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Geotechnical Applications of Sewage Sludge Stabilized with Biomass Ash and its Effect on Soil Nutriential Properties: A Critical Review

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Abstract: ***In this review article the usage of waste sewage sludge and the biomass ash for improving the engineering and non-engineering properties' of both concrete and soil are discussed in detail. Numerous past research works were studied in detail so as to predict the behavior of biomass ash and waste sewage sludge when used for the stabilization process of soil and concrete. Past studies related to the usage of stabilized sewage sludge and biomass ash were studied in a detailed manner and depending upon the past studies several conclusions has been drawn which are discussed further. Several studies related to the usage of the waste sewage sludge for improving soil physical, chemical and biological properties showed that the usage of waste sewage sludge improve the physical properties, chemical properties, macro-nutriential properties and micro-nutriential properties up to a great extent. Depending upon the results of the past studies it can be concluded that the usage of sewage sludge has positive impact over all the properties of soil and this waste should be utilized in improving the properties of soil rather than dumping. Numerous studies related to the usage of the biomass ash showed that biomass ash has positive impact over both soil as well as concrete. Studies related to the usage of the biomass ash in soil showed that there was a positive response of the stabilized soil after its stabilization with the biomass ash. Studies related to the usage of the biomass ash in concrete showed that the biomass ash can be used up to 10 percent replacement of the ordinary Portland cement so as to attain maximum strength results from it.***

Keywords: Sewage Sludge Stabilization, Biomass Ash, Soil Stabilization, Soil Nutrients, Sustainable Material, Environmental Effect

I. INTRODUCTION

A. General

Soil stabilization is basically the process of improving the engineering and non-engineering properties of the weak soil using various kinds of chemical and mechanical techniques. Various chemical additives can also be used for the stabilization process of soil that includes several chemical, several ashes, several fibers, and several supplementary cementitious material. In this review article the usage of sewage sludge and biomass ash has v been discussed in detail.

Figure. Soil Stabilization
https://mintekresources.com/the-importance-of-soil-stabilization/

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B. Sewage Sludge

Sewage sludge is defined as the residue obtained after the treatment of water in a municipal water treatment plant. This waste residue is very much rich in minerals and chemicals. In other words sewage sludge is the byproduct of the water treatment plants that is rich in minerals, chemical and biological agents. These chemicals and minerals can be used in soil for improving its nutriential properties. This waste can also be used for the soil stabilization process that involves in improving numerous engineering and non-engineering properties of the soil. Basically after getting this waste, this waste is dumped in open sites and this dumping is very much hazardous from the ecological pointy of view. So therefore an alternative should be determined so as to prevent its harmful effects over the environment.

Figure. Sewage Sludge
https://www.discovermagazine.com/environment/sewage-sludge-is-flush-with-gold-and-platinum

C. Biomass Ash

Generally biomass ash can be derived from the combustion of various bio products such as wood, rice husk, coconuts etc. all the residues of these bio products when combusted they lead to the formation of biomass ash. Previously this by-product was used by various researchers for enhancing the properties of soil as well as concrete.

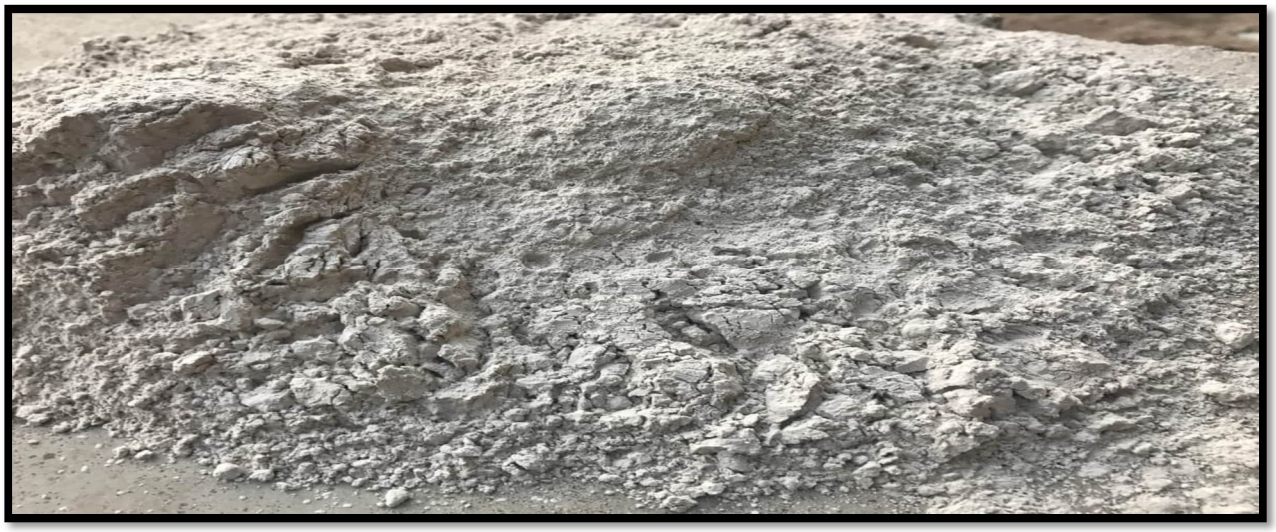

Figure. Biomass Ash
https://www.biomassengineeringequipment.com/conveyors-for-ash-handling/

