

Surface and sub surface soil mapping using geological and geotechnical investigation for Western Cauvery Delta, Thanjavur and Thiruvarur Districts, Tamil Nadu, India.

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Abstract: Subsurface investigation is ascertaining, Properties and types of soil at various depths in study area. This finding is useful for geologist, geotechnical engineers and Agricultural scientist. Selected site in study area, the envoy sub surface soil sample has collected with help of Standard Penetration Test (SPT) sampling techniques. Collected sub surface soil sample has tested in Laboratory and resulting soil properties are tabulated. From geo referenced Tamil Nadu soil prepared by National Bureau of soil survey and Land use Planning (ICAR), Nagpur, Department of Agriculture, Tamil Nadu, the soil unit has mapped with help of Arc MAP. Study area Key map, soil sample location map has prepared From LISS IV image data and Survey of India Topo sheets. Using Garmin GPS the Geo coordinate has observed while sampling on different site on the Study area.

Key Words: Arc map, Density, Geo coordinate, GPS, Sampling and SPT.

I. Introduction

Soil is most important after Air and Water in the earth, more than 90% world food production is dependent on soil. Arthur Holmes defines “Geological point of view soil may be defined as the surface layer of the mantle of the rock waste in which the physical and chemical process of weathering co operates in intimate association with biological process”. Arther N.Strahler and Alan H.Strahler defines “Soil as a natural surface layer containing living matter and supporting or capable of supporting plants. Soil contains three major mineral constituents, sand, silt and clay, besides these also contain air, water, dissolved or crystalline salt and decomposed or un decomposed organic matter(K.M Bhattacharya, 2010).The soil named as, sand, silt and clay based on the corresponding Mass percentage exceeds about 85, 87 and 40 respectively in a given mass of soil (K.M Bhattacharya, 2010). Study of soil types, effects of local soil condition and soil properties study will help to civil engineers.

Western Cauvery delta (fig.1) enclosed by 78°45’30’’E - 10° 07’40’’ N to 79°49’20’’E - 11° 06’20’’ N and it covers 15 Survey of India top sheet number is 58 J13,J14,N1, N2,N3,N4,N5,N6,N7,N8,N9,N10,N11,M8,and M12. Elevation of the terrain in study area is increased from east to west side.

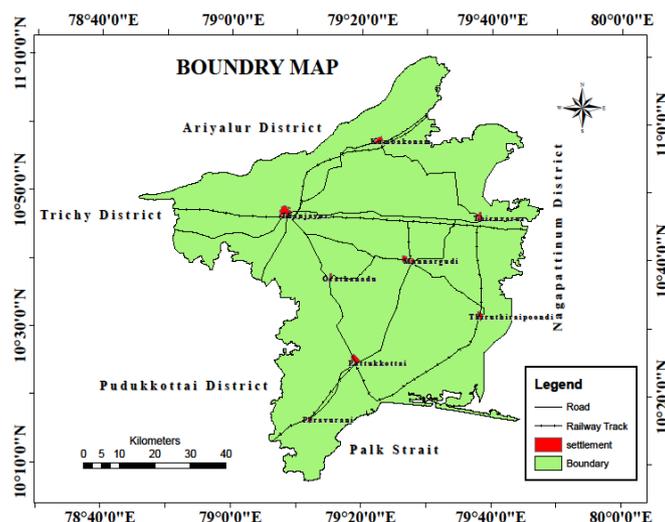


Fig (1). Base and boundary Map – Study Area.

