PHYSICO-CHEMICAL CHANGES IN SOIL DUE TO SULPHURIC ACID CONTAMINATION

T.S. Umesh, Associate professor, Dept. of Civil Engg., SIT, Tumkur. email: t_s_umesha@yahoo.co.in.
H. D. Sharma, Assistant professor, Dept. of Civil Engg., SIT, Tumkur. email: hdevasharma@yahoo.co.in
S. V. Dinesh, Professor, Dept. of Civil Engg., SIT., Tumkur. email: dineshsv2004@yahoo.com.
P.V. Sivapullaiah, Professor, Dept. of Civil Engg. Indian Institute of Science, Bangalore. email: siva@civil.iisc.ernet.in
Swamy.C.Basim, Associate prof., Dept. of CE., Central Connecticut State University, USA. email:s_basim@yahoo.com

ABSTRACT: Acid contamination of soil can adversely affect the geotechnical properties of soil even at low concentrations. The effect of sulphuric acid contamination (0-15%) on the behavior of three types of soils viz., black cotton soil, a dispersive soil called Suddha soil and a red loamy soil with varied clay content has been studied. Specific surface of all the soils decrease due to acid contamination. The liquid limit decreased for all the three soils with increase in sulphuric acid concentration generally due to increase in electrolyte concentration of the pore fluid and consequent decrease in the thickness of double layer developed. This indicates the reduction in water holding capacity and increase in the frictional resistance and decrease in cohesion in soil. With increase in acid concentration the cation exchange capacity of soils decreases. There is a decrease in the optimum moisture content of soils. Unconfined compressive strength has significantly reduced due to loss of cohesion.

INTRODUCTION
Soil is being contaminated by anthropogenic sources such as leakages from waste containment facilities, accidental spills and industrial operations. Industrialization, high population growth and uncontrolled exploration of natural resources have resulted in environmental degradation, bringing in unanticipated changes in the engineering behavior of soils. Pollution has direct or indirect effects on soil properties. The alteration of the physical, mechanical and 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 types of contaminants include various substances such as inorganic acids, alkalis, sulphates, organic contaminants, toxic or phytotoxic metals, and combustible substances. Soil acidity is common in all regions where precipitation is high enough to leach appreciable quantities of exchangeable ions or the amount of ions adsorbed. Many natural processes contribute to emission of sulphur compounds in the atmosphere. These compounds may lead to acid rain leading to ground contamination. Sulphuric acid is used as raw material in many industrial applications.

Sivapullaiah et al (2000) [1] have reported the effect of sulphate on strength behavior of black cotton soil. Laredj et al (2008) [2] has reported the effect of chemical solutes concentration changes on deformation behavior of expansive soil. Ramesh et al (2008) [3] have reported the effect of sulphuric acid on the compaction and strength properties of black cotton soil. Grzegorz Jozefaciuk and Grzegorz Bowanko. (2002) [4] reported the effect of acid attack on the crystal structures of aluminosilicate minerals. The mechanical behavior of soils predominantly depends on mineralogical composition, physicochemical interaction between particles, inter particle forces, pore fluid chemistry and soil structures. Thus there is a need to understand the geotechnical behavior of acid contaminated soils. In the present paper an attempt is made to study the effect of sulphuric acid contamination on the behavior of three types of soils namely black cotton soil, Suddha soil and red loamy soil. The clay content of soils varied from 2 to 60 percent. The acid contamination is varied from 0-15%.

MATERIALS AND METHODS
Soils Used
Black cotton soil was collected from Gulbarga, in Karnataka state. This is an expansive soil with a liquid limit of 80 percent. It has 60 percent clay, 20 percent silt and 20 percent sand. This can be classified as clay of high compressibility (CH) as per IS classification. A local dispersive soil called Suddha soil is collected from a depth of 1.0 to 1.5 m from the ground level. It possesses good strength in dry condition and upon increase in moisture content looses strength. This soil is silty sand with 60 percent sand, 27 percent silt and 13 percent clay. The soil is classified as SM. Red soil available near the campus of SIT,
Tumkur is collected from a depth of about 1 m from ground level. This soil is a sandy soil with 2 percent gravel, 91 percent sand, 5 percent silt and 2 percent clay and belongs to CI group as per IS soil classification.

**Acid Used**

Laboratory reagent sulphuric acid was used in concentrations of 2.5, 5, 10 and 15 percent.

**Laboratory Acid Contamination of Soils**

The soil was mixed with 2.5, 5, 10 and 15 percent of sulphuric acid. The soil was thoroughly mixed with sulphuric acid and uniform acid distribution was ensured. The contaminated soil was then transferred to polythene bags and kept in the desiccator before testing.

