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EFFECT OF SEA WATER INTRUSION ON GEOTECHNICAL AND PHYSIOCHEMICAL BEHAVIOR OF SOIL - (CASE STUDY: ARRIYANKUPPAM BACKWATER)

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Abstract- Sea water intrusion in soil causes changes in geotechnical and physiochemical behavior in soil. The backwater formed by Arriyankuppam sea (East direction) which intrudes in nearby land areas and changes are seen. Bore holes at 1.5 - 3 meters is excavated and undisturbed soil samples are collected using core cutter at 15 different locations taking 5 samples in each direction (West, North and South) and then the tests are conducted in lab. Physiochemical tests in soil which includes pH, EC, TDS, Alkalinity and Chloride shows that the soil parameters are greatly affected by seawater intrusion and due to which the geotechnical parameters such as Consistency limits, Swelling index and Unconfined compressive strength parameters tests are conducted on Backwater and Tap water and the results are compared. An excessive seawater intrusion is seen more in some parts of land region. The various results found on Arriyankuppam region is presented.

Keywords –Seawater Intrusion, Geotechnical Tests, Physiochemical Tests**.**

I. Introduction

Soil is an essential constituent for construction activity, therefore due to sea water intrusion in seashore areas the soil gets affected and causing disturbances in construction of superstructure and forming soil salinization. In coastal region, the uncontrolled exploitation of groundwater intended for domestic purpose, industrial and agricultural purposes unbalances the dynamic equilibrium between flowing groundwater, favoring seawater intrusion (Hakan et al. 2013).The physiochemical interaction in soils are different for different types of soils, they are primarily due to ion exchange or nature of pore fluid (P.V Sivapullaiah 2009). Soil salinization is the accumulation of free salts in the soil to such extent which leads to degradation of soil. The small changes in soil has to be noted, because a small change in engineering properties can change the parameter used in designing soil structures and other related structures (Mohammad et. Al 2014).

In this study, the salinity present in soil and geotechnical changes that takes places in soil due to seawater intrusion was investigated.

II. Materials and Methods

A. Description of Study Area

Pondicherry is about 293 sq. km. in aerial extent with a total population of about 0.6 million. Arriyankuppam River is situated in Pondicherry, between Latitude 11°55'N and 12°30'N and Longitude 70°05'E and 80°05'E. This is a fan medium river basin with drainage of about 100Sq.kms. Arriyankuppam River, which originates from the River Sankaraparani, at Nalla ReddyPalayam (about 10 kms from the sea shore) usually gets cut off from River Sankaraparani, during non-monsoon period and the water is more or less stagnant during other seasons (Vijayakumar 2012) . The aerial photography is given in figure 1.

B. Materials

In this study, fifteen undisturbed clayey samples were collected from different directions taken five samples in each direction away from sea shore. The Samples are taken at an approximate depth of 3 meters at a distance 100mts, 200mts, 400mts, 600mts and 1000mts from backwater. The backwater is collected in a bottle and then packed in an air tight container. The sampling methodology is given in figure 2.

C. Methods

The undisturbed samples are taken and then Unconfined Compressive strength test is done as per ASTM D2166-85, and then the remaining samples are oven dried (800c), crushed and sieved for grain size distribution, specific gravity and are done as per ASTM D792. Liquid, Plastic and Shrinkage limits were determined according to ASTM D4318. The free swell index as per IS 2720 (Part 40) 1977 is done for determining the Swelling index of soil.

Similarly soil samples were collected from same locations air-dried passed through 2mm sieve and then 100 grams of soil samples is dissolved in 1 litres backwater and then pH & EC using pH meter and Conductivity meter. Total Dissolved Solids was analysed using approximate method of analysis Alkalinity and Chloride tests were conducted as per standards.

Fig.1. Location of Arriyankuppam backwater

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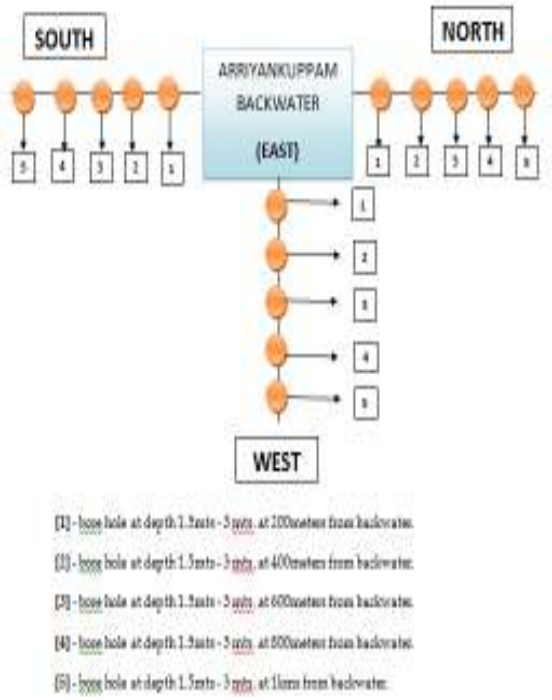

Fig.2. Sampling methodology In standard laboratory tests distilled water can be used in testing of soil samples.