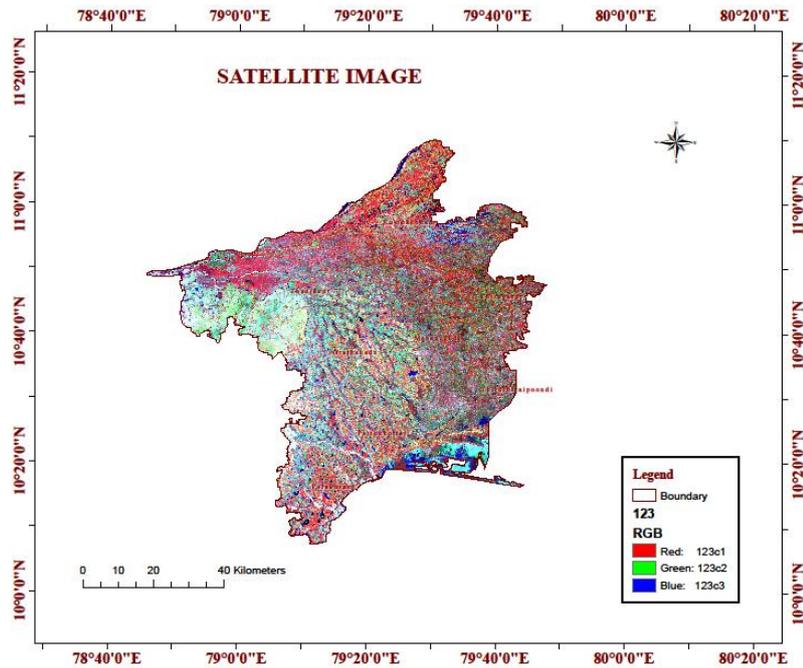


Fig (2). IRSP6 Satellite image – Study Area.

1.1 Geology and soil types

The study area mainly occupied with Cretaceous, Tertiary and Alluvial deposits (Fig-3). Cretaceous formation with lateritic cap covered in vallam upland's. It has classified in two categories, 1). Alluvial soil deposit and 2). Lateritic soil deposit and Delta basin distinct three stages, 1). Late Jurassic –Early cretaceous rift stage, 2). Late cretaceous and 3). Post cretaceous.

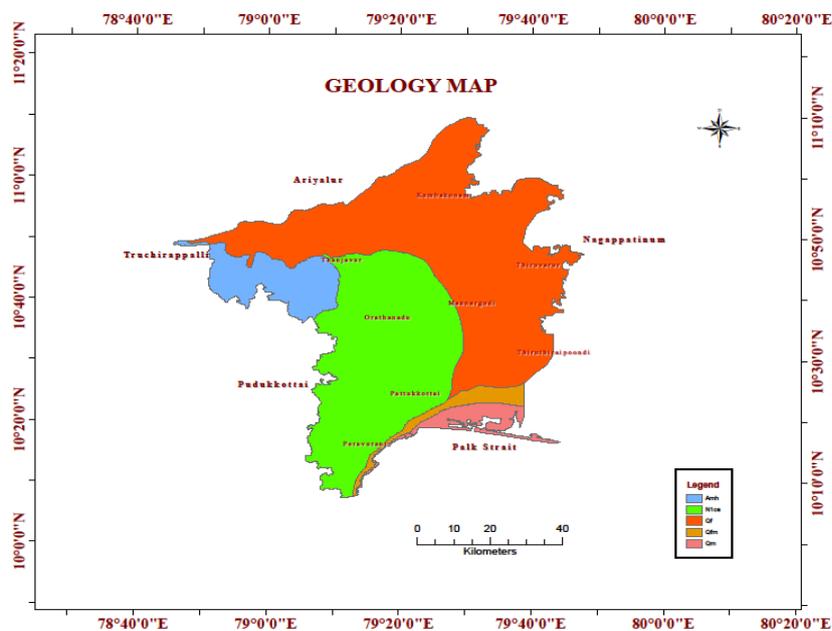


Fig (3). Geology Map.

1.1.1 Soil types.

Various soil types has identified from geo referenced National Bureau of soil survey and Land use Planning (ICAR), Nagpur, Department of Agriculture, Tamil Nadu. Sixteen soil mapping unit has identified named as 156,159,179,188,189,191,192,198,203,215,230,235,243,253,262 and 273 (Fig-3). Each and every soil unit has technically described and classified finally all the units are tabulated (Table-1). The coastal soils deposits are exaggerated by salinity due to sea water intrusion (Table.2).

