Experimental study on the change in soil properties due to dumping of organic solid wastes

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Abstract. Urbanization and population growth leads to increase in solid waste generation. In order to maintain the environment clean, technique called open dumping is used widely to dump the waste material. Dumping waste in the soil has various effects which results in change in soil characteristics, generation of leachate and also affects the ground water quality. In this study, an attempt has been made to compare the properties of natural soil and waste dump soil. The collected sample has been tested for pH, chloride, electrical conductivity, hardness, alkalinity and acidity. In this experimental study, the collected soil sample was placed in a glass container to make visual inspection. The change in soil properties were investigated by dumping organic solid waste such as food waste, vegetable waste etc., on the soil surface. Test results showed that, the physic chemical and engineering properties of the soil had been changed due to contamination and the variation was not relevant since the study period was very less. Hence to predict the change in the property of contaminated soil, long term studied has to be made in the future and it has to be checked for its suitability to agricultural activities.

Key words: Organic solid waste, soil properties, open dumping site

1. Introduction

Open dumping of solid waste changes the property of soil. The contaminated soil will have decaying organic matter, due to the presence of decaying organic matter engineering properties in the contaminated soil decreases compared to the uncontaminated soil. Kitchen waste, paper, plastic, glass, cardboard, clothes are used. In addition to the above said material, sand, brick, concrete block etc., may also be dumped [2]. After decomposition of waste, to check the change in soil properties samples were collected inside, outside and near the landfills areas to a certain distance [4]. The chemical tests like pH, electrical conductivity, water soluble salts, organic matter, Biological Oxygen Demand test, Chemical Oxygen Demand test, chloride content determination, alkalinity test, nitrogen, phosphorous, potassium, iron, water soluble chloride sand sulphates, calcium carbonates were performed [2][4][5].

Apart from chemical tests, Moisture content, specific gravity, particle size distribution, permeability, shear strength, atterberg’s limit, maximum dry density, cohesion, compressibility, are done for contaminated soil and uncontaminated soil [1][3]. The tests are conducted in soil to water ratio1:5 using digital meter, organic matter by Tyurin method, particle size analysis by hydrometer method, soil textural classes by textural triangle, PCORD version 4.6-analysis of ecological data [6]. The disposal of solid waste in the municipality has resulted in increase of metal concentration in the soil. Due to municipal Solid Waste dumping, the soil properties changed by increasing Cu, Zn, Cd, Pb, Ni and Cr which prove that level of pollution increased [7][8].

Depending upon the properties of solid waste, the soil properties varied. Increase in cohesion and compressibility make the soil more plastic but pollutes the underground water surface. This will affect the forest areas and farming soils. The growth of grass was retarded and also the ground water was polluted [8][9]. The soil was found to be either acidic or alkaline depending on the composition of waste materials dumped in the soil [10][12].
Even though open dumping of solid waste changed the properties of soil, but it was within the limit in certain places. The soil characteristics such as potential of hydrogen, electrical conductivity, Ca\(^{2+}\), Na\(^+\), and K\(^+\) were found and parameters like Stream Quality Index, Structure -Activity Relationship, Cation-Exchange Capacity and Electrostatic potential were also derived [5][13]. Since some of the parameters are within the limit, waste materials are used as fertilizers in areas where soil lost its natural fertility and productivity due to human caused process like mining. In some areas, the test result showed that there is an improvement in soil fertility and soil promotes itself in vegetation cover [11].

2. Materials and methodology

2.1. Materials
A glass tank of size 60 cm x 25 cm x 50 cm was used for the experimental study. Representative soil was taken for the open dump site near Sathyamangalam. The in situ field density and moisture content of the soil was maintained in the glass tank. The soil was filled up to a height of 35 cm and 15 cm was left free at the top. Organic solid waste comprising of vegetable waste, food waste, egg shell etc., was dumped on the soil surface. Distilled water was frequently poured on the surface to study the effect on the soil properties prone to critical conditions (frequent rainfall).

2.2. Tests performed
Sieve analysis was carried out using standard sieves, in order to classify the soil based on particle size distribution. Core cutter was used to find the field density of the soil. Specific gravity of the soil was found using pycnometer. Direct shear test was performed for the soil to find the angle of internal friction. The parameters such as pH, Electrical conductivity, chloride concentration, hardness, alkalinity and acidity of the soil samples were determined during chemical analysis of soil sample.

2.3. Methodology
The soil was excavated from the field and kept in oven for 24 hours to make it dry. After 24 hours the soil was taken out of oven and was filled in the glass tank. The field density and water content were maintained the same as obtained in the test results. After the soil has been filled the organic solid waste was filled to the desired depth of 10cm. Distilled water was sprinkled over the dumped organic solid waste to represent the precipitation. In the presence of atmospheric carbon and moisture, the waste material began to decay. After the wastes are completely decayed the contaminated soil sample lying below the dumped waste was taken for analysis. The soil sample was water digested. 1gm of Soil was mixed with 100 ml of distilled water and was kept in an orbital shaker for 8 hours. The filtrate was extracted using a whatman filter paper. The extract sample was analysed for pH, electrical conductivity, chloride, hardness, alkalinity and acidity.

