# Comparison of Soil properties between Normal Land and Waste Dump Site

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**Abstract.** Geotechnical aspects & properties of the soil from the waste dump site sometimes show diverted behavior in comparison with normal land site. Soil from waste dump site shows abrupt nature & it may be acidic or alkaline based on the categories of the effluent that are being dumped on the top soil. When the soil treated with waste, it shows different nature than normal condition due to penetration of Leachate. This study aims to investigate into the effect of pH on the geotechnical properties of soil of normal land and waste dump sites and comparison between them based on the tests and considerations presented in this paper. To demonstrate this experiment, disturbed and undisturbed soil samples were collected from some selected locations of Khulna region. Experiments were conducted following the ASTM (2004) methods. The obtained results show that pH has a prominent influence on geotechnical properties including Specific Gravity, Plastic Limit (PL), Liquid Limit (LL), Shrinkage Limit (SL), Moisture Content, Undrained shear strength and preconsolidation stress of soil samples. Based on the test results it is seen that for the normal land soil show different behavior than the soil from dump site. Soil from dump site may range pH below 7 to upper 7, but for the normal land soil it shows always greater than 7. For this basic difference sometimes some properties of these two did not well match. Therefore, this paper provides insight regarding how the geotechnical properties of soil change with pH.

**Keywords:** Acidity, alkalinity, pH of Soil, geotechnical properties, normal land, dump site.

## 1 INTRODUCTION

Civilization directly affects the changes of natural parameters. To keep pace with the flow of civilization consumption of commodities is increasing and industrialization is spreading rapidly. This finally leads to generation of solid and liquid waste and exploration of natural resources resulting in environmental degradation including soil pollution. Irrational disposal of waste creates an important source of soil pollution. Soil pollution results in modification of the physical, chemical and biological properties of soil restricting or preventing its use in the various applications. Moreover the geotechnical properties of waste materials can easily vary within broad ranges, change significantly with time. Hence changing behavior of soil is a challenging topic in the current soil mechanics concept. The impact of soil contamination on engineering behavior of soil has become a matter of leading concern for Geotechnical Engineers. They mainly deal with the physical properties of foundation soil. Soil waste interaction can however affect almost all the properties of soils. The effect of pollutants can be very similar to the effect of weathering. The nature of soil pollutant interactions depends on the mineralogy of soil and type and concentration of the pollutant (Umesha et al. 2011).

The unintended modification of soil properties due to interaction with pollutants can lead to various geotechnical problems. Conventional geotechnical principles cannot be extended to contaminated soil behavior. However in the south-western region in Bangladesh like Khulna, due to the increasing trend of urbanization and industrialization, marginal sites need to be utilized for the development of infrastructure facilities (Rafizul et al. 2010) and this requires knowledge about the condition of soil here. Geotechnical
Properties also show some variation as the distance increases. This may or may not be due the influence of varying chemical compositions in the soil.

In Khulna region, the organic soil layer exists in most of the places within a depth of 10 to 25 ft below the existing ground surface (Rafizul et al. 2009). Sometimes it may be close to the top surface in some place where wastes are dumped. Also the nature of organic contents and geotechnical properties of this soil are found to vary from place to place with pH. Soil acidity or alkalinity may result from pollution of soil (Umesha et al. 2012). Sometimes with the varying types of waste (household or industrial) exposed on the soil pH of soil changes. Precipitation permits leach appreciable quantities of exchangeable base forming cat ions (C2+ Mg, K and Na+) from the surface layers of soil (Umesha et al. 2012). The undrained shear strength decreases significantly for the decrease of pH generally. Because the undrained shear strength is a function of organic content for a natural soil (Rabbee et al. 2012). Acidity leads to changes in anion and cation exchange capacity of soil to a small extent. Along with the change in ion exchange capacity there is alteration of the exchangeable ions or the amount of ions adsorbed. Some other experiments related to it like the effect of acid rain on the geotechnical properties of high and low plasticity and black cotton soils was examined (Sharma et al, 2010, Sharma et al, 2011 and Sharma et al, 2012). It was revealed that the acid rain affects the consistency limits as well as the strength properties of the soil. The variation was more pronounced in soils with low plasticity than those with high plasticity. Generally, partially saturated clayey soils having high plasticity are very sensitive to variations in water content and show excessive volume changes. Such soils, when they increase in volume (Grytan et al. 2012). The nature of soil both in the vertical and horizontal directions is unpredictable (Rabbee et al. 2012). Moreover, the subsoil in this region consists of recent alluvial deposits and organic and organic composition and often creates problem to geotechnical engineers in designing economic foundations for strength and high compressibility (Alamgir et al. 2001).