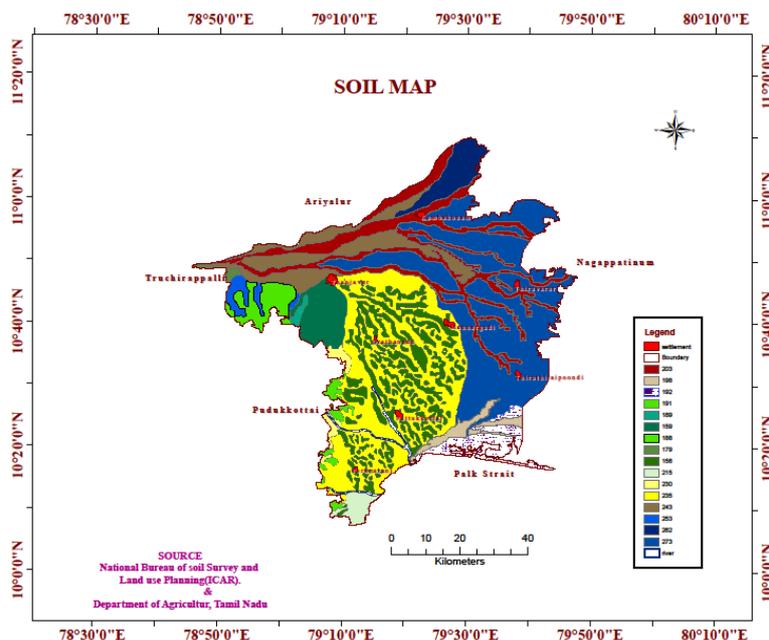


Fig (4). Soil Map.

Table -1, SOIL Mapping unit, Soil Description and Soil Classification

S.No	Mapping Unit	Description	Classification	Area (Sq km)
1.	156	Very deep, moderately well drained, loamy soils on gently sloping land, moderately eroded, associated with very deep, moderately well drained, clayey soils.	Fine-loamy, mixed, kandic Paleustalfs. Fine, kaolinitic, kandic paleustalfs.	896.37
2.	159	Very deep, well drained, clayey soils on nearly level land, slightly eroded, associated with very deep, well drained, loamy soils with moderate erosion.	Fine, kaolinitic, kandic paleustalfs. Fine-loamy, mixed, oxyc Ustropepts.	84.32
3.	179	Moderately deep, well drained, gravelly loamy soils on very gentle sloping lands, moderately eroded, associated with deep, well drained, calcareous, gravelly loam soils with severe erosion.	Loamy-skeletal, mixed, typic haplustalfs. Loamy-skeletal, mixed, typic Ustropepts.	18.22
4.	188	Moderately shallow, well drained, gravelly clay soils on undulating lands, moderately eroded, associated with deep, well drained, gravelly clay soils with slight erosion.	Clayey-skeletal, kaolinitic, Kanhaplic Haplustalfs. Clayey-skeletal, kaolinitic, kandic Rhodustalfs.	158.74
5.	189	Shallow, Well drained, gravelly clay soil on gently sloping land, moderately eroded, associated with moderately shallow, Well drained, gravelly loamy soils.	Clayey-skeletal, kaolinitic, Kanhaplic Haplustalfs. Loamy-skeletal, mixed, Oxyc Ustropepts.	18.29
6.	191	Deep, well drained, loamy soils on gently sloping land, moderately eroded, associated with Deep, and well drained loamy soils.	Fine-Loamy, mixed, kanhaplic Haplustalfs.	69.10
7.	192	Deep, Very poorly drained, strongly saline, clayey soil on nearly level marshy land slightly eroded.	Fine, Mixed, typic Tropaquents. Fine, Mixed, typic Halaquents.	193.69
8.	198	Very deep, moderately well drained, sandy soil on gently sloping sand ridges, moderately eroded, associated with deep, moderately well drained, loamy soil on very gently sloping lands.	Mixed, typic Utipsammants.	96.40
9.	203	Moderately deep, moderately well drained, stratified, Loamy soil on nearly level, tank irrigated lands. Slightly eroded associated with very deep, imperfectly drained, cracking clay soils.	Coarse-loamy, mixed, typic ustifluvents. Fine, montmorillonitic, vertic Ustropepts.	716.91
10.	215	Deep, imperfectly drained, calcareous, Loamy soil on nearly level, tank-irrigated lands, slightly eroded, associated with, deep, imperfectly drained, calcareous, cracking clay soils.	Fine-Loamy, mixed, typic Ustropepts. Fine, montmorillonitic, vertic Ustropepts.	70.22
11.	230	Very deep, well drained, clayey soils of nearly level valleys, slighted eroded, associated with very deep, and poorly drained, cracking clay soils.	Fine, mixed, typic Ustropepts. Fine, montmorillonitic, vertic Ustropepts.	51.32
12.	235	Deep, moderately well drained, clayey soils of nearly level valleys, slighted eroded, associated with deep, Imperfectly drained, clayey soil of gently sloping valleys.	Fine, mixed, typic Ustropepts. Fine, mixed, Aquic Haplustalfs.	1208.42
13.	243	Very deep, imperfectly drained, loamy soils of nearly level valleys, slighted eroded, associated with, deep, well drained, and stratified, loamy soils.	Fine-loamy, mixed, fluventic Ustropepts. Fine-loamy, mixed, typic, ustifluvents.	451.18
14.	253	Very deep, moderately well drained, calcareous, cracking clay soils of nearly level valleys slightly eroded.	Fine, montmorillonitic, vertic Ustropepts.	73.10
15.	262	Deep, imperfectly drained, cracking clay soils on nearly level, tank-irrigation lands, slightly eroded, associated with, very deep, imperfectly drained, cracking clay soils.	Fine, montmorillonitic, vertic Ustropepts. Fine, montmorillonitic, udic chromusterts.	189.41
16.	273	Very deep, imperfectly drained, calcareous cracking clay soils on nearly level, tank-irrigation lands, slightly eroded, very deep, imperfectly drained, cracking clay soils with moderate erosion.	Fine, montmorillonitic, udorthentic chromusterts. Fine, montmorillonitic, vertic Ustropepts.	1609.51

