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CONTENTS

Investigating Coastal Sediment Characteristics: A Comprehensive Study of Grain Size Analysis in and Around the Vedaranyam Coast, Tamil Nadu, India

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Abstract

This comprehensive study investigates the coastal geomorphology and sediment characteristics from Kodiakkarai to Vedaranyam in the southeast coastal tract of Tamil Nadu, India. Auger samples from 30 locations were analyzed to understand grain size variations, mineralogical composition, and sediment deposition mechanisms. Field observations revealed diverse geomorphological features, including beach ridges, swales, rivers, mudflats, and backwaters. Cumulative frequency curves displayed predominantly unimodal distributions, with some samples exhibiting bimodal patterns. Grain size parameters, such as mean size, standard deviation, skewness, and kurtosis, were extensively used to characterize sediments. The study provides insights into the depositional environment, showcasing features from fine to coarse sand, well-sorted to poorly sorted, and strongly coarse-skewed to very finely skew. Sedimentological patterns on the beach are attributed to marine processes.

Keywords: Coastal geomorphology, sedimentology, grain size distribution, cumulative frequency curves, marine processes, mineralogical, depositional environment, Tamil Nadu, India.

Introduction

The southern coastal tract of Tamil Nadu, spanning 360 km from Kodiyakarai to Arcottuthurai (Latitudes 10°16' to 10°23' N and Longitudes 79°48' to 79°52' E), is situated in the Nagapattinam district at the southern tip of India. Well-connected by roads and railways, the region's economic pillars include agriculture, tourism, fishing, and aquaculture. Geologically diverse, the area showcases formations from the Archaean, Mesozoic, Tertiary, and Quaternary ages. The predominantly flat land features extensive black and alluvial soil inland and coarse sand along the seashore. With a tropical climate, the highest temperature recorded is 40.3°C in June, and the lowest is 20.4°C in January. Annual precipitation is 1,369 mm, with 55% during the northeast monsoon and 45% during the southwest monsoon. Denudational landforms like shallow and deep buried pediments surround the region. In the Cuddalore region, Tertiary-age Cuddalore sandstone dominates, with sedimentary high grounds exceeding 80 meters. The eastern coastal region, covering the majority of the district, includes flood plains of various ages and coastal beach landforms. The gently angled coastal

slope gives way to marine sedimentary plains. Non-shore areas between coastal sedimentary fields and surface flood plains comprise sand dunes and back swamps.

Study Area

The southern coastal tract of Tamil Nadu, spanning 360 km from Kodiyakarai to Arcottuthurai (Latitudes 10°16' to 10°23' N and Longitudes 79°48' to 79°52' E), is situated in the Nagapattinam district at the southern tip of India. Well-connected by roads and railways, the region's economic pillars include agriculture, tourism, fishing, and aquaculture. Geologically diverse, the area showcases formations from the Archaean, Mesozoic, Tertiary, and Quaternary ages. The predominantly flat land features extensive black and alluvial soil inland and coarse sand along the seashore. With a tropical climate, the highest temperature recorded is 40.3°C in June, and the lowest is 20.4°C in January. Annual precipitation is 1,369 mm, with 55% during the northeast monsoon and 45% during the southwest monsoon. Denudational landforms like shallow and deep buried pediments surround the region. In the Cuddalore region, Tertiary-age Cuddalore sandstone dominates, with sedimentary high grounds exceeding 80 meters. The eastern coastal region, covering the majority of the district, includes flood plains of various ages and coastal beach landforms. The gently angled coastal slope gives way to marine sedimentary plains. Non-shore areas between coastal sedimentary fields and surface flood plains comprise sand dunes and back swamps.

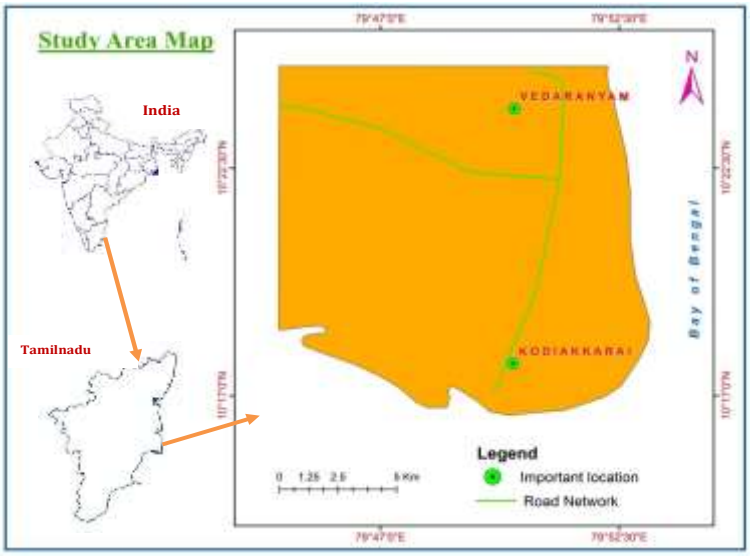

Figure 1 Study area map

Drainage: The district is drained by several rivers, including Kollidam and Cauvery in the north, Virasolanar and Uppanar in the central part, and Arasalar, Tirumalairajan Ar, Vettar, Kedurai Ar, Pandavaiar, Vedaranyam canal, and Harichandra Nadi in the southern part of the district.

Rainfall and Climate: The district experiences rainfall influenced by both southwest and northeast monsoons. Intensive storms, often associated with cyclones from the Bay of Bengal, contribute to the rainfall, which occurs almost throughout the year. The normal annual rainfall is approximately 1230 mm, with variations across different parts of the district. The climate is humid and tropical, characterized by hot summers, mild winters, and moderate to heavy rainfall. Temperatures range from 40.6 to 19.3°C, with higher relative humidity (70–77%) during October to November.

Geology and Soils: The predominant soil textures in the Cauvery delta include clayey, clayey loamy, silty clay, sandy clay, loamy, sandy loam, and sandy soils. The soils are characterized by high clay content, low nitrogen and phosphorus, and high potassium and lime content. Along the east coast, soils are predominantly sandy loam near the surface, transitioning to sandy clay loam below, with higher sodium content and poor drainage. The district has 15 identified soil series, with major ones including Kolathur, Adhanur, Kilvelur, and Meelkadu. Hydrological soil groups A, B, C, and D are widespread, indicating varying infiltration and runoff potential in different blocks.

Geomorphology: Due to underlying sedimentary formations, the district exhibits natural levees near Mayiladuthurai, covering the entire district. The coastal plain features beaches, beach ridges, mud flats, swamps, and backwaters. Deltaic plains are present near the confluence of the River Coleroon with the sea in the east and in the south. Floodplain deposits are observed along river courses.

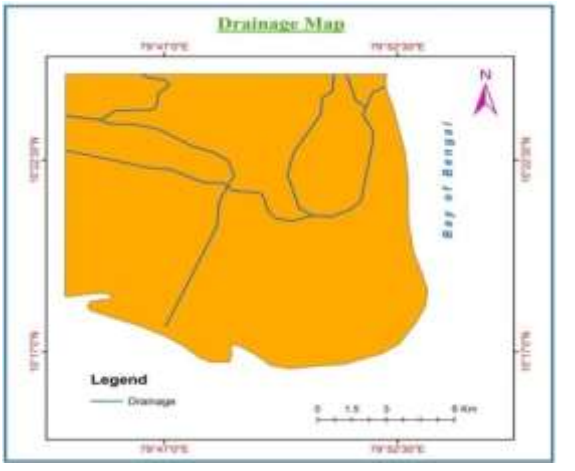

Figure 2 Drainage map

Materials and Methods

Field Work and Sample Collection

Broad field work was conducted in the Kodiyakarai to Arcottuthurai coast to collect the sediment, the field equipment's like measuring tape, camera, field note, pen, pencil, and eraser, hammer and study area Toposheets are taken to the field. To know geographical location and accessibility byusing GPS (Global Positioning System) readings. The GPS helps to access the places easily. While traversing along the beaches,the nature and type of coastal features are taken note of. In beach, lagoon and dune are recorded. Thirty samples were collected using augur sampling technique.

Table 1 Latitude and longitude values sample collected in the study area

ID	LATTITUDE	LONGITUDE	LOCATION
1	10º16'28"	79º48'59"	Kodiyakarai
2	10º16'28"	79º48'59"	Kodiyakarai
3	10º16'29"	79º50'00"	Kodiyakarai
4	10º16'51"	79º49'49"	Kodiyakarai
5	10º16'29"	79º49'0"	Kodiyakarai
6	10º22'28"	79º52'13"	Vedharanyam
7	10º22'28"	79º52'13"	Vedharanyam
8	10º22'28"	79º52'17"	Vedharanyam
9	10º22'30"	79º52'09"	Vedharanyam
10	10º22'22"	79º52'13"	Vedharanyam

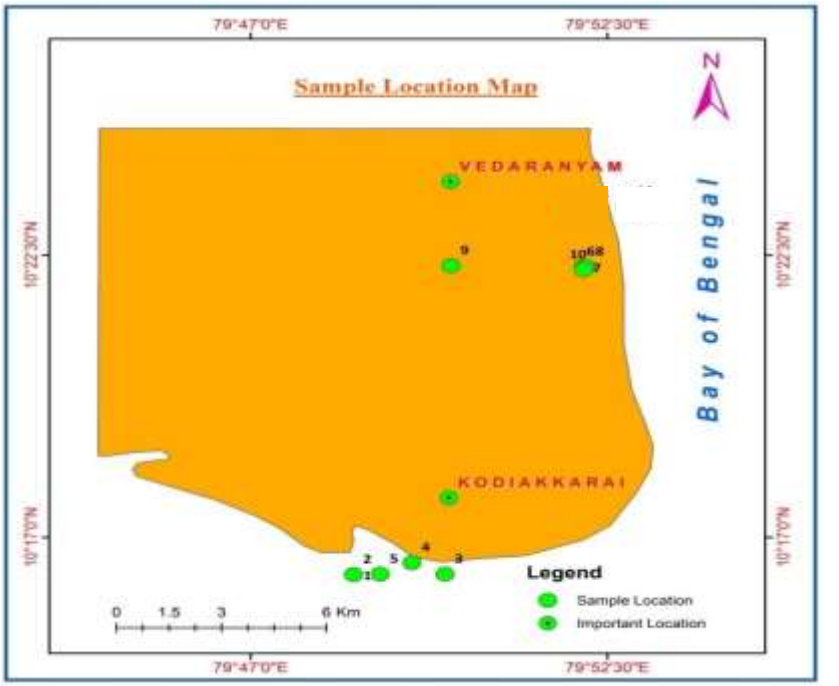

Figure 3 Sample location map

Samples Analysis

Thirty collected samples underwent sedimentological analysis after being subjected to a hot air oven at 60°C for moisture content removal. The bulk and dominant samples were selected and processed using the coning and quartering method. Subsequently, dry sieving was conducted following the flow chart methodology adopted in the study.

Laboratory Procedure: Sieve Analysis

Sample Preparation: Samples (SB 1- SB 14) were cleaned, and 100g of sediments were sieved for 20 minutes using a mechanical Rotap sieve shaker.

Sieving Process: Sieve sets were arranged in descending order of grain size at half phi intervals (+40, +45, +50, +60, +70, +80, +100, +120, +140, +170, +230, +270, and -270 in ASTM sieves).

Calculation: Each fraction's weight was measured, and size parameters were calculated using Folk and Ward's (1968) methodology. Cumulative weight percentages were also determined.

Grain Size Parameters: Two methods, the moment method and graphic method, were employed for calculating grain size parameters. The graphic method, involving the creation of a graph and taking quantitative readings, was particularly emphasized, following Folk (1966).

Sampling Technique:The sieving technique, proposed by Ingram (1971), was applied to separate grains of various size classes. Initially, 100g of the sample was prepared by removing carbonate and organic matters using dilute hydrochloric acid and hydrogen peroxide, respectively. The cleaned samples underwent a 20-minute sieving process using Ro-tap sieve shaker machine. B.S.S aperture size sieves were arranged on phi (ϕ) intervals starting from +40, +45, +50, +60, +70, +80, +100, +120, +140, +170, +230, +270, and -270 in ASTM sieves. Size parameters were calculated using Folk and Ward's (1968) and Inman's method (1958).

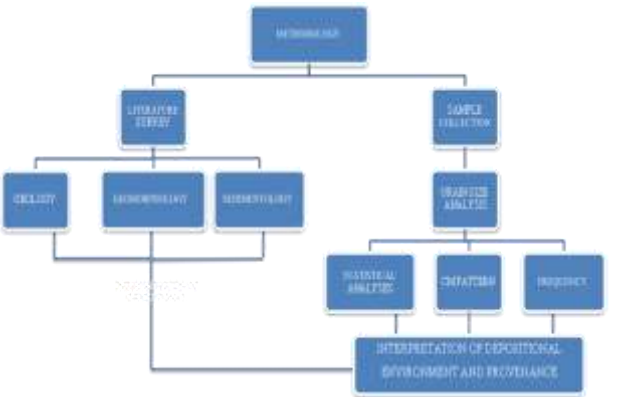

Figure 4 Flowchart showing the Methodology of the study

Coastal Geomorphology

The study of coastal geomorphological landforms is crucial for understanding coastal processes and guiding effective coastal zone management. In this study, multi-temporal satellite data, particularly Landsat ETM data from the year 2020, was employed to generate a coastal geomorphological map. Image pre-processing techniques were applied to rectify geometric and radiometric errors in the satellite data. The Landsat image was registered to a previously registered ETM base year image using the Universal Transverse Mercator (UTM) Zone-Datum World Geocoded System (WGS) 84. Following the rectification process, an Area of Interest (AOI) was selected, and initial study sites were subsetted and designated in the ETM image. Digital development of the satellite data was performed using ArcGIS 10.7 software, facilitating the identification of various depositional and erosional coastal geomorphological landforms in the study area. The coastal geomorphological landforms observed in the study region are primarily associated with the Cauvery delta. These landforms include different fluvial, fluvio-marine, and marine features. The finer declaration of geomorphic interpretation aimed to calculate the responses of the geosystems. The digitally processed satellite data revealed several coastal geomorphic features, including Beach Ridge (Young Coastal Plain), Coastal Plain, Lagoon (Young Coastal Plain), Mud Flat (Young Coastal Plain), Sand Dune, and Swale. While the entire study region exhibited coastal geomorphological features, positive features such as clear drainage systems and rivers were identified throughout the area. Erosional landforms, like low beach cliffs observed in some locations, were also noted. The comprehensive mapping of coastal geomorphological features provides valuable insights into the natural processes involved in their formation and distribution, contributing to a better understanding of the coastal dynamics in the Cauvery delta.

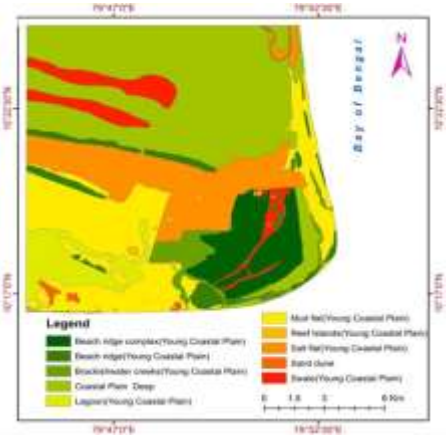

Figure 5Coastal geomorphology

Beach Ridge

A beach ridge is a ridge parallel to the shoreline formed by wave action, commonly composed of sand and sediment derived from underlying beach material. The process of sediment movement by waves is known as littoral transport, and the parallel movement along the shoreline is referred to as longshore transport.

Coastal Plain

A coastal plain is a flat and low-lying piece of land adjacent to the ocean. These plains are distinct from the interior by nearby landforms such as mountains.

Lagoon

A lagoon is a shallow body of water separated from a larger body by barrier islands or reefs. Coastal lagoons and atoll lagoons are common types. They are identified in areas with mixed sand and gravel coastlines.

Mudflat

Mudflats, also known as tidal flats, are coastal wetlands formed in intertidal areas where sediments accumulate due to tides or river deposits. Global analysis suggests their extensive presence, comparable to mangroves. Mudflats are found in sheltered areas like bays, bayous, lagoons, and estuaries.

Sand Dune

A sand dune is a mound, hill, or ridge of sand situated behind the beach affected by tides. Over time, windblown sand is trapped by beach grass or stationary objects. The form and location of dunes regularly change due to the influence of wind and waves.

Swale

A swale is a shady or marshy place, where it refers to a shallow channel with gently sloping sides. Swales can be either natural or man-made, and artificial swales are often designed as infiltration basins to manage water runoff, filter pollutants, and enhance rainwater infiltration.

Grainsize analysis

Grain size stands out as a fundamental characteristic of sediment particles, influencing their entrainment, transport, and deposition (Ikhane et al., 2013). Utilizing data derived from sieve analysis, a graphical representation of beach sediments from Vedaranyam to Kodiakkarai was meticulously crafted in the form of histograms and cumulative curves. The histogram, a widely employed method for presenting grain size data, is essentially a bar diagram where the weight percentage of sediment in each size class is depicted as rectangular bars. Conventionally, grain size is plotted on the abscissa (X-axis), while the frequency weight percentage is represented on the ordinate (Y-axis). In most sediment histograms, a unimodal distribution, termed a modal class, is observed. However, instances of bimodal or polymodal distribution may arise. Bimodal distributions exhibit two distinct maximum bars, whereas polymodal distributions showcase multiple maximum bars. Frequency curves, portrayed as smooth curves, illustrate the variation in weight percentage as a continuous function of

grain size. The grain size is plotted on the x-axis (abscissa), while the cumulative weight percentage is plotted on the y-axis (ordinate), typically ranging from 0 to 100 percentages. The frequency curves provide an overview of the total sediments. The majority of samples from the study area exhibit a unimodal distribution, with only a few showcasing a bimodal pattern. According to Sahu (1964), the emergence of unimodal and bimodal distributions may be attributed to the diversity in the size range of source materials and the derivation of sediments from one or two sources (Pettijohn, 1984).

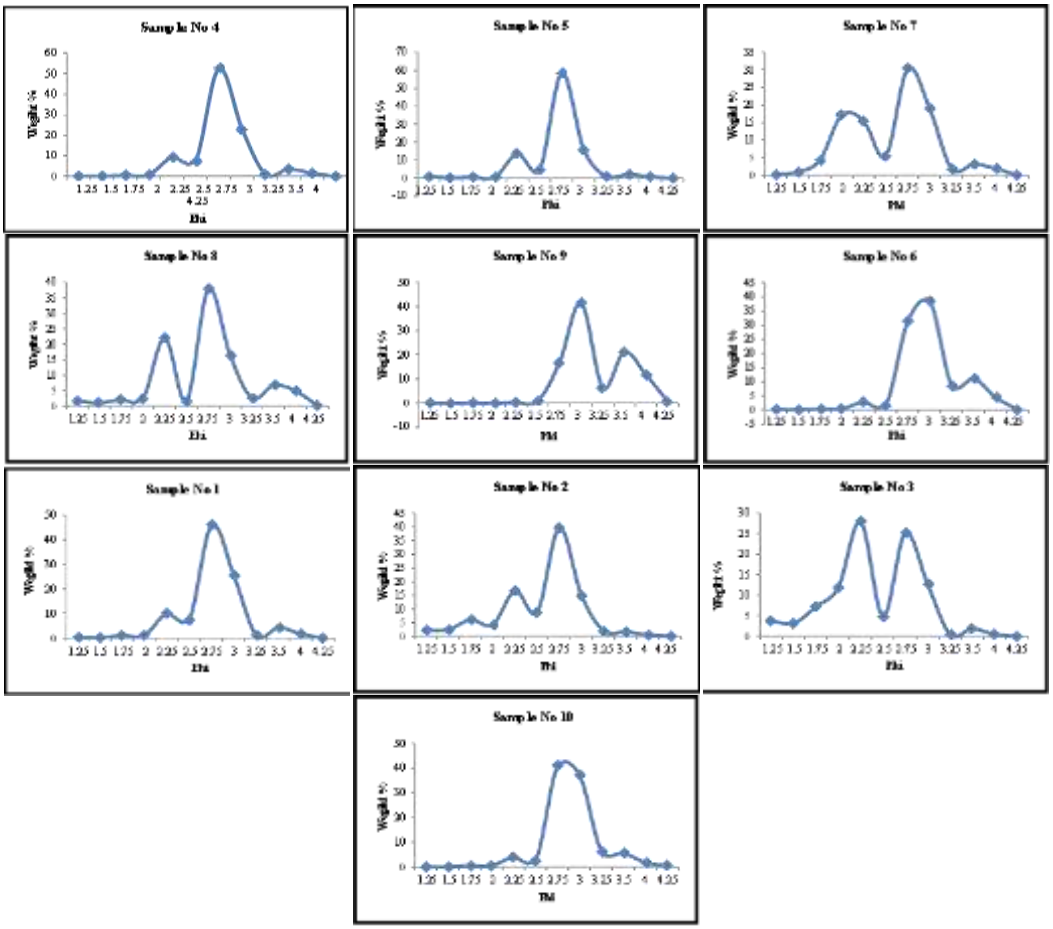

Figure 6 Frequency curves of Sample.1, 2, 3, 4, 5, 6, 7, 8, 9 & 10

Basic Statistical Parameters

Four fundamental grain size parameters, crucial for describing grain size distribution, are mean, standard deviation, skewness, and kurtosis. Additionally, median and mode play significant roles in understanding variations in grain size concerning the environment of deposition and energy conditions of the depositing medium (Folk and Ward, 1957). The

geostatistical parameters mean, median, sorting, skewness, and kurtosis are calculated using the formulas proposed by Folk and Ward (1968) and Inman (1958).

