IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# EFFECTIVENESS OF AQUACULTURE WASTE SLUDGE ON GEOTECHNICAL PROPERTIES OF BENTONITE-RED SOIL MIXTURE

[1]Megha B Raj, [2]Revathy v s

[1]M Tech Student, [2]Associate professor

[1]Dept of Civil Engineering,

[1]Marian Engineering , Trivandrum,India

*Abstract:* The rearing of fish is mainly conducted in ponds made of concrete, earthen, plastics or wooden materials. Sludge generated consists of organic materials, Inorganic materials that end up at the bottom of ponds. Dewatered sludge is a soil-like material. Due to a lack of proper environmental planning aquaculture waste (sludge) gets decomposed and reacts to the soil and contaminating the soil and affecting the geo-environmental and geotechnical properties of the soil Aquaculture waste sludge mainly consist of stabilized excreta,uneaten food particles and biofloc.This paper discusses the effectiveness of Aquaculture waste sludge on Redsoil-bentonite mixture. A laboratory study was conducted on Redsoil-bentonite mixture treated with Aquaculture waste sludge, and variation in soil properties such as Unconfined compressive strength and hydraulic conductivity was analysed. The Aquaculture waste sludge was added in different concentrations so as to identify an optimum dosage.

*Index Terms* **- Redsoil-bentonite mixture, Aquaculture waste sludge, Compressive Strength, hydraulic conductivity**

## I. INTRODUCTION

Removal of solids or nutrients from the effluents of fish farms is often required because of priority and regulations given to minimizing the effect of the discharge on the environment (Bastian, 1992, Ewart et al., 1995, Idaho DEQ, 1998).Sludge from aquaculture is a potential fertilizer.But it cannot be used directly as fertilizer because of the presence of trace amount of heavy metals and chemical polymers.Aquaculture waste sludge is generally considered as bio-waste product.Mechanical properties of natural soil are insufficient in most of engineering applications. Addition of aquaculture waste sludge to the clayey soil will affect the geotechnical and geoenvironmental properties. The ability of bentonite to bind water molecules is able to prevent bulk water from entering,causing bentonite hydraulic conductivity to decrease.

This paper attempts to understand and evaluate the effect of Aquaculture waste sludge in terms of engineering properties when added to the redsoil-bentonite mixture. Different concentrations of the Aquaculture waste sludge was used in this study and the effects on Unconfined compressive strength and hydraulic conductivity was evaluated.

## II. MATERIALS AND METHODS

of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.

### 1. RED PROPERTIES

Red soil was collected from Venniyoor village, Thiruvananthapuram at a depth of 1m from the ground surface. Samples were collected from a depth of about 2m below the ground surface. The properties of soil were determined as per IS 2720. The properties of Red soil are given in table 1. Figure. 1 shows the picture of the collected red soil and the particle size distribution curve is presented in Fig. 2.

**TABLE 2.1:Properties of red soil**

| Property | Measured value | Property | Measured value |
|---|---|---|---|
| Specific Gravity | 2.63 | UCC(kN/m$^2$) | 39.23 |
| Liquid limit (%) | 34.4 | clay % | 30.4 |
| Plastic limit (%) | 21.42 | silt % | 15.6 |
| Plasticity index (%) | 12.98 | sand % | 154 |
| OMC (%) | 10.2 | Permeability cm/s | 4.6*10$^{-4}$ |
| MDD(g/cc) | 20.7 | IS Classification | SC |
| | | | |

