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Influence of Aquaculture Sludge on the Geotechnical Properties of Soils :A Review

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***Abstract*— This Rearing of fishes are mainly conducted in ponds made of concrete, earthen, plastics or wooden materials. Sludge generated consist of organic materials, Inorganic materials that end up at the bottom of ponds. Intensive aquaculture farming creates negative impact on environment due to effluents generation. Major disposal methods of aquaculture sludge are agricultural employment, land restoration, sludge to landfill operations. Dewatered sludge is a soil like material. Fish harvesting is majorly controlled by concrete tanks. Due to lack of proper environmental planning waste (sludge) gets decomposed and reacts to the soil and contaminating the soil and affecting the geo environmental and geotechnical properties of the soil. Geotechnical properties of the soil such as plastic, shrinkage, compressible and low shear strength and low California bearing ratio are affected. In a landfill clay barrier, the exposure of leachate will affect mineralogical units of clays, distance between clay platelets, osmotic pressure between layers, and repulsive forces between layers. In microscopic and mesoscopic scale, distance between the clay platelets (volume change) depends on the valance of cations and ionic strength of the leachate. Landfill leachate (NH4+) interaction with smectite clays will result in exchange of the inter layer cations, decrease in double diffusion layer, and improvement in hydraulic conductivity. Long term exposure of leachate (NH4+) may cause hazardous consequences of environment. Aquaculture effluents diverted into nearby irrigation canals without any treatment, leads to eutrophication in the canals.**

I. INTRODUCTION

Erosion of the watershed results in suspended particles of mineral soil, inorganic matter and organic matter entering a pond in runoff. Wave action, rainfall, and water currents from mechanical aeration results in erosion of embankments and shallow edges to suspend soil particles. In addition, nutrients added to ponds in fertilizers, manures, and feeds cause phytoplankton blooms which will result increase in the concentration of suspended organic particles. Expansive clays volume change behaviour must be calculated; mainly pavement construction, canal lining, shallow foundations, excavation, and fills. The behaviour of the volume change is primarily affected by the moisture content, over burden pressure, and loading circumstances. Highways or pavements are particularly at risk because expanding subgrades' seasonal variations in moisture content. Due to the low weight of the structure or inability to withstand the potential for swelling, light residential buildings resting on expansive clays display extensive fissures. Additionally, there are a very few numbers of instances when clays and leachate from solid waste landfills interact to significantly increase hydraulic conductivity and reduce swelling behaviour. On the swell shrink behaviour of expansive clays, numerous authors have been studied. The effects of chemical additions on the characteristics of expansive clays have been extensively studied throughout the world, including cement, lime, calcium chloride, sodium silicate, fly ash, rice husk ash, and powdered granulated blast furnace slag. Their research suggests that mixing chemical additives with clays can result in cementitious compounds like flocculation, agglomeration, or cementitious compounds itself. The chemicals Al3+, Ca2+, Mg2+, K+, Na+, NH4+, and Li+ may be able to exchange cations with clay particles by these mechanisms. Clay barriers in landfills alter the mineralogical units of clays, the distance between clay platelets, the osmotic pressure between layers, and the attractive forces between layers as a result of leachate exposure. The valence of cations and ionic strength of the leachate affect the distance between clay platelets (volume change) at the microscopic and mesoscopic scales. Numerous writers have reported on the impact of leachate on clays' behaviour when their volume changes. Smectite clays and landfill leachate (NH4+) interact to exchange interlayer cations, reduce the double diffusion layer, and improve hydraulic conductivity. Leachate (NH4+) exposure over an extended period of time may also have harmful effects on the ecosystem. Due to mineral disintegration and faulted structures, landfill leachate with high alkalinity, in particular the presence of ammonia (NH4+) cations, combines with clays to produce colloidal content. Over time, clays lose their flexibility and the double diffusion layer improves, causing clays to act like sand. One of the main cations that affects clays, including bentonite, is ammonia (NH4+). The sludge leachate from aquaculture ponds is currently of greatest concern due to its high alkalinity (NH4+) content. Additionally, there had been no investigation into how aquaculture leachate affected expansive clays' tendency to shift volume. Intensive aquaculture farming is practiced in India's coastal state of Andhra Pradesh, where it leads the country in production. However, there is currently no information from journal papers on the impact of aquaculture leachate on ground water, particularly addressing interactions between aquaculture leachate and clay. The high-density seed, feed, antibiotics, disinfectants, and chemical requirements of intensive aquaculture farming allow for adverse environmental effects owing to effluent creation. Particularly in India, there are currently no aquaculture wastewater treatments in use. On the other hand, ongoing farming, crops, and aquaculture sludge age out and interact with subsurface clay, which can contaminate ground water bodies. Dewatered sludge resembles earth in texture. Concrete tanks play a vital