**Tests Conducted**

The experiments were conducted to determine the pH, cation exchange capacity, specific surface area, Atterberg’s limits compaction characteristics and unconfined compressive strength.

The pH of the soil specimen was determined by the electrometric method as per IS: 2720 (part 26)-1987. The cat ion exchange capacity of the soil specimen was determined as per IS: 2720 (Part 24) 1976. The specific surface area of the soil specimen is determined as per ASTM C837, Methylene blue titration method. Atterberg’s limits of the soil specimen was determined as per IS: 2720 (part 5) – 1985. The Standard proctor compaction characteristics of the soil specimen was determined as per the Indian Standard specification IS: 2720 (part 7)-1980. The unconfined compression test of the soil specimen was determined as per the Indian Standard specification IS 2720 (Part 10)-1991 (Reaffirmed 1995). All the reported results are the average results of three tests.

**RESULTS AND DISCUSSION**

Figure 1 shows the variation of Atterberg’s limits for various sulphuric acid concentrations in the pore fluid for black cotton, suddha and red loamy soil. It is observed that with increase in sulphuric acid concentration the liquid limit decreases for all the three soils. A reduction in liquid limit is generally due to increase in electrolyte concentration of the pore fluid and consequent decrease in the thickness of double layer developed. A reduction in liquid limit generally indicates an increase in the frictional resistance and decrease in cohesion in soil. Plastic limit increases initially till 5 percent contamination and thereafter there is a slight decrease in the values of plastic limit for black cotton soil. But for suddha soil the plastic limit increases up to 2.5 percent acid concentration in the pore fluid and then it decreases up to 15 percent concentrations of acid. Where as for red soil plastic limit decreases with increase in acid concentration. It is observed that with increase in any acid concentration the plasticity index decreases for all the three soils. This clearly brings out the change in the plasticity characteristics with increase in acid concentration in the pore fluid.

Soil-water acidity is important to the geotechnical engineers because of its corrosive effect on foundation structures and construction materials. The pH value is used for indicating the degree of contamination in most aqueous phases including acid rain, acid mine drainage and leachate. Figure 2 shows the effect of acid concentration on pH of soil. As expected the pH is found to decrease with increase in acid concentration. The reduction in the pH of soil may also be due to the leaching of cat-ions and the adsorption of H+ ions due to the ion exchange reaction [5]. The pH plays a very important role in the behaviour of clay suspensions. A low pH promotes a positive edge to negative surface interaction, often leading to flocculation from suspension. Stable suspensions or dispersions of clay particles often require high pH condition [6]. The stability of clay particles is affected by low pH because acid attacks clay particles at edges and releases Al ions [7]. There will be marked changes due to acid attack in the crystal structures of aluminosilicate minerals because of dissolution of structural ions and/or rearrangement of the structure [4].

![Figure 1 Atterberg’s limits of black cotton, suddha and red soil](image1)

![Figure 2 Effect of acid concentration on pH](image2)
Physico-chemical changes in soil due to sulphuric acid contamination

Figure 3 shows the variation of cation exchange capacity with pH. There is a reduction in the cation exchange capacity of soils when contaminated with acid. Cation exchange capacity value is pH dependent. It increases with increase in pH value and decreases with decrease in pH value. In soils composed mainly of non-expansive clay minerals, the type of adsorbed cation is of greatest importance in influencing the behavior of the material in suspension and the nature of the fabric in sediments formed [6].

Figure 4 shows the variation of specific surface area with liquid limit. Liquid limit decreases with reduction in specific surface area. Increased acid concentration has resulted in decrease of liquid limit and now it is clearly observed that this is due to decrease in specific surface area. This is indicative of the reason for the loss of plastic property and the soil shows more of silt behaviour.

Figure 5 to 7 show the compaction behaviour for sulphuric acid contaminated black cotton, suddha and red soils respectively. It is observed that optimum water content show increasing trend up to 5 percent acid concentration and then show decreasing trend up to 15 percent acid concentration compared to soil with water for black cotton soil. On the other hand there is continuous reduction in optimum moisture content for suddha soil and red soil. The maximum dry unit weight show decreasing trend with increase in acid concentration compared to soil with water for all the three soils. The reduction in optimum moisture content at higher acid concentration indicates that the soil has got less affinity or less absorption capacity for water due to increase in the electrolyte concentration in pore fluid.
CONCLUSIONS

A comprehensive experimental study is made to know the effect of sulphuric acid contamination on the behavior of three types of soils namely black cotton soil, Suddha (local name) and red loamy soil. There is alteration of the engineering properties of soil.

There is decrease in pH, liquid limit, cation exchange capacity and specific surface area. There is a decrease in the optimum moisture content, Strength has significantly reduced which is attributed to change in the water holding capacity of the soil and consequent loss of cohesion.

REFERENCES