(Based on Tamil Nadu soil prepared by National Bureau of soil survey and Land use Planning (ICAR), Nagpur, and Department of Agriculture, Tamil Nadu).

Table -2 Salinity Area.

S.No	Problems In Coastal Area	Location
	Salinity.	Peravurani. Sethubavachatram. Adirampattinam.

II. Materials And Methods

IRS P6 LISS IV satellite image (fig.2), survey of India topo sheets, ICAR Soil Atlas and SPT instruments are used. Base map, soil map, and sampling location maps are prepared with help of above data source. Soil sample has collected with help of SPT test from the field.

Soil samples are collected from selected 9 sites in the study area and bore hole locations are designed as BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8 and BH9. Methodology has detailed in the flow chat diagram (Fig. 5).

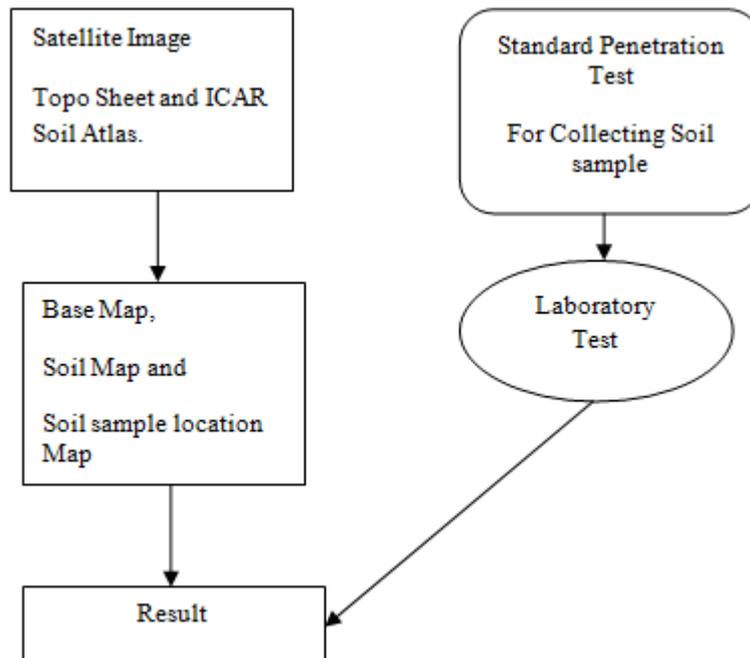


Fig. (5)- Methodology Flow chart.

