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Research Paper

CHANGE IN INDEX PROPERTIES OF BLACK COTTON SOIL DUE TO ACID CONTAMINATION

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With the growth in industrial sector, pollution in the form of liquid, solid and gas gets increase. Industrial effluent discharges on the land get mixed with soil and effect geotechnical properties of soil. Here in this paper sulphuric acid, phosphoric acid and nitric acid are used in the different percentage of concentration ranging from 0% to 15% is mixed with soil, so as to synchronize it with industrial sewage containing acidic content. Thus this paper reports the probable effect of acid on index properties of black cotton soil. The test performed on acid contaminated soil shows considerable variation in behavior of soil. The result indicates that Atterberg's limit and swelling and shrinking % is altered due to acid contamination.

Keywords: Soil contamination, Industrial sewage, Acid, Geotechnical properties, Synchronize

INTRODUCTION

Industrial activity is important for economic growth of any country but simultaneously it produces large amount of waste. This waste can be in solid, liquid or gaseous form. This waste contains of acidic matter, alkalis, dyes, organic waste, toxic metals, etc., when such pollutant mixed with soil, geotechnical properties of soil gets changed due to soil-pollutant interaction. Thus, soil contamination or soil pollution is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, acid rain, accidental spills, agricultural chemicals, leakage in sewer liner from industries and residence, or improper disposal of waste. This adversely affects the behavior of natural soil mainly due change in anion and cation exchange capacity. Sridharan *et al.* (1981) has reported the heaving of subgrade soil due to the leakage of phosphoric acid. Masashi (1997) investigates that the increased rate of leaching of cation and absorption of H^+, SO_4^{2-}, NO_3^-, PO_4^{3-} and CO_3^{2-} due to mixing of chemicals containing these ions alter physical, chemical and engineering properties of soil. Sivapullaiah (2009)suggests the increase in swelling behavior of black cotton soil due to addition of sulphuric acid from 1N to 4N concentration because of increased leaching rate of potassium ion between interlayer. Ivan Gratcher, Ikuo Towhata (2011) has reported that variation in geotechnical properties

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of soil due to action of acid depends on the mineral present in soil composition and it structure. The present study is carried out on high plastic soil from Jabalpur region to find out the degree of variation in atterberg's limit swelling and shrinkage behavior of soil on adding sulphuric acid, phosphoric acid and nitric acid in variable concentration.

MATERIALS AND METHODS

Black Cotton Soil

To analyze the effect of acid concentration on soil, black cotton soil from a village Archha, Jabalpur (MP) is collected. It is oven dried at 105°C to remove moisture and tests were performed to obtain geotechnical properties of virgin soil. The results obtained are shown in Table 1.

Table 1: Geotechnical Properties of Black Cotton Soil

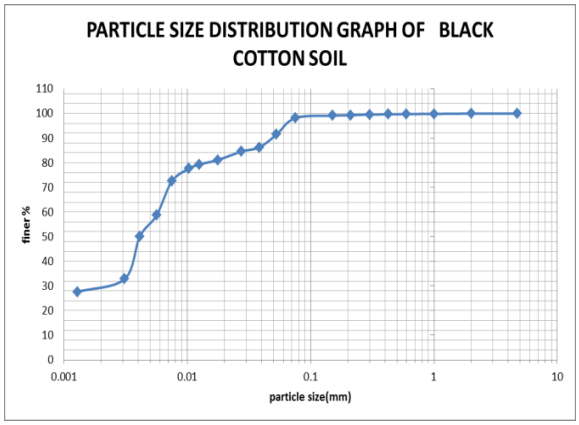
S.No.	Characteristics	Result
1	Specific gravity	2.32
2	Sand%	2
3	Silt %	67
4	Clay%	31
5	Liquid limit (%)	72.21
6	Plastic limit (%)	28.32
7	Plasticity Index (%)	43.88
8	Soil Type	CH
9	Shrinkage limit (%)	2.985
10	Differential Free Swell (%)	60

According to IS classification of soil the sample is named as CH (clay with high plasticity). The particle size distribution of collected soil sample is shown in Figure 1.

CONTAMINATING AGENTS

Commonly used industrial acids are used in varying concentration to contaminate the soil. These acids are Sulphuric Acid (H_2SO_4), Phosphoric Acid (H_3PO_4) and Nitric Acid (HNO_3).

