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# STUDY ON THE EFFECT OF pH ON CLAY

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**Abstract -** *Soil pollution as a part of land degradation is caused by industrial activity, agricultural chemicals or improper disposal of waste. The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons, various salts of chemicals, solvents, pesticide, sulfate, lead and other heavy metals. Due to contamination there will be changes in both geotechnical as well as chemical characteristics of soil. The change in pH value of soil due to the presence of contaminants in the soil is the basic parameter to identify the degree of contamination in soil. It has a great influence on geotechnical and chemical characteristics of native soil. The study is conducted on Kaolinite clay with various contaminants such as pore fluids, heavy metal, salts, and non-metal.*

***Key Words***: **Hydro carbons, contaminants, degradation, heavy metal, pore fluids**

## 1. 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 accidental spills, industrial waste, acid rain, alkali rain, etc are called as anthropogenic sources. Pollution has direct or indirect effects on properties of soil. 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 chemicals from industrial wastes. The main type of contaminants include various substance such as inorganic acids, alkalis, sulphates, organic contaminants, toxic or phytotoxic metals and also combustible substances. Soil acidity is common in all regions where precipitation is high enough to leach appreciable quantities of exchangeable base forming cations from the surface layers of soil. When certain minerals presented in soil are disturbed or exposed to atmosphere due to excavation they get oxidized to form acids. The majority of acid water is derived from acid rain, leakage from industries, underground reservoirs and waste disposal sites.

Penetration of chemicals and pore fluids into the soil will affect the properties of soil to a great extent. Due to contamination there will be changes in the geotechnical properties of the soil. The change in pH of the soil due to the effect of contaminants has a strong influence on the geotechnical properties as well as on the chemical characteristics. The purpose of this study is to find the variations in the pH due to the effect of various contaminants such as pore fluids, salts as well as heavy metals under various concentrations. The clay used for the study purpose was kaolinite (CL). The pH value is used for indicating the degree of contamination in most aqueous phases including acid rain, acid mine drainage and leachate. The effect of these contaminants can increase or decrease the pH of the soil widely. This change in the pH of soil can make the soil weak. The stability of clay particles is affected by low pH because acid attacks clay particles at edges and releases Al ions.

The effect of pore fluids on pH will reduce the thickness of diffused double layer and thus the clay particles get thickened and thereby reducing the liquid limit. Different industrial units such as chemical industries, metal industries, oil refineries, petrochemicals, tanneries, pharmaceuticals, textiles etc usually discharges raw chemical which are highly reactive. The toxic metal such as iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn) are essential trace elements to plant life while lead (Pb), chromium (Cr), nickel (Ni), and cadmium (Cd). They are toxic even at a very low concentration. 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 requires high pH condition. Due to the variation in pH there will be change in crystal structure of ions or rearrangement of the structure. Thus there is a need to understand the variation in pH of contaminated soils.

## 2. MATERIALS

### 2.1. Soil

The soils used in this study was kaolinite a low plasticity clay (CL). It is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al2Si2O5 (OH)4$. It is a layered silicate mineral, with one tetrahedral sheet of silica ($SiO4$) linked through oxygen atoms to one octahedral sheet of alumina ($AlO6$) Octahedral. Rocks that are rich in CL clay are known as CL clay or china clay. It has a low shrink–swell capacity and a low cation-exchange capacity (1–15 meq/100 g). Kaolinite clay used in this study was collected from English India Clay Limited, Trivandrum. Properties of kaolinite are given in table I.

**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 ($kN/m^2$) | 63.274 |
| OMC (%) | 23 |
| Dry density (g/cc) | 1.56 |
| Percentage clay (%) | 53 |
| Percentage silt (%) | 45 |
| Percentage sand (%) | 2 |
| IS Classification | CL |
| pH | 6.5 |

## 2.2 REAGENTS

Chemicals used in this study for artificially contaminating the soil were: Sodium chloride, Sodium hydroxide, Acetic acid (Pore fluids), Sodium chloride, Calcium chloride, Magnesium chloride (Salts), Ferric chloride (Heavy metal), Sodium thiosulphate (Non metal). All the chemicals were obtained from Laboratory supplies, Trivandrum. Soil was contaminated under varying concentration from lower to higher molarities such as 0.1M, 0.2M, 0.3M, 0.4M, 0.5M, 1M, 2M, 3M, 4M, 5M.

