Impact of dyeing industry effluents on geotechnical properties of soil

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Abstract. In developing countries concentration on pollutants produced by industries such as dyeing, tanneries industries are exceptionally high. The disposal of untreated industrial waste water similar to dyeing effluent on soil is a widespread practice in developing nations. The unprocessed effluents severely deteriorate the soil properties. The study on dyeing effluents from industries affects engineering properties of soil. Hence the soil properties have to be improved for intensification of soil for the constructional activities. The soil properties are very much exaggerated by dyeing effluent which produces the soil and water pollution. In this study textile industry effluent is taken as pollutants and laboratory experiments are carried. The affected soils were treated with marble dusts as admixture to improve the soil properties. For assessment polluted and unpolluted soil samples are treated with 20% of dyeing effluent and tests were conceded out to identify an extent of the contamination. The cured samples show a decrease in strength values up to 30% with raise in the percentage of infectivity (dyeing effluent). The geotechnical properties and their stabilization using marble dust are determined with mixtures and explored.

[Keywords: Dyeing effluent, geotechnical properties, Marble dust]

1. Introduction

Owing to industrialization and urbanization process, disposal of effluent into the ground the earth has triggered infinite changes in the geotechnical properties of soil (Muhammad Irfan et al. 2018). These colored dyes after usage is disposed of directly onto the soil, which in turn changes the strength characteristics and alters the soil profile. The Atterberg’s limits and the plasticity index of the polluted soil were rather lower than the sterilized soil (Narasimha Rao and Indiramma, 2009). Seepage from waste landfills into soil stratum affects the stability sustaining structure. Atterberg’s limit values reduces by increases with a percentage of effluent and addition of a textile effluent reduces the pH of the soil (Phani Kumar Vaddi et al. 2015). Discarding of solid or liquid effluents, the waste by-products over the land cause modifications of the index properties in the vicinity of industrialized zone. (Chethan 2017). The soil contaminated with dyeing effluents show changes in the compression index, pre-consolidation pressure, coefficient of consolidation and swelling pressure (Mallikarjuna Rao et al. 2008). The soil samples from contaminated and sterilized area shows low moisture content and high consistency limits (Fawole and Ibikunle 2019). The soil found at a depth similar to sub-grade is subjected to curing with dye effluent,
which has been artificially induced for pollution. The results show that increase in dye effluent, decreases the value of CBR and the percentage of water required for change of matter of soil like plastic limit, liquid limit (Jagadeesh Kumar et al. 2017). The dielectric constant decreases inter particle shearing resistance and increase in double layer attain maximum liquid limit (Shah and Shroff 1998). The clayey soil which treated with reliable proportions of alkaline effluents is having a lower dry density (Shivaraju et al. 2017). Due to untreated effluent, the property of soil decreases the values of pH, plasticity and unconfined compressive strength. The primary and secondary treatment were carried out with lime-alum and alum with treated effluent and alum-treated soil sample indicates increase in strength related to alum-lime treated soil (Sreeja and Deepthy 2017).

2. Study area
Soil samples are collected from the site at Pallipalayam, near Cauvery river. The soil samples were composed in the pattern of three rings surrounding the dyeing industry and ten samples in each ring were collected. Distance between the location of soil samples and the consecutive rings are at a distance of 2m from each other. The collection patterns of soil samples in the consecutive rings are shown (Figure 1). To evade the possible influence of dumping waste, the soil samples were procured 1.5m deep from the ground surface. The soil samples were collected in polythene covers and labelled and air dried for testing. The soil samples are preserved and analyzed the impact of effluent from the collected samples.

3. Methodology
Grain size analysis, specific gravity, compaction factors, Atterberg’s limits, compressive strength and direct shear tests represents the index and engineering properties of the collected samples are investigated. To improve the soil strength properties industrial by-product of marble dusts were added to deteriorate soil samples at proportions of 5%, 15%, and 25% by mass in order to get better soil properties. For improving the engineering properties of soil marble dust (Figure 2) are used as admixture as they are with calcium carbonate. Marble dust used in this study was collected from marble stone quarries in Hosur. The compaction factors, specific gravity and direct shear tests were determined for the admixture of the marble dust.

![Figure 1. Collection pattern of samples](image1)

![Figure 2. Marble dust](image2)
Index property tests such as sieve analysis, (IS 2720 part-4-1985) consistency limits test (IS 2720 part-5-1985) were conducted to obtain soil classification and plasticity indices of soil samples. The compaction test (IS 2720 part-7-1985) was carried out to obtain the compaction factors namely, optimum water content and maximum dry density for all the samples. From utmost point of compaction curve, compaction factors are identified for the soil samples in consecutive rings. The direct shear test (IS 2720 part-39-section -1-1978) and unconfined compressive test (IS 2720 part-10-1991) was carried out for assessing the shear parameters of all soil samples. From the test results the soil samples with poorly graded soil, stabilized with marble dust with varying percentages. From each consecutive ring, 30% to 40% of soil samples were falls under poorly graded soil as per Indian standard classification system.