Fig 2.1 Red soil

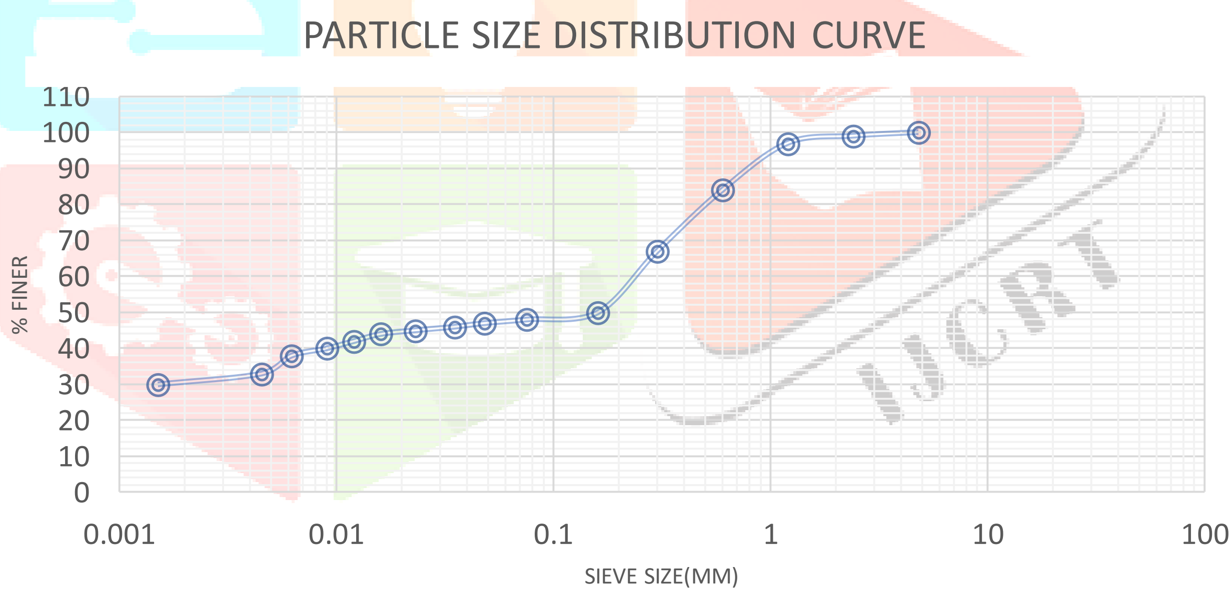


**Fig 2.2:Particle size distribution of red soil**

## 2. SODIUM BENTONITE

Sodium Bentonite purchased from Gtech constructions pvt Ltd trivandrum.The properties of sodium bentonite is listed in Table 2 and Figure 3 shows the image of Sodium bentonite

**TABLE 2.2 Properties of bentonite**

| Property | Measured value | Property | Measured value |
|---|---|---|---|
| Specific Gravity | 2.6 | UCC(kN/m$^2$) | 84.3 |
| Liquid limit (%) | 380 | clay % | 60 |
| Plastic limit (%) | 50 | silt % | 30 |
| Plasticity index (%) | 330 | sand % | 10 |
| OMC (%) | 40 | IS Classification | CH |
| MDD(g/cc) | 15.7 | | |