III. Result And Discussion

Sixteen soil mapping units are identified and area has calculated using ARCMAP and Computed area are tabulated (Table-1). Fine, montmorillonitic, udorthentic chromusterts and Fine, montmorillonitic, vertic Ustropepts classified soils covered in 27.27%. It is described as Very deep, imperfectly drained, calcareous cracking clay soils on nearly level, tank-irrigation lands, slightly eroded, very deep, imperfectly drained, cracking clay soils with moderate erosion. Loamy-skeletal, mixed, typic haplustaifs and Loamy-skeletal, mixed, typic Ustropepts classified soils covered very less percentage in 0.30%. It is decribed as moderately deep, well drained, gravelly loamy soils on very gentle sloping lands, moderately eroded, associated with deep, well drained, calcareous, gravelly loam soils with severe erosion.

Table -3 Soil unit and area in percentage.

S.No	Mapping Unit	Area (Sq km)	Percentage	S.No	Mapping Unit	Area (Sq km)	Percentage
1	156	896.37	15.18	9	203	716.91	12.19
2	159	84.32	1.43	10	215	70.22	1.19
3	179	18.22	0.30	11	230	51.32	0.86
4	188	158.74	2.68	12	235	1208.42	20.47
5	189	18.29	0.31	13	243	451.18	7.64
6	191	69.10	1.17	14	253	73.10	1.23
7	192	193.69	3.28	15	262	189.41	3.20
8	198	96.40	1.163	16	273	1609.51	27.27

3.1 Soil Mapping Unit, Soil Description And Soil Classification.

(Based on Tamil Nadu soil prepared by National Bureau of soil survey and Land use Planning (ICAR), Nagpur, and Department of Agriculture, Tamil Nadu).

MAPPING UNIT - 156

Very deep, moderately well drained, loamy soils on gently sloping land, moderately eroded, associated with very deep, moderately well drained, clayey soils. Fine-loamy, mixed, kandlc Paleustalfs and Fine, kaolinitic, kandlc paleustalfs. Covered with 896.37 sq km and it is 15.18 % in study area.

MAPPING UNIT – 159Very deep, well drained, clayey soils on nearly level land, slightly eroded, associated with very deep, well drained, loamy soils with moderate erosion. Fine, kaolinitic, kandlc paleustalfs and Fine-loamy, mixed, oxic Ustropepts. Covered with 84.32sq km and it is in 1.43%.

MAPPING UNIT – 179

Moderately deep, well drained, gravelly loamy soils on very gentle sloping lands, moderately eroded, associated with deep, well drained, calcareous, gravelly loam soils with severe erosion. Loamy-skeletal, mixed, typic haplustaifs and Loamy-skeletal, mixed, typic Ustropepts. Covered with 18.22sq km and it is in 0.30 %.

MAPPING UNIT – 188

Moderately shallow, well drained, gravelly clay soils on undulating lands, moderately eroded, associated with deep, well drained, gravelly clay soils with slight erosion. Clayey-skeletal, kaolinitic, Kanhaplic Haplustaifs and kaolinitic,kandlc Rhodustalfs. Covered with 158.74 sq km and it is in 2.68 %.

MAPPING UNIT – 189

Shallow, Well drained, gravelly clay soil on gently sloping laterite land, moderately eroded, associated with moderately shallow. Well drained, gravelly loamy soils. Clayey-skeletal, kaolinitic, Kanhaplic Haplustaifs.Loamy-skeletal, mixed, Oxic Ustropepts. Covered with 18.29 sq km and it is in 0.31%.

MAPPING UNIT – 191

Deep, well drained, loamy soils on gently sloping land, moderately eroded, associated with Deep, and well drained loamy soils. Fine-Loamy,mixed, kanhaplic Haplustaifs. Covered with 69.10 sq km and it is in 1.17 %.

MAPPING UNIT – 192

Deep, Very poorly drained, strongly saline, clayey soil on nearly level marshy land slightly eroded. Fine,Mixed,typic Tropaquents. Fine,Mixed,typic Halaquepts. Covered with 193.69sq km and it is in 3.28 %.

