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Effect of Chitosan in Consistency Limits on CH and CL Clays

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***Abstract*: Soil pollution as a part of land degradation is caused by industrial activity, agricultural chemicals, improper disposal of waste etc. There will be change in the geotechnical properties of the soils due to contamination. Depending on the pollutants the geotechnical properties can vary. One of the common pollutant is Sulphur. Increase in Sulphur content in soil is due to industrialization .The presence of Sulphur in soil causes leaching of cations and also it causes damage to concrete structures. The study focuses on the variation in the consistency limits of the Sulphur contaminates clays and its remediation. Chitosan is a natural by-product obtained from the Sea food industry. It is used to remove the heavy metals from soil as well as from water. It is a Cationic polymer which has a high sorption capacity. Therefore it is used as a remediating material in the present study.**

***Keywords*: Chitosan, Sorption**

1. Introduction

A. General

The growing rate of soil and water contamination has promoted a number of studies in the effects of chemicals on geotechnical properties of soils. The contamination in the subsurface as well as in the surface occurs due to industrial wastes. The alteration of physical, mechanical, chemical properties of the soil near the industries occurs mainly as a result of their pollution or contamination by industrial chemicals.

B. Effect of sulphur contamination on soils

Sulphur contamination in India has been in many developed cities such as Delhi, Chennai, Mumbai, Kolkata and some of the mining cities. Coal, Fertilizers, Chemical industries, Cement factories, Thermal power plants, Aluminium plants, Gypsum building materials are major sources of sulphate contamination in India. Under aerobic condition Sulphur gets oxidised to Sulphate. The presence of Sulphur in soil causes lower pH leaching of cations as well as causes damage to concrete structures.

C. Remediation

The increase in Sulphur content in form of Sulphate cause both subsoil and underground water pollution. Hence it is needed to immobilize the contaminants and thus preventing from leaching into the soil. A suitable remediating material is to be needed to immobilize the contaminant and a suitable material is obtained. Chitosan is a by-product of the alkaline deacetylation of Chitin; in amide group it is hydrolysed to a primary amine group to produce Chitosan. It is soluble in acidic solution. It is a Cationic polymer which has a high sorption capacity due to presence of amino and hydroxyl groups. The interaction is due to ion exchange, sorption and Chelation. Chitosan is an effective material to reduce soil erosion. It is an effective material to use as a remediating material.

2. Objectives

- To study the basic characterization of Sodium Bentonite, Kaolinite.
- To study the variation in consistency limits of sulphur contaminated soils
- To find the efficiency of removal of Sulphate ions in clays by varying the percentage of Chitosan

3. Materials and methodology

- *Sodium Bentonite:* Sodium Bentonite was purchased from Associate Chemicals, Kochi.
- *Kaolinite:* Kaolinite was purchased from English India Clay limited, Trivandrum.
- *Chitosan:* Chitosan was purchased from Matsyafed, Trivandrum.

Table 1
Properties

Properties	Kaolinite	Sodium Bentonite
Specific gravity	2.62	2.57
Permeability (cm/s)	6.65 x 10^-7	2.8 x 10^-9
Liquid limit (%)	33	332
Plastic limit (%)	22	40.1
Plasticity index (%)	11.2	29
Shrinkage limit (%)	14.1	15.6
UCS (kN/m^2)	63.27	112.7
OMC (%)	22.5	37
Dry density (g/cc)	1.56	1.26
% Clay	53	82
% Silt	45	10
% Sand	2	8
IS Classification	CL	CH
pH	6.5	8.6

4. Result

A. *Variations due to addition of sulphur*

Table 2
Variation in Liquid limit

Concentration (M)	CL Clay	CH Clay
0	33	332
0.1	32	183
0.5	31	178
1	29.1	163
2	28.6	158
3	27.3	136
4	25	121
5	22.9	111

The Liquid limit for both CL and CH clays decreased in 5M, this is because as the Sulphur ions concentration increases there decreases the net negative charge. The reduction in charge reduces the immobilised water.

Table 3
Variation in plastic limit

Concentration (M)	CL Clay	CH Clay
0	21.8	40.1
0.1	18.3	36.2
0.5	14.8	28
1	13.2	26.4
2	12.8	25
3	12.5	24.8
4	11.4	23.2
5	10.5	23

The Plastic limit of contaminated clays also got reduced when concentration reached to 5M, the increased concentration of ions reduced the plastic limit.

Table 4
Variation in shrinkage limit

Concentration (M)	CL Clays	CH Clays
0	14.1	15.6
0.1	13.3	14.8
0.5	12.01	12.4
1	11.4	10.11
2	11.32	8.76
3	10.8	6.5
4	10.4	5.7
5	10.11	3.3

The Shrinkage limit of contaminated clays also got reduced when concentration reached to 5M, the increased concentration of ions reduced the Shrinkage limit. This is due to increase in ion concentration leads to decreasing the double layer to shrink and thereby forming flocculated clay particles.

B. *Effect of chitosan*

With the addition of Chitosan, Liquid limit of CL clay got increased from the contaminated clay. The liquid limit was found to increase due to addition of decontaminating agent because it is a good adsorbent which adsorb the anions and are hold on the negative sites of chitosan thus immobilizing the effect of anion. Thus CL clays water holding capacity increased to 50% and 69% for CH clays.

The Plastic limit of decontaminated clays found to be increased from the contaminated values because of the immobilization of the Sulphate ions by the Chitosan and thus regaining the water holding capacity. About 69% increase in CL clays and 54% for CH clays.

Table 5
Variations in liquid limit

Concentration (M)	CL Clays	CH Clays
0	33	332
0.1	32.7	312
0.5	31.8	305.98
1	30.2	298
2	30	294
3	28.4	285.32
4	28.2	283.45
5	28	270.35

Table 6
Variations in plastic limit

Concentration (M)	CL Clays	CH Clays
0	21.8	40.1
0.1	18.3	39
0.5	14.7	38.75
1	13.11	37.23
2	12.64	36.8
3	12.5	35.45
4	11.5	33
5	10.4	32

Table 7
Variations in shrinkage limit

Concentration (M)	CL Clay	CH Clay
0	14.1	15.6
0.1	13.3	15.42
0.5	12.02	14.89
1	11.3	14.02
2	11.25	13.98
3	10.7	13.26
4	10.5	12.65
5	10.10	12.01

The results of Shrinkage limit on decontaminated CL clays shows that presence of decontaminating agent enhanced the Shrinkage resistance. There is about 59% increase in Shrinkage limit for CL clays and 76% increase for CH clays.

5. Conclusion

- From the results of Liquid limit, as the concentration increases the Liquid limit got reduced for both CL and CH clays.
- It was found that there is 23% and 65% reduction in Liquid limit for CL and CH clays.
- Due to addition of Chitosan the Liquid limit of both CL and CH clays increased.
- When Chitosan added to the soil, it adsorbs the anions thus the electrolytic concentration got reduced and clay gains the water holding capacity and the liquid limit increased.
- In case of Plastic limit, it was found to be reduced with increase in sulphur concentration. It is due to decrease in double layer due to flocculated structure. Due to addition of Chitosan Plastic limit increased for both CL and CH clays.

- Shrinkage limit reduction is 29% and 78% for CL and CH clays as the Sulphur content increased.
- When Chitosan added Shrinkage limit increased due to reduction in diffused double layer thickness.

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