Figure 1: Particle Size Distribution Curve



METHODOLOGY

The laboratory research have been conducted on the black cotton soil from Jabalpur region and dried soil sample passing from 4.75 mm is properly mixed with given acids in concentration varies from 0-15% and kept in plastic bags for 3 days so as the soil gets contaminated and then soil is used to performed test. The samples are named as:

Sample 1: Soil + 0% acid concentration

Sample 2: Soil + 2% acid concentration

Sample 3: Soil + 4% acid concentration

Sample 4: Soil + 6% acid concentration

Sample 5: Soil + 8% acid concentration

Sample 6: Soil + 12% acid concentration

Sample 7: Soil + 15% acid concentration

TESTS CONDUCTED

The experiments were conducted to determine specific gravity, Atterberg's limits and differential free swell.

Specific gravity of the soil specimen was determined as per IS: 2720 (part 3/sec 1) – 1980.

Atterberg's limits of the soil specimen was determined as per IS: 2720 (part 5) – 1985.

Shrinkage limit of the soil specimen was determined as per IS: 2720 (part 6) – 1972.

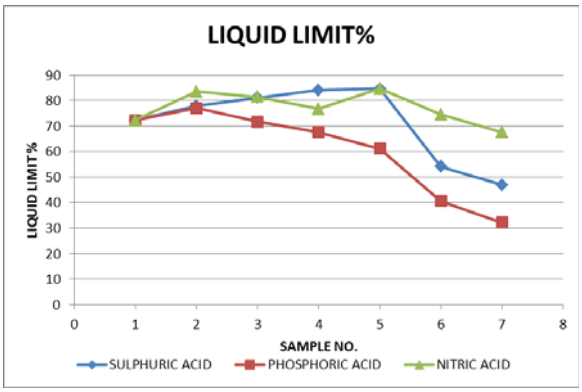
Swelling percentage of the soil specimen was determined as per IS: 2720 (part 40) – 1977.

RESULTS AND DISSCUSION

Liquid Limit

Figure 2 shows the variation in liquid limit for different acid concentration in pore fluid of black cotton soil. Liquid limit of simple black cotton soil was found to be 72.21% which changes in different trends with different acid. Umesha *et al.* (2012) suggests liquid limit for increasing acid concentration decreases continuously from low concentration till end but results found through this research reports liquid limit increases with increase in acid concentration from 0% to 8% in sulphuric acid and on further increase in concentration to 15%, liquid limit shows a rapid decrement. Whereas, liquid limit of soil contaminated by phosphoric acid increases initially at 2% acid contamination and then continuously decrease with increase in acid concentration. In case of nitric acid, liquid limit of contaminated soil increase abruptly at 2% concentration and then reduces till 6% and again increase to 84.88% at 8% concentration and further it starts to decrease.

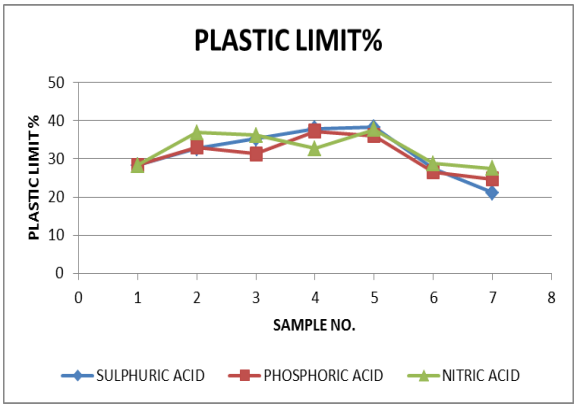
Figure 2: Effect of Acid Concentration on Liquid Limit



PLASTIC LIMIT

Figure 3 shows the variation in plastic limit for different acid concentration mixed with black cotton soil. Umesha *et al.* (2012) reported initial increase in plastic limit till 5% concentration and then slight decrease for higher concentration of acid but in general plastic limit was higher than initial value. Similar type of results were observed in this case also with difference that plastic limit increase till 8% and then it decreases; however overall reduction in plastic limit is observed at higher concentration in all three acids.

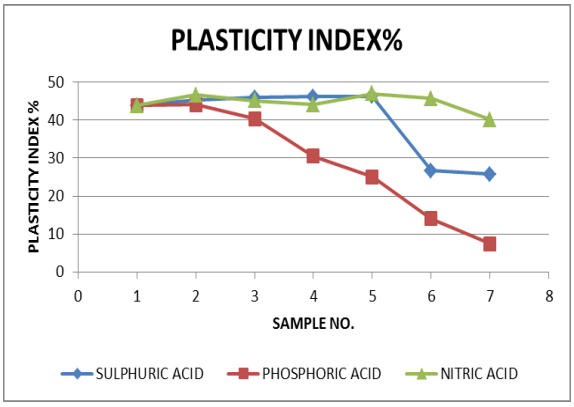
Figure 3: Effect of Acid Concentration on Plastic Limit



PLASTICITY INDEX

Figure 4 show the variation of plasticity index of black cotton soil for different concentration of sulphuric acid, phosphoric acid and nitric acid. It has been observed that overall plasticity index decreases for all three acids, with maximum variation has been seen in phosphoric acid which reduces from 43.88% for simple soil to 7.47% at 15% acid concentration. For sulphuric acid and nitric acid, plasticity index increases till 8% concentration of respective acid, then decreases at higher concentration.