If the effect of chemicals on the geotechnical properties can be proved, the problems that geotechnical engineers faces while placing new structures on sites with contaminated soils can be reduced.( Meril George et al. 2011). To check the problems faced while intended to utilize the marginal sites of Khulna containing soil like the selected samples it is necessary to quantify the changing properties of the selected samples. This inspired us to investigate changes in geotechnical properties such as Specific Gravity, Plastic Limit (PL), Liquid Limit (LL), Shrinkage Limit (SL), Moisture Content, Undrained shear strength, recompression index and pre-consolidation stress of soil samples from normal land and waste dumping sites with pH of the relevant samples.

## 2 EXPERIMENTAL DETAILS

### 2.1 Sample Collecting

In this study, the sites were specified as Industrial dumpsite and household dumpsite or normal land site. With this objective, both disturbed and undisturbed soil samples were collected from several selected locations of Khulna region to perform analysis. From the existing ground surface, the soil samples were collected at a depth of about 4 to 8 feet. A series of tests were conducted to determine Specific Gravity, Plastic Limit (PL), Liquid Limit (LL), Shrinkage Limit (SL), Moisture Content, Undrained shear strength and pre consolidation stress of collected soil sample. The results were obtained from the average of these tests.

## 2.2 Test performance

Consistency of the original and treated soil samples were determined by Atterberg limit test. Specific gravity of original and treated soil samples was determined according to ASTM D854. According to ASTM D-2166 the unconfined compressive strength of the specimens was determined. Consolidation test (ASTM D-2435) was performed on the soil samples of 63.5 mm diameter and 25 mm height to determine the Settlement characteristics of soils (GRYTAN et al. 2012). ASTM D 4318 – 00; Liquid Limit, Plastic Limit was performed. ASTM D 2216 – 98 Laboratory Determination of Water (Moisture) Content was also performed.

The pH of the soil is a useful variable in determining the solubility of soil minerals and the mobility of ions in the soil. The PH of the original soils was determined by ASTM D4972. 10g of air dried samples were mixed with 10mL of distilled water thoroughly to perform these tests and it was kept still for some moments according to code. Then after some time, the probe of the pH meter was penetrated into the top surface and then the values of PH were recorded from the pH meter.

Consistency of soil is expressed in terms of liquid limits and plastic limits are extensively used to characterize the fine-grained fractions of soils from the dump site. Factors which significantly affect the consistency of soil depend on the type of soil in most cases. The effects of shrinkage of fine grained soils are of considerable significance to cause serious damage to small building and highway pavements Consistency at all. And that is determined by Atterberg limit test (ASTM D-4318-10).

Specific gravity is used in phase relationship of soil such as void ratio and degree of saturation. It is also generally the indirect measurement of density of soil. According to ASTM D854-10 Specific gravity of soil samples was determined. Shear strength parameters were determined by direct shear test (ASTM D3080-3) of the compacted soil specimens (GRYTAN et al. 2012). The unconfined compressive strength of the specimens was determined according to ASTM D-2166-98.

# 3 RESULTS AND DISCUSSIONS

The above mentioned tests that were conducted demonstrates the effects of pH on the different soil samples from different sites of both industrial dumpsite and normal land site to the geotechnical properties of soil. The properties are Specific Gravity, Plastic Limit (PL), Liquid Limit (LL), Shrinkage Limit (SL), Moisture Content, Undrained shear strength and pre consolidation stress of soil. Therefore, laboratory tests such as Atterberg limits, unconfined compressive strength, and consolidation tests were performed for several soil samples. Pure water has a pH very close to 7 at 25 °C. So, 7 is marked as neutral line whereas Soil with a pH less than 7 are said to be acidic and soil with a pH greater than 7 are basic or alkaline.

It can be observed from the plot of specific gravity against pH values as in graph that the trend of plotting consists of concave curves for both industrial dump site and household land site soil samples within the range of 2.6 to 2.8. What is noticeable is that industrial soil samples exhibits acidic nature as well as basic nature on pH scale basis whereas household dumpsite soil sample only exhibits basic nature. However, one tendency for both curves show that with the increase of pH value of the soil samples, there is an overall increase in the specific gravity.