**FIGURE 2.3 Sodium Bentonite**

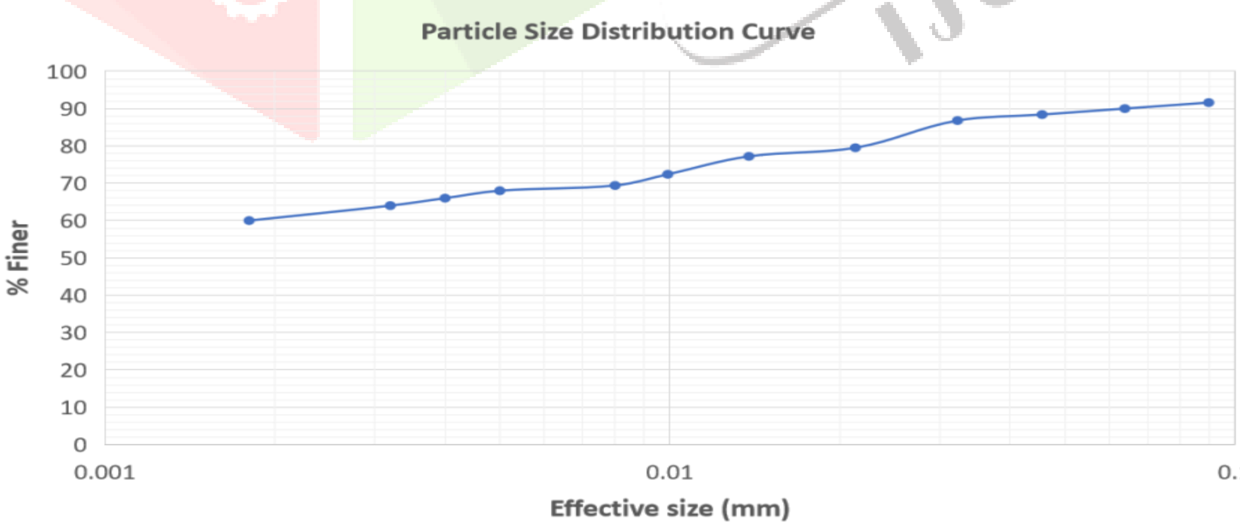


**Fig 2.4 Particle size distribution of sodium bentonite**

### 3. AQUACULTURE WASTE SLUDGE

Aquaculture waste sludge was collected from shrimp farming,mangalathu village,Munroe island.Composition of aquaculture waste sludge was tested from Soil analytical laboratory, Thiruvanathapuram

**TABLE 2.3 Properties of bentonite**

| Materials | Composition | Rating |
|---|---|---|
| Organic carbon | 1.50% | Medium(2-10%) |
| Phosphorous | 3.02 kg/ha | Low(<11kg/ha) |
| Potassium | 10.75kg/ha | Low (<110kg/ha) |
| Calcium | 759.10ppm | 500-4000ppm |
| Organic carbon | 1.50% | Medium(2-10%) |

### METHODOLOGY

The study investigates the effect of Aquaculture waste sludge treatment on unconfined compressive strength and hydraulic conductivity of the soil.Unconfined compressive strength tests as per IS 2720 part 10 were performed on redsoil-bentonite specimens. The specimen for the test had a diameter about 3.9 cm and length of 7.5cm. As per the mentioned standard, the loading speed should be about 0.5 to 2.5% axial strain/min.

For hydraulic conductivity, the test were done as per IS 2720 part 17. For a falling head test arrangement the specimen shall be connected through the top inlet to selected stand-pipe. The bottom outlet shall be opened and the time interval required for the water level to fall from a known initial head to a known final head as measured above the centre of the outlet shall be recorded. The stand-pipe shall be refilled with water and the test repeated till three successive observations give nearly same time interval.

Permeability k is calculated as

$$k = 2.303 \times \frac{aL}{At} \times \log_{10}(\frac{h1}{h2})$$

## III. RESULTS AND DISCUSSION

### A)*Effect of Bentonite on compressive Strength*

Figure 4 shows the variation of compressive strength for different concentrations of bentonite contents. The UCS value increases with increase in Aquaculture waste sludge concentrations up to optimum content for the bentonite. This is because When bentonite is added, the soil structure becomes flocculated due to reduction in interparticle repulsion. Lambe (1960) reported that greater repulsion results in lower shear strength. Therefore, the soil has higher shear strength when bentonite is added because the repulsion is reduced. Bentonite content of 15% gives the maximum UCS and is considered as the optimum mixture.Beyond the optimal dosage, the UCS value decreases due to further addition of bentonite will not be occupy in the voids, which result in lack of bonding between bentonite and red soil mixtures. Table 3 shows the variation of unconfined compressive strength according to the addition of bentonite content. The maximum compressive strength for bentonite is at 15% is 108 $kN/m^2$.

