, DOI 10.1007/s13146-016-0300-y.

4. S. Gopinath, K. Srinivasamoorthy, K. Saravanan, R. Prakash, C.S. Suma, Faizal Khan, D. Senthilnathan, V.S. Sarma, Padmavathi Devi (2015) Hydrogeochemical characteristics of coastal groundwater in Nagapattinam and Karaikal aquifers: implications for saline intrusion and agricultural suitability. Journal of Coastal Sciences, Volume 2 Issue No. 2 - 2015 Pages 1-11.

5. S. Gopinath, K. Srinivasamoorthy, K. Saravanan, C. S. Suma, R. Prakash, D. Senthilnathan, N. Chandrasekaran, Y. Srinivas and V. S. Sarma (2016) Modeling saline water intrusion in Nagapattinam coastal aquifers, Tamilnadu, India, Modeling Earth Systems and Environment, DOI 10.1007/s40808-015-0058-6.

6. S.Gopinath, K.Srinivasamoorthy, K.Saravanan, C.S.Suma, R. Prakash, D.Senthinathan and VS.Sarma.Vertical Electrical Sounding for Mapping Saline Water Intrusion in Coastal Aquifers of Nagapattian and Karaikkal, South India. Sustainable Water Resources Management (2017). DOI 10.1007/s 40899-017-0178-4.

K. Srinivasamoorthy

(PRINCIPAL INVESTIGATOR)

Dr. K. SRINIVASAMOORTHY
Associate Professor
Department of Earth Sciences
Pondicherry University
Puducherry - 605 014, India.

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