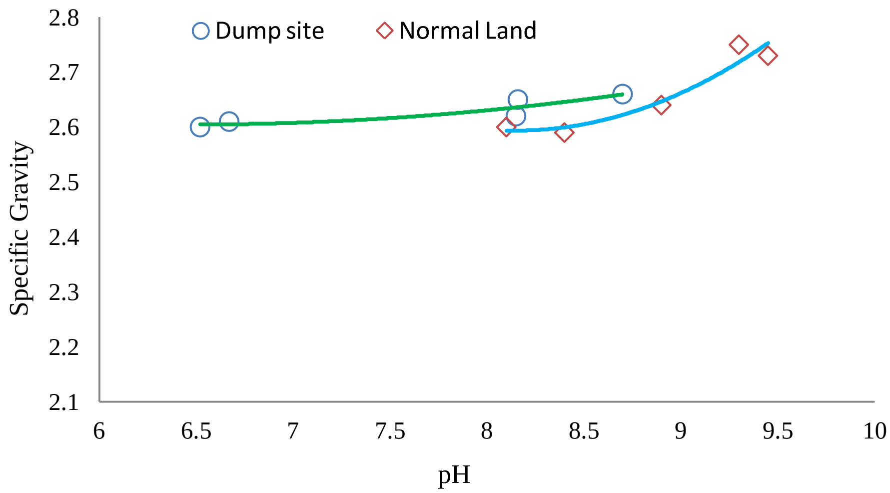


Figure: 1 Changes in Specific Gravity of soil from dump site & normal land

Now, considering the relation of Plastic Limit with the pH of soil component it can be seen that for Industrial dumpsite soil sample a convex curve and for normal land soil sample a concave curve is obtained. Considering dumpsite soil sample, the Plastic limit value increases with the increase of pH within some range , then it falls below the previous plotted points i.e., with the increase of pH, the Plastic Limit value decrease results in a convex curve. Whereas for normal land soil sample, the value of Plastic Limit decreases with the increase of pH for some small range then Plastic limit value abruptly starts increasing with pH. In this case also, Industrial site soil sample has acidic property and basic property whereas household site soil contains only alkali.

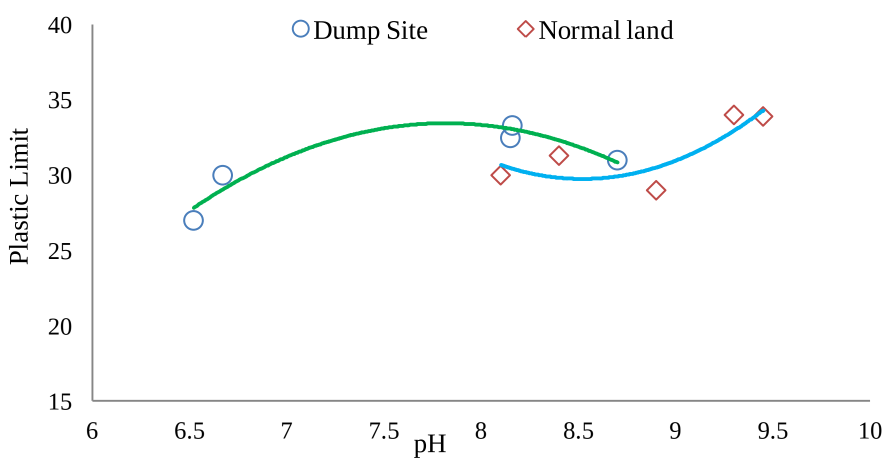


Figure: 2 Changes in Plastic Limit of soil from dump site & normal land

The relation of Liquid Limit with pH of soil samples exhibits the same tendency as the behavior of Plastic Limit with pH. However, the curve formed for industrial dumpsite sample is almost linear as the values plotted are within limited variations and lies within a small range from 41 to 50 and is a convex curve. The range for normal land sample is below the industrial site sample and it is within 30 to 41 and is a concave curve.