**Table – 2:** Physical and chemical properties of reagents

| Reagents | Molecular formula | Boiling point ºC | pH | Colour |
|---|---|---|---|---|
| Sodium chloride | NaCl | 1413 | 7 | Colourless crystals |
| Magnesium chloride | $MgCl_2$ | 1412 | 5.3 | colourless crystalline solid |
| Calcium chloride | $CaCl_2$ | 1935 | 7 | White powder |
| Ferric chloride | $Fecl_3$ | 316 | 2 | Green black |
| Sodium thio sulphate | $Na_2O_3S_2$ | 100 | | Colourless crystals |
| Sodium hydroxide | NaOH | 1660 | 12.1 | Opaque crystal |
| Acetic acid | $C_2H_4O_2$ | 118 | 2.4 | Colourless |

## 3. METHODS AND METHODOLOGY

The clay obtained from the various clay industries were artificially contaminated using various contaminants such as pore fluids, salts and heavy metals. The experiment was conducted to determine the variation in pH of clay contaminated by different sources such as acid rain, leakage from industries, underground reservoirs and waste disposal sites. The pH was determined using a digital pH meter. The pH of the uncontaminated soil was found out initially. Then various molarities of contaminants say 0.1M, 0.2, 0.3 etc up to 5M were added to contaminate the sample. The pH variation corresponding to each molarity of contaminated soil was found out using pH meter as per IS: 3025(Part 11).

### 3.1. pH Test

Test was conducted to determine the pH of various contaminated soil with the contaminants under different molarities varying from lower to higher concentrations using a digital pH meter. Experimental procedure of the determination of pH as per IS: 3025(Part 11) is as follows:

Three major steps are involved in the experiment.

i. Calibrating the Instrument

ii. Preparation of sample

iii. Testing of sample

i. Calibrating the Instrument:

Using the buffer solutions calibrate the instrument.

- pH 7 buffer solution was taken prepared in a 100 mL beaker.
- After that the electrode was placed in the beaker containing the stirred buffer and the reading was noted from the pH meter. Thus the instrument was calibrated.

After calibration the electrode was removed and washed with distilled water.

ii. Preparation of sample

- Soil sample was contaminated by adding different molarities of contaminants.
- Each sample of various molarities (0.1, 0.2, 0.3, 0.4, 0.5, 1, 2, 3, 4, 5M) of contaminants were prepared by mixing the contaminants of measured molarity with water in a 100ml beaker.
- The prepared sample were kept for 1 hour.

iii. Testing of sample

- After 1 hour the samples were taken for testing ph.

- The electrode was kept in the beaker containing sample and noted the stable reading from the pH meter.
- After noting the reading of one sample another sample of various molarities were also tested after washing the electrode using distilled water.
- This process was continued and variation in pH of different contaminated clay was obtained and it was used for tabulation.

**Fig 1. pH meter**

## 4. RESULTS AND DISCUSSION

The effect on pH due to the presence of contaminants of various concentration in kaolinite which is a CL clay was studied. The following results were obtained from the present study.

### 4.1.STUDY OF pH ON SALT CONTAMINATED KAOLINITE CLAY

Kaolinite clay was contaminated with various molarities of salts such as Sodium chloride, Calcium chloride and Magnesium chloride. It was found that the initial pH of uncontaminated kaolinite clay was 6.5 which goes on decreasing by the addition of varying concentration of sodium chloride and magnesium chloride. But pH goes on increasing while calcium chloride was added. The table 3 shows the obtained values.

**TABLE -3:** pH variation of kaolinite clay contaminated with salts.

| Molarity | pH of contaminant concentration | | |
|---|---|---|---|
| | Sodium chloride | Calcium chloride | Magnesium chloride |
| 0 | 6.5 | 6.5 | 6.5 |
| 0.1 | 6.2 | 6.55 | 5.8 |
| 0.2 | 6.1 | 6.61 | 5.78 |
| 0.3 | 6.05 | 6.65 | 5.72 |
| 0.4 | 5.9 | 6.72 | 5.71 |
| 0.5 | 5.72 | 6.84 | 5.7 |
| 1 | 5.68 | 6.91 | 5.62 |
| 2 | 5.66 | 7.23 | 5.44 |
| 3 | 5.7 | 7.49 | 5.38 |
| 4 | 5.82 | 7.47 | 5.33 |
| 5 | 5.84 | 7.37 | 5.28 |