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II. LITERATURE REVIEW

A. Sewage Sludge

1) *(Skowrońska et al., 2020):* In this research work related to the soil. Sewage sludge was primarily used to improve the chemical and the biological properties of the soil. Municipal sewage sludge contains several minerals and chemical agents so therefore it was decided to use these chemical and minerals so as to improve the physical, chemical and biological properties of the soil. Overall five different mixes were prepared depending upon the percentage of the municipal sewage sludge and then proper testing was carried out with the help of field tests and the laboratory tests. So as to carry out the research work first sewage sludge was collected and then tested for is physical properties and its chemical composition. Then this waste sewage sludge was applied over the soil in a controlled manner so as to preserve the originality of the soil so that the harm to the soil due to the application of the waste sewage sludge can be prevented. From the test results it was conclude that with the usage of the waste sewage sludge there was a positive impact over the chemical properties and the microbial activity of the soil. It was also found that the, Increase in the dosage of the waste sewage sludge, increases the carbon as well as the nitrogen content of the soil.
2) *(Sahin et al., 2020):* In this research work sewage sludge stabilized with gypsum was used to improve several engineering and non-engineering properties of the soils. Sewage sludge was derived from the waste generated from the locally available municipal sewage sludge which is first tested properly so as to obtain its physical properties and chemical composition. Afterwards this waste sewage sludge was treated with the help of gypsum so as to stabilize it in a uniform manner. After proper stabilization of this waste sewage sludge, the obtained stabilized sewage sludge was applied over the soil so as to improve or predict the effect of waste sewage sludge over the saline sodic properties of the soils. After proper application of the stabilized sewage sludge over the soil. Several parameters such as ph. value, electrical conductivity, total organic matter, nitrogen concentration, calcium carbonate concentration, cation exchange capacity, exchangeable sodium capacity and many more were tested and from the test results it was conclude that the usage of the waste sewage sludge improves both engineering as well as non-engineering properties of the soil up to a great extent.
3) *(Bogusz & Oleszczuk, 2020):* In this investigational work two materials were used to improve the physical, chemical and biological properties of the soil. Waste sewage sludge was used in combination with the bio char so as to improve numerous properties of the soil. The main of the research work was to study and predict the effect of presence of cadmium, copper and lead in sewage sludge over the physical, chemical and biological aspects of the soil. Sewage sludge was used in combination with bio char at 2.5 percent, 5 percent and 10 percent. So as to carry out the research work first both the materials were collected and then tested for its physical properties and the chemical composition. Then both the materials were used in combined form so as to predict the effect of their usage over numerous soil properties. From the test results it was found that with the application of sewage sludge and bio char over the soil the concentration of cadmium , copper and lead in the soil increases that concluded that application of these materials can only be done under controlled conditions and beyond that the usage increases the toxicity of the soil.,
4) *(Urra, Alkorta, Mijangos, Epelde, & Garbisu, 2019):* In this experimentation work related to the soil improvement, waste sewage sludge was mainly used to improve the chemical as well as the biological properties of the soil. Firstly sewage sludge was collected from the local available municipal water treatment plant and this waste sewage sludge was tested property so as to determine its physical properties and the chemical composition. Then this waste sewage sludge was applied over the soil in a controlled manner so as to test its biotic as well as its abiotic properties. Sewage sludge in this case was used at different proportions so as to predict the most optimum usage percentage of the waste sewage sludge. After this the soil was tested properly for its physical, chemical and biological properties in a detailed manner. From the test results it was found that the with the application of the sewage sludge over the soil, the concentration of copper and zinc in the soil increases up to a greater extent which was very much beneficial for the soil. It was also found that the application of the waste sewage sludge has positive impact on the macro-nutriential and the micro-nutriential properties of the soil. It was suggested at the last that sewage sludge should be applied to soil in a controlled manner so as to preserve the ordinal natural properties of the soil.
5) *(Głąb et al., 2018):* In this research work three different kinds of the materials were used in combined form so as to improve the physical properties and the chemical properties of the soil. Generally bio-char, sewage sludge, maize compost were used in separate form as well as in combined form so as to improve several engineering as well as non-engineering properties of the soil. Sewage sludge was derived as a waste from the municipal water treatment plants free of cost, then maize compost was prepared at the site with the help of mixing tools and the bio char was produced as the charcoal by the pyrolysis process of the biomass. Then all these three material were used in combined form as well as separate to improve the physical and chemical properties of the soils. Basically thee kind of mixture were prepared first with only maize compost, second with maize compost

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and sewage sludge and third with maize compost, sewage sludge and bio char. Then all these mixes were applied to the soil and tested properly for its physical and chemical properties. From the test results it was found that the combination with all the three materials that is with maize compost, sewage sludge and the bio char give the most optimum results with respect to the soil water retention and chemical properties of the soil.