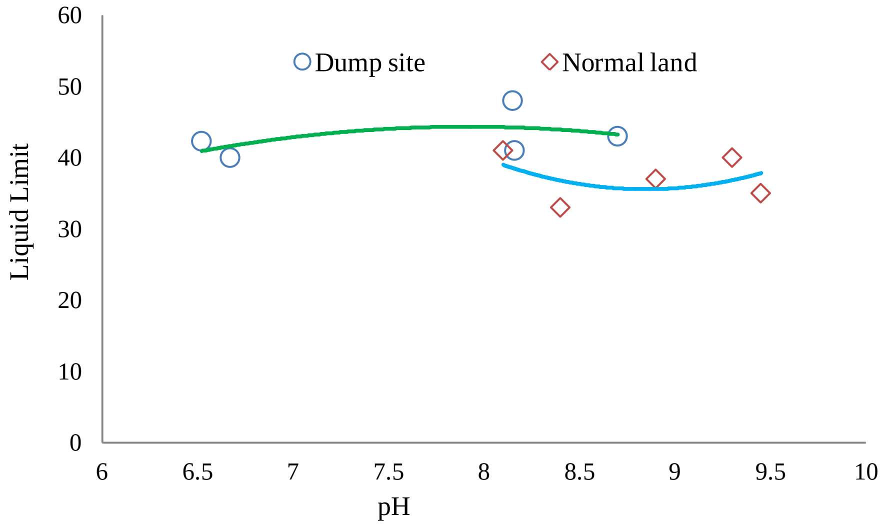


Figure: 3 Changes in Liquid Limit of soil from dump site & normal land

The figure 4 shows the Changes of Shrinkage Limit with pH. The curves obtained from the plotted values of two different types of sites show a unique nature between them for which these two curves intersect each other. The values of Shrinkage Limit increases with pH and after reaching to a certain value it decreases with the increase of pH resulting in a parabolic curve. For normal land site the value of Shrinkage Limit only increases with the value of pH which measures the soil sample in this site is only alkaline in nature.

Figure 5 below shows behavior of soil sample based on moisture content with pH. The plotted values of both dumpsite samples and normal land samples formed concave curves. The value of moisture content for both types of soil samples increased with the increase of pH. The plotted points for normal land curve lie below the dumpsite soil sample points.