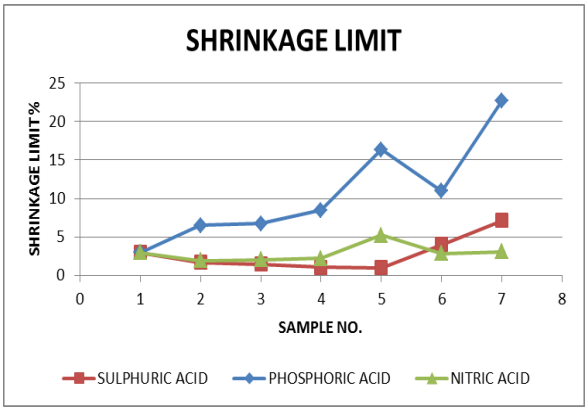
Figure 4: Effect of Acid Concentration on Plasticity Index



SHRINKAGE LIMIT

Figure 5 shows variation of shrinkage limit for different acid concentration in pore fluid of black cotton soil. As reported by Grytan Sarkar (2012) shrinkage limit increases with increase in acid concentration similar variation has been observed through experimental test. In case of phosphoric acid, shrinkage limit increases at certainly higher rate from lower acid concentration. While there is initial decrement in shrinkage limit for sulphuric acid till 8% acid concentration then increases for higher concentration. Shrinkage limit for nitric acid decreases initially from 2.98% for simple soil to 2.25% at 6% concentration, a sudden hike is observed at 8% concentration and again it decreases to 3.08% on further increase in acid concentration to 15%.Out of three acids order of shrinkage limit is phosphoric acid >sulphuric acid > nitric acid.

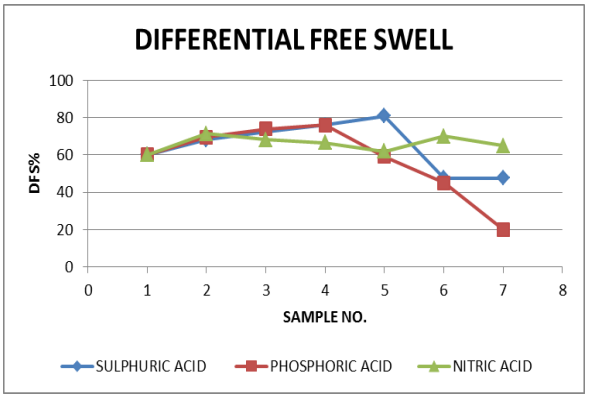
Figure 5: Effect of Acid Concentration on Shrinkage Limit



DIFFERENTIAL FREE SWELL

Figure 6 show the variation of swelling % for sulphuric acid, phosphoric acid and nitric acid at different concentration with soil. Sivapullaiah (2009) reports an increase in swelling of soil on adding sulphuric acid of increasing concentration

Figure 6: Effect of Acid Concentration on Swelling %



from 1N to 4N. In this case Differential free swell for simple black cotton soil is found to be 60% which increases in all three acids till 8% with highest swelling was observed in sulphuric acid. Then it starts to decrease at higher concentration of sulphuric acid and phosphoric acid while there is overall increment in swelling in case of nitric acid from 60% for simple soil to 65% at 15% concentration.

CONCLUSION

Significant changes in index properties of black cotton soil have been observed on adding acid of even small concentration; however trend of variation is different for sulphuric acid, phosphoric acid and nitric acid.

- Variation in liquid limit and plastic limit results the increase in Plasticity index is for H_2SO_4 and HNO_3 till 8% acid concentration and then sudden decrement for higher acid concentration. On the other hand plasticity index for H_3PO_4 gradually decrease from lower concentration.
- Shrinkage limit shows an opposite trend as it decreases at lower concentration of sulphuric and nitric acid and then increases for higher concentration value. But for phosphoric acid shrinkage limit goes on increase from initial addition on acid.
- Swelling volume of soil increases with initial addition of acid till 8% acid concentration which shows sudden decrease on further increase in acid concentration.
- Initial increment in swelling and plasticity index shows negative effect of acidic pollutant on black cotton soil.

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