Mean: The statistical average expressed in phi (ϕ) units. Different formulas have been suggested by various researchers, but the widely accepted one is proposed by Folk and Ward (1957). The mean represents the average size of the total distribution of sediments.

Median: The size at which half of the particles, by weight, are coarser, and half are finer.

Mode: The most frequently occurring particle diameter.

Sorting: Measured by a coefficient, which is the square root of the ratio of quartiles q3/q1, where q3 and q1 are the 25th and 75th percentage values, respectively. Perfectly sorted sediments have a coefficient of 1.0.

Skewness: A measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. Skewness may be measured by q1q3/(median). Skewness values can be positive, negative, or even undefined.

Kurtosis: A measure of peakedness expressed as q3-q1/2(p90-p10). Based on the procedures illustrated by Folk & Ward (1958) and Inman (1958), graphical measures were calculated from the cumulative frequency, providing insight into the nature of the beach sediments from Kodiyakarai to Arcottuthurai.

Folk &Ward Formula (1958)

Median=50 percentile

Mean $m\Phi=P_{60}+P_{50}+P_{84}/3$

Standard deviation (or) dispersion Md $\Phi=P_{84}-P_{16}/ 4+ P_{95}+P_{5}/6.6$

Skewness= $(P_{16}+P_{85})\_ P_{50}/ 2(P_{84}\_ P_{16})$

Kurtosis=$(P_{95}\_P_{5})/2.44(P_{75}\_P_{25})$.

GRADISTAT Software

Samples have been sieved for grain size and the data were analyzed based on the GRADISTAT program (version 8.0). Textural parameters were calculated using software GRADISTAT version 8.0 (Blott 2000), and are given according to the method proposed by Folk and Ward (1957). The following are interpretations.

Mean

Mean is the statistical average expressed in phi (Φ) units. Different researchers have suggested different formulae, for calculating these statistical parameters, but the widely accepted one is put forward by Folk and Ward (1957). In the present study most of the samples from Kodiyakarai to Arucottuthurai region are beach sediment is very coarse silt to fine sand.

Sorting Coefficient

From the measurement of sorting valve or standard deviation or dispersion, the following classes are suggested by folk (1968).

Lessthan 0.35	-very well sorted
0.35- 0.50	-well sorted
0.50- 0.71	-moderately well sorted
0.71- 1.00	-moderately sorted
1.00- 2.00	-poorly sorted
2.00- 4.00	-very poorly sorted

Morethan4.00 -extremely poorly sorted (Babu & Simha)

Standard deviation of beach sediments of study area shows the range from 0.3 to 2which falls on the category of very well sorted from**poorly sorted**. Kodiyakarai to Arcottuthurai beach having very poorly sorted.

Skewness

Skewness value is the pure number and this value is represented with a positive or negative sign. Symmetrical curves have skewness value -0.01; excess of fine materials is positively skewed, while negatively skewness result shows with an excess of coarse material. The following of the values of skewness of any deposits is suggested by folk as follows (folk&ward)

- +1.0to+0.3 -very fine skewed
- +0.3to+0.10-fine skewed
- +0.10to-0.10-nearlysymmetrical
- -0.10to-0.30-coarselyskewed
- -0.30to-0.1 -strongly coarse skewed

The skewness class of beach sediment of study area skewed within the range from-**0.027 to 0.54** which falls on the category of the strongly coarse skewed to very finely skewed.

Kurtosis

Kurtosisispeakednesslikeskewnessinvolvestheratioofspreadhenceitisapurenumberthe following are the limit for kurtosis byfolk (1968)

- Lessthan0.67 -very platykurtic
- 0.67–0.90 -platykurtic
- 0.90–1.11 -mesokurtic
- 1.11–1.50 -leptokurtic
- 1.50–3.00 -very leptourtic
- Morethan3.00 -extremely leptokurtic

Kurtosis value was ranging from **1.033** to **21.06 which** are shown in the study area. Samples present in meso kurtic to extremely leptokurtic. The beach sediment of the study area shows generally, the mean, standard deviation, skewness 0.01 to + 0.2, kurtosis classes 0.7 to 1.2, which are represented as, well sorted to moderately sorted, finely skewed to symmetrical, and platy kurtic to mesokurtic respectively.

Table 2 Textural Parameters of Beach Sediments

S. No	Mean	Std Deviation	Skewness	Kurtosis	Mean class	Std Deviation class	Skewness class	Kurtosis class
1	2.63	0.38	-1.13	12.69	Fine sand	Very Well sorted	Symmetrical	Very Leptokurtic
2	2.39	0.57	-1.96	9.69	Fines and	Well Sorted	Very coarse Skwened	Mesokurtic
3	2.21	0.64	-1.61	7.47	Fines and	Well Sorted	Symmetrical	Mesokurtic
4	2.64	0.32	-0.46	11.8	Fine sand	Very Well Sorted	Symmetrical	Very Leptokurtic
5	2.56	0.40	-2.70	21.06	Fine sand	Very Well Sorted	Coarse Skewed	Very Leptokurtic
6	2.85	0.37	-0.79	11.68	Fine sand	Very Well Sorted	Fine Skewed	Leptokurtic
7	2.44	0.48	-0.10	4.02	Fines and	Well Sorted	Coarse Skewed	Platykurtic
8	2.56	0.59	-1.26	8.64	Fines and	Well Sorted	Symmetrical	Leptokurtic
9	3.04	0.38	-0.08	6.83	Very fine sand	Well Sorted	Very Fine Skwened	Mesokurtic
10	2.77	0.33	-0.18	10.81	Fine sand	Very Wel lSorted	Symmetrical	Leptokurtic

Conclusion

This comprehensive study encompasses crucial aspects of the current research, focusing on the interpretation of field and laboratory studies to achieve the predefined objectives, including the investigation of geomorphological changes and mineralogical characteristics. The study spans from Kodiakkarai to Vedaranyam in the southeast coastal tract of Tamil Nadu, characterized by a humid climate and a diverse drainage pattern featuring rivers such as Kollidam, Cauvery, Virasolanar, Uppanar, Arasalar, Tirumalairajan Ar, Vettar, Kedurai AR, Pandavaiar, Vedaranyam canal, and Harichandra Nadi. The primary goal is to uncover coastal geomorphic processes, mineral nature, and their provenance. Fourteen auger samples were analyzed to understand grain size variations and identify minerals. The study delves into the grain-size distributions of sediments, shedding light on the mechanisms of sediment deposition. Field observations reveal various geomorphological features, including beach ridges, swales, rivers, mudflats, paleo tidal flats, backwaters, creeks, salt pans, and more. Cumulative frequency curves indicate a predominantly unimodal distribution in the majority of samples, with a few exhibiting a bimodal distribution. This variability may arise from differences in the size range of source material and the derivation of sediments from one or two sources. The grain size parameters, including mean size, standard deviation,

skewness, and kurtosis, are extensively used in this study. The characteristic grain size distribution of beach and dune sediments provides insights into the depositional environment of the study area. The textural characteristics of the sediments from various beach environments indicate a range of features, such as fine to coarse sand, very well-sorted to poorly sorted, strongly coarse-skewed to very finely skewed, and mesokurtic to extremely leptokurtic, as represented by skewness and kurtosis values. Sedimentological studies emphasize that depositional patterns on the beach are primarily influenced by marine processes.

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Palaeo-Environmental Reconstruction Using Benthic For *aminifera* in the gulf of munnar, Ramanathapuram, Tamilnadu, India

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INTRODUCTION

Oneofthebasictenetsofgeologyist hepresentisthekeytothe past. In thepresent context this simply means that if we document the distribution of organisms today, and have somedegreeofunderstandingofwhatcom binationof environmental variables controlsthose distributions, then we can use this information to reconstruct past environments by using the fossilized representatives of the modern organisms as Paleoenvironmental indicators. This classicuseofmicrofossils,alongwithbiost ratigraphy,isofgreatsignificanceinthesea rchfor oil and gas.Thecoast isauniqueenvironment, whereLand, Seaand atmosphere interact and interplay continuously influencing a strip of spatial zone defined as a Coastal zone. These Coastal zones are important as they are most Dynamic, Fragile and amenable to changes due to changing terrestrial and mare processes, including human activities. Hurricane, Typhoon, Tornado, Storm and Tsunami are the natural hazards which are usually disturb the coastal environment and ecosystem. All these coastal disasters lead to potentially serious forms of coastalfloodrisk.Theyoftencausewidespr eadfloodingacrosslowlyingcoastalareasa ndon many occasions cause loss and damage to the life and structures. The flooding on the coast duringthe stormandtsunamiareoften associated withthedepositionofmarinesediments. A definiteidentificationofPalaeotsunamior Stormdepositsingesontherecognitionofa smany diagnostic characteristics as possible. However, it's still important to understand the context conditionsatthetimeofdeposition(Witter etal2001)andabletoidentify aprobabletsunami source if possible. The systematic study of such sediments can provide much valuable informationabouttheincidenceanddistrib utionoftheseeventsinthepast.Thispropos edpiece of research will be attempted in this direction through micro paleontological analysis particularly foraminiferal analysis which provides the information regarding the source and mode ofdeposition ofthe sediments ofanextreme event. The Scope of the study flashes the Palaeo depositional environmentsto relate the Micro Palaeontological observations of tsunami wave dynamics. Whether, the area had experienced an extreme event and if so, its cyclicity.AdetailedstudyonCoastalGeo

morphologyandGeologyoftheKadaladiregionin Southern East Coast ofTamilnadu. The present study used the environmental characteristics and Ostracodes and Foraminiferal distribution to determine the impact of Tsunami or Storm sediments (M.Sureshgandhi,A.Solai& S.P.Mohan 2007). To Study the coastal Geomorphology and method of trench sampling of thestudy area.To Study the method of separation of Microfossils.To Study the Micro faunal assemblage of the sediments.To Interpret the Palaeo depositional environment of the study area.

STUDYAREA

Ramanathapuram is a district located in the Southern part of TamilNadu on the East CoastofIndia.Itsgeographicallocationisspreadbetween905'and950'ofNorthLatitude and7810'and7927'ofEastLongitude(NADP,2008).Itispredominantinagricultural and fishingactivities.Thedistricthasatotalgeographicalareaof4233.44sq.km.Itisdividedinto seven Taluks such as Kadaladi, Kamuthi, Mudhugulathur, Paramakkudi, Ramanathapuram, Rameswaram andThiruvadanai.OutofsevenagroclimaticzonesofTamilNadu,thisdistrict falls under Southern zone (Balachandran, 2009). Kadaladi is a taluk also a block in RamanathapuramdistrictintheIndianstateofTamilNadu.Ramanathapuramdistrict is divided into 7 Taluks. The Taluks are further divided into 11 blocks, which further divided into 400 villages (Balachandran, 2009). Ramanathapuram district is surrounded by Pudukkottai district onNorth, Sivagangai and Virudhunagar districts, on the Northwest and West,ThoothukudidistrictadGulfofMannarontheSouth,andBayofBengalandPalkstrait on the East (Balachandran, 2009).

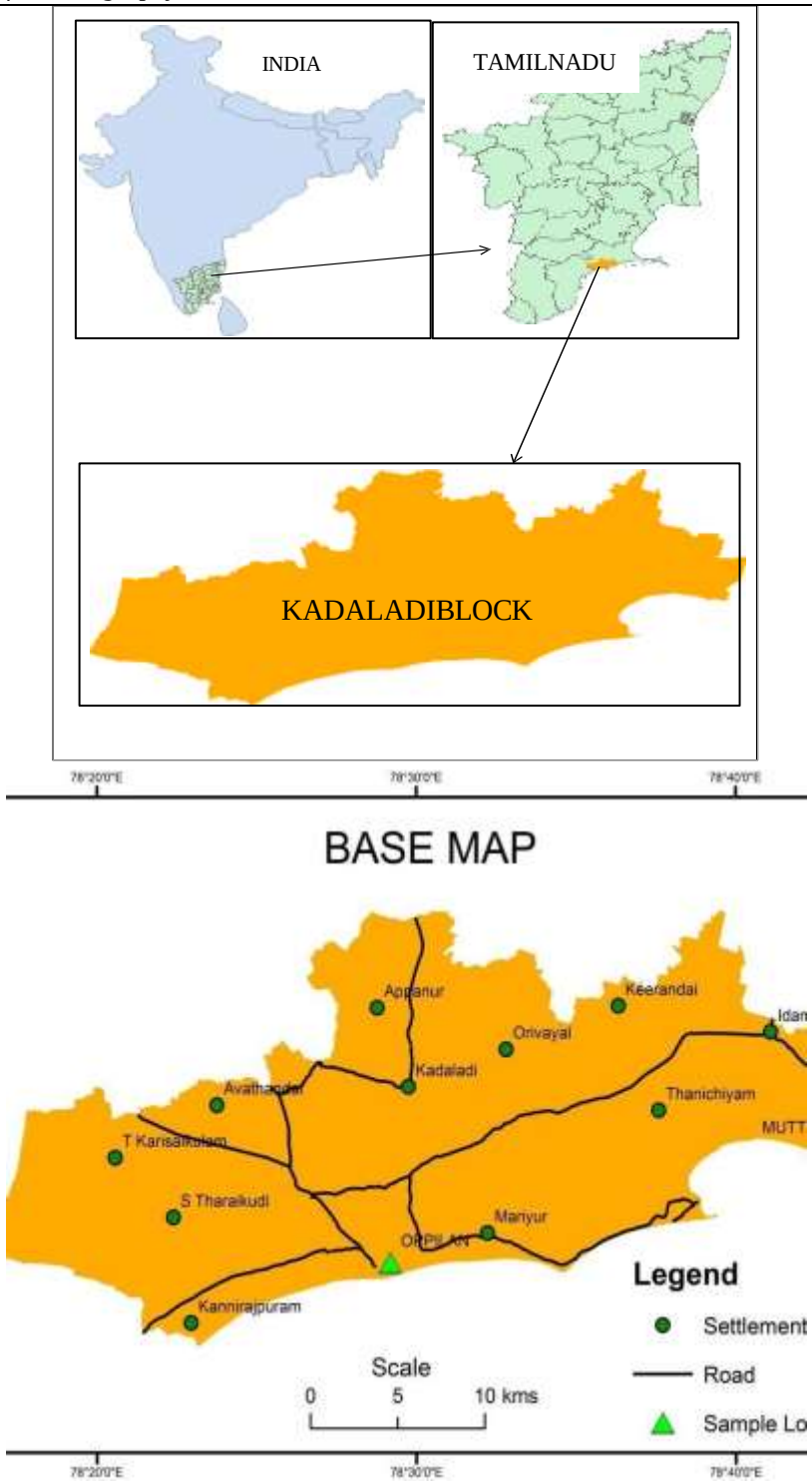

Fig.1:STUDYAREAMAP

GEOLOGICALSETTING

Most of the area is covered by the unconsolidated sediments of Quaternary age except in the Northwestern part, where isolated patches of Archean crystalline and Tertiary Sandstone are exposed. The Archean are mainly represented by the Charnockite group of rocks comprising Garnetiferous Granulite and the Khondalite group of rocks made up of Quartzite Gneisses (NADP, 2008). Tertiary Sandstone (Cuddalore Formation) comprises Pinkish, Yellowish, Reddish (variegated Colours) Medium to Coarse grained sandstone and Claystone.Itisoverlainbythinalluviumandexposedtowardsnorthof VaigaiRiver(NADP, 2008). Detached exposures of Laterite and Lateritic soil are seen in the Northwestern part of the district. A major part of the district is covered with the Fluvial, Fluvio-marine, Aeolian and Marine sediments of Quaternary age. The Fluvial deposits which are made up of Sand, SiltandClayinvaryingdegreeofadmixture occuralongtheactivechannelofVaigai,Gundar, ManimutharandPambarrivers.Theyhavebeencategorizedinto Levee,Floodbasin,Channel bar/ Point bar and Palaeo-channel deposits. The Palaeo channel deposits comprise brown coloured, fine to medium sands well-preserved Cross-beddings (Balachandran, 2009). The Aeoliandepositscompriseredsandswhichareinnatureofancientdunesandoccurovera

3.2KmwideandeightKmlongstretchandlieparalleltotheSeaCoast.Theseare separated bymarshydepositsofblackClays. TheSandsareunderlain by Calcareous Hardpan(NADP, 2008). Limestone, Graphite, Gypsum, Limonite and Garnet are the important mineral resources of the district (Balachandran, 2009).

HYDROLOGICAL SETTING

Thedistricthasbeendividedintothreezoneswith referencestoLaterite,Floodbasin andcoastalPlainareas respectively. FurtherthеareaisdemarcatedintoManimuthar-Pambar basin,VaigaideltaandVaipar-Gundarbasin.TheNorthwesternpartofthe Ramanathapuram district exposes isolated patches of Archean crystalline and Cuddalore Sandstone capped by Laterite/Lateritic Soil.The yields of bore wells of 60 to 90 m depth in the crystalline vary from 3 to 400 lpm draw down of 10-12m water head (NADP, 2008). The Saline aquifers in coastal tracts occur toa depth range of 80m from ground level followed by fresh water aquifers. The quality of ground water varies from alkaline to high saline types in the district (NADP, 2008). In Most places, Ground water available at a depth beyond 6 to 7m is Saline. The fresh water available within 6 to 7m depths dries up quickly within 2 to 3 months after Monsoon.Thereisacutedrinkingwatershortageinmostpartoftheyear.Hydrogeologically, the district can be classified as Omtofoir zones as detailed below (NADP, 2008). Areas covered by Sand Dunes, Beach ridges, Pockets of Strand Plains, Pockets of Natural Levees, PocketsofPalaeoChannels,PocketsofPed

imentsandValleyfillscoveredbyCrystalli neand Tertiary Sand stones. The depth of water level varies from few cm to 5M (NADP, 2008). It occurs in the Northern part of the district in Thiruvadanai Taluk.The Thickness of the Cretaceous aquifer is in the order of 20 to 30M. This is underlined by Crystalline basement. In the Artesian belt area of Thiruvadanai taluk of Ramanathapuram district, Fresh ground waterisavailableatadepthrangeof350m–450minandaroundThiruvadanai,Neerkundram, Vellaiyapuram andin some otherplaces of Thiruvadanai taluk (NADP, 2008). This occurs in certain Pockets ofriver course, Pockets ofPalaeo channels, PartsofPedimentsandValley fills and in major parts of stand plains (NADP,2008). The River flowing in the district is Vaigai,whichstartsfromMaduraiandendsatpalkstraightinRamanathapuram.Agriculture area is being irrigated by Cannals, Tanks (linked to Vaigai) and Ground water. Several plans andschemeshavebeenintroducedforuninterruptedwatersupplyforDomesticandEconomic activities(Balachandran, 2009).TheMajorpartof RamanathapuramdistrictfallsinGundur-VaigaiRiverbasin.VaigaiandGunduraretheimportantriversandinaddition,Virusuli , Kottakariyar and Uppar are the other rivers draining the district The Vaigai river originating from Madurai district enters the Ramanathapuram district, crosses Paramakudi and ends in AthankarairuntheThiruvadanaitaluk.TheriverGundarwhichoriginatesinKamuthitaluk entersinMudukulathurtalukandendsinRamanathapuramtaluk.Therearetworiverbasins and five minor basins in the district such as Vaigai river basin, Sarugani riverbasin, Manimutharminorbasin,Gundarminorbasin,ArjunaNadhiminorbasin, Goundanathis and Kanal Odai minor basin. All the rivers are seasonal and carry substantial flows during Monsoon period (Balachandran, 2009).