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role in regulating fish harvesting. Waste (sludge) decomposes and reacts with the soil, contaminating it and changing its geo environmental and geotechnical properties as a result of improper environmental planning. Affected soil has geotechnical characteristics such plasticity, shrinkage, compressibility, poor shear strength, and low California bearing ratio. The exposure of leachate will have an impact on the mineralogical units of clays, the spacing between clay platelets, the osmotic pressure between layers, and the repulsive forces between layers in a landfill clay barrier. In microscopic and mesoscopic scale, distance between the clay platelets (volume change) depends on the valance of cations and ionic strength of the leachate. Landfill leachate (NH4+) interaction with smectite clays will result in exchange of the inter layer cations, decrease in double diffusion layer, and improvement in hydraulic conductivity. Long term exposure of leachate (NH4+) may cause hazardous consequences of environment. Aquaculture effluents diverted into nearby irrigation canals without any treatment, leads to eutrophication in the canals. The addition of aquaculture sewage results in cation exchange between the clay particles and the sludge, it is discovered. Increases in aquaculture sludge content were observed to reduce soil rebound and linear shrinkage. Investigations were carried out using sludge from aquaculture deposits on dump sites and control dump sites, which were both located 30 metres apart.

II. LITERATURE REVIEW

In this paper, Nagaraju et al. (2021) conducted experimental tests to study the volume change behavior of aquaculture leachate exposed expansive clays and also explores the effect of aquaculture leachate on the environment. Aquaculture sludge at the bottom of the aquaculture pond at age of 7 years in Bhimavaram, Andhra pradesh, India was taken for the study leachate is collected with the help of electro-magnetic stirring process. Intensive aquaculture practice involves usage of higher dosages of minerals and chemicals in the aquaculture ponds. Due to the intensive activity, there is a formation of aquaculture waste sludge at the bottom of the ponds. In this study, experimental investigation was carried with various concentrations of aquaculture waste sludge blended with the expansive clays.

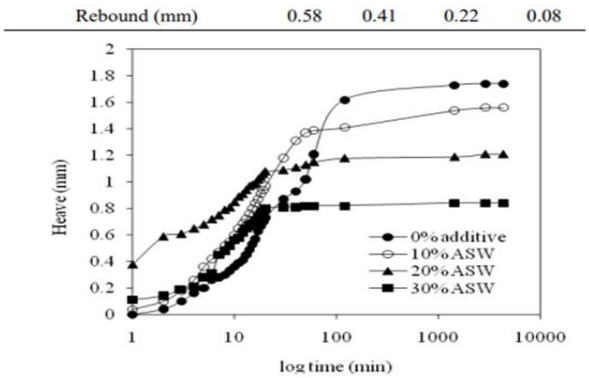

Fig 1 shows the Rate of heave of aquaculture sludge blended clay

The rate of heave of blended clay samples are decreased with increase in aquaculture sludge content. This can be attributed due to the ion exchange between ammonia and clay particles. The swell potential and swelling pressure of the blended clay samples are gradually decreased with increase in aquaculture sludge content. This is due to the decrease in plastic behavior.

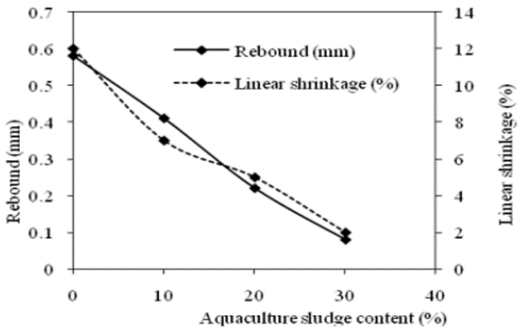

Fig. 2 shows the effect of aquaculture sludge content on linear shrinkage and rebound

Ion exchange process between the clay particles and aquaculture leachate reduces the plasticity and subsequently reduction in the linear shrinkage values of blended clay samples is obtained. Ion exchange is a key factor in limiting volume change behavior of clays exposed with leachate having ammonia presence Indicates that rebound values decrease with increasing aquaculture sludge content. The decrease in rebound values indicates the reduction in plastic behavior that result in less rebound potential.

