# "The Effect of Industrial Effluents on Plasticity, Compaction and Strength Characteristics of Shedi Soil"

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***Abstract*: Rapid industrialization has resulted in enormous generation of liquid and solid wastes and such wastes have been dumped on land either intentionally / unintentionally. However, such studies are important for understanding the interaction of pollutants in industrial wastewaters with soils and from a Geotechnical Engineering perspective. In view of the above, attempts have been made in this study to comprehensively investigate the effect of two wastewaters, namely, pharmaceutical wastewater and battery effluents. This study also involves with the evaluation of the effect of Industrial Effluents contamination on geotechnical properties of Shedi soil by varying percentages of industrial effluents namely 5%, 10%, 15%, 20%, 25%. And aims to improve geotechnical properties of Shedi soil amended with Industrial Effluents and to determine the change in geotechnical properties like Atterberg's limits, Compaction and Shear strength, which were cured for various curing periods for 7 days, 14 days, 28 days and 60 days. If there is an improvement in engineering behaviour of soil, there is a value addition to the industrial wastes can be used as stabilizer. If there is degradation of engineering behaviour of soil then solution for decontamination is to be obtained.**

***Keywords:* Soil Contamination, Shedi Soil, Pharmaceutical industrial effluent, Battery industrial effluent, Index Properties, Compaction characteristics, Shear strength parameters, Scanning Electron Microscopy.**

## I. 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 of 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 behaviour etc. Among the above issues, modification of soil behaviour 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). Hence the scope of the present studyis: to study the effect of the chosen industrial wastewaters on the index properties and strength characteristic of the chosen Shedi soil. To understand the significant changes in the contaminated soils through a set of appropriate sophisticated analytical techniques like SEM. Saravanane et.al. (2016) studied the Influence of Pharmaceutical Effluent on the Physico – Chemical Behaviour and Geotechnical Characteristics of Cohesive Soil Systems. Further, effort has not been directed to simulate the process of contamination close to the field conditions in the laboratory studies (Murugaiyan et al 2004). Effect of Certain Industrial Effluents on Compaction characteristics of an Expansive Soil was reported by A V Narasimha Rao(2012) and investigation was done for Tannery, Textile and Battery effluents. The effect of lead effluent from batteries on soil properties was reported by ashok kumar (2016).

## II. MATERIALS AND METHODS

### *2.1 Shedi Soil*

The Shedi soil is procured from the nearby village at Kumta, Bhatkal, Karnataka which has been sampled at depth of 2m below ground level. Properties of Shedi soil is shown in Table 1 respectively.

### *2.2 Pharmaceutical Effluent*

The effluent samples from pharmaceutical industry were collected from Strides sushan acrolab which is a well-known Indian pharmaceutical company. The collected effluent samples were colourless. It is practically insoluble in water, with a solubility of 0.02 g per 100 mL at 25 °C. Properties of pharmaceutical effluents are shown in Table 2 respectively.

### *2.3 Battery Effluent*

Battery effluent is a colourless liquid and soluble in water in proportion. The untreated raw effluent sample was collected from a Battery Production Industry from Peenya industrial estate located in Bangalore region which is a manufacturer of storage batteries predominantly consists of lead and sulphuric acid. Properties of battery effluents are shown in the Table 3 respectively.

Table 1: Properties of Shedi soil

| Parameter | Value |
|---|---|
| Gravel size fraction (%) | 0.00 |
| Sand size fraction (%) | 98.74 |
| Silt and clay size fraction (%) | 1.26 |
| Coefficient of Uniformity, Cu | 4.296 |
| Coefficient of Curvature, Cc | 1.227 |
| IS Classification | SP-MI |
| Shrinkage limit (%) | 19.55 |
| Liquid limit (%) | 42 .00 |
| Plastic limit (%) | 26.74 |
| Plasticity index (%) | 15.26 |
| Optimum moisture content (%) | 23.25 |
| Maximum dry unit weight ($kN/m^3$) | 1.61 |
| Friction angle (Degree) | 29.42º |
| Cohesion ($kg/cm^2$) | 0.201 |

