IJIRMET ISSN (Online): 2456-0448
International Journal Of Innovative Research In Management, Engineering And Technology
Vol. 4, Issue 1, January 2019

STUDY ON THE EFFECT OF SULFUR CONTAMINATION ON SOILS AND ITS IMMOBILIZATION

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Abstract: Soil pollution as a part of land degradation is caused by industrial activity, agricultural chemicals or improper disposal of wastes. Due to contamination there will be changes in both geotechnical as well as chemical property of soils. Sulphur contamination is one of the major pollution caused on both soils as well as in ground water, due to industrialization. Contamination due to sulphur causes lower pH, leaching of cations and also produces damages to concrete structures. The study deals with the effect of sulphur contamination in a clayey soil and a field contaminated sandy soil, and its remediation using Chitosan which is a natural by-product obtained from the sea food industry. The variation in geotechnical properties of contaminated clay was studied. From the study it was observed that the Atterberg limits, pH and UCC strength got reduced and coefficient of permeability got increased in the case of clayey soil while, chemical analysis test was performed on both contaminated and decontaminated field soil. The immobilization of sulphur content in these soils were carried out by the addition of a decontamination agent called Chitosan. The variation in geotechnical properties was also studied after decontamination. The removal efficiency of sulphur in soils was found by conducting Chemical analysis test and found that there is about 78% and 90% removal in clay and sand respectively.

Keywords: Contamination, Immobilization, Chitosan, Decontamination

I. INTRODUCTION

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 surface and subsurface contamination usually occurs due to industrial waste, acid rain, accidental sills etc are called anthropogenic sources. Pollution has direct or indirect effects on soil properties. The alteration of the physical, chemical properties of the soil in the vicinity of industrial plants occurs mainly as a result of their pollution or contamination by the industrial chemicals. The main type of contaminants include various substance such as inorganic acids, alkalis, sulphates, organic contaminants, toxic or phytotoxic

metals and combustible substances.Sulfur contamination is one of the major pollution caused in both soil as well as in ground water, due to industrialization. Mined sulfur is mostly from salt domes or bedded deposits. The vast majority is produced as a by-product of oil refining and natural gas processing. Under aerobic soil condition sulfur gets oxidized to sulphate. The presence of sulfur in soil causes lower pH leaching of cations as well as causes damages to concrete structures. In the previous century, increased concentrations of SO_2 in the atmosphere associated with fossil fuel combustion, wet deposition, and acid rain were reported (Zhao et al. 2003). Despite the reduction of sulfur deposition in recent decades, there are still some sulfur contaminated soils, and in consequence, there is still a need to study the

negative impact of sulfur excess on soil properties (SołekPodwika et al. 2016). Remediation of sulfur contaminated soils is a need to regain its properties.

OBJECTIVES OF STUDY

The goal of this paper is to determine the effect of sulfur contamination on geotechnical properties of clay and chemical analysis of sandy soil to find the concentration of contamination and also to find the efficiency of removal of sulfate on both soils using a decontaminating agent called Chitosan which is a byproduct obtained from sea food manufacturing industry. To find the optimum amount of chitosan to be used in CL clay.The variation in geotechnical properties of remediated clay is also focused on this study.

MATERIALS

Soil

The soils used in this study was kaolinite a low plasticity clay (CL) and sand. Kaolinite clay used in this study was collected from Thonnakal, Thiruvananthapuram and sand was collected from Alappuzha. Properties of kaolinite and sand used for the study are given in table 1 and table 2.

Reagent

Sodium thiosulphate salt was used as the contaminant for artificially contaminating the clay. It was obtained from Laboratory supplies, Trivandrum. Soil was contaminated under varying concentration from lower to higher

IJIRMET ISSN (Online): 2456-0448
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molaritiessay0.1,0.5,1,2,3,4,5M. Sandy soil collected from the field was found to be contaminated by chemical analysis test.
Remediating agent
Chitosan is a byproduct obtained sea food manufacturing industries. It is a cationic polymer that has a high sorption capacity due to the presence of amimo and hydroxyl groups. Chitosan powder was collected from Malsyafed, Trivandrum for the study.