METHODOLOGY

Asapreludetosamplecollection,abasemaphaspreparedusinggeologicalsurvey of India toposheet (58K/12). All the prominent and permanent objects like River, Tanks, Roads, and Elevation are marked in the base map. By browsing the web sources and referring different literatures, additional information pertaining to the study area were collected. Remote sensing LANDSAT data were used to prepare study area map and Geomorphology map. Sampling locations are determined in the laboratory based on the Geomorphologyofthearea andthegeometryofthebeachline.Thesamplingintervalswere approximately10km.About14sampleswerecollectedfrom2locationsusingtrench method.

Allthesampleswerecollectedfromthetrenchesduginthecoastbeyondthehightidelineof the trenches have photographed. The sediments were transferred to polythene bags and subsequently to cloth bags. The bags were properly labeled at the sampling site itself. The sediment samples were dried in an oven at 60^0 C to remove the moisture. Fromthe dried

sample100gmhasselectedbyrepeatedprocessofconingandquarteringtoensureuniformity andavoiderrorsinanalysis.Thesampleswaresoakedinwaterforovernight,werestirredand decanted repeatedly using distilled water until a clear column ofwater without any turbidity was obtained. During that process, wherever necessary, the samples were frequently rubbed by hand to eliminate the attached clay particle. The samplewere dried and weight loss was taken note of, as the sample were found to be rich in organic matter, they were treated with 30%byvolume of H_2O. Afterwashing,the sampleweredried and weighed.Theweightloss accountedforthetotalorganicmatter.Then ,thesamplesweretreatedwith1:1HCltodissolve and remove the calcareous shelly fragments presents in the sediments. After proper washing and drying, the sample were weighed and the weight loss was taken as the weight of the Carbonates.

SAMPLESTATIONS

SampleNo	**Longitude**	**Latitude**	**Depth**	**Natureof the Samples**
OPP-A	78°29’06”E	9°08’06”N	30 CM	SurfaceSand
OPP-B	78°29’06”E	9°08’06”N	13 CM	HeavyMinerals
OPP-C	78°29’06”E	9°08’06”N	45 CM	Sand
OPP-D	78°29’06”E	9°08’06”N	16 CM	HeavyMinerals
OPP-E	78°29’06”E	9°08’06”N	13 CM	Sand
OPP-F	78°29’06”E	9°08’06”N	11 CM	HeavyMinerals
MV-A	78°42’36”E	9°11’23”N	10 CM	FineSand
MV-B	78°42’36”E	9°11’23”N	10 CM	CoarseSand
MV-C	78°42’36”E	9°11’23”N	30 CM	FineSand
MV-D	78°42’36”E	9°11’23”N	4 CM	Heavy& Light Minerals
MV-E	78°42’36”E	9°11’23”N	6 CM	FineSand
MV-F	78°42’36”E	9°11’23”N	6 CM	CoarseSand
MV-G	78°42’36”E	9°11’23”N	14 CM	Heavy& Light Minerals
MV-H	78°42’36”E	9°11’23”N	20 CM	Heavy Minerals

(Fig2)–OPPILAN

(Fig3)-MUTTUVALASAI

MICROPALAEONTOLOGICALANALYSIS

Micropalaeontology is the branch of Palaeontology that studies Microfossils, or Fossils that require the use of a microscope to see the organism, its Morphology and its characteristicdetails.Microfossilsarefossilsthataregenerallybetween0.001mmand 1mm in size,the study of which requires the use of light or electron Microscope.Fossils which can bestudiedwiththenakedeyeorlow-powderedmagnification,suchasahandlens,arereferred to as macrofossils. For example, many fossil genera of Foraminifera, which are protists are known from shells (called 'tests') that were as big as coins, such as the genus Nummulites. Microfossils are a common feature of the geological record, from the Precambrian to the Holocene. They are most common in deposits of Marine environments, but also occur in Brackishwater, FreshwaterandTerrestrialsedimentary deposits. Tsunamigeneticsediments that deposited on the beach sites of Kadaladi taluk Coast.Microfauna which must have been deposited with this deposits. Foraminiferal study is the best way to study Palaeotsunami sediments.Thepresentstudyusedenvironmentalcharacteristicsand Foraminiferadistribution to determine the impact of tsunami sediments. The Microfossils contained in sediments can provide a large amount of information on past environments. Microfossil assemblages are indicators of the physical and chemical conditions of their habitat, providing access to qualitativeorquantitativereconstructions ofenvironmentalparameters.TheMicrofaunaland Microfloral inventory and concentration calculations can incorporate the geochemical signature from the environment in which they form. The Morphological description for the selected species for specificidentification, the present taxa have been compared with the hypotypes reported from the palk strait(Suresh Gandhi, 1999). All the taxa illustrated are reposited in the Museum of the Department of Geology,Alagappa.Govt.Arts.College. The Microscopic photography of few selected species have been taken and presented.

RESULTAND DISCUSSION

The general distribution of the foraminifers is characteristic of an assemblageunder marine influence and dominated Ammonia tepida indicates tropical environment.Benthic foraminifera and gastropods are also used as tool for tracking transgression andregression events in lagoons connected to the open sea. The distribution of calcarina species indicates the shallow environments of high-water energy on hard Sub Strates inparticular on exposed reel flat forms. The following shallow marine species are widely distributed in the post-tsunamisedimentsnamelySpiroloculinacummunis,Quinqueloculinalamarckiana, Ammonia beccarii, Ammonia tepida, Elphidium crispum. Inner shelf species of Bolivina, which is a good indicator of strong marine influence of environments. Bolivina prefers muddy

sub stratum and is restricted to bathyal and marginal conditions. Mostofspecieswere brokentest has been suggested to indicate high energy depositional indicate the tsunami origin. (Murray 1993,Dawso1996).Thistsunamigenetics edimentsdepositedonthesecoastallandfo rmsare derived fromcontinentaland inner shelfenvironment duetothe tsunami. ATotalnumberof 20 genera, 14 families belonging to 41 benthic foraminiferaland gastropod species are identified. Arenaceous- Agglutinated Species: Textularia agglutinants, Calcareous Porcelaneous Species: Spiroculina Communis, Quinqueloculina cultrate, Q.costata, Q.seminulum, Q. tropicalis Calcareous Perforate Species: Ammonia beccarii; A. dentata; A.tepida, Elphidium crispum, Assilinaammonoids, Loxostomina limbata;

ForaminiferalDistribution

Out of the 14 sediment samples were collected from Beach and Core samples, living foraminifera have been observed in selecting samples but very rare in occurrence in few stations.Thelargestpopulationwasfoundt ooccurinoffshoresamples.Thevariationn oted in the standing crop of all the samples the study areas is presented. The significant variation inthedistributionoftotalandlivingspecies assemblagesmaybeduetosedimentationa swell as due to the Wave action and tidal current. The general trend in modern shallow water foraminiferal assemblages in the increasing species diversity in line with increasing salinity gradients and environmental stability. The genus Ammonia, Asterorotalia, elphidium is dominatingthetotalassemblagesfollowed byQuinqueloculina,TriloculinaandSpiro loculina in the study region. The following species are widely distributed in the offshore samples, namely A.beccarii, A.dentata, A.tepida, S.communis, Q.elongatum, Q.lamarckiana, Q.seminulum, T. trigonula, E. crispum, P. hispidula, and A. ammonoides. Sand is deposited all along the coast. Black sand is covered in this region. A totalof 15 species belonging to 7 generaareidentifiedinthebeachsamples. AmongthemA.beccariishowsahigherabu ndance inthebeachstationsbarringoneortwo.Foll owedbyA.dentataandA.tepidia.inbeacha reas the sediment is fine grained nature. The foraminiferal distribution is lesser in amount. The dead species found in this region may bedue to sediment transport along the beachside from offshore region. Top core: Foraminiferal fauna at this depth is very poor compared to other depths ofthe present study. Some families of this group reported from this depth are Rotaliidae, Elphididae, Hauerinidae, Rosalinidae. The respective species belongs to these families are A.beccarii, A.tepida, E.crispum, P.hispidula, Q.lamarckiana, Q. seminulum has beenobserved.Thecoarsetomediumsandi sobservedinthetopofthecoresamplemayf avor for distribution of foraminifera. Middle Core : foraminiferal fauna at this depth belonging to thefamiliesreportedareRotaliidae,Elphid

idae,andHauerinidae.Speciesareveryrare inthe middlecore.OnlyafewspecimensofVertebralinastriataandQ.elongatahavebeenobserved. A.tepida, E. crispum, E. discoidale, are the other rare species observed in the middle of the core. Bottom Core: The great abundance of specimens of Elphididae, Rotaliidae, Nonidae, Bolivinitidae, foraminifera is found in this area of depth are Rosalinidae, Fischrinidae, Hauerinidae, Spiroloculinidae. Some of the dominant families atthis depth are Rotaliidae, Elphididae and Hauerinidae. A. beccarii is the most abundant species. Top Core : Foraminiferal fauna at this depth is very poor compared to other depths of the present study. Somefamiliesofthisgroupreportedfromthisdepthare Rotaliidae,Elphididae,Hauerinidae, Rosalinidae, Fichrinidae. The respective species belongs these families are A.beccarii, A.tepida, E. crispum, E.discoidale, P.hispidula, Q. elongata, Q.lamarckiana, Q.seminulum. only a few specimens of V .striata and Q. elongatehave been observed. A. beccarii is very dominant in that coastal sampling period. Middle Core : Foraminiferal fauna at this depth belonging to the families reported are Rotaliidae, Elphididae, Hauerinidae. Species are very rare in the middle core. A.beccarii, A.tepida, E. crispum, E. discoidale, Q.elongate is the speciesobserved.BottomCore:Thegreatabundanceofspecimensofforaminiferaare found in this area namely. Elphididae , Rotaliidae, Nonionidae, Bolivinitidae, Rosalinidae, Fischrinidae, Hauerinidae, Spiroloculinidae. Some of the dominant families at this depth are Rotaliidae,ElphididaeandHauerinidae.A.beccariiisthemostabundantspecies.Thespecies like A.inflata, E. repantas and T. rotunda are veryrare. In boththe core samples , A.beccarii is the only dominant and abundance species.Due to the tidal fluctuation, the distribution of foraminifera is varied respect to depth. Thedeeper depths receive more number of species. Duetosedimentdeposition,thetopofthecorereceiveslessernumberofspeciesdistributions.

CONCLUSION

Ingeneral,theextremeeventssuch asstormsortsunamicanalterthehydrodynamic conditions considerably, and can cause rapid accumulation of sediment with significant changesinaccumulation ofdeep Foraminiferaand somegastropods.Thegreat Indonesian earthquaketriggeredatsunamiwaveacrosstheof Bengalandinundatedcoastal lowlands along the southeast coast of Tamilnadu on 26 Dec.2004. The Okhi storm hit recentlyalongtheeastcoastofKanyakumarimighthaveagitatedtheGulfofMannarcoast too which might be caused the high energy deposits all along the study area witnessed by the deposition of deep marine fossils like benthic foraminifera, some gastropods and ostracods on surface of the coastal regions along the southeast coast ofTamilnadu onDec 2017. This study applied multivariate statistical techniques to determine the benthic foraminiferato changes in the environment. These group exhibit a similar association to the environmental gradients. However, the benthic

foraminifera show a much stronger correlation. The benthic foraminifera are strongly correlated to changes in water depth, percent carbonate mud, percent gravel, organic carbon flux, temperature and salinity. The application of a preservation index, based on two foraminiferal genera, and taking into account both fragmentation and dissolution, provides a good indication of the degree of sedimentreworking.However,thestrengthoftheforaminiferal-environmentrelationship, even at fine scales, suggests that preservation is more strongly influenced by the low sedimentationratesratherthansedimentreworkingthroughtransportacrossthismarginthe consistency between species distributions and environmental variables, despite the high degree of degradation in many of the samples, provides much greater confidence in applying benthic habitat mapping techniques around the Gulf of Mannar margin, where sedimentation rates are low and reworking high In my collected samples, the benthic foraminifera in essence of **Spiroculina Communis, Quinqueloculina Lamarckiana, Ammonia Beccarii, Ammonia Tepida, Elphidium Crispum, Bolivina** are having deep marine properties like salinity,sub stratum, temperature, depth, habitat. Recently these fossilsareoccurringinOffshoreandbeach areas. High Wave energy or an extreme event only cantrigger to deposit thesedeepmarine sediments into Offshore or Beach areas. So, in thislocation,the sediments weredeposited by a tsunami wave and the Okhi Storm.

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Textural and Mineralogical Observation of Red Soil in Cretaceous Formation, Ariyalur, Tamilnadu, India

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Abstract

The study examines about the red soil deposit and it's an omnipresent geomorphologic feature present in the Cretaceous formation, Ariyalur. One of the inland Cretaceous formations is located around the Koothur village in Tamilnadu, India. Textural and mineralogical studies were carried out in the red soil and its compact sandstone outcrops. The sediments are moderately sorted to well-sorted and finely skewed nature which indicates that fluvial depositional environment. Petrography and X-ray diffraction analysis reveal the predominance of quartz and feldspars along with the accessory minerals like ilmenite, rutile, garnet, magnetite, hematite, zircon, diopside, hypersthenes and biotite. The depositional environment indicates that the sediments are fine-grained with high maturity index. Despite that the sediments are formed by fluvial sources, the reddening character in the red soil deposits is due to oxidation and leaching of iron-bearing minerals by percolating surface water from high rainfall.

Keywords: Red soil, Textural analysis, Mineralogy, Oxidation, XRD.

Introduction

The diverse array of rocks and minerals has emerged across different geological ages, with soil or sediments representing the ultimate outcome of weathering. Pedology, the scientific study of soil, reveals that soil variation hinges on multiple factors: the nature of the source rock, climate, vegetation, topography, and the time of formation. Within soil classification, the geological categorization centers on two primary formations: Residual soil and Transported soil. Specifically focusing on red sediments resting on the Upper Cretaceous formation in the Koothur region of Tamilnadu, India, studies were conducted to decipher their granulometric character, petrographical nature under a microscope, powder mineralogy through XRD analysis. These investigations aimed to interpret the depositional environment and source rock characteristics of these recent red sand deposits. By analyzing granulometry and mineralogy, the objective was to deduce the depositional environment of the red soil. These findings provided insights into the nature of the soil and its origins, shedding light on the environmental and geological history of the study area.

Study area

The study area Koothur red soil outcrop is located at a distance of 8 km

in the western direction from Ariyalur. The exact outcrop lies between latitudes from 11.135 to N 11.170 and longitudes from 79.020 to 79.055. (Figure.1). The area falls in the toposheet number 58M/ 4, 1 inch = 1mile scale map published by the Survey of India, (1920).

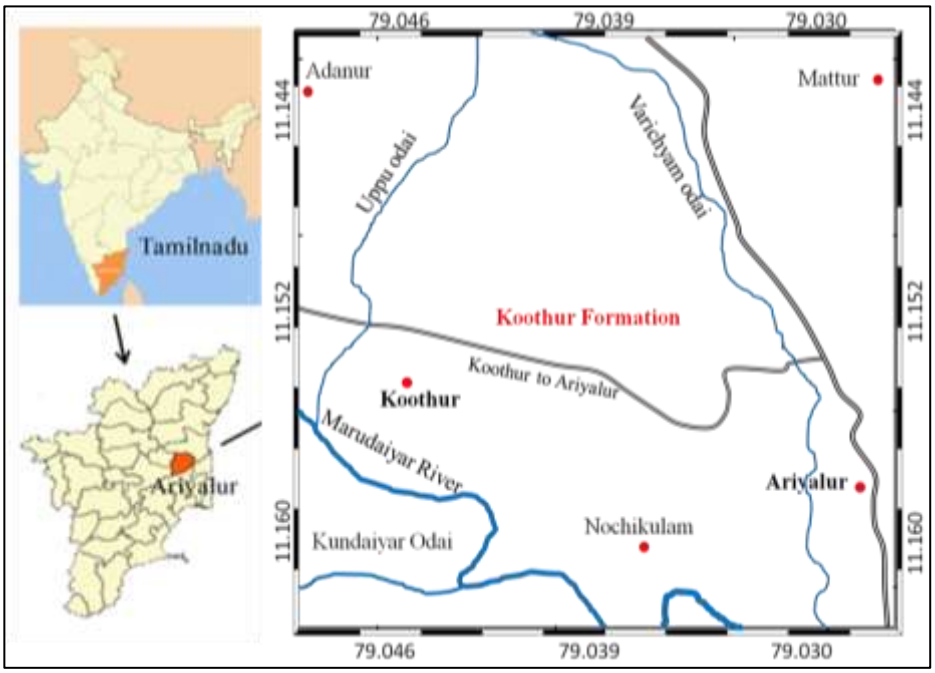

Figure 1.Location Map of the study area.

Geology and setting

The geological landscape surrounding the Koothur outcrop area comprises distinct rock formations from various geological eras. This sequence begins with the Archaean basement rocks, characterized by residual structural high hills, primarily composed of charnockite and granitic gneisses. These rocks exhibit a striking orientation with a strike of N 65 degrees East and South 65 degrees West. The Archaean formations are succeeded by either Upper Gondwana or Upper Cretaceous outcrops, often displaying unconformities in the basin region. The Ariyalur district exhibits a robust sedimentary sequence from the Cretaceous system of the Cauvery Basin, characterized by both clastic and carbonate facies. These formations, classified into Uttatur, Trichinopoly, and Ariyalur, possess maximum thicknesses of 900m, 600m, and 1500m, respectively. Notably, the Trichinopoly formation overlays the Uttatur formation in an unconformable manner. The focus of the proposed research revolves around studying the Recentand Sub-Recent surface outcrops of Koothur's red sediments. This investigation aims to understand the stratigraphic succession of these sediments observed from well sections,

mine sections, and sub-aerial exposures, providing valuable insights into their composition, origin, and geological evolution. It is shown in the Table 1.

Table 1. Stratigraphical succession of the study area

ERA	GROUP	FORMATION
RECENT		Red Sand, Alluvium, Calcrete, Sand Stone, Laterite
UPPER CRETACEOUS	TRICHINOPOLY	Garudamangalam
		Paravay
	UTTATHUR	Karai Shale
		Maruvathur Clay
		DalmiapuramL.St
		Calcareous Grey Shale
UPPER JURASSIC to LOWER CRETACEOUS	UPPER GONDWANA	Therani Plant fossil
		Boulder Conglomerates
ARCHAEAN		Granitic gneiss and Charnockite

RESEARCH METHODOLOGY

The field study involved a meticulous examination of outcrop features like texture, sedimentary structures, and erosional surfaces to gather crucial evidence for understanding depositional environments. Detailed observations were made on-site, documenting these features through descriptions, photographs, and precise measurements. Advanced field techniques were employed, utilizing specialized instruments and grain size charts to ensure accurate and standardized descriptions of grain sizes. Additionally, representative samples were collected from various lithologies for subsequent geochemical analysis. The collected samples underwent a meticulous cleaning process, following which 100 grams of red sand was subjected to sieving for 15 minutes using a Ro-tap sieve shaker machine. Sieves calibrated to quarter phi intervals (25, 35, 60, 120, 230, 270, and pan) as per ASTM standards were utilized. Each fraction obtained from sieving was meticulously weighed, and the size parameters were calculated following the Folk and Ward (1968) methodology. The interpretation of the depositional environment of the red sand was based on a synthesis of field observations and the analysis derived from the micro-thin sections. This meticulous approach was employed to ascertain and delineate the conditions and context under which these red sediments were deposited.

RESULT AND DISCUSSION

FIELD OBSERVATION

The study area suggests that the red sediments likely originated as fluvial deposits, transported by the Uppuodai and Varichurodai. The distinctive red coloration observed in these sediments is believed to have formed through secondary processes involving in situ pedogenic leaching and the oxidation of iron-bearing minerals. These transformations likely

occurred under semiarid to arid climatic conditions. Furthermore, the presence of calcrete, appearing as an undulating outcrop beneath the red soil, indicates a replacement deposit. This phenomenon might be attributed to differential rates of evapotranspiration of groundwater stemming from the Cretaceous aquifer below the red soil outcrop. Similar occurrences have been reported in the Sathankulam region, speculated to originate from the Tertiary aquifer.This interpretation aligns with previous studies and findings in related research works (Escowitz 1896; Hendrik Falck et al., 2015; Perumal et al., 2017, Sanuprava Mohapatra et al., 2015; Perumal and Udayanapillai, 2015, 2019; Ashraf Alf Seddique and Ashraful Hoque, 2015; Ibrahim Khalil et al., 2016; Sulieman et al., 2015; Udayanapillai and Ganasamoorthy, 2013; Pettijohn et al., 1957; Perumal, 2017). The field photographs illustrating the features of the study area are depicted in (Figure 2 a-d). These visual representations provide valuable insights into the geological characteristics and the observed formations within the research site.

Figure 2.Field Observation Photographs.

