

# Effect on Geotechnical Properties of Black Cotton Soil Using Pharmaceutical Effluent

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**Abstract** – This study was carried out to identify the effect of pharmaceutical effluent on the geotechnical properties of black cotton soil with the view to evaluating possible challenges posed by pharmaceutical effluent on the geotechnical properties of black cotton soil. Contaminated specimen was prepared by mixing soil up to 15% effluent by dry weight of the soil in step concentration of 5%. Results indicates a decrease in specific gravity, liquid limit, plastic limit, maximum dry density and unconfined compressive strength with increase in effluent content. Analysis of variance showed that pharmaceutical effluent has significant effect on the parameters of black cotton soil.

**Key Words:** Pharmaceutical effluent, Black cotton soil, Specific gravity, Liquid limit, Plastic limit, Maximum dry density, unconfined compressive strength

## 1 .INTRODUCTION

The economic growth and development of a country depends on the rate of industrialization in the country. This has led to rapid industrialization in the developing countries like India and hence is the production of enormous amount of liquid and solid wastes. In the past, waste thus generated have been disposed off indiscriminately, especially on land, causing serious environmental problems which include degradation of soil nutrients and thus affecting agricultural production, ground water contamination, modification of soil behavior etc. Among the above issues, modification of soil behavior is of importance and posing greater challenges to the geotechnical engineers.

Liquid wastes pose greater problems in handling them, when compared to solid wastes, because, contamination is triggered at relatively faster rate, due to its physical state (i.e. liquid). It is well understood that the organic and inorganic pollutants present in effluents, in general, affect the various geotechnical characteristics of fine-grained soils, such as its index properties, strength and deformation. To understand the effect of pharmaceutical effluents on black cotton soil, soil-pollutant interactions are very important which are primarily influenced by three factors, which include soil type and its mineralogical constituents, chemical characteristics of waste water and soil-pollutant interaction period.

## 1.1 Pharmaceutical Effluent

Pharmaceutical effluents are waste generated by pharmaceutical industry during the process of drugs manufacturing. Pharmaceutical industries suffer from inadequate effluent treatment due to the presence of recalcitrant substances. The pharmaceutical industry in India at that time was based on traditional, ayurvedic and unani medicines. It was basically an industry comprising of small and medium sized plants engaged in marketing formulations based on imported bulk drugs.

Many pharmaceutical industries are responsible to generate toxic effluent as a consequence of their operation. The waste water generated from these industries possess solids, biodegradable and non-degradable organic compounds etc. Pharmaceutical effluents offer basic information about the reliability of the aquatic habitat in rivers and streams, into which they are discharged.

## 1.2 Black Cotton Soil

Expansive soil, popularly known as black cotton soils in India are, amongst the most problematic soils from Civil Engineering construction point of view. Black cotton soil is heavy clay soil, varying from clay to loam. It is generally light to dark grey in color. Cotton grows in this kind of soil.

The Black cotton Soil is very hard when dry, but loses its strength completely when in wet condition. Montmorillonite is a predominant mineral of black cotton soils. The swelling and Shrinkage behavior of black cotton soils originate mainly from this mineral.

## 2. OBJECTIVES

The main objectives of this study are:

- To evaluate the effect of contamination on the geotechnical properties of black cotton soil.
- To access the effect of contamination on the study area.
- To determine the kind of material that would be suitable for construction in contaminated site and remediation.
- To determine the possible challenges posed by industrial hazardous waste.

### 3. PROCEDURE FOR CONTAMINATION

The soil from the site is dried and the pebbles and vegetative matter present, if any, are removed by hand. It is further dried and pulverized and sieved through a sieve of 4.75 mm to eliminate gravel fraction, if any. The soil mixed with different percentages of pharmaceutical effluents from 5 to 15%, in increments of 5%. The contaminated soil prepared thus is stored for a required 7 days, 14 days for uniform distribution of the effluent.