Table 1: Initial properties of Kaolinite clay

Properties	Values
Specific gravity, G	2.62
Permeability(cm/s), K	6.65x 10^{-7}
Liquid limit (%)	33
Plastic limit (%)	21.8
Plasticity index	11.2
UCS (kN/m^2)	63.27
OMC (%)	23
Dry density (g/cc)	1.56
Percentage clay (%)	53
Percentage silt (%)	45
Percentage sand (%)	2
IS Classification	CL
pH	6.5

Table 2: Initial properties of S1

Properties	Values
Specific Gravity	2.66
Internal Friction Angle, Ø (degrees)	33
Permeability (cm/s)	0.0156
Percentage of coarse sand (%)	9.6
Percentage of medium sand (%)	71.9
Percentage of fine sand (%)	18
Percentage of gravel (%)	0.5
pH	5.2

METHODOLOGY
The initial properties of clay and field soil (S1) s was found out. Chemical analysis was performed on soil S1 collected from field to find the elements causing contamination. Kaolinite clay was artificially contaminated by varying concentrations of lower to higher molarities (0.1,0.5,1,2,3,4,5M) and kept for 1 day. The variation in Atterberg limits, unconfined compressive strength, permeability, and pH was studied Also sulphur contamination on S1 was also studied by conducting chemical analysis test. All the test were performed after remediation on both

soils by providing 1 day curing time. The optimum amount of Chitosan on Kaolinite clay was found by performing Chemical Analysis test on varying percentages of chitosan powder after providing 1 week of curing time.

RESULTS AND DISCUSSIONS

Chemical analysis of S1 taken from Alappuzha was done. The result obtained showed the presence of sulfur in that soil is excess than the permissible limit.The optimum dosage of Chitosan powder to be added in Kaolinite clay was found. The effect of Sulfur on geotechnical properties of kaolinite and S1 were studied. The geotechnical properties and efficiency of removal of sulfur in the remediated sample was also carried out. The following results were obtained from the present study.

a) Chemical Analysis of Field soil (S1)

S1 was collected from Alappuzha. The soil was found to be polluted due to nearby industrial waste disposal. Chemical analysis has been carried out to find the contaminants present in the collected soil sample. The test was done from Central Analytical Laboratory, Trivandrum. The results obtained for chemical analysis is given in Table 3.

Table 3. Chemical analysis of S1

Metal constituents	Concentration (ppm)
Iron	38.38
Manganese	5.58
Zinc	6.56
Copper	1.12
Lead	2.08
Nickel	0.28
Sulphur	789.16

The result obtained shows that the concentration of Sulphur is beyond the limit which is causing contamination.

b) Optimum dosage fixation by Chemical analysis test and UCC strength

The dosage of Chitosan is fixed by chemical analysis test on Kaolinite clay and UCC strength was found on varying the percentages of chitosan powder.Clay contaminated with higher concentration of sulfur (5M) was taken and various percentages of chitosan was added to find the efficiency of immobilization of contaminant. The results obtained by varying percentages of chitosan is given in Table 4.

Table 4.Concentration of sulfur content and UCC strength by the addition of various percentage of chitosan

Percentages (%)	Concentration of sulfur content (ppm)	UCC (kN/m^2)
0	441.03	15.2
0.5	417.35	25.66
1	374.12	38.44
2	315.34	45.05
3	264.65	52.11
4	198.12	59.48
5	110.55	63.22
6	107.1	71.21
7	104.65	82.55
8	101.33	89.36

It was found that after the addition of 5% chitosan there was no further significant removal occurred. Thus 5% chitosan powder was taken as the optimum dosage. The UCC strength result shows that as the percentage of chitosan increases it improves the strength of CL clay. There was about 76% increase in strength was obtained.

c) Variation in geotechnical properties of Sulphur contaminated and remediated CL clay

i. Liquid Limit (IS 2720 Part 5)

CL clay was artificially contaminated using sodium thiosulphate in various concentrations and liquid limit was found out. It was obtained that It was found that due the increase in the degree of concentration of contaminant the liquid limit was found to be decreasing. When the sulphur contaminant reached to 5M, the liquid limit got reduced to 23%. The remediation has been carried out on the contaminated samples using the decontaminating agent chitosan. The results showed that the liquid limit of the remediated clay got increased from the contaminated one. The results obtained is given in Table 5

Table 5. Liquid limit of contaminated and decontaminated CL clay

Concentration (M)	Variation in liquid limit of CL clay	
	Contaminated (%)	Decontaminated (%
0	33	33
0.1	32	32.8
0.5	31	31.5
1	29	30.2
2	28.5	30
3	27	29.4
4	25	28.8
5	23	28

ii. Plastic Limit(IS 2720 Part 5)

It was found that the plastic limit of the contaminated clay was reducing due to the increased concentration of sulfur contaminant. The plastic limit was reduced to 10.6% when the concentration of the contaminant was 5M and after remediation 69% gain in plastic limit has been attained. The results obtained were shown in Table. 6

Table 6. Plastic limit of contaminated and decontaminated CL clay

Concentration (M)	Variation in plastic limit of CL clay	
	Contaminated (%)	Decontaminated (%
0	21.8	21.8
0.1	18.4	21.4
0.5	14.76	20.6
1	13.2	20.4
2	12.8	19.4
3	12.5	17.4
4	11.4	16.5
5	10.6	18.4

iii. UCC strength (IS 2720 Part 10)

The value of UCC got reduced when the concentration of the contaminant increased to 5M whereas by the addition of decontaminating agent the UCC strength increased. About 70% regain in strength was attained after remediation. The results obtained is given in Table 7.