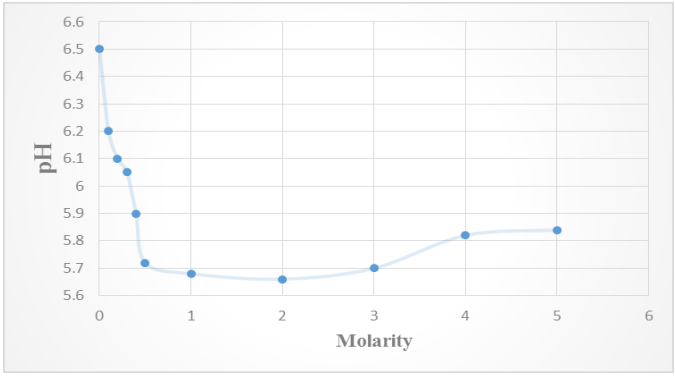


**Fig 2 pH variation of sodium chloride contaminated kaolinite clay**

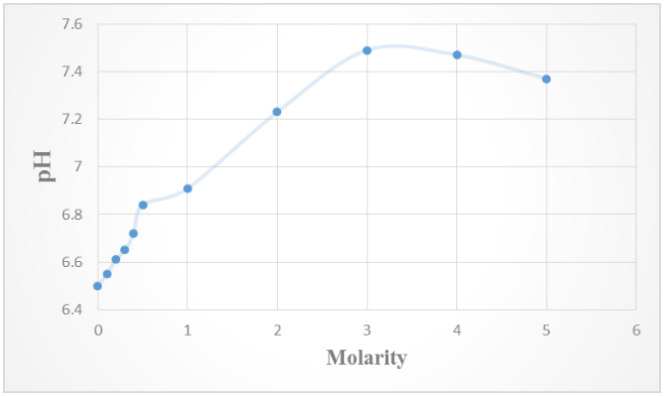


**Fig 3 pH variation of calcium chloride contaminated kaolinite clay**

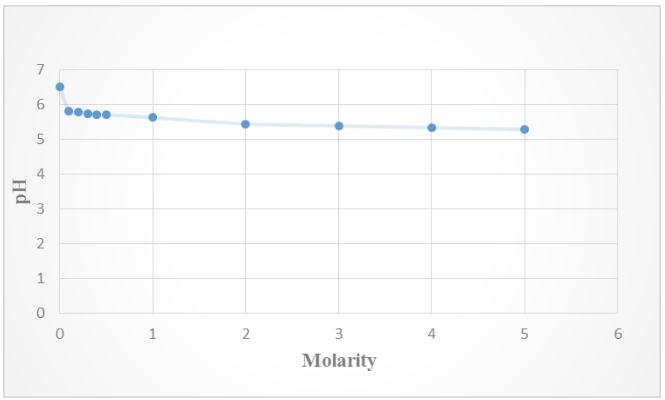


**Fig 4 pH variation of Magnesium chloride contaminated CL clay**

### 4.2. pH VARIATION OF PORE FLUID CONTAMINATED KAOLINITE CLAY

Kaolinite clay was contaminated with various molarities of pore fluids. It was found that due to the presence of sodium hydroxide pore fluid the pH of kaolinite gets increased since sodium hydroxide is a highly alkaline substance. When acetic acid is used it reduced the pH of the soil and turns the soil highly acidic. Table 4 shows the obtained results.

**Table – 4:** pH variation of pore fluid contaminated kaolinite clay

| DESCRIPTION | pH OF CONTAMINANT | |
|---|---|---|
| MOLARITY (M) | Sodium hydroxide | Acetic acid |
| 0 | 6.5 | 6.5 |
| 0.1 | 12.11 | 3.1 |
| 0.2 | 12.22 | 2.97 |
| 0.3 | 12.25 | 2.91 |
| 0.4 | 12.36 | 2.8 |
| 0.5 | 12.47 | 2.75 |
| 1 | 12.5 | 2.53 |
| 2 | 12.52 | 2.31 |
| 3 | 12.36 | 2.17 |
| 4 | 11.7 | 2.03 |
| 5 | 11.26 | 1.95 |