### 4. EXPERIMENTAL INVESTIGATIONS

#### 4.1 Materials used

1. Black cotton soil
2. Pharmaceutical effluent

#### 4.2 Test Conducted

1. Specific gravity test
2. Liquid limit test
3. Plastic limit test
4. Compaction test
5. Unconfined compression test

### 5. RESULTS AND DISCUSSION

#### 5.1 Specific Gravity

The specific gravity of Black cotton soil was determined as per IS: 2720 part 3, 1980, the specific gravity of black cotton soil decreases as the percentage of effluent increases for various days of curing such as 7 days and 14 days.

**Table-5.1: Specific Gravity Values for Varying Percentages of Effluent on Various Curing Days of Black Cotton Soil**

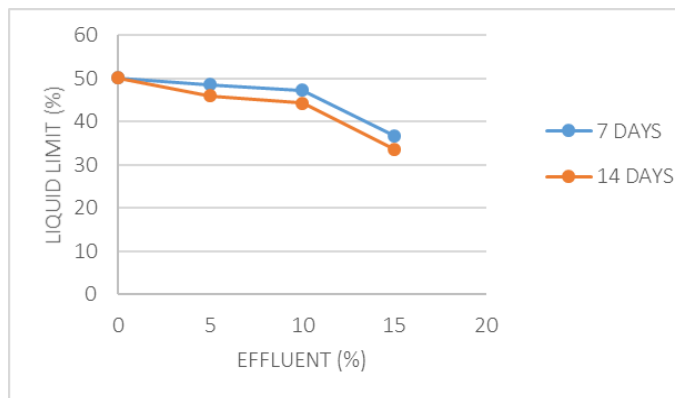
SPECIFIC GRAVITY		
EFFLUENT/ CURING DAYS	7 DAYS	14 DAYS
BLACK COTTON SOIL ALONE	2.75	2.75
BLACK COTTON SOIL + 5% EFFLUENT	2.67	2.45
BLACK COTTON SOIL + 10% EFFLUENT	2.56	2.24
BLACK COTTON SOIL + 15% EFFLUENT	2.32	1.92

#### 5.2 Liquid Limit Test

The liquid limit test has been conducted as per the code IS: 2720 part 5, 1985, the liquid limit results on black cotton soil contaminated with various percentages of pharmaceutical effluents cured for 7, 14 days shown in below table 5.3.

**Table-5.2: Liquid Limit Tests Result for Black Cotton soil**

LIQUID LIMIT TEST		
EFFLUENT/ CURING DAYS	7 DAYS (%)	14 DAYS (%)
BLACK COTTON SOIL ALONE	51.88	51.88
BLACK COTTON SOIL + 5% EFFLUENT	48.5	46
BLACK COTTON SOIL + 10% EFFLUENT	47.20	44.20
BLACK COTTON SOIL + 15% EFFLUENT	36.76	33.6



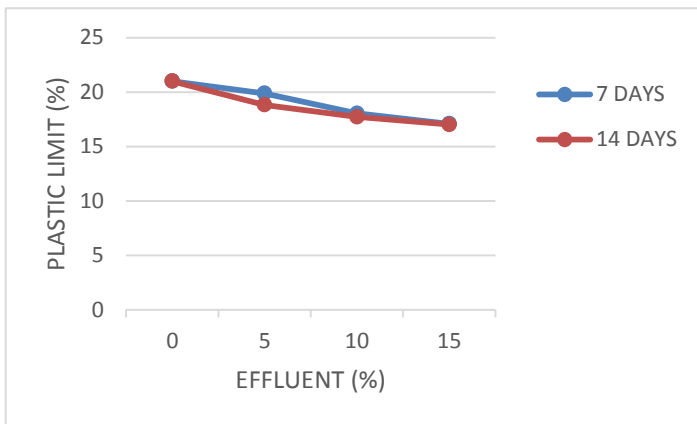
**Fig-5.2: Liquid Limit Test Graph for Various Mixing of Effluent**

#### 5.3 Plastic Limit Test

The plastic limit test has been conducted as per the code IS: 2720 part 5, 1985, the plastic limit results on black cotton soil contaminated with various percentages of pharmaceutical effluents cured for 7, 14 days are shown in below table