GRAIN SIZE ANALYSIS

A graphical representation of the sieve analysis data obtained from the Red sediments of the Koothur area was crafted in the form of histograms and cumulative curves. Frequency curves, presented as smooth curves, depict the variation of cumulative weight percentage across a continuous range of grain sizes. Grain size is plotted along the horizontal axis (x-axis), while the cumulative weight percentage is represented on the vertical axis (y-axis), scaling from 0 to 100 percentages. These curves provide a visual understanding of the distribution of grain sizes within the sediment samples. Additionally, geostatistical

parameters including Mean, Median, Sorting, Skewness, and Kurtosis were computed using the formulas outlined by Folk and Ward (1968). These parameters offer valuable insights into the characteristics and statistical properties of the sediment grain sizes, aiding in the analysis and interpretation of the sedimentary composition. The corresponding figures (Figure 3. a-e) visually represent these geostatistical parameters, enhancing the understanding of the grain size distribution and properties within the Red sediments of the Koothur area.

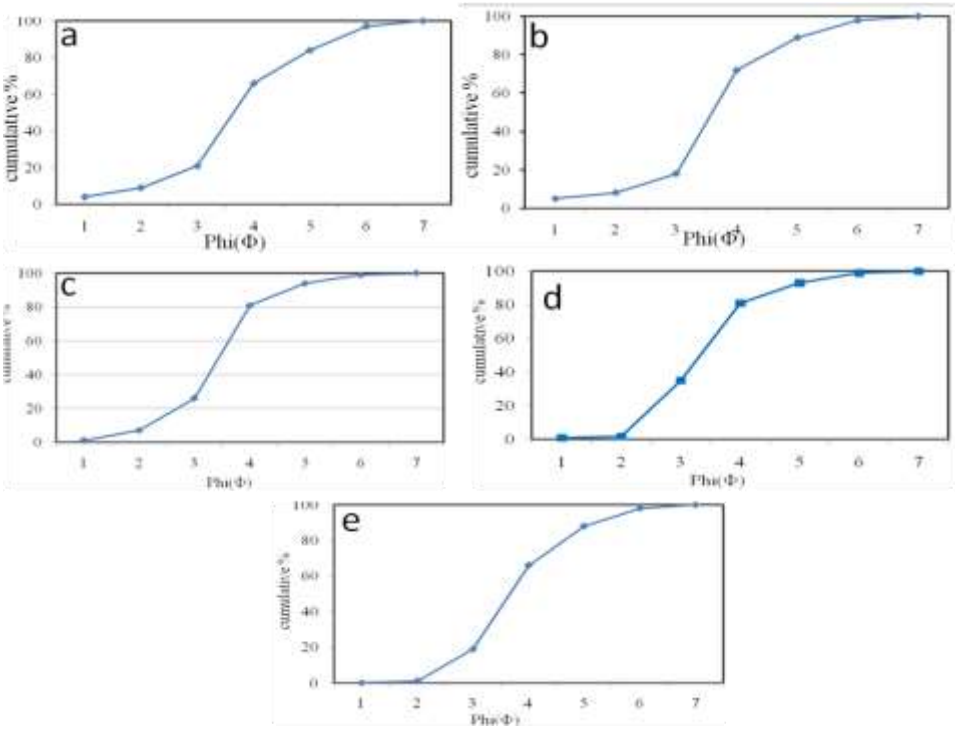

Figure.3.a-e. Cumulative frequency curve of red sediments.

The characteristics of sediment grain sizes were evaluated using specific statistical measures:

Median: This represents the particle size at which half of the particles, by weight, are coarser and the other half are finer.

Mode: Refers to the diameter that occurs most frequently among the particles.

Sorting: Quantified by a coefficient, which is the square root of the ratio of quartiles q3/q1. Here, q3 and q1 correspond to the 25 and 75 percentage values respectively. Perfectly sorted sediments exhibit a coefficient of 1.0.

Skewness: This measures the asymmetry of the probability distribution of a random variable around its mean. It can be calculated using the formula q1*q3/(median). The skewness value can be positive,

negative, or even undefined.

Kurtosis: Represents the peakedness of the distribution and can be expressed as (q3-q1) / 2(p90-p10). It provides insight into the nature of the distribution's shape. (Table 2)

Utilizing the procedures outlined by Folk and Ward (1958), these statistical measures were derived from the cumulative frequency data. The interpretation of these measures assists in understanding the nature and characteristics of the red sand formation in the Koothur area, shedding light on its grain size distribution and overall composition.

1. Median = 50 percentile
2. Mean $m\Phi = P_{60}+P_{50}+P_{84}/3$
3. Standard deviation (or) dispersion$Md\Phi = P_{84} - P_{16}/ 4 + P_{95} + P_5/ 6.6$
4. Skewness =$(P_{16} + P_{85}) \_ P_{50}/ 2(P_{84} \_ P_{16})$
5. Kurtosis = $(P_{95} \_ P_5)/2.44 (P_{75} \_ P_{25})$

Table 2. Attribute of Frequency Distribution

Attribute	Technical name	Uddens terminology	Statistical measure
Average	Measure of the central tendency	Chief significant (or) Maximum	Median (or) 50 percentile
Sorting	Dispersion	Number of size grades	Coefficient sorting q3/q1
Symmetry	Skewness	Predominance of coarse (or) fine admixture	Coefficient of skewness q1,q3/(Median)^2
Peakedness	Kurtosis	Quantity in the maximum plugrange	Coefficient of q3-q1/2(p90-p10)

HISTOGRAMS OF THE RED SEDIMENTS

The grain size analysis of the study area reveals a unimodal distribution ranging between phi values of 0.5 to 4.5. Specifically, the Red sediments in the Koothur area demonstrate a mean size within the range of 0.63 to 1.80 phi, while the median values fall between 0.65 and 1.81 phi. Assessing the measurement of sorting through standard deviation or dispersion, the standard deviation of the Red sediment samples within the study area spans from 0.39 to 0.94 phi. This range categorizes the sediment as well to moderately sorted. Skewness, a dimensionless value, signifies the deviation from symmetry in the distribution curve. A skewness value of 0.00 indicates a symmetrical distribution, with positive or negative values indicating an excess of fine or course materials, respectively. In the case of the Red sand sediment of the study area, the skewness ranges from 0.37 to 1.69, indicating a finely skewed distribution. Kurtosis, representing peakedness, involves the spread ratio and is a dimensionless value.(Table 3). As per Folk (1962), specific limits define kurtosis classifications. For the Red sediments in the study area, the kurtosis values span from very platykurtic to platykurtic. Furthermore, a bivariate plot of standard deviation versus graphic mean, following

Friedman (1961) and Moiola and Weiser (1968), illustrates the depositional environment of the sediments. The results of the standard deviation versus graphic mean analysis for this study area align with a river environment (Figure 4 a-e and 5), providing valuable insights into the nature of the depositional setting for the analyzed sediments.

Table 3.The result of the size analysis

SAMPLE	MEAN	STANDARD DEVIATION	SKEWNESS	KURTOSIS	MEDIAN	STD DEVIATION CLASS	SKEWNESS CLASS	KURTOSIS CLASS
1	0.63	0.39	0.37	0.72	0.65	WELL SORTED	FINE SKEWED	PLATYKURTIC
2	1.62	0.57	0.58	0.76	1.66	MODERATELY WELLSORTED	FINE SKEWED	PLATYKURTIC
3	1.34	0.77	0.79	0.67	1.25	MODERATELY SORTED	FINE SKEWED	PLATYKURTIC
4	1.80	0.94	1.53	0.68	1.81	MODERATELY SORTED	FINE SKEWED	PLATYKURTIC
5	1.49	0.71	1.69	0.74	1.35	MODERATELY WELLSORTED	FINE SKEWED	PLATYKURTIC

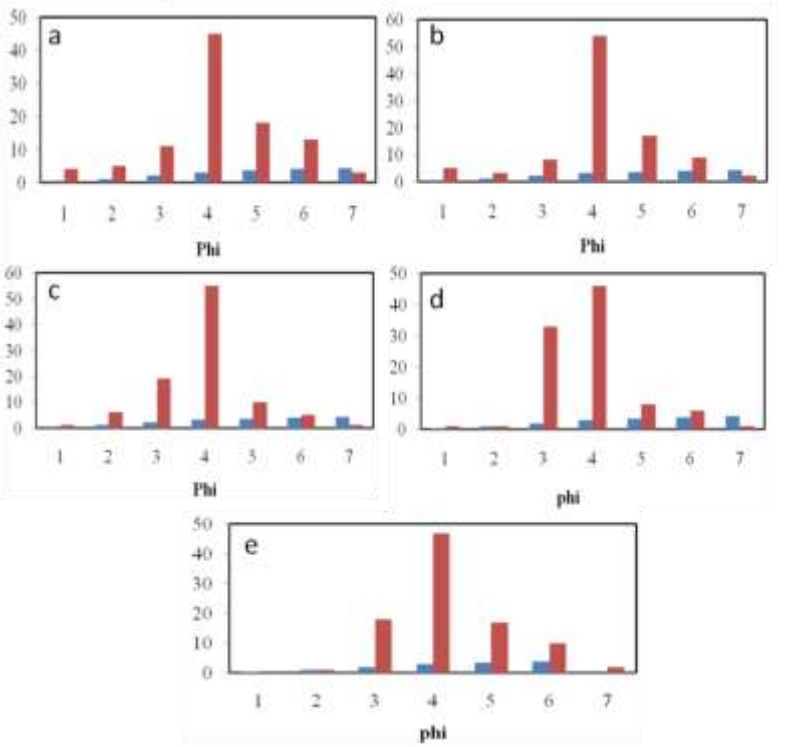

Figure.4.a-e.Histogram of red sediments

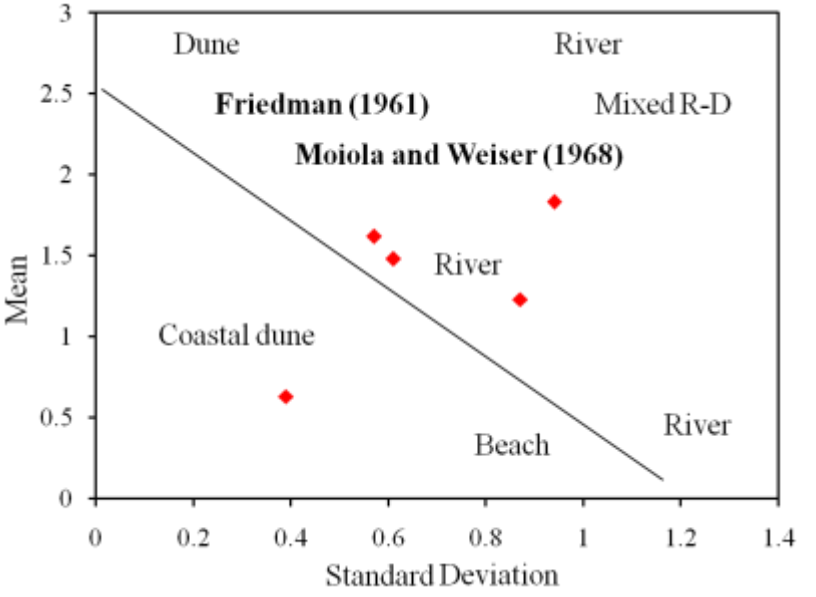

Figure 5. The bivariate plot of standard deviation vs graphic mean (after Friedman (1961) &Moiola and Weiser (1968)

X-RAY DIFFRACTION ANALYSIS The mineralogical composition

of the red sediments in the Koothur area was assessed through X-ray diffraction (XRD) analysis. X-ray diffraction patterns aid in identifying minerals based on their 'd' spacing values and corresponding intensities, as depicted in (Figure 6. a-e). Reference materials such as (Sachinath Mitra, 1962; Perumal and Udayanapillai, 2019, 2015; Escowitz, 1896; Sanuprava Mohapatra et al., 2015; Perumal et al., 2017, 2016; Ibrahim Khalil et al., 2016; Perumal, 2017; Sulieman et al., 2015; Pettijohn et al., 1957) and other published literature were consulted to aid in the identification of minerals present in the X-ray diffractogram. The mineralogical analysis reveals the presence of several minerals in the Red sand, notably quartz, biotite, hypersthene, ilmenite, diopside, hematite, and rutile. Among the alkali minerals, biotite, ilmenite, quartz, and microcline are the dominant minerals, constituting approximately 37.93%, 6.89%, and 10.34% of the composition, respectively. Rutile, while present, comprises a lower concentration at approximately 3.445%. Based on these findings, it can be inferred that the principal source rocks contributing to the red sediments encompass khondalite, granite, charnockite, and similar rock formations. These minerals constitute the primary contributors to the mineralogical makeup of the analyzed red sediments within the study area.

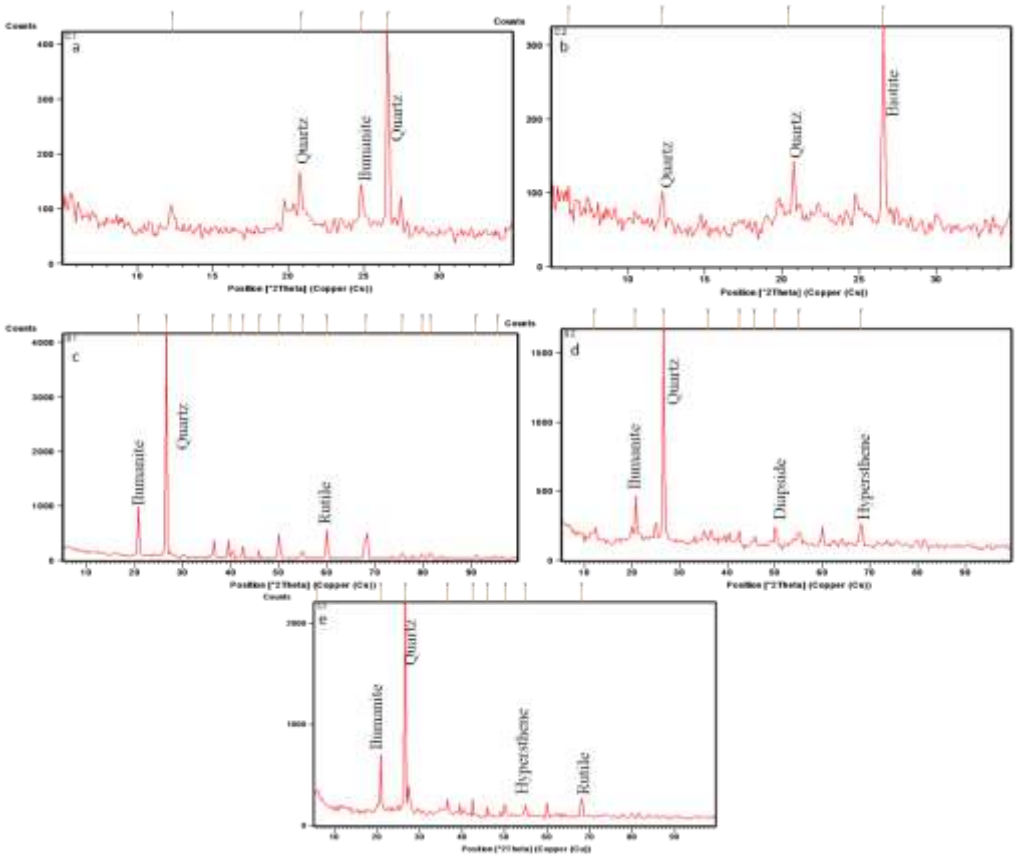

Figure 6.The X-ray diffraction of the Red sediments.

CONCLUSION

The following are the salient features of this work Red sands are a ubiquitous geomorphological feature across this terrain, prominently present throughout the study area. Textural analyses conducted reveal that the teri sediment exhibits medium grain size characteristics. The computed mean, median, standard deviation, skewness, and kurtosis values range from 0.67 to 2.03 phi, categorizing the sediment as well to moderately sorted, finely skewed, and displaying very platykurtic to platykurtic distributions. These findings suggest a depositional environment indicative of fluvial deposits. X-ray diffraction results shed light on the mineralogical composition of the sediment. The identified minerals include quartz, microcline, biotite, ilmenite, rutile, kyanite, diopside, goethite, hematite, magnetite, and tourmaline, contributing to the intricate mineral makeup of the studied sedimentary formations.

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Analysis of Groundwater Quality for Northern Coastal Region of Ramanathapuram District, Tamilnadu, India

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Abstract

Groundwater is the main source of water in the arid and semi-arid environment which fulfills the requirement of different beneficial-uses drinking, domestic, and irrigation particularly for the rural population.Ramanathapuram district is lies between 9° 05' and 9º 50' North Latitude and 78º 10' and 79º 30' East Longitude.Groundwater samples were collected as grid from at 20 locations during the post monsoon seasons in the year 2021. The physical parameters taken into consideration are color, odor, turbidityand temperature. The chemical parameters taken into consideration are hydrogen ion consideration (pH), specific conductance (EC), total dissolved solids (TDS), total hardness (TH) and all major cations and anions. They are analyzed for various physicochemical parameters in the laboratory. Calcium (Ca) and Magnesium (Mg) were determined titrimetrically using standard EDTA; Chloride (Cl) was determined by standard $AgNo_3$ titration; Bicarbonate (HCO_3) was determined by titration with H2SO4; Sodium (Na) and Potassium (K) were determined by Flame photometer; Sulphat (SO_4) was determined by spectrophotometric turbidimetry. The study area of Ramanathapuram groundwater quality indicate that it was not contaminated in many areas by the reported parameters. The reason for contamination of some place of Ramanathapuram is due to saline water intrusion to contaminated the groundwater. The study area is always under stress due to increasing population and more demand for water resources.

Keywords: Groundwater quality, Drinking and irrigation purpose, Suitability health risk assessment, Sensitivity analysis.