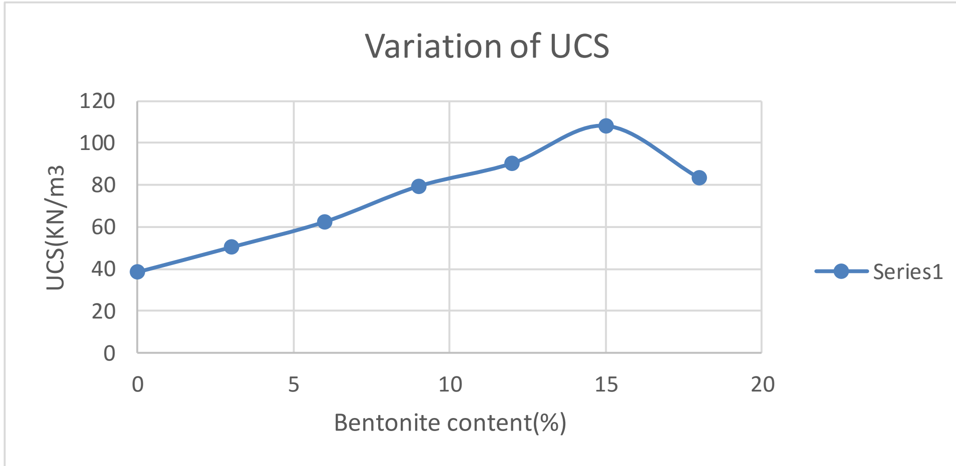


Fig 2.5 variation of ucs by addition of bentonite

Table 2.4 variation of ucs by addition of bentonite

| **Bentonite %** | **UCS(kN/m$^2$)** |
|---|---|
| 0 | 39.2 |
| 3 | 50.2 |
| 6 | 62.3 |
| 9 | 79.2 |
| 12 | 90.1 |
| 15 | 108.0 |
| 18 | 83.2 |

### *B) Effect of Bentonite on hydraulic conductivity*

Figure 5 shows the variation in coefficient of permeability for different percentage of bentonite contents. The hydraulic conductivity of soil decreases with addition of bentonite content. The hydraulic conductivity of redsoil in this study was $4.6*10^{-4}$ cm/s. The results of the permeability tests shows that there is a significant decrease in the hydraulic conductivity of soil with the addition of bentonite. The high specific surface of bentonite and fine bentonite particles which resulted in adsorption of a large number of hydrated cations as well as water molecules contributed to decrease of hydraulic conductivity in the red soil-bentonite mix (Kenney et al., 1992).Table 4 shows the phenomenal reduction in hydraulic conductivity of the bentonite addition ranging from 0% to 18% by weight of soil.

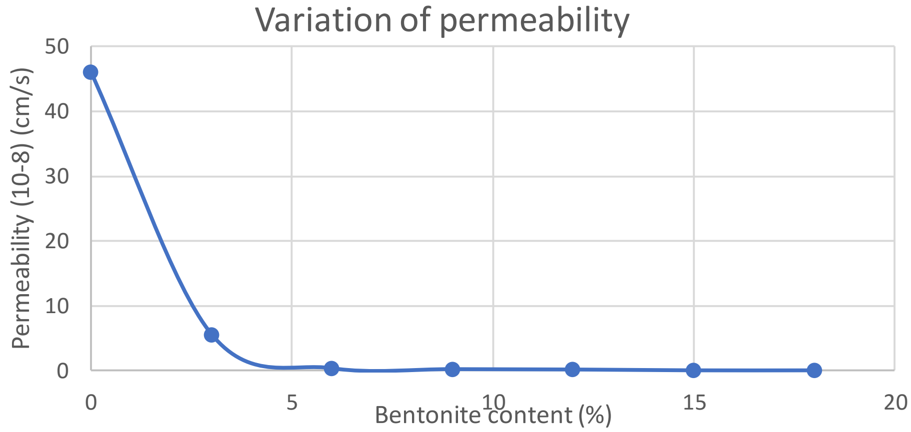


Fig 2.6 Variation of permeability by the addition of bentonite content

TABLE 2.5 Variation of permeability

| Bentonite % | Coefficient of Permeability cm/s |
|---|---|
| 0 | 4.6×10-5 |
| 3 | 3.58×10-6 |
| 6 | 3.45×10-7 |
| 9 | 2.04×10-7 |
| 12 | 1.52×10-7 |
| 15 | 2.07×10-8 |
| 18 | 1.86×10-8 |