MAPPING UNIT – 198

Very deep, moderately well drained, sandy soil on gently sloping sand ridges, moderately eroded, associated with deep, moderately well drained, loamy soil on very gently sloping lands. Mixed, typic Utipsammments. Coarse-loamy, mixed typic ustifluvents. Covered with 96.40sq km and it is in 1.163 %.

MAPPING UNIT – 203

Moderately deep, moderately well drained, stratified, Loamy soil on nearly level, tank irrigated lands. Slightly eroded associated with very deep, imperfectly drained, cracking clay soils. Coarse-loamy, mixed, typic ustifluvents.Fine,montmorllionitic, vertic Ustropepts. Covered with 716.91sq km and it is in 12.19 %.

MAPPING UNIT – 215

Loamy soil on nearly level, tank- irrigated lands, slightly eroded, associated with, deep, imperfectly drained, calcareous, cracking clay soils. Fine-Loamy, mixed,typic Ustropepts, Fine,montmorllionitic, vertic Ustropepts. Covered with 70.22 sq km and it is in 1.19 %.

MAPPING UNIT – 230

Very deep, well drained, clayey soils of nearly level valleys, slighted eroded, associated with very deep, and poorly drained, cracking clay soils. Fine, mixed, typic Ustropepts. Fine,montmorllionitic, vertic Ustropepts. Covered with 51.32sq km and it is in 0.86 %.

MAPPING UNIT – 235

Deep, moderately well drained, clayey soils of nearly level valleys, slighted eroded, associated with deep,Imperfectly drained, clayey soil of gently sloping valleys. Fine, mixed, typic Ustropepts.Fine,mixed,Aquic Haplustaifs Covered with 1208.42 sq km and it is in 20.47 %.

MAPPING UNIT – 243

Very deep, imperfectly drained, loamy soils of nearly level valleys, slighted eroded, associated with, deep, well drained, and stratified, loamy soils. Fine-loamy, mixed, fluventic Ustropepts, Fine-loamy, mixed, typic, ustifluvents. Covered with 451.18 sq km and it is in 7.64 %.

MAPPING UNIT – 253

Very deep, moderately well drained, calcareous, cracking clay soils of nearly level valleys slightly eroded.Fine,montmorllionitic, vertic Ustropepts. Covered with 73.10 sq km and it is in 1.23 %.

MAPPING UNIT – 262

Deep, imperfectly drained, cracking clay soils on nearly level, tank-irrigation lands, slightly eroded, associated with, very deep, imperfectly drained, cracking clay soils. Fine,montmorllionitic, vertic Ustropepts, Fine,montmorllionitic,udic chromusterts. Covered with 189.41sq km and it is in 3.20 %.

MAPPING UNIT – 273

Very deep, imperfectly drained, calcareous cracking clay soils on nearly level, tank-irrigation lands, slightly eroded, very deep, imperfectly drained, cracking clay soils with moderate erosion. Fine, montmorillonitic, vertic Ustropepts, Fine, montmorillonitic, udic chromusterts. Covered with 1609.51sq km and it is in 27.27 %.

3.2 Field Investigations.

As per IS code 2131—1981, the Standard Penetration Test (First revision) for soil is conducted in selected site on the study area and the boreholes were designated as BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8 and BH9 (Fig 6.) which have been progressed down to 06.00 to 07.00 m depth below the existing ground level (Table -4).

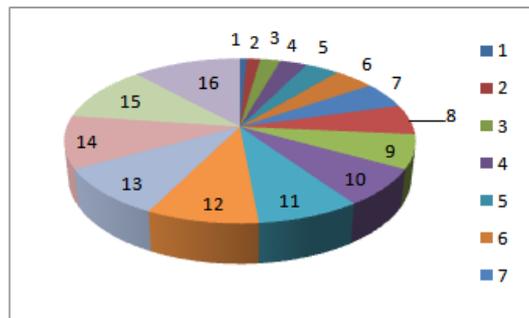


Fig (6). Percentage classified soil.

Table -4 Depth and borehole design.