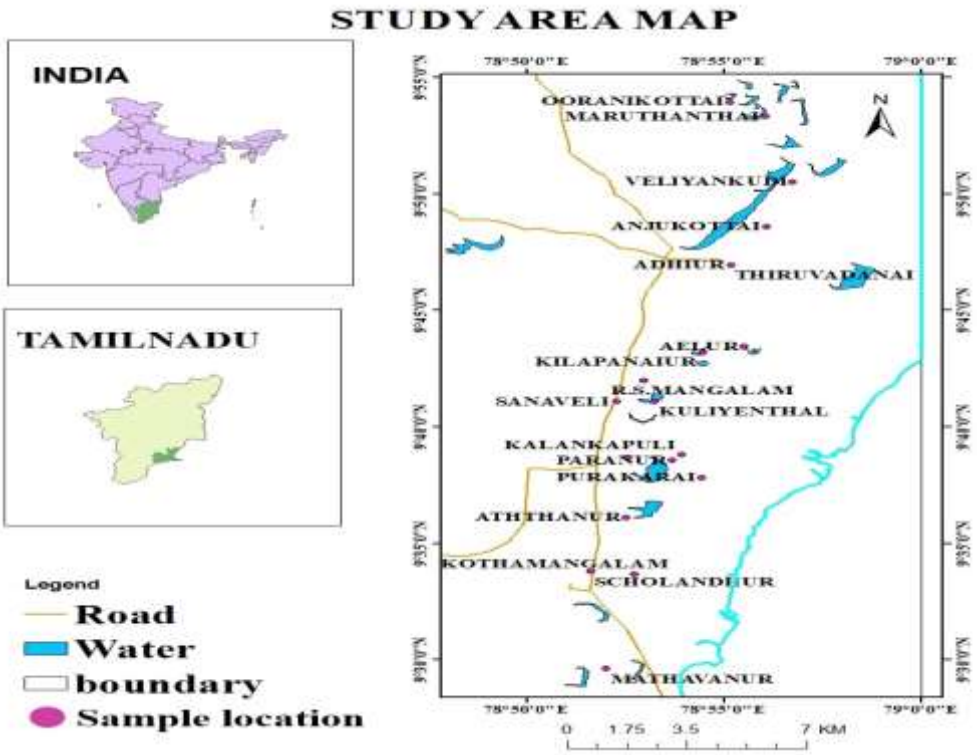
Introduction

Groundwater can cause directly or indirectly, change in groundwater quality. The intrusion into a freshwater aquifer of low-quality surface water or groundwater, because of the change in hydraulic gradient due to groundwater quality. It covers ordinary open wells of varying dimension dug or sunk from the ground surface into water bearing stratum to extract water for irrigation purposes. Groundwater supports about two-thirds of the world's population by supplying freshwater for drinking and other house need application (Li et al 2018 a, Adimalla et al 2018 a). Water is the chemical substance with chemical formula H_2O one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom (Bansal &

Dwivedi 2018). Water is a tasteless, odorless liquid at ambient temperature and pressure. Despite two-thirds of our planet is covered with water, the specter of water insecurity, i.e., lack of reliable source of freshwater with appropriate quality and quantity, is hovering over almost all parts of the world. Less than 1% of fresh water is trapped as groundwater in the aquifers which are recharged through rainfalls (Gursimran et al. 2013). The excess water leads to flood and lack of it results in drought and famine. It must be remembered that any natural or manmade activity on the surface of the earth will impact on the quality and quantity of water (Thomas et al 2018).The Goal 6 of the UN Sustainable Development Goals (SDG), in particular, recognizes the importance of achieving "universal and equitable access to safe and affordable drinking water for all" by the year 2030.The excessive and improper use of chemical fertilizers, animal manures, insecticides, and pesticides, improperly built or poorly located and/or maintained septic systems for household wastewater, leaking or abandoned underground storage tanks and piping, improper disposal or storage of wastes and chemical spills at local industrial sites, over exploitation and unwise use of groundwater have not only depleted groundwater availability, but also made its quality inferior and scarce

Study area

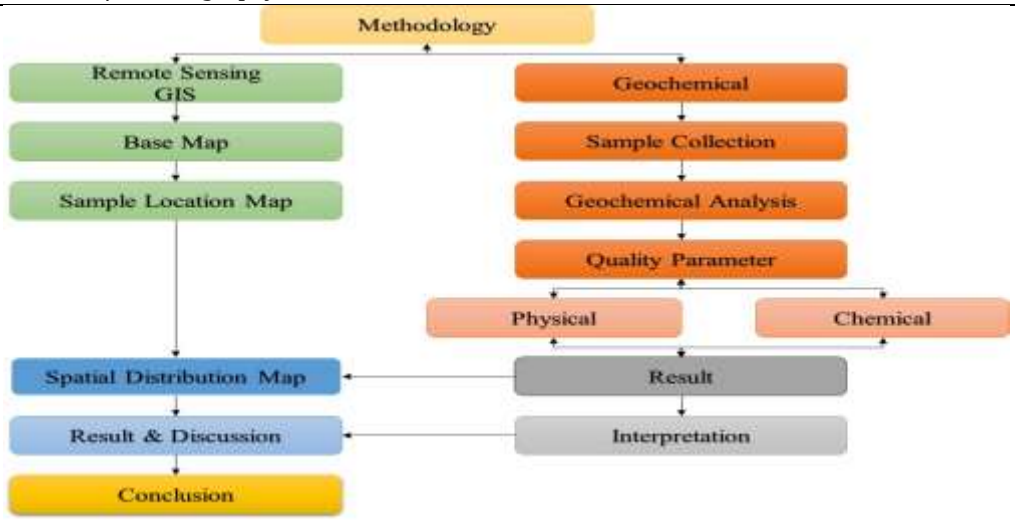
Ramanathapuram district is lies between 9° 05' and 9º 50' North Latitude and 78º 10' and 79º 30' East Longitude. The district receives the rain under the influence of both southwest and northeast monsoon. Ramanathapuram district comprises 7 taluks, 11 blocks and 2362 villages. Ramanathapuram District has an area of 4123 km^2. It is bounded on the north by Sivaganga District, on the northeast by Pudukkottai District, on the east by the Palk Strait, on the south by the Gulf of Mannar, on the west by Thoothukudi District, and on the northwest by Viruthunagar District. The district contains the Pamban Bridge, an east-west chain of low islands and shallow reefs that extend between India and the island nation of Sri Lanka. As of 2011, Ramanathapuram district has a population of 1,353,445. Most of the area is covered by the unconsolidated sediments. The northeast monsoon chiefly contributes to the rainfall in the district. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Palk Strait. The southwest monsoon rainfall is highly erratic and summer rains are negligible. The annual normal rainfall (1970-2000) of Ramanathapuram district is 821 mm. Three projections of rainfall over Ramanathapuram for the periods 2010-2040 (2020s), 2040-2070 (2050s) and 2070- 2100 (2080s) with reference to the baseline (1970- 2000) indicate an increase of 0.1%, 1.0% and 1.0% respectively.The district a Tropical climate. The period from May to June is generally hot and dry.



Material and Methods

This chapter describes the methods of sample collection and analytical procedure adopted for analysis of groundwater samples of Ramanathapuram district using different analytical methods. To evaluate the impact of contaminants on groundwater of Ramanathapuram district, water samples were collected from 20 different selected sites in January 2021.

Flow chart for methodology



To assess the level of groundwater quality, sampling of groundwater done from hand pumps and bore wells located in residential and agricultural areas, as per the standard procedure. The samples were collected in acid-washed polyethylene bottle.Before sample collection bottles were rinsed thrice with water to be sampled and then samples were collected. Electrical conductivity (EC) and hydrogen ion concentration (pH) were determined on the field itself using digital meters. Twenty villages from Ramanathapuram district, each one sample in every village, so that drawn sample represent the real groundwater quality of the area. Every sample was coded adequately and mark code on sampling bottles by permanent marker at two places, recorded all the information regarding name of the sampling location, source and date of collection in field work. Before collection of samples the pipeline of bore wells and hand pumps were flushed for a sufficient period of time, so that actual sample can be collected which represents the actual quality of groundwater. The samples were collected from twenty spot and then carry together,Sample bottles were rings thrice with the water to be collected and then filled completely to avoid encroachment of air bubble. Sample bottles screw- caped tightly and brought to the laboratory. The samples were preserved in refrigerator at 40˚f. The analysis of pH was made in field with the help of systronic make portable pH meter. Groundwater samples of various locations were analyzed for determination of degree of pollution with respect to the following physiochemical parameters and heavy metals opted for investigation of $P^{H,}$ EC (Electrical conductivity), TDS (Dissolved solids), Calcium, Magnesium, Sodium, Potassium, Chloride, Bicarbonate. The groundwater samples collected to the field and samples were analyzed in the laboratory for concentrations of major ions. They are analyzed for various physicochemical parameters in the laboratory. Calcium (Ca) and

Magnesium (Mg) were determined titrimetrically using standard EDTA; Chloride (Cl) was determined by standard $AgNo_3$ titration; Bicarbonate (HCO_3) was determined by titration with H2SO4; Sodium (Na) and Potassium (K) were determined by Flame photometer; Sulphate (SO_4) was determined by spectrophotometric turbidimetry. The After completion of the analysis of major ions, the ion balance error was calculated. In general, the ion balance error was within 10%. All concentrations are expressed in milligrams per liter (mg/l), except pH, EC and TDS. The EC concentrations were expressed in µs/cm and TDS concentrations were expressed in ppm. The spatial analysis of various physicochemical parameters was carried out by using GIS contouring methods with Q GIS. The inverse distance weighted (IDW) interpolation techniques have been used for preparing the spatial distribution maps for each physicochemical parameter. The spatial distribution map of the pH, EC, TDS, TH, cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (Cl^{-}. HCO_3^{-}, SO_4^{-}, NO_3^{-} and F^{-}). The soluble inorganic constituents of irrigation water react with soils as ions rather than as molecules.

Results and Discussions

The Groundwater quality data were shown in Table.4.1 during the year of 2020. Groundwater quality in the Ramanathapuram district with the help of Q-GIS data were interpolated for the spatial distribution map. The spatial structures were also identified interpolating the scattered data, in order to have temporal series of spatially continuous maps of the parameters. We used Inverse Distance to a power gridding method as a smoothing interpolator. In this method data are weighted during interpolation such that the manipulation of one point relative to other declines with the distance. In particular, we use a quadratic law for computation of the weight, and a low value for smoothing parameters. The quality of water used for drinking purpose depends on the chemical, radiological and biological contents of the water. In the present study the quality of water with respect to major ions was estimated. The various parameters analyzed were compared with the standard guideline values as suggested by the Bureau of Indian Standard (BIS 2012) and World Health Organisation (WHO) for drinking water quality (Table.4.2) to evaluate the suitability of groundwater in the study area for human consumption. Concentration of chemical parameters of water samples.pH was measured in the field itself because the pH of the sample can change due to carbon dioxide from the air dissolving in the sample water. A Systronics pH meter of 0.01 readability was used for the measurement of pH.Electrical conductivity (EC) was measured with Systronics conductivity meter. 0.01M KCl solution was used as the standard reference solution.Total Dissolved Solvents (TDS) also measured with Systronics conductivity meter.

The table shows the descriptive statistic of Physical and Chemical parameters of water samples.

S.NO	VILLAGE NAME	Physical Parameters			Chemical Parameters (ppm)					
		pH	EC(µS/cm)	TDS (ppm)	Ca	Mg	Na	K	Cl	HCO_3
1	OORANIKOTTAI	8.01	520	260	5	5	34	6	130	60
2	MARUTHANTHAI	7.61	1175	588	15	15	62	8	400	90
3	VELIYANKUDI	8.06	1364	680	10	5	52	7	450	116
4	ANJUKOTTAI	7.84	214	107	5	5	50	7	70	23
5	THIRUVADANAI	7.88	861	428	5	5	48	6	280	69
6	ADHIUR	8.21	1188	596	5	5	220	32	250	84
7	AELUR	7.99	379	189	5	5	30	5	110	27
8	KILAPANAIUR	8.18	748	374	15	5	110	15	90	134
9	A.R. MANGALAM	8.1	1719	857	10	15	370	48	270	152
10	SANAVELI	8.37	1819	910	5	15	240	40	350	259
11	KULIYENTHAL	7.86	624	312	5	5	80	12	120	86
12	R.S. MANGALAM	8.53	1760	878	5	10	150	18	530	135
13	AVARANTHAL	8.05	1527	766	10	10	200	30	340	155
14	PARANUR	8.16	364	181	10	20	420	50	1190	95
15	KALANKAPULI	8.13	511	255	5	10	24	3	100	106
16	PURAKARAI	8.03	369	184	10	5	40	5	50	67
17	ATHTHANUR	8.23	362	182	5	10	600	60	820	211
18	SCHOLANDHUR	8.35	270	134	5	10	350	45	700	171
19	KOTHAMANGALAM	7.87	254	127	5	5	20	2	60	23
20	MATHAVANUR	8.05	840	420	10	10	132	16	120	121

Hydogen ion concentration (pH)

pH is the measure of hydrogen ion concentration value in water which indicates whether a solution is acidic, neutral, or basic. The pH required must be in the range of 6.5–8.5 for the drinking purpose (BIS, 2009). The pH of the groundwater samples lies between 7.61 and 8.53 indicates that the underground water in this area is ideal for agricultural as well as domestic purposes.The pH of water changes with the production of hydrogen or hydroxyl ion during different chemical reactions. It is noticed that water with low pH is tend to be toxic and with high degree of pH it is turned into bitter taste. The pH values of the groundwater samples ranged from 7.6 to 8.6 neutral to alkaline nature.The hydrogen ion concentration (pH) in the water samples varies from 7.14 to 8.15 with an average of 7.53. pH is rich in north side. As per the WHO standards, all the sample season fall within the recommended limits (6.5 to 8.5) for human consumption.

Drinking water quality standards WHO (2004) and BIS (2012)

Parameters	WHO (2004)		BIS (2012)	
	Acceptable limit	Permissible limit	Acceptable limit	Permissible limit
Ph	7.0-8.5	9.2	6.5-8.5	
EC			-	-

TDS	500	1500	500	2000
Ca^{2+}	75	200	75	200
Mg^{2+}	50	150	30	100
Na^{+}	-	200	-	-
K^{+}	-	500	-	-
Cl^{-}	200	600	250	1000
HCO_3^{-}	-	600	250	1000
SO_4^{2-}	200	400	200	400
NO_3^{-}	-	45	45	No relaxation

Unit: concentrations are in mg/L except EC (µS/cm), and pH.

pH – Limiting values with respect to BIS standard

S.NO	pH – Limiting values	Portability	Percentage of samples%
1	<6.5	Non-Potable	Nil
2	6.5-8.5	Potable	100
3	>8.5	Non-Potable	Nil

Electrical conductivity(EC)

Electrical conductivity (EC) is a measure of water capacity to convey electric current and importance to salinity; which greatly affects the taste. Chemically pure water has a low electrical conductivity, indicating that it is a good insulator. It directly related to concentration of ionized substances in water and may also be related to problems in excessive hardness EC is expressed in terms of the specific electrical conductivity, which is defined as the reciprocal of electrical resistance in Ohm (Q), in relation to a water cube of edge length 1 cm at 25°C. Electrical conductivity is the capacity of electrical current that passes through the water. The most desirable limit of EC in drinking water is prescribed as 1,500 µS/cm.EC rich in center of the study area. The open and bore well EC results are given in Table.

EC - Limiting values

S.NO	EC-Limiting values	Portability	Percentage of samples%
1	<750	Good	55
2	750-4000	Medium	45
3	>4000	Poor	Nil

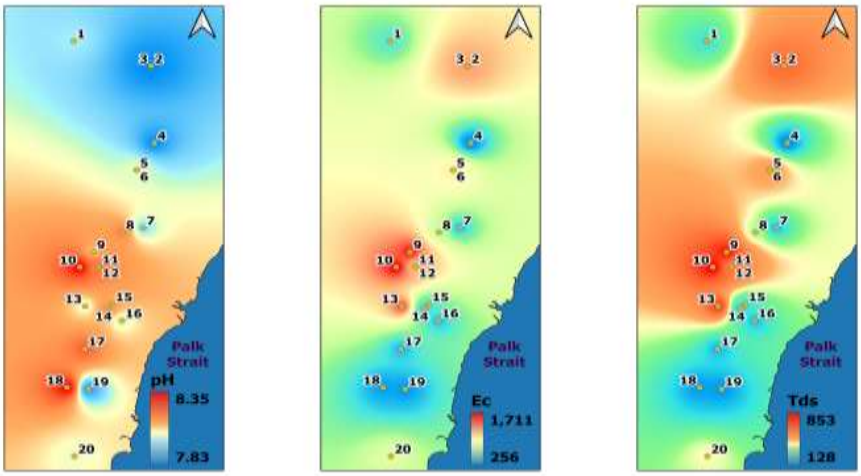
Total dissolved solids (TDS)

Total dissolved solids (TDS) refer to the total amount of all inorganic and organic substances including minerals, salts, metals, cations, or anions that are dispersed within a volume of water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions bicarbonate, chloride, nitrate, and sulphate in groundwater. The concentration of Total Dissolved Solids ranges from 107 to 910 mg/l with an average of 421.4 mg/l. TDS rich in some place in center part of the study area. The limiting

values of TDS are given in Table.

TDS - Limiting values

S.NO	TDS-Limiting values	Portability	Percentage of samples%
1	<500	Good	65
2	500-2000	Medium	35
3	>2000	Poor	Nil



pH **Ec** **TDS**

Spatial distribution of pH, EC and TDS in the samples.

Calcium (Cu)

Calcium is one of the most abundant substances in the water. The high concentration of calcium ions can cause abdominal ailments and is undesirable for domestic use as it causes encrustation and scaling (Kumar et al. 2014). It is produced because of dissolution processes of sedimentary rocks (calcite, aragonite, limestone, dolomite and gypsum) and from weathering of igneous rocks like (pyroxene, amphibole and plagioclase feldspar).Calcium rich in some place in center part of the study area. About 95% calcium in human body stored in bones and teeth.All the samples fall within the acceptable and allowable limit, Spatial distribution map shows.

Calcium limiting values

S.NO	Calcium limiting values	Portable	Percentage of sample%
1	<75	Acceptable limit	100
2	75-200	Allowable limit	Nil
3	>200	Not Potable	Nil

Magnesium (Mg)

Magnesium ions are smaller than sodium and calcium ions and it is one of the necessary elements for plants and animals. Magnesium is also found in igneous rocks and minerals such as (olivine, pyroxene and amphiboles) and metamorphic rocks such as (serpentine and talc). It is an essential for proper functioning of living organisms and found in minerals like dolomite, magnesite etc. Human body contains about 25g of magnesium (60% in bones and 40% in muscles and tissues) (Ramesh and Balakumaran 2018).The higher concentration of the magnesium due to rock water interaction and rest of the portion was observed in downstream portion. The limiting values for magnesium are given in Table.4.7. Magnesium rich some of the place in north side.Magnesium concentration ranges from 5 to 20 mg/l. The spatial distribution map shown.

Magnesium limiting values

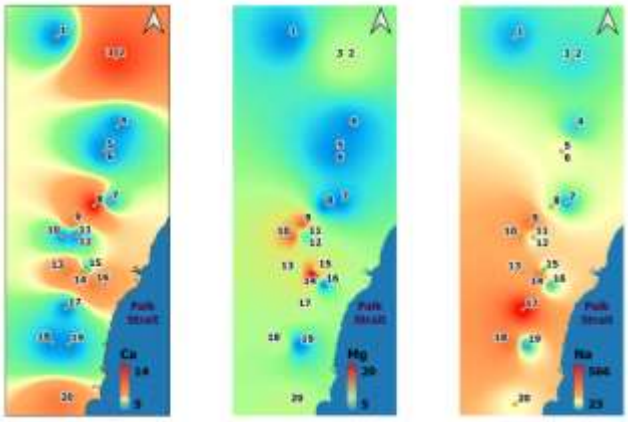
S.NO	Magnesium limiting values	Potable	Percentage of samples%
1	<30	Acceptable limit	100
2	30-100	Allowable limit	Nil
3	>100	Not potable	Nil

Soudium (Na)

Sodium is a metallic element and found in less quantity in water. The source of sodium in groundwater and comes from erosion of alkalinity feldspar and evaporation rocks and from ionic exchange of clay minerals. Human activities can have significant influences on the concentration of sodium in ground and surface water. Proper quantity of sodium in human body prevents many fatal diseases like kidney damages, hypertension, headache etc.., (Ramesh and Balakumaran 2018). Sodium concentration is good if it is less than 250 mg/l (WHO, 1996) concentration. Sodium is found to be the most abundant ion in the groundwater of the study area.Sodium rich in center part of the study area. The open well sodium concentration in the groundwater of the study area ranged from 20 to 600 mg/l, with an average value of 161.6 mg/l shown in the Table.4.8 and the spatial distribution map shown.

Sodium limiting values

S.NO	Sodium limiting values	Potable	Percentage of sample%
1	<200	Acceptable limit	65
2	>200	Not Potable	35



Ca **Mg** **Na**

Spatial distributions of Ca, Mg and Na in the study area.

Potassium (K)

Potassium is slightly less common the sodium in igneous rocks but more abundant in all sedimentary rocks. The main source of potassium is the products formed by weathering of igneous minerals like (orthoclase, biotite and feldspathoid leucit) and sedimentary rocks. Potassium is an essential element for plants and animals; however, high concentration may be harmful to human nervous and digestive systems due to its laxative effects. Potassium deficient in rare but may led to depression, muscle weakness, heart rhythm disorder etc. The elements present in plants material and are lost from agricultural soil by crop harvesting and removal as well as leaching and runoff on organic residues (Ramesh and Balakumaran, 2018).Potassium concentration is good if it is less than 10 mg/l for domestic water (WHO, 1996). Potassium concentration ranges from 3 to 60 mg/l. Potassium classification is done in accordance with European standards. Potassium content in water more than 10 ppm is indicative of pollution as shown in the Table.4.9. Potassium spatial distribution map Fig.4.9. Potassium rich center part of study area. Open and bore well Potassium concentration was very high in sample 6, 9, 10,13,14,17 and 18. spatial distribution map shown.

Potassium limiting values

S.NO	Potassium limiting values	Potable	Percentage of sample%
1	<10	Acceptable limit	45
2	>10	Not Potable	55

Chloride (Cl)

The source of chloride in groundwater is from dissolution of sedimentary rocks particularly

evaporates like halite and sylvite and ancient sea water entrapped in sediments. Chloride is also abundant in the minerals found in igneous rocks like apatite, feldspathoid and sodalite. Chloride is also obtained from the dissolution of salts of hydrochloric acid as NaCl, $NaCO_2$ and added through industrial and domestic waste water, sewage, sea water etc. Excess chloride (>250 mg/l) imparts a salty taste to water. High chloride concentration affects the aesthetic property of water including taste and renders it unsuitable for drinking purpose. Consumption of high-chloride water leads to health issues related to hypertension, ventricular hypertrophy, osteoporosis, renal stones, kidney disease, heart disease and asthma. (Kirubakaran et al .2015).Based on the WHO standards, twelve samples fall in not potable zone shown in Table.4.10. The open well Chlorite concentration in the groundwater of the study area ranged from 50 to 1190 mg/l, with an average value of 321.5 mg/l. chloride rich in very few samples in center part of the study area.Chloride spatial distribution map is shown.