### *A)* Effect of Aquaculture waste sludge on Compressive Strength

Figure 6 shows the variation of compressive strength for different concentrations of Aquaculture waste sludge contents on optimum redsoil-bentonite mixture. The UCS value increases with increase in Aquaculture waste sludge concentrations up to optimum content. This is because; Sludge ash exhibits pozzolanic activity with soil which results in increase in compressive and bending strengths (Chen and lin 2009)Beyond the optimal dosage, the UCS value decreases due to further addition of bentonite will not be occupy in the voids, which result in lack of bonding between bentonite and red soil mixtures.Table 3 shows the variation of unconfined compressive strength according to the addition of AWS content on optimum redsoil-bentonite mixture. The maximum compressive strength for AWS at 25% is 166.52kN/m$^2$.

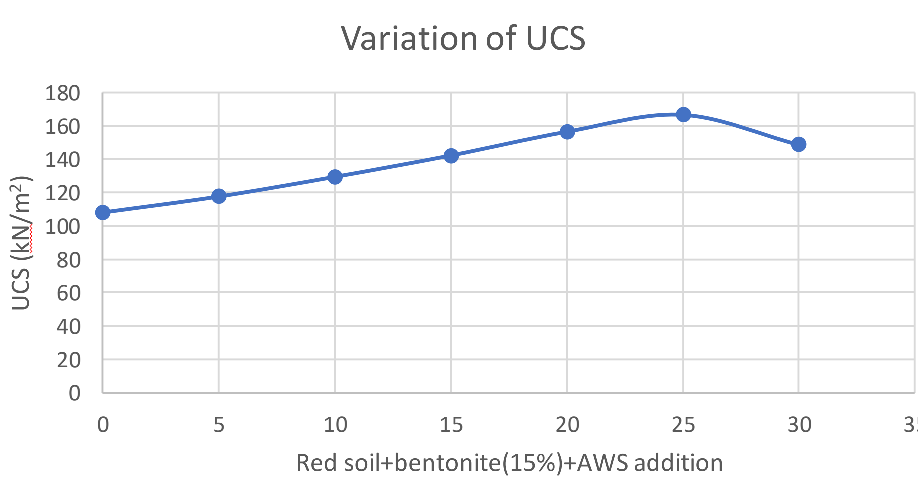


Fig 2.7 Variation of UCS

TABLE 2.6 Variation of UCS

| Aquaculture waste sludge % | UCS(kN/m$^2$) |
|---|---|
| 0 | 108.0 |
| 5 | 117.56 |
| 10 | 129.32 |
| 15 | 142.12 |
| 20 | 156.32 |
| 25 | 166.52 |
| 30 | 148.61 |

*B) Effect of Aquaculture waste sludge on hydraulic conductivity*

Figure 5 shows the variation in coefficient of permeability for different percentage of Aquaculture waste sludge contents to optimum redsoil -bentonite mixture. The hydraulic conductivity of soil decreases with addition of AWS on optimum redsoil-bentonite mixture. The hydraulic conductivity of redsoil-bentonite mixture in this study was 2.7*10$^{-8}$ cm/s. The results of the permeability tests shows that there is a small decrease in the hydraulic conductivity of soil with the addition of AWS to optimum redsoil-bentonite mixture. Due to the sludge addition, chemical characteristics of soil and effluent get changed which result into a small decrease in hydraulic conductivity. Table 4 shows the phenomenal reduction in hydraulic conductivity of the AWS addition ranging from 0% to 25% by weight of soil.