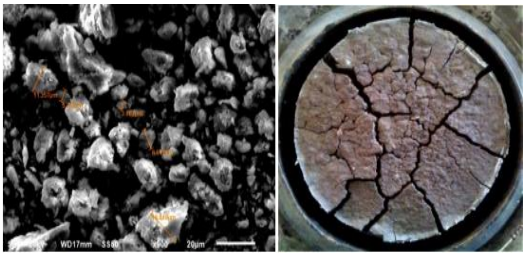

Fig 3 shows Sem and snap shot image of untreated expansive clay

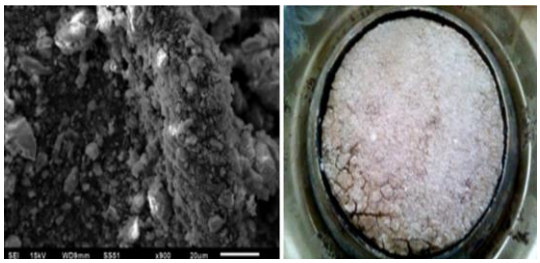

Fig 4 shows Sem and snap shot image of treated expansive clay with aquaculture sludge

leachate exposure samples were flocculated and size of the particle increased, but also linear shrinkage of the samples were decreased. Particles become powdered like substance without any intact due to chemical reactions. when the clays

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exposed with aquaculture leachate having high ammonia (NH4+) concentration contributes the cation exchange and may be broken the double diffusion layer. Clay mineral transformation occurred by means of cationic exchange and clay minerals yielded to lose plasticity behavior

In this paper Kennedy et al.,(2020)studied about the geotechnical property variation comparison of Dump site and Control Dump site.The study areas are in obio/akpor local government areas of rivers, namely; Rukpoku dumpsite laying between longitudes 7°.00 ’15" e and latitudes 4°.90’ 36" n. Igwuruta between longitudes 7°.01 ’36" e and latitudes 4°.95’ 64" n. Rumuokoro between longitudes 6°.98 ’80" e latitudes 4°.86’ 51" n, in the Niger delta of south-south of Nigeria.Soil samples were collected by using hand-dug agar, sealed in plastic bags and placed in plastics to prevent moisture loss during transport. Samples collected at a depth of 1800 mm, and after 7 days of air drying, geotechnical laboratory analysis of soil properties was performed to determine the physical properties. Investigations conducted on Dump sites and Control Dump sites, which is 30m away from each dumpsite

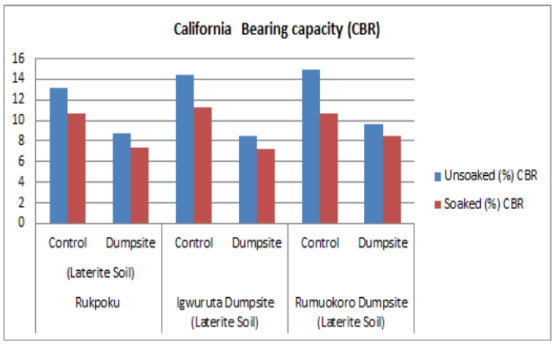

Fig-5 shows California bearing ratio of Control and Dumpsites

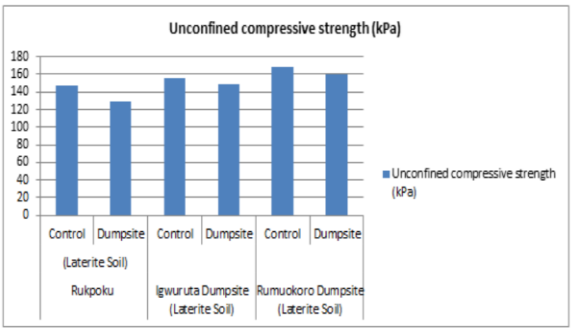

FIG-6 unconfined compressive strength (kpa) of control and dumpsite

III. CONCLUSION

The following principal conclusion may be drawn from the literature study:

- The addition of aquaculture sludge to the expansive clay decreased the rate of heave and swell potential.
- It is found the addition of aquaculture sludge causes cation exchange between the clay particles and aquaculture sludge.
- Rebound and linear shrinkage of soil was found to decrease with increasing aquaculture sludge content.
- SEM and snapshots of the treated and untreated expansive clays confirm the cation exchange between the clay particles and aquaculture sludge, which contributed to reduction in plasticity.
- High ammonia concentration presence in the aquaculture sludge causes cation exchange and may break the double diffusion layer, and hydraulic conductivity may increase.
- Results indicated reductions in unconfined compressive strength of Control sites, these results showed that the presence of leachate materials has a great effect on soil properties of tested.
- Results of California bearing ratio obtained showed that the presence of contaminants from waste dumpsites affected the geotechnical properties of tested soil with higher percentage values of dumpsites over control sites.

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