Chloride limiting values:

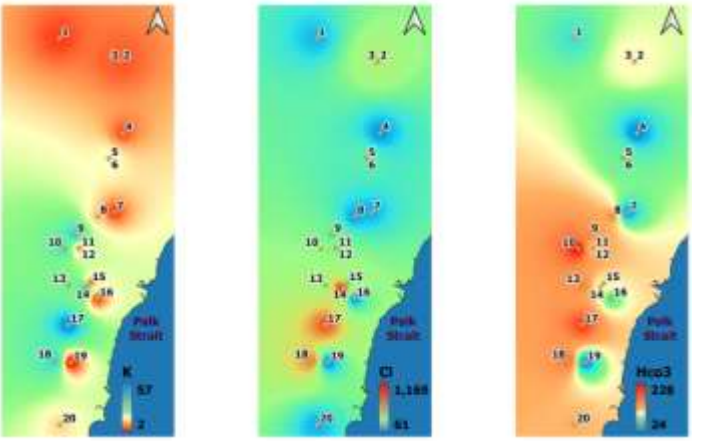
S.NO	Chloride limiting values	Potable	Percentage of samples%
1	<250	Acceptable limit	45
2	>250	Not potable	55

Bicorbonate (HCO_3)

Bicarbonate ions are considered the source of water alkalinity. Alkalinity is the ability of water for interaction with ion of hydrogen. CO_2 gas in the atmosphere or in the soil dissolved in water is the principal source of bicarbonate, in addition to solution of carbonate rocks and oxidation of organic matter. It is the standard alkaline constitute found almost all surface and groundwater bodies and therefore affects alkalinity and hardness of water. Mostly bicarbonates are soluble in water i.e., bicarbonate of magnesium and calcium etc, is the main causes of hardness of water. The hard water is not suitable for drinking purpose and causes the gastro diseases. No standard limits have been provided by the Bureau of Indian Standards for level of carbonate and bicarbonate in drinking water (Ramesh and Balakumaran 2018) Bicarbonate rich in few places in north side. Bicarbonate concentration in groundwater of this area is varies from 23 mg/l to 259 mg/l with an average value of 109.2 mg/l. Bicarbonate spatial distribution map Shown.

Bicarbonate range values

S.NO	Bicarbonate limiting values	Potable	Percentage of samples%
1	<500	Acceptable limit	100
2	>500	Non potable	Nil

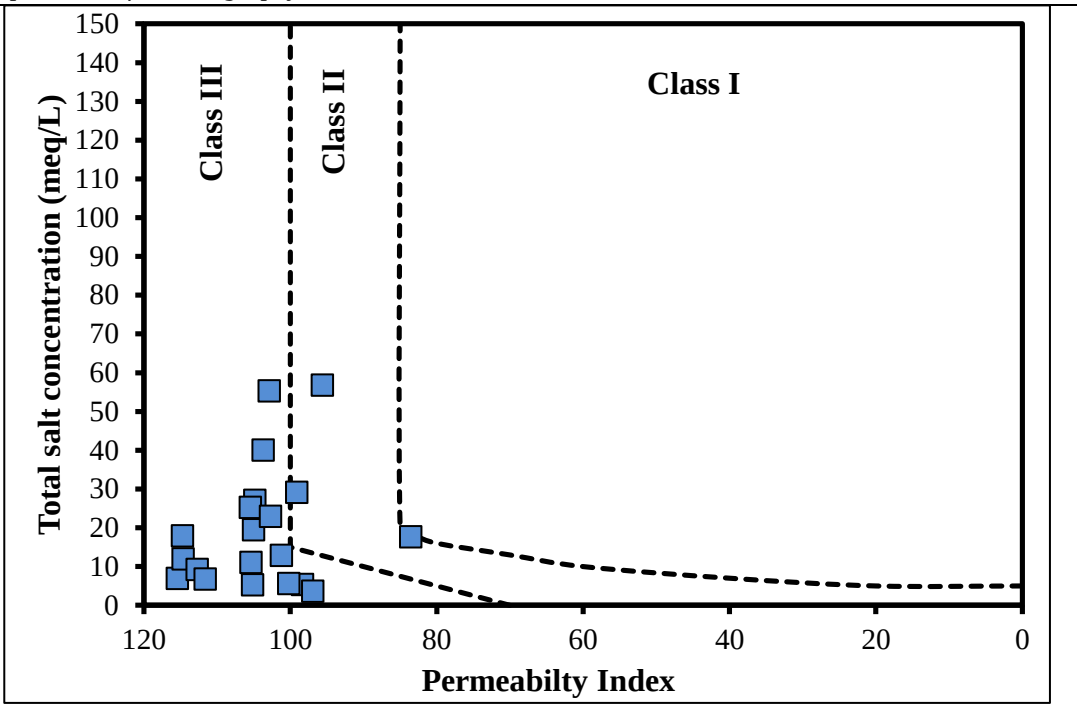


K **Cl** **HCO_3**

spatial distributions of K, Cl and HCO_3in the study area.

Permeability index (PI)

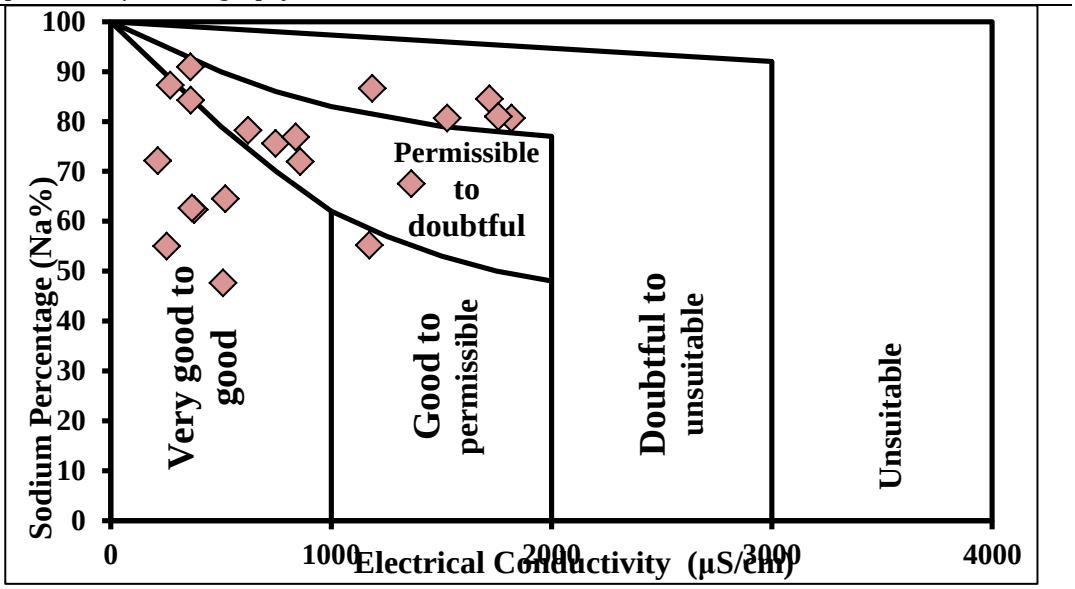
Permeability index developed by Doneen in 1964 is important parameters that influence the quality of water for irrigation. Soil permeability is affected or reduced by long term use of irrigation water containing high salts (Sing and Sing 2008). A criterion for assessing the suitability of water for irrigation was based on PI water and can be classified as class I class II and class III orders. Class I and class II water was categorized as good for irrigation purpose with 85% or more maximum permeability. Class III water was unsuitable with 15% of maximum permeability. None of the groundwater samples of the study area belongs to class I, 15% of samples of the study area belongs to class II and 85% of samples fall in class III. The increased % of groundwater samples under class III are due to dilution and subsequent lower values of PI.



Suitability of groundwater for irrigation based on permeability index in the study area.

Sodium percentage (%) diagram

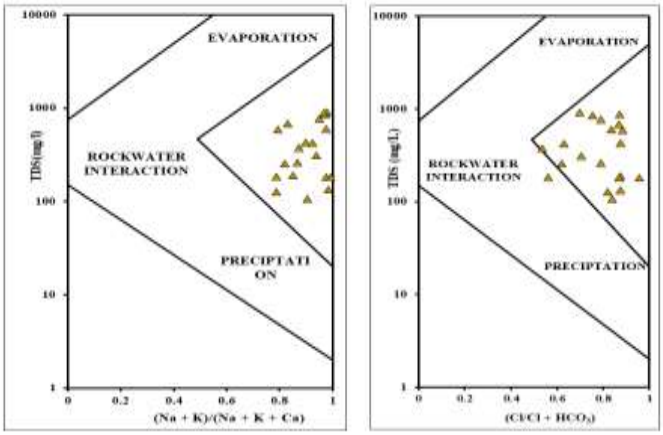
Sodium considered as the main factor for determine groundwater suitability for agricultural purposes. Irrigation water containing large amounts of sodium is of special concern because, it reduces soil permeability and porosity as well as increases the hardness of soil, thus will affect the plant growth or stunted growth. Presence of sodium is usually expressed in terms of Na% and is calculated by the formula (Ramesh 2018). The classification of groundwater for irrigation was grouped based on sodium percentage as Very good (<20%), Good (20-40%), Permissible (40-60%), Doubtful (60-80%) and Unsuitable (>80%). Based on Na% the value <60% is suitable for irrigation purposes and >60% is unsuitable. The (Fig.4.5) samples range from 37% to 77%. Wilcox's proposed a classification in which Na% is correlated against EC of salts to find the suitability of water for irrigation. According to this classification, in the study area 8 samples are falls in the Very good to good limit, 1 sample is fall in the good to permissible limit. 6 samples are fall in the permissible to doubtful limit. 5 samples fall in doubtful to unsuitable limit and none of the samples are fall in unsuitable limit. The agricultural yields are generally low in lands irrigated with water belonging to doubtful to unsuitable category.



Suitability of groundwater for irrigation based on Na% in the study area.

Gibbs diagram

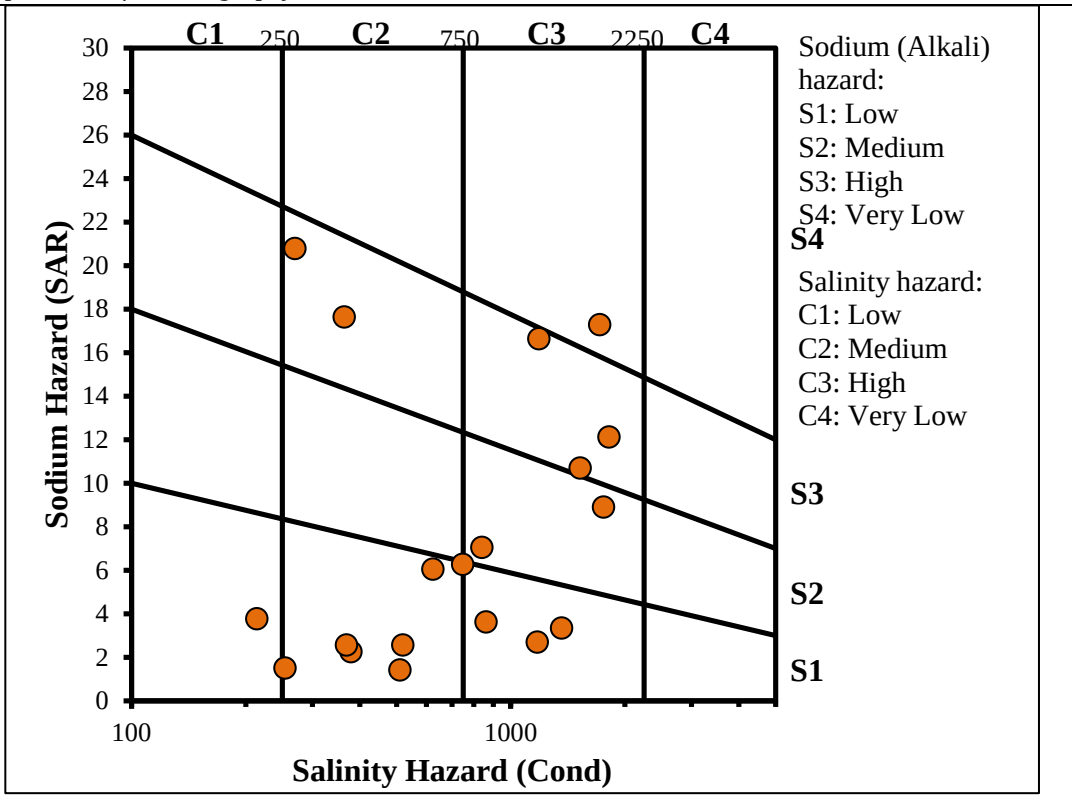
Gibbs diagram is widely used to establish the relationship of water composition and aquifer lithological characteristics. Three distinct fields such as precipitation dominance, evaporation dominance and rock–water interaction dominance areas are shown in the Gibbs diagram (Gibbs, 1970). The predominant samples fall in the rock–water interaction and evaporation field of the Gibbs diagram (Fig. 4.6). The rock–water interaction field indicates the interaction between rock chemistry and the chemistry of the percolated waters under the subsurface condition.The best measures of a water likely effect on soil permeability, soil structure and create toxic conditions for plant growth is the water SAR considered together with its EC. The US salinity diagram which is based on the integrated effect of EC (salinity hazard) and SAR (alkalinity hazard) has been used to assess the water. The results of the study revealed that SAR of the water samples varied from 1.0 to 10.



Mechanisms governing groundwater chemistry (after Gibbs, 1970)

Ussl wilcox diagram

The best measures of a water likely effect on soil permeability, soil structure and create toxic conditions for plant growth is the water SAR considered together with its EC. The US salinity diagram which is based on the integrated effect of EC (salinity hazard) and SAR (alkalinity hazard) has been used to assess the water. The results of the study revealed that SAR of the water samples varied from 1.0 to 10. 2 samples are fall in Low sodium and low salinity hazard.6 samples are fall in low sodium medium and salinity hazard.2 samples fall in high sodium and medium salinity hazard.3 samples are fall in low sodium and high salinity hazard.3 samples are fall in medium sodium and high salinity hazard. 3 samples are fall in high sodium and high salinity hazard. only one sample fall in very low sodium and high salinity hazard. Fig.4.7 shows the Suitability of groundwater for irrigation based on sodium and salinity hazard.

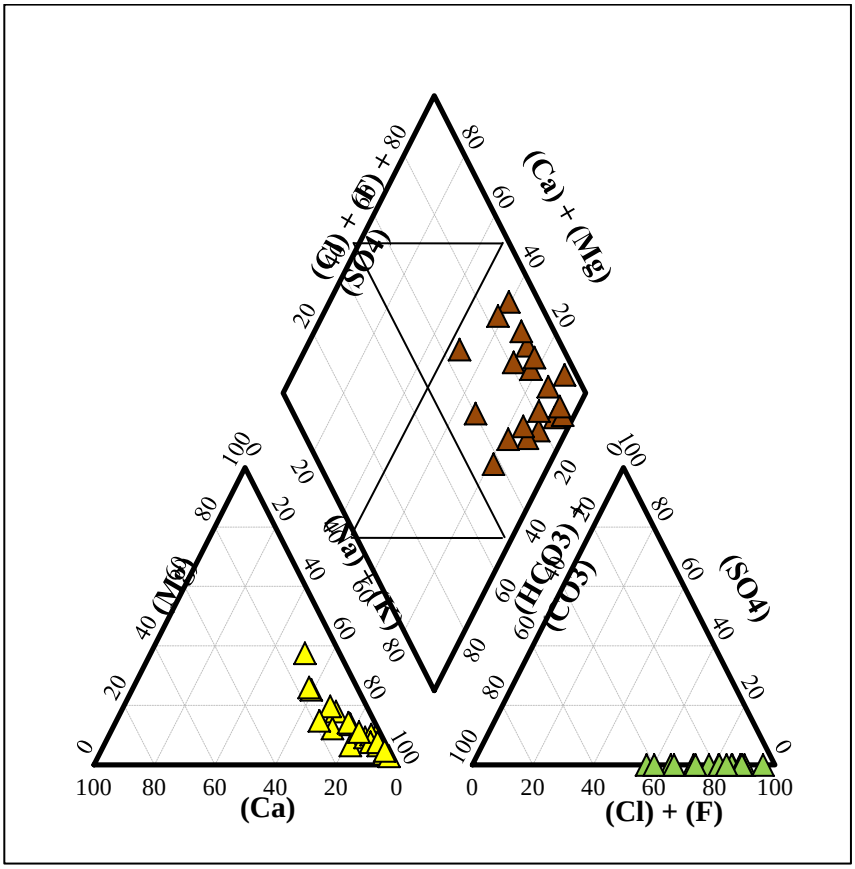


Suitability of groundwater for irrigation based on sodium and salinity hazard.

Piper trilinear diagram

The hydro chemical evolution of groundwater can be understood by plotting the major cations and anions in the piper trilinear diagram (Piper 1944). The nature and distribution of hydrochemical facies can be determined by providing insights into how groundwater quality changes within and between aquifers. Trilinear diagrams can be used to delineate the hydrogeochemical facies, because they graphically demonstrate the relationships between the most important dissolved constituents in a set of groundwater samples in the study area. The hydro-geochemistry of groundwater in the study area was evaluated using the concentrations of major cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (HCO_3^-, SO^{2-}_4 and Cl^-) in meq/l. hydrogeochemical facies for groundwater in the study area is shown in a piper diagram (Fig. 4.8). The piper diagram indicates that sodium is the major cation and chloride is the major anion. Hydrochemical process indicates that alkalis (Na^{+}+ K^{+}) and strong acids (Cl^-+SO_4^{2-}) dominated over the alkaline earth (Ca^{2+}+Mg^{2+}) and weak acids. The plot shows majority of water samples fall in the field of Na–Cl type and these samples are found to be located near the coast, may be due to seawater intrusion (Prasanna et al, 2011). Some samples are also representing mixed water types (Ca–Na–HCO_3–Cl type and Ca–Mg–C1– SO_4 type) indicating anthropogenic

contaminations (Srinivasamoorthy et al. 2011). The plot shows (Fig 4.8) that the groundwater 70 % of samples fall in NaCl type, 25 % of samples fall in mixed Ca-Mg-Cl type and 5 % sample fall Na-K-HCO3 type facies.



Piper diagram shows the hydro geochemical facies of the study area.

Conclusions

The study area of Ramanathapuram groundwater quality indicate that it was not contaminated in many areas by the reported parameters. The reason for contamination of some place of Ramanathapuram is due to saline water intrusion to contaminated the groundwater. The study area is always under stress due to increasing population and more demand for water resources. The hydro geochemical analysis of the study reveals that the groundwater is fresh to brackish and moderately high to hard. Statistical analysis demonstrate that the abundance of cations is in the order: $Na^{+} > Ca^{2+} > Mg^{2+} > K^{+}$, while the abundance of anions is in the order: $HCO3^{-} > Cl^{-}$ are dominant ions among the studied cations and anions. Among the different parameters analyzed, it was seen that EC, Total hardness, pH was in the BIS permissible limits in most of the samples. The concentration of calcium ion is within the permissible

limit for drinking purpose except few locations. 65% of the groundwater samples have exceeded the acceptable limit for sodium. Magnesium ion concentrations are within the acceptable limit for drinking purpose. 55% of the groundwater samples have exceeded the acceptable limit of Potassium (K).55% of the groundwater samples have exceeded the acceptable limit of Chloride. 95% of the groundwater samples have exceeded the acceptable limit of Bicarbonate. According to Gibbs diagram, the predominant samples fall in the rock–water interaction dominance and evaporation dominance field. Majority of samples have been found suitable for irrigation purposes as per the USSL diagram, Wilcox diagram and other agricultural indices. According to Sodium Percentage Diagram the agricultural yields are generally low in lands irrigated with water belonging to doubtful to unsuitable category. Based on this Suitability of groundwater for irrigation based on permeability index study the groundwater quality of the study area is suitable for drinking as well as irrigational uses in most of the region except from very few locations. The groundwater 70 % of samples fall in NaCl type, 25 % of samples fall in mixed Ca-Mg-Cl type and 5 % sample fall Na-K-HCO3 type facies. The origin of Cl in groundwater may be attributed to the Na–Cl-rich seawater encroachment to the aquifer. However, the change from NaCl to Ca–Mg–Cl type groundwater may be due to the cation exchange reaction.