Table 2: Properties of Pharmaceutical effluents

| Sl No. | PARAMETER | VALUE, |
|---|---|---|
| 1 | pH | 6 |
| 2 | Total Chlorides, as Cl | 2800 mg/L |
| 3 | Total Sulphates, as $SO_4$ | 1040 mg/L |
| 4 | Total Nitrogen, as N | 0.012 mg/L |
| 5 | Total Phosphates, as P | 0.011 mg/L |
| 6 | Total Sodium, as Na | 177 mg/L |
| 7 | Total Potassium, as K | 13.4 mg/L |
| 8 | Total Calcium, as Ca | 22350 mg/L |

Table 3: Properties of Battery Effluent

| Sl No. | PARAMETER | VALUE |
|---|---|---|
| 1 | pH | <1 |
| 2 | Total Chlorides, as Cl | 95.4 mg/L |
| 3 | Total Sulphates, as SO4 | 192170 mg/L |
| 4 | Total Nitrogen, as N | 6.4 mg/L |
| 5 | Total Phosphates, as P | 3.2 mg/L |
| 6 | Total Lead as Pb | 0.06 mg/L |
| 7 | Acidity as Sulphuric acid | 13.4 mg/L |
| 8 | Total Calcium as Ca | 1.4 mg/L |

### *2.4 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 battery effluent and pharmaceutical effluents from 5 to 25%, in increments of 5%. The contaminated soil prepared thus is stored for a required 7days, 14days, 28days and 60days curing in air tight containers for uniform distribution of the effluent. The soil effluent mixtures are mixed thoroughly before testing as shown in Figure 1.

Figure 1: Contaminated soil kept for curing in air tight containers

## III. RESULTS AND DISCUSSION

The work comprises of comparing the effect of Industrial Effluents contamination on geotechnical properties of Shedi soil by varying percentages of industrial effluents namely 5%, 10%, 15%, 20%, 25%, with different molding water contents and different dry densities which were cured for various curing periods for about 7, 14. 28 and 60 days and analysing the significant changes in the contaminated soils through a set of appropriate sophisticated analytical techniques like SEM for untreated and industrial effluent treated soils. Because of the predominant role of sulphates and chlorides in both the effluents, causes change in structure of soil and results with the increase or decrease of the strength, 28 days of curing period is considered as an optimum curing period for all the tests.

### *3.1 Effect on Consistency Limits:*

For pharmaceutical effluent Consistency limits (liquid limit, plastic limit, and plastic index) decreases this could be attributed to ion exchange at the surface of soil particle. The chlorides in the additives reacted with the lower valence metallic ions in the soil microstructure and causes decrease in double layer thickness. The decrease in double layer causes decrease in Consistency limits. Whereas for battery effluent Consistency limits (liquid limit, plastic limit, and plastic index) increases due to absorption of sulphates that is known to be present in battery effluent on to the Shedi soil surface. The figure 2, figure 3 and figure 4 has graphs for Liquid, Plastic and shrinkage limit.