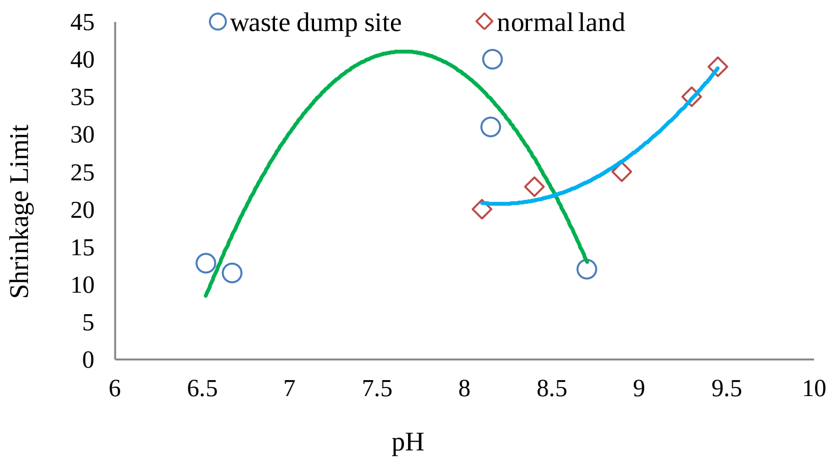


Figure: 4 Changes in Liquid Limit of soil from dump site & normal land

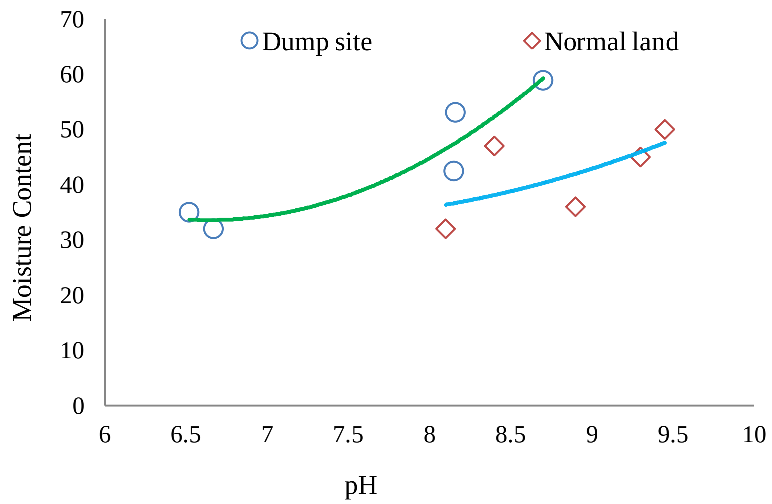


Figure: 5 Changes in Moisture Content of soil from dump site & normal land

Now the most important parameter undrained shear strength of soil which shows a well quantified behavior with pH. In case of both the samples from industrial dumpsite and normal land site Undrained shear strength increase with increase in pH and abruptly going through a certain value it decreases with the decrease in pH value. It indicates soil lose its structure when in contact with acidic environment. Figure 6 shows the change in undrained shear strength with pH. It also shows that the curve pattern for both site samples are the same and the only differences are dumpsite curve is below the normal land curve and occurs in both acidic and alkaline environment whilst normal land curve forms in alkaline environment.

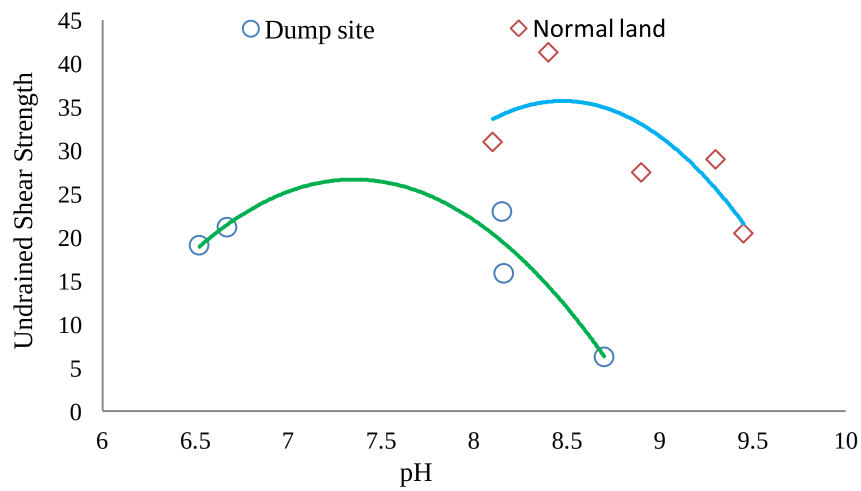


Figure: 6 Changes in Undrained Shear Strength of soil from dump site & normal land

Pre consolidation stress of industrial dumpsite soil sample increases with increase in pH , and it decreases with decrease in pH for normal land soil sample for a short extent then it increases infinitely with the increase of pH. Figure 7 shows change in pre consolidation stress with pH of soil.

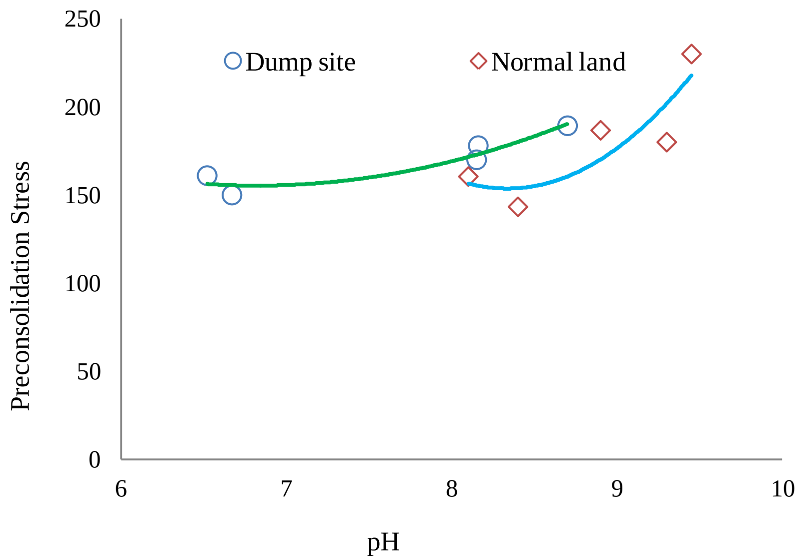


Figure: 7 Changes in Preconsolidation Stress of soil from dump site & normal land

## 4 CONCLUSIONS

After performing some sophisticated test and laboratory work based on the above test result the following conclusions can be drawn:

- It is prominent from the above graphs that soil samples from industrial dumpsite can be acidic in nature as well basic for some samples but the normal land soil samples are all basic in nature.