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KUIPER BELT

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The Kuiper Belt is a doughnut-shaped region of icy bodies extending far beyond the orbit of Neptune. It is home to Pluto and Arrokoth. Both worlds were visited by NASA's New Horizons spacecraft. There may be millions of other icy worlds in the Kuiper Belt that were left over from the formation of our solar system. Scientists call these worlds Kuiper Belt objects (KBOs), or trans-Neptunian objects (TNOs). Trans-Neptunian objects are objects in our solar system that have an orbit beyond Neptune.Similar to the asteroid belt, the Kuiper Belt is a region of leftovers from the solar system's early history. Like the asteroid belt, it has also been shaped by a giant planet, although it's more of a thick disk (like a donut) than a thin belt.The Kuiper Belt shouldn't be

confused with the Oort cloud, which is a much more distant region of icy, comet-like bodies that surrounds the solar system, including the Kuiper Belt. Both the Oort cloud and the Kuiper Belt are thought to be sources of comets.The Kuiper Belt is truly a frontier in space – it's a place we're still just beginning to explore and our understanding is still evolving.

MARINE ECOSYSTEM

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Marine ecosystems are aquatic environments with high levels of dissolved salt, such as those found in or near the ocean. Marine ecosystems are defined by their unique biotic (living) and abiotic (nonliving) factors. Biotic factors include plants, animals, and microbes; important abiotic factors include the amount of sunlight in the ecosystem, the amount of oxygen and nutrients dissolved in the water, proximity to land, depth, and temperature. Sunlight is one of the most important abiotic factors for marine ecosystems. It's so important that scientists classify parts of marine ecosystems-up to three—by the amount of light they receive. The topmost part of a marine ecosystem is the euphotic zone, extending down as far as 200 meters (656 feet) below the

surface. At this depth, there is sufficient light for regular photosynthetic activity. Most marine life inhabits this zone. Below the euphotic zone is the dysphotic zone, which can reach from 200 to as deep as 1,000 meters (656 to 3,280 feet) below the surface. At these depths, sunlight is still available, but only enough to facilitate some photosynthesis. Below the dysphotic zone lies the aphotic zone, which does not receive any sunlight.

MARINE POLLUTION

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INTRODUTION

Today the world and particularly Europe are concerned with the pollution of marine environments, which result in instant and long-term damages to coastal and marine habitats and ecosys- tems. Unfortunately, various recent disasters (e. g., in Alaska), alongside all other current sources of pollutions, have proven that the current means of struggle are inefficient. It is thus in- creasingly urgent to develop new solutions for fighting pollution by combining actors' skills from the maritime field.Worldwide seas and oceans are under threat where recent ac- cidental oil spills, such as the ERIKA tragedy or the IEVOLI SUN accidents, have jeopardized the marine environment, causing both immediate and long-term damage to coastal and marine habitats and ecosystems. The last tragedy in Alaska (December 2004) demonstrates the permanence of such phenomena.However, according to the report"The EU Fleet and Chronic Hydrocarbon Contamination of the Oceans", dated November 2004, chronic hydrocarbon contamination from washing-out tanks and dumping bilge water and other oily waste represents a danger at least three times greater than that posed by oil slicks that result from oil tanker accidents. Every year around 3,000 cases of illegal hydrocarbon dumping are detected in European waters. The amount of hydrocarbons received by European

waters each year has been estimated to be 109,000 tons, 62% of them (around 90,000 tons) being small spillages of less than 20 tons.

In addition, land-based activities (industry, agriculture) and 'run-offs' from land are major sources of coastal water pollution. Other issues which are equally or even more dangerous than oil pollution also threaten the marine world, for example, alien species migration, NOx and SOx emissions, hydrocarbons in bal- last water, biocides, pollution from ship-building, pollution from ship repair, pollution from ship scrapping, and noise pollution that affects sea mammals. Taking all these manifold sources of pollution into account and the fact that current protection measures are limited, a stronger involvement of EU citizens and decision-makers is needed to protect and conserve the marine environment. It is therefore more than necessary to develop innovative and efficient means for early prevention, detection, warning and treat- ment of all

types of marine pollution. As environment problems are trans-boundary by definition, it is necessary to develop and spread new solutions that will be efficient on the European scale.

METHODS

This work on an overview of marine pollution follows the metho- dology presented below. Firstly, worldwide and well-known databases (such as Science Direct, GeoRef, SpringerLINK, etc.) on technological research were searched studied. All collected re- ferences were divided into 27 sections following the key words: marine pollution, oil spills, detection techniques, oil spills model- ling, oil containment, oil recovery, in-situ oil burning, sunken oil recovery, oil spills behaviour, oil disposal, debris disposal, Marine Pollution (MARPOL), International Maritime Organisation (IMO) conventions, notification/report system, classification so- cieties, port state control, liability and compensation, environ- mental protection government acts, port regulation, land use, alien species migration, ballast water, hull / propeller cleaning, Nox / SOx emissions, hydrocarbons control, biocides, ship build- ing / repair / scrapping pollutions, and biogeochemical modelling. In general, a very good response from searching into databases was detected, i. e. approximately 2,000 references were analysed following the search results. The limiting publishing year was se- lected as 1990 because older articles were found only in a very few databases and, following conventional search during the overview assessment, are not up-to-date and have no novelty from the scientific or commercial point of view. Statistical estimation using Excel spreadsheets and statisti- cally approved results were used for the overview so as to assess data from the technological and commercial points of view.

MARINE SEACUCUMBERS

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These are in the echinoderms from the class Holothuroidea. They are marine animals with a leathery skin and an elongated body containing a single, branched gonad. They are found on the sea floor worldwide. The number of known holothurian species worldwide is about 1,786, with the greatest number being in the Asia-Pacific region Many of these are gathered for human consumption and some species are cultivated in aquaculture systems. The harvested product is variously referred to as trepang, namako, bêche-de-mer, or balate. Sea cucumbers serve a useful role in the marine ecosystem as they help recycle nutrients, breaking down detritus and other organic matter, after which bacteria can continue the decomposition process. Like all echinoderms, sea cucumbers have an endoskeleton just below the skin, calcified structures that are usually reduced to isolated microscopic ossicles (or sclerietes) joined by connective tissue. In some species these can sometimes be enlarged to flattened plates, forming armour. In pelagic species such as Pelagothuria natatrix (order Elasipodida, family Pelagothuriidae), the skeleton is absent and there is no calcareous ring.

Sea cucumbers are named for their resemblance to the fruit of

the cucumber plant. Most sea cucumbers, as their name suggests, have a soft and cylindrical body, more or less lengthened, rounded off and occasionally fat in the extremities, and generally without solid appendages. Their shape ranges from almost spherical for "sea apples" (genus Pseudocolochirus) to serpent-like for Apodida or the classic sausage-shape, while others resemble caterpillars. The mouth is surrounded by tentacles, which can be pulled back inside the animal. Holothurians measure generally between 10 and 30 centimetres long, with extremes of some millimetres for Rhabdomolgus ruber and up to more than 3 metres for Synapta maculata. The largest American species, Holothuria floridana, which abounds just below low-water mark on the Florida reefs, has a volume of well over 500 cubic centimeters (31 cu in), and 25–30 cm (10–12 in) long. Most possess five rows of tube feet (called "podia"), but Apodida lacks these and moves by

crawling; the podia can be of smooth aspect or provided with fleshy appendages (like Thelenota ananas). The podia on the dorsal surface generally have no locomotive role, and are transformed into papillae. At one of the extremities opens a rounded mouth, generally surrounded with a crown of tentacles which can be very complex in some species (they are in fact modified podia); the anus is postero-dorsal. Holothurians do not look like other echinoderms at first glance, because of their tubular body, without visible skeleton or hard appendixes. Furthermore, the fivefold symmetry, classical for echinoderms, although preserved structurally, is doubled here by a bilateral symmetry which makes them look like chordates. However, a central symmetry is still visible in some species through five 'radii', which extend from the mouth to the anus (just like for sea urchins), on which the tube feet are attached. There is thus no "oral" or "aboral" face as for sea stars and other echinoderms, but the animal stands on one of its sides, and this face is called trivium (with three rows of tube feet), while the dorsal face is named bivium. A remarkable feature of these animals is the "catch" collagen that forms their body wall. This can be loosened and tightened at will, and if the animal wants to squeeze through a small gap, it can essentially liquefy its body and pour into the space. To keep itself safe in these crevices and cracks, the sea cucumber will hook up all its collagen fibers to make its body firm again.

The most common way to separate the subclasses is by looking at their oral tentacles. Order Apodida have a slender and elongate body lacking tube feet, with up to 25 simple or pinnate oral tentacles. Aspidochirotida are the most common sea cucumbers encountered, with a strong body and 10–30 leaflike or shield-like oral tentacles. Dendrochirotida are filter-feeders, with plump bodies and 8–30 branched oral tentacles (which can be extremely long and complex).

METHANE HYDRATES

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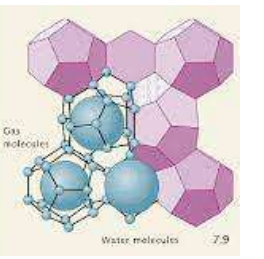
Methane hydrates also known as Methane clathrate (CH4.5.75H2O) or (8CH4.46H2O) are white, ice-like solids that consist of methane and water. The methane molecules are surrounded by a cage of interlocking water molecules. That occurs naturally in subsurface deposits where temperature and pressure conditions are favorable for its formation.(Low temperature and high pressure). Methane gas is primarily formed by microorganisms that live in the deep sediment layers and slowly convert organic substances to methane. These organic materials are the remains of plankton that lived in the ocean long ago, sank to the ocean floor, and were finally incorporated into the sediments. Methane hydrates are only stable under pressures in excess of 35 bar and at low temperatures. The sea floor is thus an ideal location for their formation: These hydrates exist in huge quantities in marine sediments in a layer several hundred meters thick directly below the sea floor and in association with permafrost in the Arctic. It is not stable at normal sea-level pressures and temperatures, which are the primary reason that it is a challenge to study.They, provide a better understanding of the ocean carbon



cycle. They occur on virtually all continental margins, and the methane they contain promotes the development of very specific ecosystem.They also play a role in the stability of the seabed ,so it is important to know the factors that may lead to their destabilization.From an applied point of view, some countries have even considered extracting these methane to use it as natural gas.

Gas hydrates are important for three reasons:

- They may contain a major energy resource
- It may be a significant hazard because it alters sea floor sediment stability, influencing collapse and landsliding
- The hydrate reservoir may have strong influence on the environment and climate, because methane is a significant greenhouse gas.

OCTOPUSES

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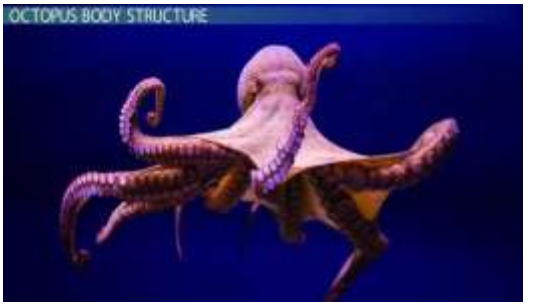
They belong to the cephalopod family and are characterized by their eight arms (not tentacles) lined with suction cups that help them maneuver and catch prey. They lack a skeleton, allowing them to fit through tiny spaces. Considered one of the smartest invertebrates, octopuses have a highly developed nervous system. They can solve puzzles, learn from experiences, and even use tools in captivity. Masters of disguise, they can change color and texture to blend seamlessly with their surroundings, enabling them to evade predators and hunt efficiently. Most octopuses possess venomous saliva used to immobilize prey. While not deadly to humans, their bites can be painful and occasionally cause irritation. They inhabit various marine environments, from shallow coastal waters to the ocean's depths. Some species reside in dens they create by burrowing into soft sediments or using discarded shells. After mating, the female lays eggs and guards them until they hatch. Octopus moms often stay



with their eggs, protecting and cleaning them until they hatch, after which they usually die. Most octopus species have relatively short lives, typically ranging from one to three years. This brief lifespan is due in part to their reproductive strategy; many die shortly after mating and laying eggs. While they lack a complex vocal system, octopuses communicate through body movements, color changes, and the use of specialized skin cells called chromatophores. Their incredible adaptability, problem-solving abilities, and unique characteristics make octopuses a source of endless fascination for scientists and nature enthusiasts alike.

MARINE MICROPLANKTON

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Plankton are the diverse group of organisms that live in the water column of large bodies of water but cannot swim against a current. As a result, they wander or drift with the currents. Plankton are defined by their ecological niche, not by any phylogenetic or taxonomic classific ation. They are a crucial source of food for many marine animals, from forage fish to whales. Plankton can be divided into a plant-like component and an animal component. Phytoplankton – such as this colony of Chaetoceros socialis – naturally gives off red fluorescent light which dissipates excess solar energy they cannot consume through photosynthesis. This glow can be detected by satellites as an indicator of how efficiently ocean phytoplankton is photosynthesising. Phytoplankton are the plant-like components of the plankton community ("phyto" comes from the Greek for plant). They are autotrophic (self-feeding), meaning they generate their own food and do not need to consume other organisms. Phytoplanktons perform three crucial functions: they generate nearly half of the world atmospheric oxygen, they regulate ocean and atmospheric carbon dioxide levels, and they form the base of the marine food web. When conditions are right, blooms of phytoplankton algae can occur in surface waters. Phytoplanktons are r-strategists which

grow rapidly and can double their population every day. The blooms can become toxic and deplete the water of oxygen. However, phytoplankton numbers are usually kept in check by the phytoplankton exhausting available nutrients and by grazing zooplankton. Phytoplankton consists mainly of microscopic photosynthetic eukaryotes which inhabit the upper sunlit layer in all oceans. They need sunlight so they can photosynthesize. Most phytoplankton is single-celled algae, but other phytoplankton are bacteria and some are protists Phytoplankton include cyanobacteria (above), diatoms, various other types of algae (red, green, brown, and yellow-green), dinoflagellates, euglenoids, cocc olithophorids, cryptomonads, chlorophy tes, prasinophytes, and silicoflagellates. They form the base of the primary production that drives the ocean food web, and account for half of the current global primary production, more than the terrestrial forests.

PLANKTON

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The word “plankton” comes from the Greek for “drifter” or “wanderer.” An organism is considered plankton if it is carried by tides and currents, and cannot swim well enough to move against these forces. Some plankton drifts this way for their entire life cycle. Others are only classified as plankton when they are young, but they eventually grow large enough to swim against the currents. Plankton is usually microscopic, often less than one inch in length, but they also include larger species like some crustaceans and jellyfish. Scientists classify plankton in several ways, including by size, type, and how long they spend drifting. But the most basic categories divide plankton into two groups: phytoplankton (plants) and zooplankton (animals). Phytoplankton is microscopic plants, but they play a huge role in the marine food web. Like plants on land, phytoplankton performs photosynthesis to convert the sun’s rays into energy to support them, and they take in carbon dioxide and produce oxygen. Because they need the sun’s energy, phytoplankton is found near the water’s surface. Zooplankton include microscopic animals (krill, sea snails, pelagic worms, etc.), the young of larger invertebrates and fish, and weak swimmers like jellyfish. Most zooplankton eats phytoplankton, and most are, in turn, eaten by larger

animals (or by each other). Krill may be the most well-known type of zooplankton; they are a major component of the diet of humpback, right, and blue whales. During the daylight hours, zooplankton generally drifts in deeper waters to avoid predators. But at night, these microscopic creatures venture up to the surface to feed on phytoplankton. This process is considered the largest migration on Earth; so many animals make this journey that it can be observed from space. Plankton are incredibly important to the ocean ecosystem, and very sensitive to changes in their environment, including in the temperature, salinity, pH level, and nutrient concentration of the water. When there are too many of certain

nutrients in the water, for instance, harmful algal blooms like red tides are the result. Because many zooplankton species eat phytoplankton, shifts in timing or abundance of phytoplankton can quickly affect zooplankton populations, which then affect species along the food chain. Researchers are studying how climate change affects plankton, from the timing of population changes to the hardening of copepod shells, and how those effects ripple through ecosystems.

PLASTIGLOMERATE

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Plastic rocks, also known as "plastiglomerates," are a relatively new type of rock that has been identified on remote islands by scientists. These rocks are formed when plastic debris, such as bottles, bags, and fishing nets, is melted and fused together with other materials, such as volcanic rock or sand.Plastic rocks were first identified by geologist Patricia Corcoran and oceanographer Charles Moore in 2012 on the beaches of Hawaii. Since then, scientists have found plastic rocks on other remote islands, including Kamilo Beach on the Big Island of Hawaii, the beaches of the French Frigate Shoals in the Northwestern Hawaiian Islands, and Henderson Island in the South Pacific.The presence of plastic rocks on these remote islands highlights the pervasive and long-lasting impact of plastic pollution on the environment. Plastic pollution not only harms marine life, but it can also become a part of the geologic record, potentially affecting future generations.Plastiglomerate's formation involves a complex interaction between human-made plastic waste and natural geological processes.

Formation Process: The formation of plastiglomerate typically requires temperatures exceeding the melting point of the plastic, which can be reached through various means such as open fires, industrial processes, or natural wildfires. Once the plastic

melts, it adheres to natural sedimentary components like sand, shells, pebbles, and other debris found on beaches or in other environments.

Types: In-situ plastiglomerate and clastic plastiglomerate are two types of plastiglomerate depending on the type of composition In-situ plastiglomerates are composed of indurated, multi-composite material made hard by agglutination of rock and molten plastic, whereas clastic plastiglomerates are composed of a melted plastic matrix including (in)organic material such as sand, wood chips, barnacle, mussel, and snail shell fragments. The polymer types most frequently found in plastic debris trapped in plastistones is polyethylene (PE), polyethylene terephthalate (PET), and polypropylene (PP), and their origins are mainly from domestic waste, such as packaging and containers, or as a result of maritime activities. Sedimentary rocks are the dominant

rock type found on the Earth's surface, and they are highly susceptible to influence by human activities. In recent years, a number of plastic-rock complexes have been reported across the globe, such as plastiglomerate, plastitar, plasticrust, and anthropoquinas. Plastistone is formed when plastic and clast from pre-existing rock are lithified together. Plastistones have been found on a global scale, both in coastal and inland regions. The polymer types most frequently found in plastic debris trapped in plastistones is polyethylene (PE), polyethylene terephthalate (PET), and polypropylene (PP), and their origins are mainly from domestic waste, such as packaging and containers, or as a result of maritime activities. Plastistones can form through a variety of means, including campfire or plastic waste burning, wave action, evaporation, or chemical bonding. Plastistones have been shown to alter the microbial communities of the surrounding environment and can generate significant amounts of microplastics and nanoplastics.

Impact and Environmental Significance: Plastiglomerate serves as a tangible marker of the Anthropocene epoch, where human activity significantly impacts Earth's geology. It raises awareness of plastic pollution and its integration into natural environments, potentially altering sedimentary records and ecosystems.

STINGRAY

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Stingrays are a group of sea rays, which are cartilaginous fish related to sharks. They are classified in the suborder Myliobatoidei of the order Myliobatiformes and consist of eight families: Hexatrygonidae (sixgill stingray), Plesiobatidae (deepwater tingray), Urolophidae (stingarees), Urotrygonidae (round rays), Dasyatidae (whiptail stingrays), Potamotrygonidae (river stingrays), Gymnuridae (butterfly rays) and Myliobatidae (eagle rays). There are about 220 known stingray species organized into 29 genera. Stingrays are common in coastal tropical and subtropical marine waters throughout the world. Some species, such as the thorntail stingray (Dasyatis thetidis), are found in warmer temperate oceans and others, such as the deepwater stingray (Plesiobatis daviesi), are found in the deep ocean. The river stingrays and a number of whiptail stingrays (such as the Niger stingray (Fontitrygon garouaensis)) are restricted to fresh water. Most myliobatoids are demersal (inhabiting the next-to-lowest zone in the water column), but some, such as the pelagic stingray and the eagle rays, are pelagic. Stingray species are progressively becoming threatened or vulnerable to extinction, particularly as the consequence of unregulated fishing. As of 2013, 45 species have been listed as vulnerable or endangered by the IUCN. The status of some other species is

poorly known, leading to their being listed as data deficient.