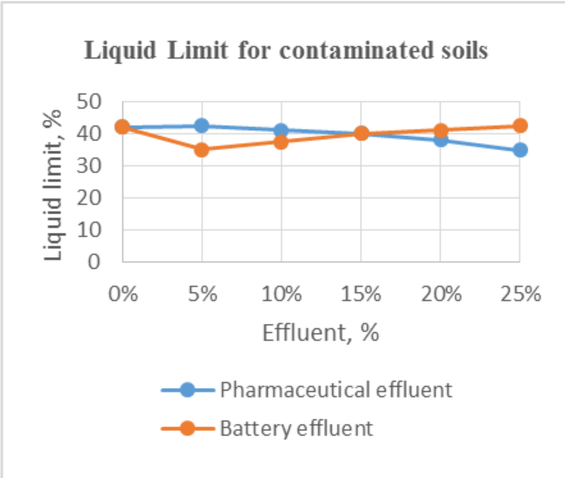


Fig. 2: Liquid Limit Graph

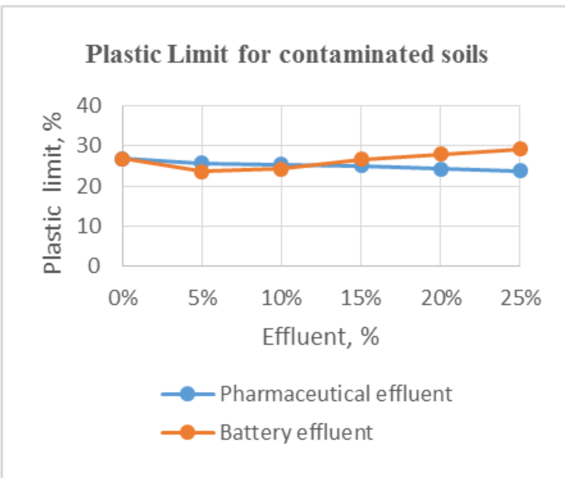


Fig. 3 Plastic Limit Graph

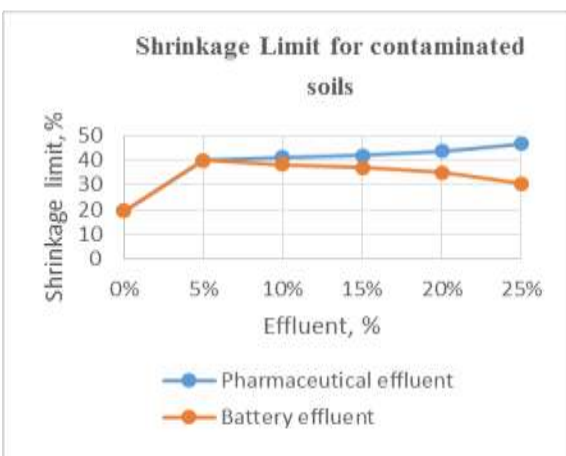


Fig. 4: Shrinkage Limit Graph

*3.2 Effect on Compaction Characteristics:*

When soil is mixed with pharmaceutical effluent the dry density increases and Optimum Pore fluid Content decreases as in figure 6. This is attributed due to adsorption of chlorides ions on to the soil particles present in the pharmaceutical effluent. When soil is mixed with Battery effluent the dry density decreases and Optimum Moisture Content increases as in figure 5. This could be attributed to ion exchange at the surface of Soil particle. This is also attributed due to adsorption of sulphates on to the clay particles present in the Battery effluent.