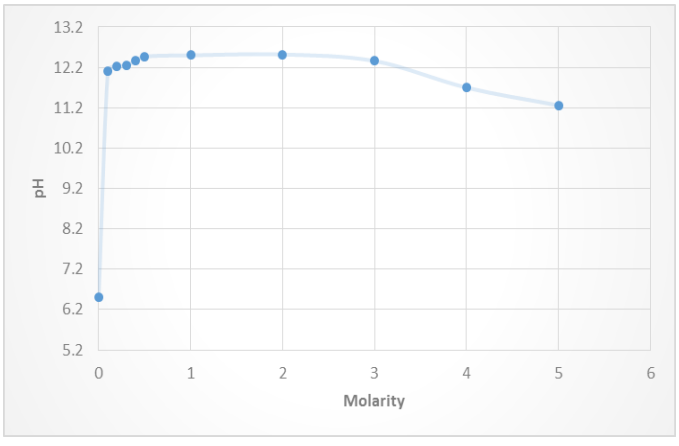


**Fig 5 pH variation of Sodium Hydroxide contaminated CL clay**

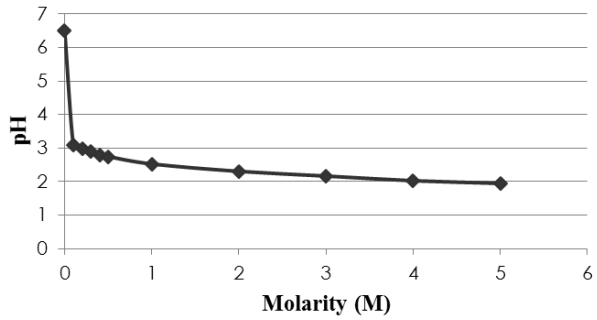


**Fig 6 pH variation of Acetic acid contaminated CL clay**

### 4.3. pH VARIATION OF HEAVY METAL CONTAMINATED KAOLINITE CLAY

Kaolinite clay when contaminated with Ferric chloride, it reduces the pH of the clay. Ferric chloride when contact with water gets dissociated and forms hydrochloric acid which in turn increases the acidity of clay.

**Table – 5:** pH variation of Heavy metal contaminated kaolinite clay

| MOLARITY | pH |
|---|---|
| 0 | 6.5 |
| 0.1 | 2.27 |
| 0.2 | 2.23 |
| 0.3 | 2.17 |
| 0.4 | 2.06 |
| 0.5 | 1.89 |

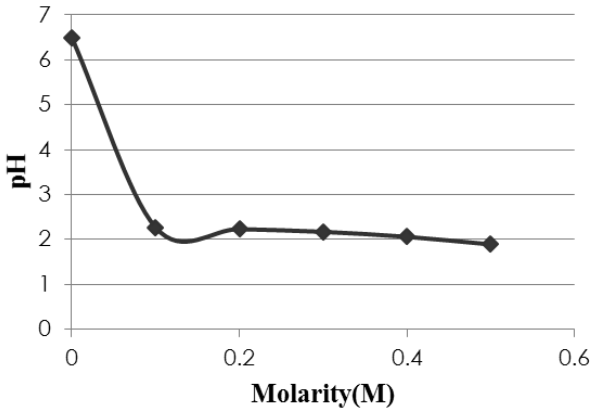


**Fig 7 pH variation of Ferric chloride contaminated CL clay**

### 4.4. pH VARIATION OF NON METAL CONTAMINATED KAOLINITE CLAY

Kaolinite clay was contaminanted with Sodium thiosulphate which is a non metal. It was found that the pH of the clay gets reduced.

**Table – 6:** pH variation of Non metal contaminated kaolinite clay

| MOLARITY | pH |
|---|---|
| 0 | 6.5 |
| 0.1 | 6.47 |
| 0.2 | 6.22 |
| 0.3 | 6.21 |
| 0.4 | 6.17 |
| 0.5 | 6.11 |
| 1 | 5.8 |
| 2 | 5.65 |
| 3 | 5.2 |
| 4 | 5.18 |
| 5 | 5.11 |

## 5.CONCLUSION

From the present study it was found that:

- There was a wide change in the pH due to the presence of contaminant.
- The concentration of contaminants plays a very important role in varying the normal pH of the clay.
- The initial pH of kaolinite was 6.5 which shows that it is acidic in nature.
- By the addition of one of the contaminant salt sodium chloride and magnesium chloride the soil pH goes on decreasing as the molarity increases and turned the soil more acidic.
- Sodium chloride is a salt with pH 7 when it combine with kaolinite $H^+$ ions were released to due chemical reaction and thus turning the soil more acidic.
- While calcium chloride increases the pH of soil and turned the soil alkaline.
- It was found that found that due to the presence of sodium hydroxide pore fluid the pH of kaolinite gets increased since sodium hydroxide is a highly alkaline substance.
- The reduction in the pH of soil may be due to the leaching of cat-ions and the adsorption of H+ ions due to the ion exchange reaction

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