Variation of liquid limit and plastic limit of clayey soils on iron and sulphur contamination

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Abstract – *a study was conducted to determine the effect of contaminants on different clayey soils. The contaminants used were iron and sulphur. The variation of geotechnical properties of the clayey soils were studied by conducting liquid limit and plastic limit test using different molarities of contaminants. The variations at molarities 0.05M, 0.1M, 0.2M, 0.4M, 0.8M, 1M. Variations in liquid limit and plastic limits were observed with increase in concentration of contaminants*

***Key Words*: contamination, bentonite, kaolinite, iron, sulphur**

1. INTRODUCTION

Heavy metals are natural constituents of the earth crust. A number of these elements are biologically essential and are introduced into aquatic enrichments by various anthropogenic activities. Heavy metals at trace levels present in natural water, air, dusts, soils and sediments play an important role in human life.. The chemical composition of soil, particularly its metal content is environmentally important, because toxic metals concentration can reduce soil fertility, can increase input to food chain, which leads to accumulate toxic metals in food stuffs, and ultimately can endanger human health.

Iron is an essential element in human nutrition. It is of great biologically significance. Lack of iron causes anaemia and it is the commonest nutritional deficiency in the world. Normal amounts of iron are essential, but abnormally larger amount adversely affects the human health. Prolonged iron accumulation may cause damage in tissues Sulphur deposition in soils causes acidification of soils mainly clayey soils. Adverse effects of sulphur contamination of soils are shown by the fall in pH, an increase of phytotoxic aluminium concentration and by losses of calcium and magnesium ions through leaching.

Rintu Molly Johnet al., (2017) studied the effect of iron on the liquid limit, plastic limit and hydraulic conductivities of two soils. The results show that iron tended to reduce the permeability of the soils. The liquid limit and plastic limit was found to increase for CL clay whereas for CH clay both the limits initially decreased and then showed an increasing trend. Soorya S.R et al., (2015) deals with an attempt to study the effect of lead and iron contamination on the liquid limit, plastic limit, free swell and strength properties of high plasticity clay. The experimental results indicated that the properties of clays were significantly affected by the lead contamination that may influences the clay liner performances.

Both of these contaminants not only cause ill effects on soil but also lead to variation in geotechnical properties of the soil and hence the variations of geotechnical properties on such contaminants are to be studied. In this study variation in liquid limit and plastic limit of bentonite and kaolinite due to different contaminants at different molarities are studied.

1.1 Objectives of the study

The main objectives of the study include:

- Study on the variation of liquid limit and plastic limit of bentonite and kaolinite on iron contamination.
- Study on the variation of liquid limit and plastic limit of bentonite and kaolinite on sulphur contamination.

2. MATERIALS AND METHODOLOGY

2.1. Soil

Two types of soils were used in the study. The first one was high plastic clay (CH) i.e., sodium bentonite and the second one was low plastic clay (CL) i.e., Kaolinite. The image of the soil sample is given in fig 1 and fig 2 respectively. The index properties are also shown in table 1 and table 2 respectively.

Fig-1: Bentonite

Fig-2: Kaolinite

Table -1: Properties of bentonite

SOIL PROPERTIES	VALUES
Specific gravity	2.59
Liquid limit (%)	336
Plastic limit (%)	47
Shrinkage limit (%)	12.4
Plasticity index (%)	289
IS classification	CH
Percentage clay (%)	82
UCS (KPa)	45.9
OMC (%)	38
Dry density (KN/m^3)	12.65
Coefficient Of Permeability(m/s)	3.2×10^{-10}

Table -2: Properties of kaolinite

SOIL PROPERTIES	VALUES
Specific gravity	2.6
Liquid limit (%)	34
Plastic limit (%)	23
Shrinkage limit (%)	14.1
IS classification	CL
UCS (KPa)	63
OMC (%)	20
Dry density (g/cc)	1.357
Percentage of clay (%)	66
Percentage of silt (%)	23
Percentage of sand (%)	11

2.2. Contaminants used

In the present study the contaminants used were Iron and Sulphur. For artificially contaminating the soil samples anhydrous ferric chloride and sodiumthiosulphate were used. Details of the contaminants used are given in table 3.

Table -3: Details of contaminants used

Parameters	Constituent salt used	Chemical formula	Molecular weight (g/mol)
Iron	Ferric chloride	$FeCl_3$	162.2
Sulphur	Sodium thiosulphate	$Na_2S_2O_3$	158.11

2.3. Test procedure

In this study the soil was contaminated using Ferric chloride and Sodiumthiosulphate. The soils was contaminated using different molarities of contaminants i.e., 0.05M, 0.1M, 0.2M, 0.4M, 0.8M, 1M. The liquid limit and plastic limit tests were carried out as per IS 2720 PART 5.