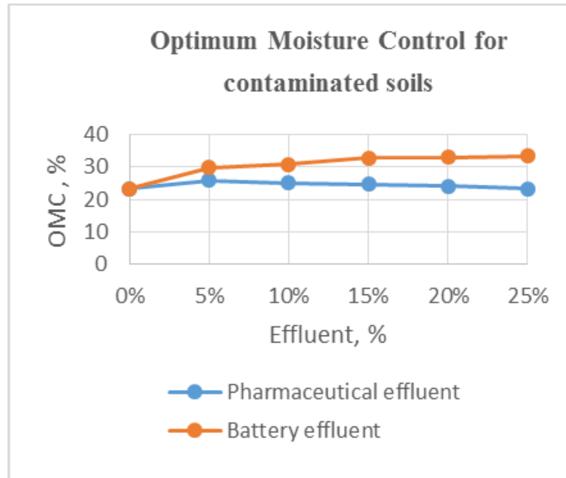


Fig. 5: OMC Graph

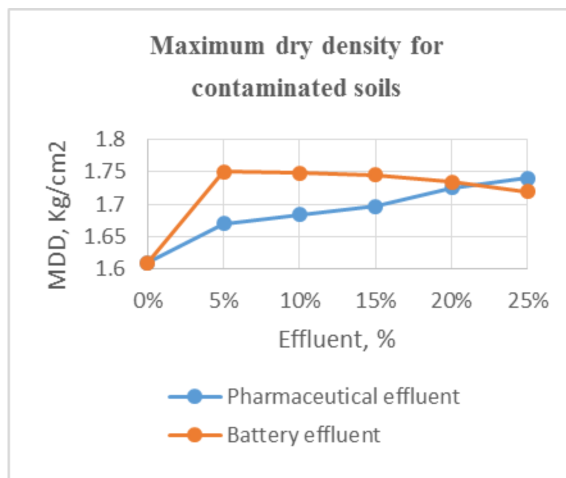


Fig. 6: MDD Graph

*3.3 Effect on Shear Strength Parameters:*

In the case of pharmaceutical effluent the increase in Undrained Cohesion values could be attributed to covalent linkages between soil particles and chlorides present in pharmaceutical effluent. The addition of the chemicals to the soil has led to an increase in inter particle attraction, leading to a flocculent structure there by an increase in shear strength. In the case of Battery effluent reduction in Untrained Cohesion Value could be attributed due to absorption of sulphates on to the clay surface causes increase in net negative charge of the clay particles which in turn increases thickness of diffused double layer around the clay particles. This issue results in increase in distance between soil particles and consequently increases in antiparticle repulsion and decrease in undrained shear strength. Hence decrease in strength andweak chemical bonding that developed between clay minerals with the reactive chemicals present in Battery effluent led to low Shear strength. The cohesion and angle of frictions are plotted in figure 7 and figure 8.

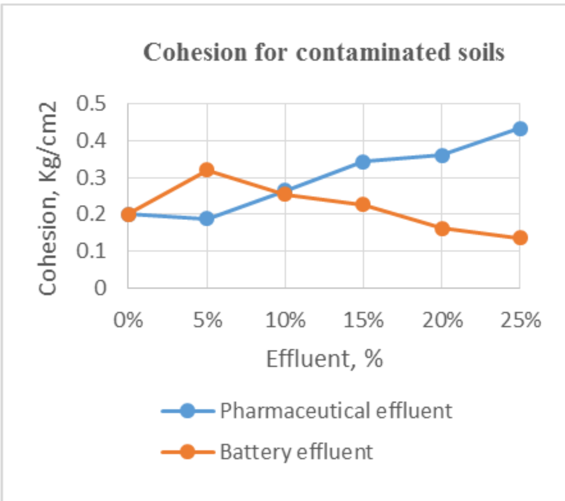


Fig. 7: Cohesion Graph

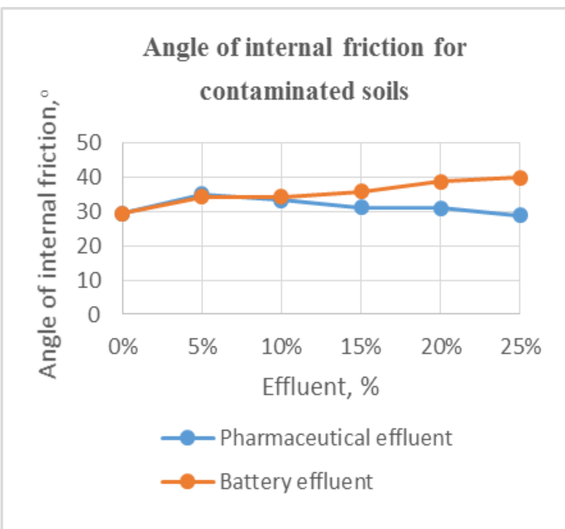


Fig. 8: Angle of Friction Graph

*3.4 Results of Scanning Electron Microscopy*

The scanning electron microscope photo micro graphs obtained for various contaminated and uncontaminated samples of shedi soils are shown in below figures and observations made from them are presented below.