S.No	Bore Hole name	Location	Depth	Types of Test
1.	BH-1	kumbakonam	7.0	SPT
2.	BH-2	Thanjavur	6.0	SPT
3.	BH-3	Mannargudi.	6.0	SPT
4.	BH-4	Peravoorani.	6.0	SPT
5.	BH-5	Orathanadu.	7.0	SPT
6.	BH-6	Thiruvarur.	6.0	SPT
7.	BH-7	Thiruthuraipondi.	6.0	SPT
8.	BH-8	Pattukkottai.	7.0	SPT
9.	BH-9	Thruvaiyaru.	6.0	SPT

The boreholes were progressed by hand-operated augers. Standard penetration tests were conducted at 1.0 m intervals. Disturbed soil samples recovered from the augers and undisturbed samples from split spoon samplers were retained for identification and classification purposes. Disturbed soil samples were enclosed in polythene bags. The samples thus recovered were transported to the laboratory for testing purposes. Ground water table was encountered at various depths in various fields from the period of field investigation Fig (7).

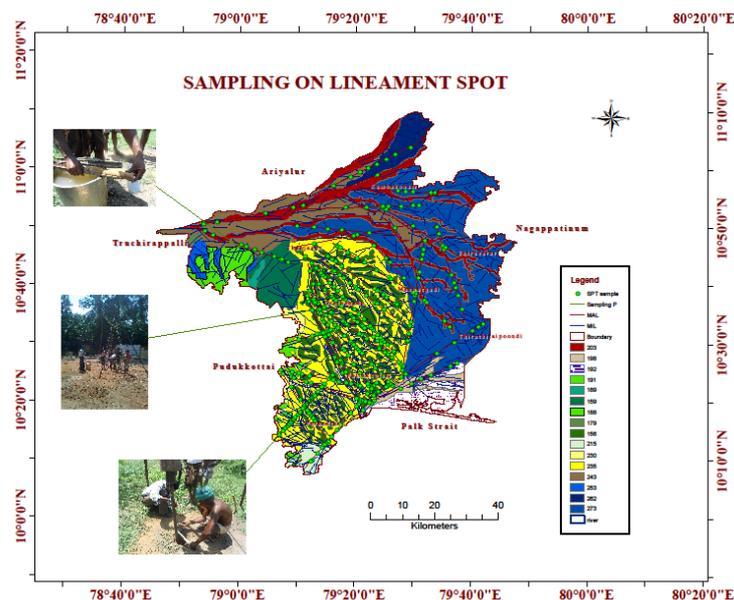


Fig (7). Soil sampling on site.

3.2.1 Laboratory Investigations.

The soil samples brought in to the laboratory and various tests has conducted for determine the following properties as per IS code 2720-1985, Grain size Analysis (second revision):

Types of soil and gradation of soil. In order to determine the above properties the following tests have been conducted, 1.Sieve analysis on coarse grained soil fraction, 2.Hydrometer analysis on fine grained soil fraction. The results from both the field investigations and laboratory tests have been analyzed and tabulated as follows:

- i. Standard penetration test values at various depths.
- ii. Soil description identifying the type of soil.
- iii. Grain size analysis indicating composition of sub soil.
- iv. The sub soil profile indicating thickness of the various soil strata.
- v. Engineering properties of the soil strata at various levels.
- vi. Variation of strength of soil strata with depth.

Detailed description and classification of soil has mapped and tabulated for 9 site in study area (Table -5 to Table -13).

Table -5 BH-1 kumbakonam Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Made up soil	0	0	0	0	0	0	0
2.	2.0		0	0	0	0	0	0	0
3.	3.0	Clayey Sand	18.23	14	22	5.1	93	77	36
4.	4.0		18.14	12	17	5.7	99	83	32
5.	5.0		18.11	16	22	6.1	93	83	40
6.	6.0	Sandy Clay	19.21	18	35	8.5	98	93	63
7.	7.0		19.41	20	51	8.7	98	89	67

Water Table was encountered at 6.0m depths during the field investigation

Table -6-BH-2 Thanjavur Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Kanker	18.11	19	41	8.5	100	91	79
2.	2.0		18.22	18	42	8.9	100	88	61
3.	3.0		18.58	20	39	9.2	82	67	25
4.	4.0	Yellowish Kanker with Lime	19.36	23		9.4	80	50	24
5.	5.0		19.42	24		8.7	89	75	51
6.	6.0		19.47	24		8.9	97	79	42

Water Table was not encountered during the field investigation.