Table 7. UCC strengthof contaminated and decontaminated CL clay

Concentration (M)	Variation in UCC strength of CL clay	
	Contaminated (kN/m^2)	Decontaminated (kN/m^2)
0	63.27	63.27
0.1	60.44	63.11
0.5	31	62.56
1	25.8	58.61
2	21.3	50.45
3	18.5	49.33
4	17.9	48.51
5	15.2	48.01

iv. Coefficient of permeability (IS 2720 Part 17)

Variation in coefficient of permeability on contaminated and decontaminated were found out. The results obtained is given in Table 8.

Table 8. Coefficient of permeability of contaminated and decontaminated CL clay

Concentration (M)	Variation in coefficient of permeability of CL clay	
	Contaminated (cm/s) x 10^{-7}	Decontaminated (cm/s) x 10^{-7}
0	5.88	5.88
0.1	6.24	5.93
0.5	7.83	6.01
1	7.51	6.23
2	8.23	6.35
3	8.94	6.54
4	9.11	6.98
5	9.34	7.11

v. pH(IS 3025 Part 11)

A 100ml of contaminated and decontaminated samples were prepared with various concentration of contaminant and tested using a digital pH meter. The results obtained were shown in Table.9

Table9. variation of pH of contaminated and decontaminated CL clay

Concentration (M)	Variation in pH of CL clay	
	Contaminated	Decontaminated
0	6.5	6.5
0.1	6.32	6.49
0.5	6.30	6.56
1	5.85	6.61
2	5.82	6.77
3	5.73	6.81
4	5.62	6.89
5	5.59	7.02

d) Chemical analysis of contaminated and remediated CL clay and S1

Chemical analysis was done on both CL and S1 for finding the extent of contamination and also the effectiveness of remediation. The results showed that there is about 78% and 90% removal of Sulphur has been attained by the addition of chitosan. The results obtained are shown in Table.10

Table 10. Concentration of Sulphur content on contaminated and decontaminated CL clay

Soils	Concentration of Sulphur content (ppm)	
	contaminated	decontaminated
CL clay	441.68	110.5
S1	789.301	83.22

CONCLUSIONS

The study was conducted to find the effect of sulphur contamination on soils. It was found that contamination can affect the soil properties depending upon the degree of contamination. Thus the remediation part also has been done by utilising a waste product Chitosan obtained from sea food industry which was found to be a good adsorbent. The following conclusions have been obtained after the study.

- The chemical analysis of S1 collected from a contaminated site shows the presence of excess sulphur in the sample.
- The optimum dosage of remediating agent was obtained as 5% after conducting chemical analysis and by analysing UCC strength results.
- the liquid limit got reduced by 23% due to contamination and about 10% reduction in plastic limit, showing the decrease in diffused double layer due to increase in electrolytic concentration and there by the formation of flocculated structures.
- The UCC strength also got reduced in the contaminated sample due to decrease in interparticle force and thus the reduction of bonding between the particles.
- The permeability of CL clay was found to be increasing by 55% due to contamination.
- The addition of remediating agent improved the properties of CL clay and also the removal efficiency of both CL clay and S1 showed good results.

- Chitosan is an excellent adsorbent for trace metals, anions etc due to the excess –OH and $-NH_2$ groups which gives high flexibility to the structure.
- Adsorption by ion exchange takes place which makes the sulphur anions adsorbed on the negative sites. This makes the immobilization of contaminant by holding it on the reachable sites.
- There is about 78% and 90% removal efficiency has been attained for CL clay and S1 respectively.

REFERENCES

[1] A. Moret, J. Rubio., (2003) Sulphate and molybdate ions uptake by chitinbasedshrimp shells, *Minerals Engineering Science direct journal*, 16(5) : 715-722

[2]**Soon Kong Yong, ManojShrivastava,PrashantSrivastava,AnithaKunhikrishnan, and Nanthi Bolan.,**(2015) Environmental Applications of Chitosan and Its Derivatives environmental contamination and toxicology, *Journal of geotechnical engineering clays*, 9(4): 112-118

[3] **Abigail Padilla-Rodríguez & Eton E. Codling.,** (2016) Potential of Chitosan (Chemically Modified Chitin) for Extraction of Lead-Arsenate Contaminated Soils, *Tylor and francis journal*, 47(9): 13–14