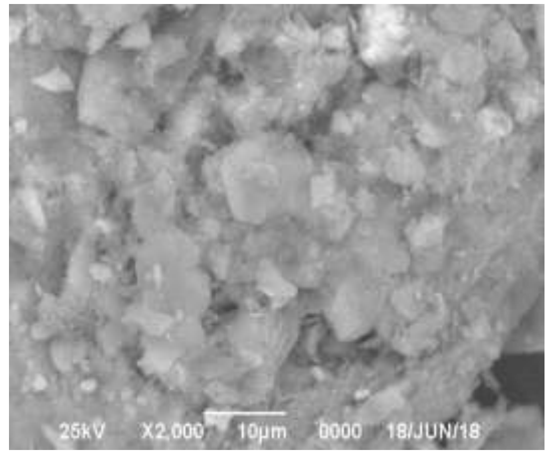


Fig. 9:SEM of the Uncontaminated Shedi Soil

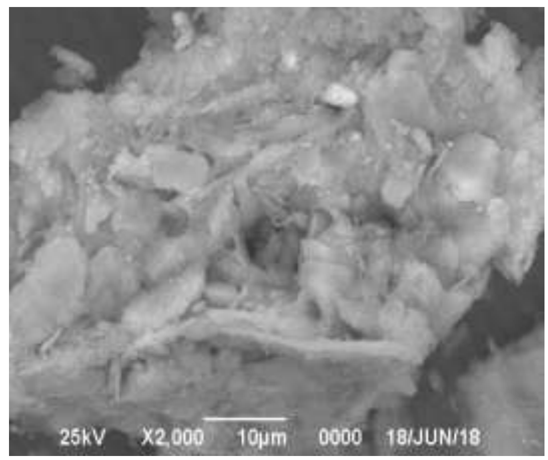


Fig. 10: SEM of Shedi Soil contaminated with Pharmaceutical Effluent

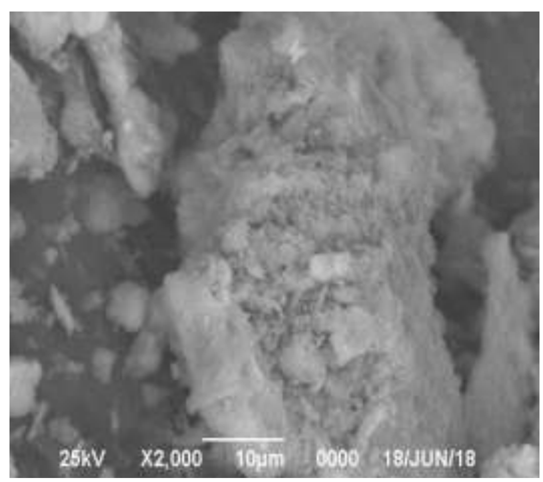


Fig. 11: SEM of Shedi Soil contaminated with Battery Effluent

When the shedi soil is contaminated with pharmaceutical effluent, the dispersed rounded structure of soil alone changes to flocculated structure with more surface to edge bonds and also due to the high cementations bonds between shedi soil and pharmaceutical effluent, high strength is developed. When the shedi soil is contaminated with battery effluent, the dispersive structure is likely to develop and the soil particles which slides over each other when sheared, causes low strength and stiffness.

## IV. CONCLUSION

1. When the soil is mixed with the pharmaceutical effluent, there is decrease in the liquid limit and plastic limit values and increase in the shrinkage limit values. For battery effluent, there is increase in the liquid limit and plastic limit values, and there is a decrease in the shrinkage limit as the percentage of effluent increases with corresponding to the curing period.
2. When the Shedi soil is mixed with the increasing percentage of pharmaceutical effluent, there is a slight decrease in the optimum moisture content and increase in the Maximum dry density. For Battery effluent, there is a slight increase in the optimum moisture content and decrease in the Maximum dry density of the contaminated soil slightly, irrespective of the curing days.
3. Shear strength parameters of the contaminated varies with the percentage of the effluent added. For pharmaceutical effluent, the cohesion value increases and the angle of internal friction decreases with respect to increase in the effluent. For battery eluent, the cohesion value reduces and the angle of internal friction increases with increases in percentage of effluent added.
4. Since there is a slight improvement in the strength properties observed during the test, pharmaceutical effluent raises the hope of value addition to the industrial wastes, which further can be used as a stabilizer. There is a slight reduction in the strength properties observed when compared to the uncontaminated soil, battery effluent cannot be used as a stabilizer, instead the soil which had got contaminated need to be further stabilized by other methods.

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