Table -7-BH-3 Mannargudi Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Sand	16.84	0	25	10.32	100	63	11
2.	2.0		17.16	0	21	10.34	98	57	9
3.	3.0		17.24	0	19	11.00	99	65	10
4.	4.0		17.5	0	21	12.18	100	60	12
5.	5.0		17.52	0	31	12.40	100	68	13
6.	6.0		17.46	0	34	12.46	100	68	13

Water Table was not encountered from the period of field investigation

Table 8 - BH-4 Peravoorani Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Lime Stone	18.00	18	> 50 Refusal	9.12	100	58	11
2.	2.0		18.24	15		8.24	100	53	11
3.	3.0		18.56	13		8.53	100	52	9
4.	4.0		18.70	10		8.56	100	52	8
5.	5.0		18.77	10		8.63	100	50	8
6.	6.0		19.00	10		8.95	100	50	9

Water Table was not encountered from the period of field investigation

Table 9- BH-5 Orathanadu Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Sandy clay	0	0	0	0	0	0	0
2.	2.0	Sandy Clay with	0	0	0	0	0	0	0
3.	3.0	Traces of Lime stone	18.23	14	22	5.1	93	77	36
4.	4.0		18.14	12	17	5.7	99	83	32
5.	5.0	Lime stone	18.11	16	22	6.1	93	83	40
6.	6.0		19.21	18	35	8.5	98	93	63
7.	7.0		19.41	20	51	8.7	98	89	67

Water Table was not encountered during the field investigation.

Table 10- BH-6 Thiruvarur Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Made up soil	15.12	0	2	15.52	100	65	37
2.	2.0		16.23	0	8	7.84	100	75	38
3.	3.0		16.46	0	19	9.20	100	67	34
4.	4.0		16.57	0	27	11.54	100	72	38
5.	5.0	Clayey Sand	18.52	23	40	12.82	100	56	24
6.	6.0	Sand	17.42	0	16	13.70	98	29	3

Table 11- BH-7 Thiruthuraiipondi Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Clay	18.79	35	6	14.35	96	88	66
2.	2.0		17.82	37	6	13.25	99	76	66
3.	3.0	Medium Stiff Clay	18.15	48	10	14.32	95	85	70
4.	4.0		18.82	52	11	13.92	94	84	74
5.	5.0		18.72	70	12	12.87	92	71	72
6.	6.0		18.56	110	21	11.22	97	86	70

Table 12- BH-8 Pattukkottai Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (k N/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Made up soil	0	0	0	0	0	0	0
2.	2.0		0	0	0	0	0	0	0
3.	3.0	Sandy Clay	6	22	22	18.36	100	75	62
4.	4.0		5	24	17	18.42	100	82	58
5.	5.0	Kanker	> 50 Refusal	28	22	12.88	100	94	30
6.	6.0			30	35	12.92	98	92	28
7.	7.0			31	51	13.14	97	95	32
8.	8.0			33		14.25	96	97	35
9.	9.0			35		15.23	95	98	25
10.	10.0			37		15.37	98	95	36

Table 13- BH-9 Thiruvaiyaru Geotechnical Site Investigation Result.

S.No	Depth(m)	Types of soil	Bulk Density (kN/m ³)	Cohesion (kN/m ²)	Observed N value	Natural water content (%)	% Passing through IS Sieves (mm)		
							4.75	0.425	0.075
1.	1.0	Madeup soil	0	0	0	0	100	52	13
2.	2.0	Silty Clay	17.24	48	7	12.98	100	83	64
3.	3.0	Silty Sand	16.78	0	21	13.31	100	52	11
4.	4.0	Sand	16.86	0	34	13.56	100	48	11
5.	5.0		16.92	0	34	12.57	100	45	8
6.	6.0		17.08	0	36	12.78	97	45	7

IV. Conclusion

This soil map will give preliminary idea about type of soil of particular site on western Cauvery delta. Observed N value, Cohesion and Bulk densities provide subsurface strata strength and the soil behavior of under

load. This above prediction data is Valuable for Architect, Civil Engineers, agricultural scientist and Geo scientist.

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