- With increasing pH Moisture content, shrinkage limit, plastic limit, liquid limit, undrained shear strength increase within some range. Then it decreases in case of highly alkaline soil for industrial dumpsite soil. The same phenomenon happens but only for undrained shear strength property of normal land soil.

- Specific gravity, Pre consolidation stress increases with increase in pH and decreases with decrease in pH for both dumpsite and normal land soil. Whereas shrinkage limit, moisture content and Pre consolidation stress increases with the increase in pH for normal landsite soil in alkaline environment.

- Plastic limit and liquid limit decrease with increase in pH up to some value and then abruptly increase with the increase in pH value.


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## References

Umesha, T.S., Dinesh, S.V., Sivapullaiah, P.V., "Effects of acids on geotechnical properties of black cotton soil," INTERNATIONAL JOURNAL OF GEOLOGY, Issue 3, Volume 6, 2012
http://www.naun.org/multimedia/NAUN/geology/16-050.pdf

George, Meril., Beena, K.S., "GEOTECHNICAL CHARACTERISTICS OF LEACHATE-CONTAMINATED LATERATIC SOIL," Proceedings of Indian Geotechnical Conference December 15-17,201 1, Kochi (Paper No.L-325.)
http://gndec.ac.in/~igs/ldh/conf/2011/articles/Theme%20-%20L%2026.pdf

Rafizul, I. M., Alamgir, M., Bashar, M. A., "Strength and Compaction Properties of Reconstituted Organic Soils of A Selected Site in Khulna Region," Proceedings of the Bangladesh Geotechnical Conference 2009, December 17, 2009, BGS-2009, Dept. of CE, BUET, Dhaka, Bangladesh, pp. 109-115

Rabbee, Tahia., Rafizul, Islam M., "Strength and Compressibility Characteristics of Reconstituted Organic Soil at Khulna Region of Bangladesh," International Journal of Engineering and Technology Volume 2 No. 10, October, 2012
http://iet-journals.org/archive/2012/oct_vol_2_no_10/68938413476671.pdf

Alamgir, M., Zaher, S.M., Haque, M.A., Kabir, M.H., "Performance of some ground improvement methods recently practiced in the soft ground of Bangladesh," Proc. of the Indian Geotechnical Conference, Indore. 2001
http://www.wastesafe.info/WasteSafe%20II/Dr_Alamgir_Web/04_publication.htm

Rafizul, Islam M., Assaduzzaman, Md., Alamgir, Muhammad., "The effect of chemical admixtures on the geotechnical parameters of organic soil: a new statistical model," hit. Journal of Applied Sciences and Engineering Research, Vol. 1, Issue 4, 2012

Rafizul, I. M., Alamgir, M., Bashar, M. A., "Characterization and Verification of Engineering Properties of Organic soil with the Emphasis on Reconstituted Soils," Procs. of the Bangladesh Geotechnical Conference, BGS 201 0, Dhaka, Bangladesh, pp. 109-115.

SARKAR, GRYTAN., ISLAM, MD. RAFIQUL., ALAMGIR, MUHAMMED., ROKONUZZAMAN, MD., "Study on the Geotechnical Properties of Cement based Composite Fine-grained Soil," International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 01, No. 02, October 2012
http://www.basharesearch.com/IJASGE/1010202.pdf

SARKAR, GRYTAN., ISLAM, MD. RAFIQUL., ALAMGIR, MUHAMMED., ROKONUZZAMAN, MD., "Interpretation of Rice Husk Ash on Geotechnical Properties of Cohesive Soil," GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING CIVIL AND STRUCTURAL ENGINEERING, Volume 12 Issue 2 Version 1.0 February 2012
https://globaljournals.org/GJRE_Volume12/1-Interpretation-of-Rice-Husk-Ash-on-Geotechnical.pdf

George, Meril., Beena, K.S., "GEOTECHNICAL CHARACTERISTICS OF LEACHATE-CONTAMINATED LATERATIC SOIL," Proceedings of Indian Geotechnical Conference December 15-17,201 1, Kochi (Paper No.L-325.)
http://gndec.ac.in/~igs/ldh/conf/2011/articles/Theme%20-%20L%2026.pdf

SARKAR, GRYTAN., ISLAM, MD. RAFIQUL., ALAMGIR, MUHAMMED., ROKONUZZAMAN, MD., “Effect of acid rain on geotechnical properties of composite fine-grained soil,” hit. Journal of Applied Sciences and Engineering Research, Vol. 1, No. 2, 2012

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