3. RESULTS AND DISCUSSION

3.1. Variation of liquid limit in bentonite due to iron and sulphur contamination.

Variation of liquid limit in bentonite due to iron and sulphur contamination is shown in chart 1. The experimental results show that liquid limit showed considerable decrease with the increase in the concentration

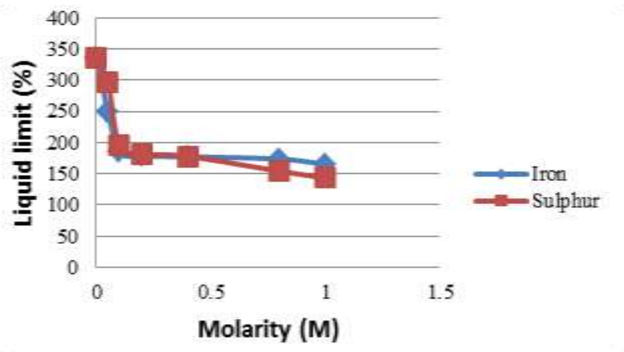

Chart 1: Variation in liquid limit

of iron and sulphur contamination in bentonite. This decrease in liquid limit may be due to the increase in salt solution. The increase in salt solution may lead to the reduction in the thickness of diffused double layer (Gleason et al., 1997, Schmitz et al., 2004).

3.2. Variation of plastic limit in bentonite due to iron and sulphur contamination.

Variation of plastic limit in bentonite due to iron and sulphur contamination is shown in chart 2.

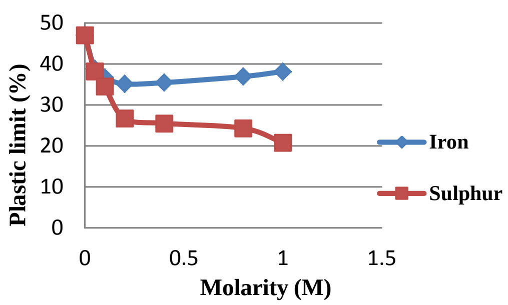

Chart 2: Variation in plastic limit

The experimental results show that plastic limit showed considerable decrease with the increase in the concentration of sulphur contamination in bentonite. This decrease in liquid limit may be due to the increase in salt solution. The increase in salt solution may lead to the reduction in the thickness of diffused double layer (Gleason et al., 1997, Schmitz et al., 2004). The plastic limit initially showed a reduction with increase in concentration of iron and later increased with increase in iron concentration.

3.3. Variation of liquid limit in kaolinite due to iron and sulphur contamination.

Variation of liquid limit in kaolinite due to iron and sulphur contamination is shown in chart 3.

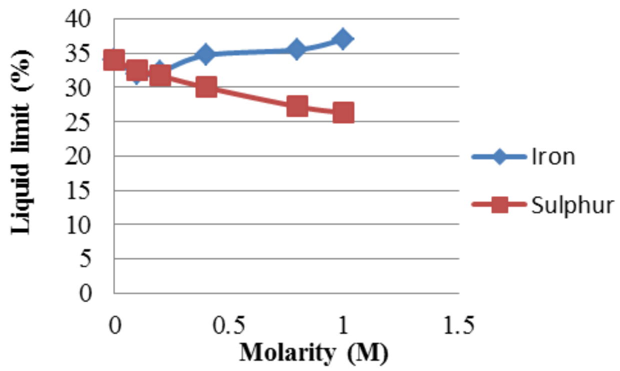

Chart 3: Variation in liquid limit

From the experimental results it was observed that the liquid limit decreased with increase in concentration of sulphur. This decrease in the liquid limit may be due to the decrease in the net negative charges. The reduction in negative charges causes reduction in immobilized water; this is because the water is attracted to the surface of the clay by electric force of various kinds including electrostatic attraction (Michaels 1959). Thus causes reduction in the thickness of diffused double layer and causes reduction in liquid limit. Liquid limit increases with increase in concentration of iron (Arasan and Yetimoglu, 2007) and this is due to the dispersion of clay particles and formation of new swelling compounds.

3.4. Variation of plastic limit in kaolinite due to iron and sulphur contamination.

Variation of plastic limit in kaolinite due to iron and sulphur contamination is shown in chart 4. From the experimental results it was observed that plastic limit showed considerable decrease with increase in the concentration of sulphur, this reduction is due to the reduction in net negative charges (Shackelford et al., 2015). The plastic limit showed considerable increase with iron contamination and this was in agreement with Arasan and Yentimoglu (2007).

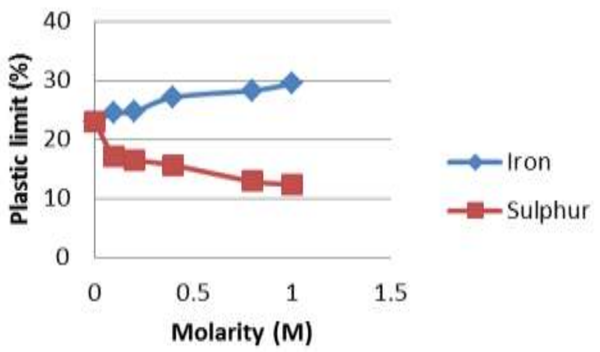

Chart 4: Variation in plastic limit

4. CONCLUSIONS

The study was conducted to investigate the variation of geotechnical properties like liquid limit and plastic limit in bentonite and kaolinite on iron and sulphur contamination. The conclusions made from the study include:

- In bentonite the liquid limit reduced to about 50.8% due to iron and 57.4% due to sulphur.
- Plastic limit reduced to about 11.42% due to iron and 48% due to sulphur in bentonite.
- An increase of about 8.82% was observed due to iron contamination and 22.6% decrease was observed due to sulphur in liquid limit of kaolinite.
- Plastic limit increased to about 27.8% due to iron and 46% due to sulphur in kaolinite.
- The reduction in negative charge and also the reduction in diffused double layer are the main reasons for the variation in the geotechnical properties in bentonite and kaolinite.

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