4. Results and Discussion
Atterberg’s limits considered as key properties of soil that is used to identify consistency of soil properties. The properties of cohesive soils includes shear parameters, drainage property, compression index and settlement are the progress of Atterberg limits. A difference in Atterberg limits in each ring constitutes the effluent contamination and it can be identified as a characteristics to modify the soil properties. Differences in plasticity indices, the liquid limit of fine graded soil varying from 35.25% to 47.65% depends upon infectivity in the site. The plasticity index of fine grained soil represents a related behavior. To facilitate, the plastic index improved from 18.33% to 21.35% at first ring, 18.33% to 23.63% in second ring and 25.55% in the outer ring based on the effluent concentration are discussed (Figure 3). The variation in Atterberg’s limits of soil is mainly due to the chemicals available in the effluent among soil grains and dyeing effluent. Plasticity index of polluted soils cause problems related to increased swell properties and settlement problems.

Figure 3. Variation in plasticity index

Compaction parameters viz. maximum dry density and optimum water content are associated with index properties used in construction of pavements and other building structures. From the three consecutive rings, 40% of the soil sample shows an increase in optimum water content that represents high-water requirement to attain a definite dry density under the same compactive effort. An increase in maximum dry density on the ordinate indicates a relatively finer material having poor engineering effectiveness. The optimum water content in virgin soil is increasing their trends whereas contaminated soil shows poor compaction with a reduction in moisture content. Increase in proportion of infectivity reduces in maximum dry density in most of the soil samples. An increase in infectivity makes the soil more plastic, thereby leading to enhance in optimum water content and has reduction in maximum dry density in
consectective rings and compaction properties are explained (Figure 4). It is observed that high water demand to attain optimum moisture in the field which in turn increases the project cost and it becomes uneconomical.

Figure 4. Variation in compactive factors of soil
Unconfined compression is a shortest assess of strength for clayey soils and increase value shows enhanced soil and vice versa. The behavior of clayey soils leading infectivity shows a decrease in strength and due to effluents contamination about 30% of soil samples that are uncontaminated. The decrease of strength owing to infectivity leads to the rupture of internal structures. The causes for the variation in strength due to effluent stagnation in the three consecutive rings are due to effluent influence of cementing materials. Variations in the strength from the three consecutive rings are shown (Figure 5).
Presence of cementing materials helps to bind the smaller particles to form aggregates. Due to effluent influence in the ground surface, the finer particles get crumbling with residual materials. As a result, an effluent modifies the cementing materials in the soil particles and consequently decreases the unconfined compressive strength.

The shear properties are exaggerated due to dyeing effluent and are measured as the degradation of engineering properties of soil in geotechnical designs. The increase in the proportion of infectivity by dyeing effluent shows increase in the volume of soil and in addition denseness of soil particles decreases and hence the shear strength varies.

**Figure 6.** Variation in shear parameters of soil
Variations are obtained in the soils of the rings of the site. The values obtained from the direct shear test are plotted and the graph is drawn between normal stress and shear stress are illustrated (Figure 6).

The soil that is not affected by dyeing effluent shows fine shear strength values whereas soil that be affected by dyeing effluent shows value lesser than the unaffected. These variations in the shear parameters show that dyeing effluent has its influence on the shear strength of the soil. The soil samples obtained near the outlet from the industry tendency to show deprived results in unconfined compressive strength and direct shear test. To increase the shear strength property of polluted soil, marble dust were added in proportions and unconfined compressive strength were studied with the soil samples from the consecutive rings. The influence of calcite in marble dust binds with the fine particles and has great potential strength in removing chemicals from the soils. The unconfined compression strength of soil treated with marble dust shows greater variation in shear properties are illustrated (Figure 7).

![Figure 7. Unconfined compressive strength of soil treated with marble dust.](image)

5. Conclusion

- The geotechnical characteristics of soil suspected to dyeing effluents to deteriorate by causing possible risks to the existing construction at the site.
- The effluents obtained from the dyeing industry are subjected to various physical and chemical properties to determine their characteristics.
- Effluents significantly reduce the engineering properties of soil, especially cohesion. The unconfined compression values and direct shear values of effluent polluted soils decreases as much as the extent of the contamination. Potential disintegration of the mineral particles, causing reduction in soil denseness which can be recognized as important causes for variations in soil parameters.
- The compressive strength of soils that are polluted kept decreasing by means of time. Both the soils failed to regain their strength with time and they abortive to achieve the soil strength.
- In view of the deterioration in soil characteristics leading infectivity and focused on stabilization of contaminated soil with marble dust which are resulted in gradual increase in values of shear strength.
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