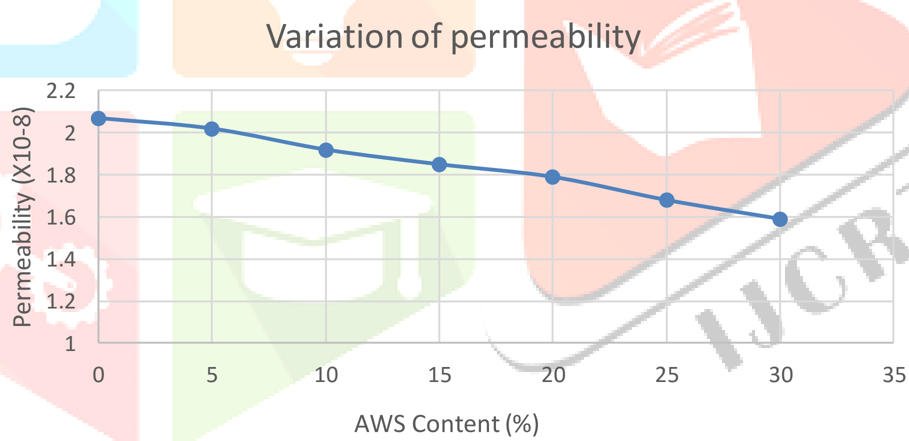


Fig 2.8 Variation of Permeability

TABLE 2.7 Variation of UCS

| Aquaculture waste sludge% | Coefficient of Permeability (cm/s) |
|---|---|
| 0 | 2.07×10-8 |
| 5 | 2×10-8 |
| 10 | 1.92×10-8 |
| 15 | 1.85×10-8 |
| 20 | 1.76×10-8 |
| 25 | 1.68×10-8 |
| 30 | 1.61×10-8 |

## Conclusion

This study investigates the effect of Aquaculture waste sludge on Red soil-bentonite mixture with different concentrations. Using experimental investigations, the following conclusions can be drawn:

1. Aquaculture waste sludge are environmental friendly bio-waste product which improve soil properties
2. The optimum value of redsoil-bentonite mixture is 15%.
3. The unconfined compressive strength of redsoil-bentonite mixture increased upto 25% of Aquaculture waste sludge
4. The hydraulic conductivity of redsoil-bentonite mixture decreased upto 25% of Aquaculture waste sludge
5. Aquaculture waste sludge is a promising bio-waste for increasing compressive strength and decreasing the hydraulic conductivity.

## Reference

1)Banerjee, R. K., and Srinivasan, K. V. (2021), "Composted Urban Refuse and Primary Sewage Sludge as a Fish-pond Manure", Agricultural Wastes, 7(4), pp. 209-219.

2)Chen, Y., Liu, X., Lei, H., Ye, W. and Cui, Y. (2019), "Adsorption Property of Pb(II) by the Laterite-Bentonite Mixture Used as Waste Landfill Liner", Advances in Civil Engineering, 40 (2), pp. 25-36.

3)Cho, W. J., Lee, J. O., and Kang, C. H. (2002), "A Compilation and Evaluation of Thermal and Mechanical Properties of Bentonite-based Buffer Materials for a High-level Waste Repository", Journal-Korean Nuclear Society, 34(1), pp. 90-103.

4)Daniel, D. E., and Wu, Y. K., (1993), "Compacted Clay Liners and Covers for Arid Site", Journal of Geotechnical Engineering, ASCE,119(2), pp. 223–237.

5)Dhanya, S., and Ajitha, A. R. (2011), "Study on the Shrinkage, Swelling and Strength Characteristics of Clay Soils under Different Environmental Conditions", Proceedings of IGC, pp. 200-237.

6)Dean, R. and Freitag, F. (1986), "Soil Randomly Reinforced with Fibres", Journal of Geotechnical engineering, ASCE, 112 (8), pp. 823-826.

7)Nagaraju, T., Sunil, B. and Chaudhary, B. (2021), "Influence of Aquaculture Sludge on Volume Change Behaviour of Expansive Clay" Proceedings of Indian Geotechnical Conference 2021 December 16-18, 2021, NIT Tiruchirappalli.