**Table-5.3: Plastic Limit Tests Result for Black Cotton Soil**

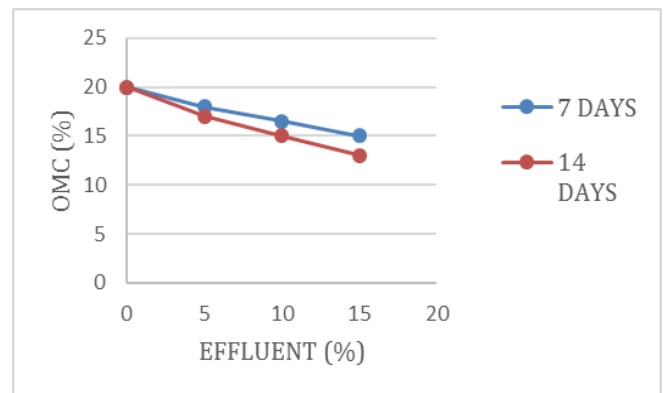
PLASTIC LIMIT TEST		
EFFLUENT/ CURING DAYS	7 DAYS (%)	14 DAYS (%)
BLACK COTTON SOIL ALONE	21	21
BLACK COTTON SOIL + 5% EFFLUENT	19.89	18.83
BLACK COTTON SOIL + 10% EFFLUENT	18.05	17.72
BLACK COTTON SOIL + 15% EFFLUENT	17.10	17.02



**Fig-5.3: Plastic Limit Test for Various Mixing of Effluent**

**Table-5.4.1: Optimum Moisture Content Result for Black Cotton Soil**

STANDARD PROCTOR TEST		
EFFLUENT/ CURING DAYS	7 DAYS	14 DAYS
	OMC (%)	OMC (%)
BLACK COTTON SOIL ALONE	20	20
BLACK COTTON SOIL + 5% EFFLUENT	18	17
BLACK COTTON SOIL + 10% EFFLUENT	16.5	15
BLACK COTTON SOIL + 15% EFFLUENT	15	13



**Fig-5.4.1 Optimum Moisture Content Graph**

**5.4 Standard Proctor Test**

The optimum moisture content results on black cotton soil contaminated with various percentages of pharmaceutical effluents cured for 7, 14 days are shown in below table 5.4.1.

The maximum dry density (MDD) results on black cotton soil contaminated with various percentages of pharmaceutical effluents cured for 7 days and 14 days are shown in below table 5.4.2.

**Table-Table-5.4.2: Dry Density Result for Black Cotton Soil**

STANDARD PROCTOR TEST		
EFFLUENT/ CURING DAYS	7 DAYS	14 DAYS
	Dry density	Dry density (kg/cm <sup>3</sup> )
BLACK COTTON SOIL ALONE	1.9	1.9
BLACK COTTON SOIL + 5% EFFLUENT	1.7	1.5
BLACK COTTON SOIL + 10% EFFLUENT	1.66	1.4
BLACK COTTON SOIL + 15% EFFLUENT	1.5	1.2