III. Experimental Works

A. Geotechnical Tests

1) Atterberg's limit

About 200gms of sample were taken on each sample for atterbergs limit and were mixed with both tap water and Arriyankuppam backwater to form a uniform paste. The effects for five samples in each direction is given in the as table 1, 2 and 3 below.

TABLE I. Results on Atterbergs limit (South to North)

Atterberg's Limit	Water type	S1[a]	S2[a]	S3[a]	S4[a]	S5[a]
Liquid limit %	Tap water	28	39	36	29	33
	Backwater	24	32	30	24	27
Plastic limit %	Tap water	23	32	30	19	22
	Backwater	17	26	26	17	12
Plasticity Index	Tap water	5	7	6	10	11
	Backwater	7	6	6	7	15

TABLE II. Results on Atterbergs limit (North to South)

Atterberg's Limit	Water type	S1	S2	S3	S4	S5
Liquid limit %	Tap water	25	28	24	32	23
	Backwater	23	22	20	27	19
Plastic limit %	Tap water	20	19	20	28	20
	Backwater	18	16	17	21	12
Plasticity Index	Tap water	5	7	4	4	3
	Backwater	5	6	3	6	7

TABLE III. Results on Atterbergs limit (East to West)

Atterberg's Limit	Water type	S1	S2	S3	S4	S5
Liquid limit %	Tap water	27	22	38	23	28
	Backwater	23	20	33	20	23
Plastic limit %	Tap water	18	19	24	19	22
	Backwater	16	17	20	15	19
Plasticity Index	Tap water	9	3	14	4	6
	Backwater	7	3	13	5	4

S1, S2, S3, S4, S5- Samples collected at distance 200mts, 400mts, 600mts, 800mts, 1kms from backwater.

2) Unconfined Compressive Strength(UCC)

Unconfined Compressive Strength was carried out in an undisturbed soil sample, Standard moulds were used to extract the sample and then test were carried in accordance with ASTMD 2166-85. The results obtained are given in table 4 below.

The graph showing variation in compressive strength with the distance is given below as figure 3.

TABLE IV. Results on Unconfined Compressive Strength (in all directions)

Distance from backwater (mts)	unconfined compressive strength (kPa) (S - N)	unconfined compressive strength (kPa) (N - S)	unconfined compressive strength (kPa) (E - W)
200	236.4	295	143
400	376.6	283.4	139
600	278	289.5	147.11
800	310	373.85	287
1000	233.6	452	659.6

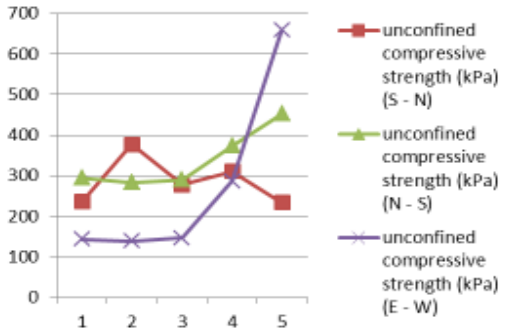

Fig.3. Variation in Compressive strength with distance X axis: Distance from seashore (meters)
Y axis: Unconfined compressive strength (kPa)

TABLE V. Results on Free Swell Index (In all direction)

Atterberg's Limit	Water type	S1	S2	S3	S4	S5
Liquid limit %	Tap water	26	32	34	46	57
	Backwater	30	36	40	53	60
Plastic limit %	Tap water	25	26	32	36	44
	Backwater	31	32	40	44	52
Plasticity Index	Tap water	28	28	37	43	48
	Backwater	35	36	43	49	53

3) Free Swell Index

Free Swell index was carried out in a oven dried sample, about 20-30 grams in each sample were taken and then the analysis was made with both tap water and Sea water. The results are given in table 5.

B. Physicochemical tests on soils

1) pH and Electrical conductivity(EC)

The soil sample received from the field shall be in accordance with IS: 2720 (Part1)-1983, about 30grams of soil sample is taken in 100ml beaker and 75ml of distilled water is added to it. The suspension shall be stirred for few seconds and covered with cover glass for one hour, with occasional stirring. It shall be again stirred well before testing. pH is measured using pH meter and has no unit and conductivity is measured using digital conductivity meter and expressed in (Ms/cm). The results are given in table 6 below.

TABLE VI. Results on pH and EC(In all direction)

Direction	Test on Soil	S1	S2	S3	S4	S5
North to South	pH	7.1	7	7.3	6.9	7.4
East to West	pH	7.0	7.3	7.9	7.6	8
South to North	pH	7	7.5	7	7.3	7.9
North to South	EC	60	59	63	62	61
East to West	EC	59	61	59	62	60
South to North	EC	60	61	60	61	52

TABLE VII. Results on TDS(In all direction)

Direction	TDS(mg/lit) on samples				
	S1	S2	S3	S4	S5
North to South	30150	29850	31500	31050	30450
East to West	29750	30300	29700	30900	30100
South to North	30000	30400	29900	30600	26200

TABLE VIII.Results on Alkalinity and Chlorides (In all directions)

Tests	Direction	Samples				
		S1	S2	S3	S4	S5
Alkalinity	North to south	206	200	213	218	221
	East to West	216	223	237	205	210
	South to North	220	217	210	220	200
Chloride (mg/lit)	North to south	600	585	535	520	560
	East to West	550	572	602	594	580
	South to North	607	590	593	579	558

2) Total Dissolved Solids(TDS)

TDS was determined using approximate method of analysis, using the value of EC obtained by

TDS= (Electrical Conductivity*1000)/2 mg/lit Eq.1

The results are tabulated below in table 7.