3. Experimental Investigation

3.1. Sieve Analysis for the Uncontaminated Soil

| S.No. | Sieve size (mm) | Weight (kg) | Percentage | Cumulative percentage | Percentage passing |
|-------|----------------|-------------|------------|-----------------------|-------------------|
| 1     | 4.75           | 0.048       | 4.8        | 4.80                  | 95.20             |
| 2     | 2.36           | 0.102       | 10.2       | 15.01                 | 84.99             |
### Figure 1
Sieve size vs. percentage of soil passing

#### 3.2. Direct Shear Test for the Uncontaminated Soil

#### Table 2. Shear stress Vs Normal stress for the uncontaminated Soil

| S.No | Normal stress (kg/cm²) | Shear load (kg) | Shear stress at failure (kg/cm²) |
|------|------------------------|----------------|-------------------------------|
| 1    | 0.5                    | 5.67           | 0.16                          |
| 2    | 1.0                    | 10.80          | 0.30                          |
| 3    | 1.5                    | 14.58          | 0.40                          |
| 4    | 2.0                    | 16.74          | 0.46                          |
| 5    | 2.5                    | 20.52          | 0.57                          |
3.3. Direct shear test for the contaminated soil

Table 3. Shear Stress Vs Normal Stress for the contaminated Soil

| S.No | Normal stress (kg/cm²) | Shear load (kg) | Shear stress at failure (kg/cm²) |
|------|------------------------|----------------|---------------------------------|
| 1    | 0.5                    | 8.10           | 0.225                           |
| 2    | 1.0                    | 10.26          | 0.285                           |
| 3    | 1.5                    | 13.50          | 0.375                           |
| 4    | 2.0                    | 17.55          | 0.488                           |
| 5    | 2.5                    | 21.52          | 0.597                           |
3.4. Core Cutter Test
The mass of the soil measured was 1640 kg. The volume of the cylinder used was 942.39 cm\(^3\). The mass density of the soil was found to be 1.74g/cm\(^3\).

3.5. Specific Gravity for the Uncontaminated Soil
Specific gravity of the uncontaminated soil using pycnometer was found to be 2.4.

3.6. Specific Gravity for the Contaminated Soil
Specific gravity of the contaminated soil using pycnometer was found to be 2.4.

| S.No | TEST          | UNCONTAMINATED SOIL | CONTAMINATED SOIL |
|------|---------------|---------------------|-------------------|
| 1    | EC (µmho/cm)  | 160                 | 142               |
| 2    | pH            | 7.78                | 7.64              |
| 3    | CHLORIDE (mg/L) | 28.36              | 14.18             |
| 4    | HARDNESS (mg/L) | 47.5               | 40                |
| 5    | ALKALINITY (mg/L) | 150               | 105               |
| 6    | ACIDITY (mg/L)  | 450                 | 170               |

**Table 4.** Uncontaminated soil Vs contaminated soil

![Figure 4. Comparison of chemical parameters for contaminated and uncontaminated soil sample](image.png)
4. Results and discussions
The soil sample was taken during the first and fifth week after the dumping of organic solid waste on it and the various properties such as particle size distribution, specific gravity, were analysed. Although the parameters such as pH, Electrical conductivity, chlorides, hardness, acidity and alkalinity varied, there is no much difference in the values except chlorides and alkalinity. This may be due to the leachate percolating into the soil mass. The contaminated soil showed decrease in the concentration of chemical parameters with respect to uncontaminated soil. The percentage decrease in electrical conductivity, pH, Chlorides, Hardness, Alkalinity and Acidity are 11%, 2%, 50%, 16%, 32% and 62% respectively. Chloride concentration and acidity in the contaminated soil was found to vary with 50% and more. The shear stress of the contaminated soil was found to be increasing for initial loading condition, then decreased and finally increased for the same normal stress. It is inferred that the soil property has to be studied on a long term basis to evaluate its change in properties due to organic solid waste dumping.

5. Conclusion
If the land is used for open dumping of solid wastes, then some precautions should be taken to prevent the leachate penetration into the ground surface. Since lots of wastes are dump in the open site the time and the rain water allows it to decay. This results in the change of physic chemical properties and engineering properties of the soil. The area near Sathyamangalam open dump site is partly residential and partly agricultural. The fertility of the soil is an important aspect for agricultural activities. The decrease in concentration of chemical parameters in the contaminated soil may prove it to be unfit for agriculture in the long term perspective. Hence the change in soil property due to open dumping of solid waste has to be studied on a long term basis to find its suitability for agricultural activities.

Once the soil properties are changed then it is unfit or not suitable for any work. In order to prevent this, certain remedial measures should be taken to prevent this act. Remedial measures like creating a permeable reactive barrier, which doesn’t allow any liquid substance to penetrate into the ground should be taken to avoid contamination of ground water. Some of the remedial measures for contaminated soil include bio ventilation, biological cell treatment, detergent leaching, immobilization, pump and treat, electro kinetics, steam stripping, chemical treatment, pneumatic fracturing etc., Each method has its own advantage and disadvantage. By analyzing the suitability of the available methods, any one of the remediation method or a combination can be adopted to prevent the further contamination of ground water and soil.

6. Further study
The study was carried only for 5 weeks. This has to be extended to study the long term effect on the soil quality due to open dumping of wastes. It has been planned to dump combined solid wastes (organic and inorganic) on the surface of the soil and study the effect on change in soil properties.

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