Anatomy

Jaw and teeth-The mouth of the stingray is located on the ventral side of the vertebrate. Stingrays exhibit hyostylic jaw suspension, which means that the mandibular arch is only suspended by an articulation with the hyomandibula. This type of suspensions allows for the upper jaw to have high mobility and protrude outward. The teeth are modified placoid scales that are regularly shed and replaced. In general, the teeth have a root implanted within the connective tissue and a visible portion of the tooth is large and flat, allowing them to crush the bodies of hard shelled prey. Male stingrays display sexual dimorphism by developing cusps, or pointed ends, to some of their teeth. During mating season, some stingray species fully change their tooth morphology which then returns to baseline during non-mating seasons.Spiracles-Spiracles are small openings that allow some fish and amphibians to breathe. Stingray

spiracles are openings just behind its eyes. The respiratory system of stingrays is complicated by having two separate ways to take in water to use the oxygen. Most of the time stingrays take in water using their mouth and then send the water through the gills for gas exchange. This is efficient, but the mouth cannot be used when hunting because the stingrays bury themselves in the ocean sediment and wait for prey to swim by. So the stingray switches to using its spiracles. With the spiracles, they can draw water free from sediment directly into their gills for gas exchange. These alternate ventilation organs are less efficient than the mouth, since spiracles are unable to pull the same volume of water. However, it is enough when the stingray is quietly waiting to ambush its prey. The flattened bodies of stingrays allow them to effectively conceal themselves in their environments. Stingrays do this by agitating the sand and hiding beneath it. Because their eyes are on top of their bodies and their mouths on the undersides, stingrays cannot see their prey after capture; instead, they use smell and electroreceptors (ampullae of Lorenzini) similar to those of sharks. Stingrays settle on the bottom while feeding, often leaving only their eyes and tails visible. Coral reefs are favorite feeding grounds and are usually shared with sharks during high tide.

Evolution

Stingrays diverged from their closest relatives, the panrays, during the Late Jurassic period, and diversified over the course of the Cretaceous into the different extant families today. The earliest stingrays appear to have been benthic, with the ancestors of the eagle rays becoming pelagic during the early Late Cretaceous.

FOSSILS

Permineralized stingray teeth have been found in sedimentary deposits around the world as far back as the Early Cretaceous. The oldest known stingray taxon is "Dasyatis" speetonensis from the Hauterivian of England, whose teeth most closely resemble that of the extant sixgill stingray (Hexatrygon). Although stingray teeth are rare on sea bottoms compared to the similar shark teeth, scuba divers searching for the latter do encounter the teeth of stingrays. Full-body stingray fossils are very rare but are known from certain lagerstätte that preserve soft-bodied animals. The extinct Cyclobatis of the Cretaceous of Lebanon is thought to be a skate that had convergently evolved a highly stingray-like body plan, although its exact taxonomic placement is still uncertain. True stingray fossils become more common in the Eocene, with the extinct freshwater stingrays Heliobatis and Asterotrygon known from the Green River Formation. A diversity of stingray fossils is known from the Eocene Monte Bolca formation from Italy, including the early stingaree Arechia, as well as Dasyomyliobatis, which is thought to represent a transitional form between stingrays and eagle rays, and the highly unusual Lessiniabatis, which had an extremely short and slender tail with no sting.

SEA ANIMAL JELLY FISH

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Jellyfish are mainly free-swimming marine animals with umbrella-shaped bells and trailing tentacles, although a few are anchored to the seabed by stalks rather than being mobile. The bell can pulsate to provide propulsion for highly efficient locomotion. The tentacles are armed with stinging cells and may be used to capture prey and defend against predators. Jellyfish have a complex life cycle. The medusa is normally the sexual phase, which produces planula larvae; these then disperse widely and enter a sedentary polyp phase, before reaching sexual maturity. Jellyfish are found all over the world, from surface waters to the deep sea. Scyphozoans (the "true jellyfish") are exclusively marine, but some hydrozoans with a similar appearance live in freshwater. Large, often colorful, jellyfish are common in coastal zones worldwide. The medusae of most species are fast-growing, and mature within a few months then die soon after breeding, but the polyp stage, attached to the seabed, may be much more long-lived. Jellyfish have been in existence for at least 500 million years, and possibly 700 million years or more, making them the oldest multi-organ animal group. Jellyfish are eaten by humans in certain cultures. They are considered a delicacy in some Asian countries, where species in

the Rhizostomeae order are pressed and salted to remove excess water. Australian researchers have described them as a "perfect food": sustainable and protein-rich but relatively low in food energy. They are also used in research, where the green fluorescent protein used by some species to cause bioluminescence has been adapted as a fluorescent marker for genes inserted into other cells or organism. The stinging cells used by jellyfish to subdue their prey can injure humans. Thousands of swimmers worldwide are stung every year, with effects ranging from mild discomfort to serious injury or even death. When conditions are favourable, jellyfish can form vast swarms, which canbe responsible for damage to fishing gear by filling fishing nets, and sometimes clog the cooling systems of power and desalination plants which draw their water from the sea.

SEAFLOOR SPREADING

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Seafloor spreading is a geologic process in which tectonic plates-large slabs of Earth's lithosphere-split apart from each other. Seafloor spreading and other tectonic activity processes are the result of mantle convection. Mantle convection is the slow, churning motion of Earth's mantle. Convection currents carry heat from the lower mantle and core to the lithosphere. Convection currents also "recycle" lithospheric materials back to the mantle. Seafloor spreading occurs at divergent plate boundaries. As tectonic plates slowly move away from each other, heat from the mantle's convection currents makes the crust more plastic and less dense. The less-dense material rises, often

forming a mountain or elevated area of the seafloor. Eventually, the crust cracks. Hot magma fueled by mantle convection bubbles up to fill these fractures and spills onto the crust. This bubbled-up magma is cooled by frigid seawater to form igneous rock. This rock (basalt) becomes a new part of Earth's crust.

SEAWEED

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Seaweed, or marine algae, encompasses a wide variety of multicellular, photosynthetic organisms that thrive in aquatic environments. There are three main types based on pigmentation: green algae (Chlorophyta), brown algae (Phaeophyta), and red algae (Rhodophyta).

1.Green Algae (Chlorophyta): These are often found in shallow waters and can range from microscopic phytoplankton to larger seaweeds like Ulva (sea lettuce). They contain chlorophyll a and b, giving them a green color.

2.Brown Algae (Phaeophyta): Typically found in cooler coastal waters, brown algae include kelp and rockweeds. They get their color from fucoxanthin pigments. Some brown algae can grow into large, complex structures, providing habitat for various marine species.

3.Red Algae (Rhodophyta): Red algae are common in both tropical and temperate waters. They contain pigments like phycoerythrin, giving them a red or purplish color. Coralline algae, which contribute to coral reef

structure, belong to this group.

Seaweed plays a vital role in marine ecosystems by providing habitat and shelter for many marine organisms.They contribute to nutrient cycling by absorbing and releasing minerals and other compounds.

Food: Seaweed is a common ingredient in various Asian cuisines. It is rich in vitamins, minerals, and often used in sushi, soups, and salads.

Biotechnology: Some seaweeds are used in pharmaceuticals, cosmetics, and other industrial applications.

Fertilizer and Agriculture: Seaweed extracts are used as organic fertilizers, enhancing plant growth and stress resistance.

Environmental Benefits: Seaweeds are being explored for their potential in carbon sequestration, helping mitigate the effects of climate change.

SUBMARINE MINERAL RESOURCES

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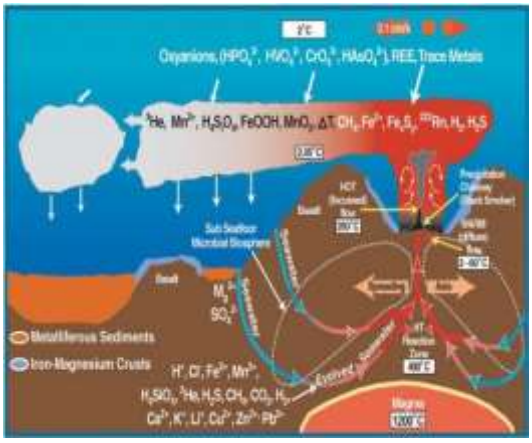
Global warming is the biggest problem that humanity is facing. Most climate scientists agree on how human intervention has affected the atmospheric change in the past two centuries, leading to a rise in global temperature by 1 °C. This is mainly due to the high production of CO2 by the energy sector, which is why it is necessary to promote accelerated growth in the renewable energy market. However, there is a shortage of critical materials in the Earth's crust, wherein China (the largest producer) has a monopolistic position in the rare earth market. This situation restricts the growth of the cleaner energies market and, in turn, generates significant political conflicts between the world's great powers. The vast mineral wealth that is available in the seabed might provide several critical metals, highlighting a large concentration of rare earth, which makes deep-sea mining a great alternative to satisfy the demand for these resources.

The ocean covers 71% of the planet's surface, and in turn is the habitat of the vast majority (97%) of living organisms (González et al., 2012, Toro et al., 2018). Due to its expanse, exploration has been complicated for humanity (Stewart and Jamieson 2019). For the most part, deep-sea mineral extraction has not been widely implemented due to several engineering challenges, such as (1) the distant location with respect to the coast; (2) it is not possible to predict climate changes in the long term; and (3) the high-pressure environment complicates the survival of any component of engineering systems (Sharma 2017). Maritime areas that are more than 200 m deep are considered as deep-sea (Danovaro et al. 2017), where there are a great wealth not only of marine species but also minerals. It is estimated that, on the ocean floor, reside the largest reserves of cobalt, nickel, and manganese, together with a considerable concentration of rare earth (COCHILCO, 2016, Pak et al., 2019). This great abundance of elements is reflected in three large mineral deposits: manganese nodules, ferromanganese crusts, and polymetallic sulfides (Schriever and Thiel 2013).

Deep-sea deposits may be the solution to the shortage of critical metals on the land surface (Pérez et al., 2020) with In turn; it would allow the renewable energy industry to be promoted more rapidly and would decrease political tensions and controversies generated by the exploitation of critical metals. However, despite the existence of a legal framework for marine mineral resources, it has not yet been possible to detail how environmental aspects will be managed for their exploitation, and the total damage that it would generate to the ecosystem is still uncertain

(Miller et al. 2018).The continuous increase in the planet's temperature is disturbing, and the principal cause is global warming (Umair Shahzad 2017). This is due to the increasing amount of greenhouse gases in the atmosphere, specially carbon dioxide (CO2) and methane (CH4) (Yerli et al. 2019). Atmospheric concentrations of both are continually increasing, resulting in the average air temperatures continuing to rise globally (Gruca-rokosz 2020) where CO2, which has an 82% share amongst greenhouse gases, is shown.

Raw materials are classified as "critical" when they are at risk of supply shortages and have more



significant impacts on the economy compared to most other raw materials (Ylä-Mella and Pongrácz 2016). In many cases, these critical materials appear in relatively small quantities (Papadopoulos, Tzifas, and Tsikos 2019), but they are essential for economic development. They are also identified as key to decrease CO2 emissions (Deady and Broom-fendley 2020) (see Table 1). Meanwhile, if simply

Manganese nodules

Marine nodules, also called manganese nodules, were discovered in 1968 in the Arctic Ocean (Lenoble, 2000, Saldaña et al., 2019). They are stony concretions with a spherical shape, between brown and black, formed mainly by Fe and Mn (Glasby, Li, and Sun 2015). These form groups of metallic oxides dispersed in the sedimentary zone of the seabed of the Pacific, Atlantic, and Indian Oceans at depths of 4500 m, reaching reserves ranging between 1 and 3 trillion tons (Pérez et al., 2020).

Environmental impacts of marine mining

The oceans are an essential part of the biosphere, influencing climate, health, and overall well-being (González et al. 2012). Of these, the deep sea covers approximately 70% of the planet, with an average depth of 3200 m (Ramirez-Llodra et al. 2011). About 50% of the seabed is an abyssal plain, composed mainly of mudflats, in addition to submarine canyons, ocean trenches, hydrothermal springs, and underwater mountains, where this great

variety of benthic habitats (seabed) .

There is a worldwide interest in the implementation of the Paris Agreement, together with the sustainable development goals set by the UN and the Intergovernmental Panel on Climate Change. Yet keeping the rise in temperature at bay is not possible in the current global context. The energy sector is the primary CO2 generator on the planet, and energy consumption has been projected to increase considerably by 2040 (>40%).

TECTITETHYACRYPTA

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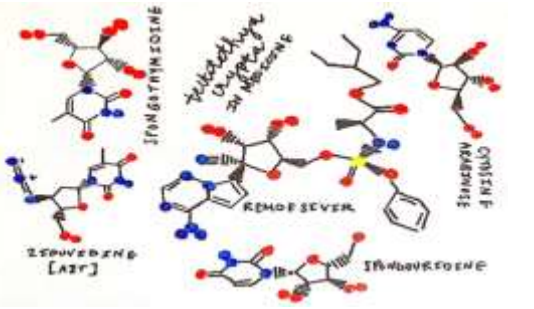
It is species of demosponge belonging to the family Tethyidae. Its classified family is characterized by fourteen different known genera, one of them being Tectitethya. It is a massive, shallow-water sponge found in the Caribbean Sea. This sponge was first discovered by Werner Bergmann in 1945 and later classified by de Laubenfels in 1949. It is located in reef areas situated on softer substrates such as sand or mud. Oftentimes, it is covered in sand and algae.This results in an appearance that is cream colored/ gray colored; however, when the animal is washed free of its sediment coverings, its body plan appears more green and gray. It's characterized with ostia peaking out of its body cavity, with the ability to abruptly open or close, changing its desired water flow rate through its mesohyl .This sponge is widely known for its contributions to the field of medicine as a source for potent nucleoside analogues used in treating H.I.V, Acute Myeloid Leukemia, pancreatic cancer, Ebola, and others. The nucleosides spongothymidine and spongouridine were isolated from this sponge, providing the basis for anti-viral drugs and anti-cancer drugs. Vidarabine, an antiviral drug, was derived from these compounds. The discovery of these nucleosides also led to the development of cytarabine for clinical use in the



treatment of leukemia and lymphoma. Gemcitabine, a fluorinated derivative of cytarabine, is used to treat pancreatic, breast, bladder, and non-small-cell lung cancer. Holding such valuable compounds, free-living within the animal, T. crypta has shaped the present and future world of medicine.

Anatomy & physiology

Body morphology

As described by Laubenfels, the body of this sponge is amorphous, bulky, and approximately the size of one's fist. Its dimensions are around 4 by 7 by 12 centimetres (1.6 in × 2.8 in × 4.7 in) and may be cylindrical, conical, or hemispherical in shape. More recent studies have indicated a larger range of size within this species. The outermost, visible layer of the animal can be seen to have flat tubercules, approximately 3 to 5 millimeters in diameter and a thick layer of sediment. Its actual olive pigment isn't easily visible under this layer of sand/ sediment. In clustered bundles on the surface of the animal are structures called megascleres, radiating and branching outwards. Ray tips are

rounded; micrasters are seen to be 8 to 12 micrometers in diameter. Star spicules makeup a layer beneath its exterior skeleton.

Size

Three main developmental phases have been identified in conjunction with the sponges' localization of course sediment within its body. The small sponges are characterized with a spherical shape and possess evenly spread sediment. The medium T. crypta sponges are seen to have a conical shape with their sediment stability with their shape and sediment concentration. Lastly, the larger sponges are concentrated near their bottom or base. The larger sponges are seen to be irregular in shape and also have evenly distributed sediments. With each body size are different habits that each acquire. Smaller sponges are unattached and are seen to rest and roll freely. The medium sponges are also unattached; however, they still have great attached on their bottom-end. Typically, 67% of their body is buried in sand.

Ecology

Tectitethya crypta can be found in shallow water, only about 1 to 20 meters in depth within the Caribbean. It dwells on a soft substrate, typically substances such as muds, sands, or clays. It can geographically be located in a reef near the Florida Keys, Dry Tortugas, and north-west shores of Cuba, as well as the Florida west coast. The larger of the sponges, sizing around 1.5-10 liters in volume are typically found attached to their substrate while the smaller sponges of this species, sizing around 0.5-1.5 liters in volume are typically found to be unattached and resting freely on their bottom.

Human relations

MEDICINE

The discovery of T. crypta allowed for the discovery of the first sponge-derived pharmaceutical drugs. The two nucleosides, spongothymidine and spongouridine, are documented as the two nucleoside analogues used in the synthesis of life-saving drugs today. These are natural products - not artificially synthesized. Marine natural products (MNP's) have been shown to have stronger bioactive properties than those from terrestrial organisms, possessing cytotoxic and antiproliferative agents. Understanding this has allowed scientists to recognize the role that these potent chemicals may play in chemical defense mechanisms and protection from prey. This may be the case for T. crypta, as it's a sessile organism not possessing an immune system. The treatment of leukemia through the use of Ara-C (cytarabine) is the first documented anticancer agent that has come about from the sponge. In fact, it was approved by the FDA in 1969 in treating non-Hodgkin's lymphoma and myeloid and myelocytic leukemia. As of today, cytarabine is one of the greatest contributors towards anti-cancer therapies. The drug disables Deoxyribonucleic Acid Polymerase, inhibiting DNA synthesis during the S phase of the cell cycle. This discovery allowed for scientists to manipulate the replication of viral DNA within its host

and put a complete halt in its division. This hallmark discovery led to the development of azidothymidine (AZT) through the use of Ara-A. Azidothymidine is utilized in the treatment of HIV-infected individuals. Vidarabine (Ara-A) alone is used in ophthalmologic applications today. A fluorinated derivative of Ara-C has contributed towards the advancement of treatment for lung, pancreatic, breast, and bladder cancer. This drug is known as gemcitabine — proven useful in its effectiveness against solid tumors such as these. Manipulation of these two original nucleoside analogues provided by T. Crypta has provided scientists and medical professionals the capability to offer humans potential cures to devastating diseases-and has inspired the future of medicine to search for "natural" cures in the sea.

THE MOON IS DRIFTING AWAY FROM EARTH

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You read that correctly! The Moon is gradually drifting away from Earth at a rate of approximately 4 cm per year. This phenomenon is caused by the Moon pulling on Earth's oceans creating tidal forces that produce a bulge of water on the side of Earth facing the Moon. This bulge in turn creates a gravitational pull on the Moon, causing it to accelerate slightly and move further away from Earth. Over time, this process has caused the Moon to move farther away from Earth each year.

This gradual drift is not noticeable on a day-to-day basis, but over millions of years, it can have significant effects on Earth's rotation. Today, most scientists believe the Moon is 'Earth's child' – a large body collided with Earth, destroying our planet's mantle and sending material into orbit from which the Moon formed. This 'big splash' theory would explain why the Moon's rocks are similar to those on Earth. Bonus fun fact: Australia is actually wider than the Moon. The Moon sits at 3400 km in diameter, while Australia's diameter from east to west is almost 4000 km. The Moon, as a sphere, has more surface area, but it's still pretty impressive.

THE MYSTERY OF WALKING STONE

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The "walking rocks" phenomenon has confounded the scientific community Scientists have puzzled over the rocks at the valley for a century. In 2010, researchers at NASA started investigating the area. Sensors were placed on the flat area at depths of three-quarters to four Inches deep. The units registered that the top layer of the soil froze in March, and it was wet up to three inches deep in April. According to this data, the team drew some conclusions. In March, the snow on the surrounding mountains flows into the valley as a thin layer of water and produces a circle of ice. In April , when a second layer of water flows into the valley, this " ice collar" under the rocks act as a boat on which the rocks float.The Ice collars are as hard as glass , therefore they leave a trail on the surface of the valley , but when they melt and disappear , only the rocks and their trails are seen afterwards.

Because there is no rain or earthquakes in this part of the valley, it eliminates the possible effects of these occurrences .Another early suggestion was that the rocks were driven by gravity. However, this theory was also discounted when it was revealed that most of the rocks are actually traveling uphill. The Racetrack Playa in California's Death Valley is famous for its "sailing stones" that appear to move across the playa floor, leaving trails behind them. The phenomenon was a mystery for decades until it was discovered that ice and wind play a role in their movement.

SCHOOL OF MARINE SCIENCES

The Department of Oceanography and Coastal Area Studies is the only one of its kind in Tamil Nadu and it was established in the year 1998 with the vision to conserve the marine resources for sustainable development and to cater to the requirement of manpower generation in the field of marine research, technology and industries. The Department is situated in a satellite campus extending over 13 acres at Thondi about 60 km away from the main campus. The Department is spread along the wave front having the facility of boat landing jetty. The Department has talented, motivated and well-trained staff members with expertise on multi-disciplinary aspects *viz*., Geological, Physical, Chemical and Biological Oceanography, Marine biotechnology, Marine microbiology, and Marine pharmacology. Our University is distinctly projecting Oceanography as the course admitting graduates from various disciplines so that the country will have skilled manpower to concentrate on the future requirements in the sphere of marine science and marine engineering. Later, during 2017the department has bifurcated in to Department of Geology with the vision to create highly competent professionals in Geology who contribute to the academia and industry by undertaking innovative research, making inventions and developing new technology and to collaborate with Western Universities and utilise the experience and expertise of international subject experts for the progress of students followed to that, the Department of Fisheries Sciences is established during 2018 with the vision to encourage sustainable fisheries and robust aquaculture practices for the constant supply of high-quality fish for everyone that complements the economic prosperity of the fishery business. Prof. S. Ravikumar, Head, Department of Oceanography and Coastal Area Studies is the Chairperson of the School of Marine Sciences, Alagappa University, Karaikudi.