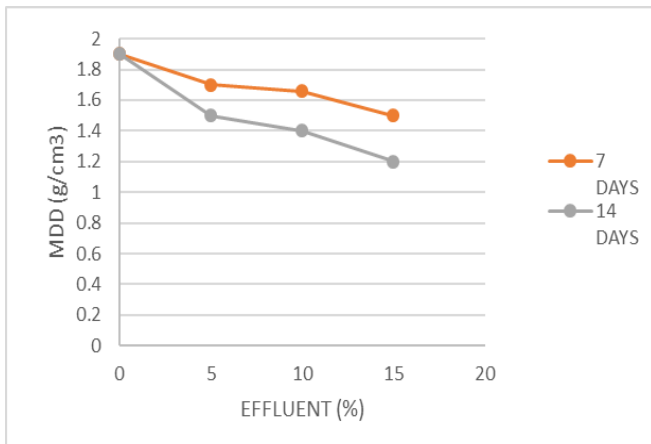


Fig-5.4.2 Maximum Dry Density Graph

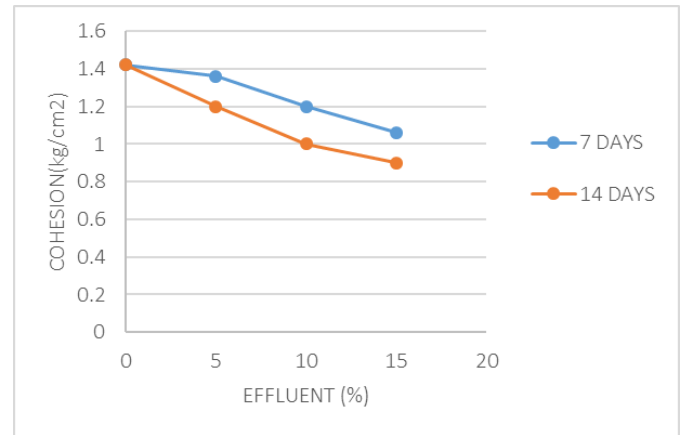


Fig-5.5.1: Cohesion Graph for Unconfined Compression Test

### 5.5 Unconfined Compression Test

The unconfined compression test has been conducted as per the code IS: 2720 part 10, 199. The unconfined compression test results on black cotton soil contaminated with various percentages of pharmaceutical effluents cured for 7 days and 14 days are shown in below table 5.5.1.

Table-5.5.1: Cohesion Tests Result for Black Cotton Soil

UNCONFINED COMPRESSION TEST		
EFFLUENT/ CURING DAYS	7 DAYS	14 DAYS
	<b>Cohesion (kg/cm<sup>2</sup>)</b>	<b>Cohesion (kg/cm<sup>2</sup>)</b>
BLACK COTTON SOIL ALONE	1.42	1.42
BLACK COTTON SOIL + 5% EFFLUENT	1.36	1.2
BLACK COTTON SOIL + 10% EFFLUENT	1.2	1.0
BLACK COTTON SOIL + 15% EFFLUENT	1.06	0.9

Table-5.5.2: Angle of Internal Friction for Black Cotton Soil

UNCONFINED COMPRESSION TEST		
EFFLUENT/ CURING DAYS	7 DAYS	14 DAYS
	<b>Angle of internal friction</b>	<b>Angle of internal friction</b>
BLACK COTTON SOIL ALONE	25	25
BLACK COTTON SOIL + 5% EFFLUENT	21	19
BLACK COTTON SOIL + 10% EFFLUENT	20	18
BLACK COTTON SOIL + 15% EFFLUENT	18	15

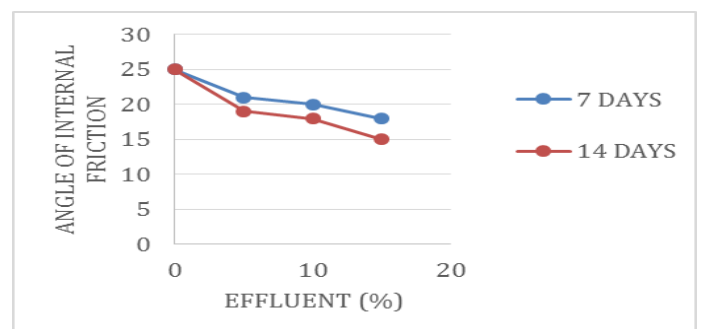


Fig -5.5.2: Unconfined Compression Test Graph for Various Mixing of Effluents

## 6. CONCLUSIONS

- When soil is mixed with pharmaceutical effluent there is a reduction in specific gravity.
- When the soil is mixed with the pharmaceutical effluent, there is decrease in the liquid limit as the percentage of effluent increases with respect to curing period.
- There is also decrease in the plastic limit values, as the percentage of effluent increases with corresponding to the curing period.
- When the black cotton soil is mixed with the increasing percentage of effluent, there is a decrease in the optimum moisture content with respect to percentage addition.
- Maximum dry density of the contaminated soil decreases with the increase in the percentage of effluent.
- Cohesion and angle of internal friction of the soil decreases when the soil is mixed with pharmaceutical effluent.

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