3) Alkalinity and Chloride

Alkalinity is to determine the presence of ions in soil sample. Presence of chloride indicated the area is subjected to seawater intrusion. Chloride and Alkalinity is determined by standard laboratory procedure. Sample 30grams is mixed in 75ml of water is normal mixing rate, and as per our requirement the sample mix is made. A relation given

by Brian et.al 2005, for indicating the presence of seawater intrusion (Alkalinity/Chloride >1) is calculated. The results on Alkalinity and Chloride are given below in table 10.

The results are tabulated below in table 8.

IV. Conclusion

In this study possible seawater intrusion along three direction from seawater was investigated.

The presence of salts in soil samples were found out by conducting physiochemical tests and the change in characteristics of soil was investigated. The pH values (6-8) was observed at various distances of excavation and the soil was found to be saline. The EC value ranges from 50Ms/cm to 60 Ms/cm, higher EC values creates saline soil. The TDS ranges from 25000-3000 mg/lit, higher the TDS value greater the area is subjected to seawater intrusion. Chloride value ranges from 500mg/lit to 700mg/lit indicates the seawater intrusion has taken place. Alkalinity/ Chloride ratio was found to be greater than 1 in all cases of testing further proving that the soil sample is affected by seawater intrusion.

Geotechnical changes in soil were observed when the excavated soil sample was tested. Liquid limit, Plastic limit and plasticity index value increases on treating with tap water compared with seawater by (3% to 7%). Shrinkage values increase on treating with sea water when compared with sea water by 2% to 8%. The Lower values in Atterbergs limit and Shrinkage index values are mainly due to silty clay type present in it. At a depth of 1.5 meter to 3 meters the soil was SILTY CLAY in Arriyankuppam back water region. The UCC strength (100 kPa to 650 kPa) ranges from a lower value to higher value as the distance of excavation increases and clay type is Stiffy in nature. Hence by using some stabilization techniques are to be carried out in construction activities near seashore.

Physiochemical tests on soils shows that the area is subjected to accumulation of salts in soil. Geotechnical properties tests revealed that change in behavior of soil may causes disturbance in future.

References

[1] Abhay K. Soni, Paras R. Pujari. “Ground water Vis-à-vis sea water intrusion analysis for a part of limestone Tract of Gujarat coast, India,” Water Resource and Protection, 2010, 2, 462-468.

[2] A.K.Bhattacharya, S.Basack, P.Maity. "Saline water intrusddion in Bhadrak and Balasorer district of Orrisa, India," Electronic Journal of Geotechnical Engineering.

[3] Hakan Arslan, YusufDemir. "Impacts of seawater intrusion on soil salinity and alkalinity in Bafra Plain, Turkey,” Environ Monit Assess (2013) 185:1027 – 1040.

[4] Mohammad Ajam, Mohammad Reza Sabour, Gorban Ali Dezvareh. "Study of water salinity effect on geotechnical behavior of soil structure using response surface method (RSM)," CienciaeNatur, Santa Maria, V.36 n. 2 June 2014, p. 360-369.

[5] Mohie Eldin Elmashad, Alaa A. Ata. "Effect of seawater on consistency, infiltration rate and swelling characteristics of montmorillonite clay," Housing and Building National Research Center.

[6] Murugaiyan. V, Anandhanarayanan. G. "Effects of Salt Solutions and Sea Water on the Geotechnical Properties of Soil –A Review". International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181.

[7] Otoko. G. R, “The Effect of Salt Water on the Physical Properties, Compaction Characteristics and Unconfined Compressive Strength of A Clay, Clayey Sand and Base Course”. European International Journal Of Science And Technology Vol. 3 No. 2.

[8] Rassoul Ajalloeian, Hadiseh Mansouri, "Effect of Saline Water on Geotechnical Properties of Fine-grained Soil," Electronic Journal of Geotechnical Engineering.

[9] P.V.Sivapullaiah., 2009. "Effect of soil pollution on geotechnical behaviour of soils," IGC 2009, 933 - 940.

[10] Vijayakumar, M. A. Sivasankaran., Murugaiyan.V. "Studies on the pollution levels in ariyankuppam backwater, Puducherry region," International Journal of Science, Environment and Technology, Vol. 1, No 5, 2012, 363 - 376.

[11] YelizYukselen-Aksoy, Abidin Kaya, Ali Hakan Ören. 2008. "Seawater effect on consistency limits and compressibility characteristics of clays". Engineering Geology 102 (2008) 54 – 61.