B. Biomass Ash

1) *(Rojo-López, Nunes, González-Fonteboa, & Martínez-Abella, 2020):* In this research work three different kind of materials were used to improve the strength parameters of the concrete. Basically metakaoline, biomass ash and granite powder was used in combined form as partial substitution of the cement for enhancing the strength aspects of the conventional normal concreter. All these material were used as partial replacement of the cement at different percentages. Metakaoline was used from 11 percent to 17 percent at an increment of 2 percent in each case, granite powder was used from 1 percent to 34 percent at an increment of 3 percent in each case and biomass ash from 6 percent to 13 percent at an increment of 1 percent in each case. Several samples were prepared depending upon the percentage of the metakaoline, biomass ash and granite powder and then cured for seven days and twenty eight days. After curing all the samples were tested for compressive strength test, flexural strength test and split tensile strength test. The test results showed that the most optimum results were found at 15 percent usage of metakaoline, 13 percent usage of the granite powder and 10 percent usage of the biomass ash when used separately.
2) *(Velay-Lizancos, Azenha, Martínez-Lage, & Vázquez-Burgo, 2017):* In this research work biomass ash was mainly used to improve the strength parameters of the concrete. Biomass ash is basically the ash derived after the combustion or burning of the waste biomass such as wood, pulp, paper etc. for carrying out the research first biomass ash was collected from the wood processing industry and then this biomass ash was tested properly for its physical properties and its chemical composition. Then this biomass ash was used as partial replacement of the ordinary Portland cement at different percentages ranging from 0 percent, 15 percent and 30 percent. Then depending upon the percentages of the biomass ash several cubes, beams and cylinders were prepared so as to perform compressive strength test, flexural strength test and split tensile strength test respectively. All the samples after preparation were cured for seven days and twenty eight days under room temperature and after proper curing were tested so as to obtain results for compressive strength, flexural strength and split tensile strength. The test results showed that addition of biomass ash can only be carried out up to 15 percent usage of biomass ash as with further increase in the percentage the strength was decreasing rapidly.
3) *(Martínez-Lage et al., 2016):* In this research work, two similar kinds of material were used in combined form and in separate for improving the strength and engineering properties of the conventional concrete. Biomass ash and dregs was used as partial replacement of the ordinary Portland cement at different percentages to improve several engineering properties of the concrete. Biomass is basically the ash generated after the combustion process of the waste biomass and the dregs are the waste heavies solid that are unburnt including the ash of the green bleaches. Both the material were used as fractional substitution of the cement and were used at 10percent, 20 percent and 30 percent. Overall seven mixes were prepared one with no other material. Three with usage of biomass ash depending upon three percentages and rest three with three different percentages of the dregs. Then several samples were prepared, cured and tested and the test results showed that maximum strength was obtained at 10 percent usage of the biomass ash as compared to all other mixes.

III. CONCLUSION

A. General

In this review article the usage of waste sewage sludge and the biomass ash for improving the engineering and non-engineering properties' of both concrete and soil are discussed in detail. Numerous past research works were studied in detail so as to predict the behavior of biomass ash and waste sewage sludge when used for the stabilization process of soil and concrete. Past studies related to the usage of stabilized sewage sludge and biomass ash were studied in a detailed manner and depending upon the past studies several conclusions has been drawn which are discussed further.

B. Sewage Sludge

Several studies related to the usage of the waste sewage sludge for improving soil physical, chemical and biological properties showed that the usage of waste sewage sludge improve the physical properties, chemical properties, macro-nutriential properties and micro-nutriential properties up to a great extent. Depending upon the results of the past studies it can be concluded that the usage of sewage sludge has positive impact over all the properties of soil and this waste should be utilized in improving the properties of soil rather than dumping.

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C. Biomass Ash

Numerous studies related to the usage of the biomass ash showed that biomass ash has positive impact over both soil as well as concrete. Studies related to the usage of the biomass ash in soil showed that there was a positive response of the stabilized soil after its stabilization with the biomass ash. Studies related to the usage of the biomass ash in concrete showed that the biomass ash can be used up to 10 percent replacement of the ordinary Portland cement so as to attain maximum strength results from it.

IV. FURTHER CREDITS

(Beltrán, Agrela, Barbudo, Ayuso, & Ramírez, 2014; Bogusz & Oleszczuk, 2020; Černe et al., 2019; Chagas, Figueiredo, da Silva, & Paz-Ferreiro, 2021; Cristina, Camelin, Pugliese, Tommasi, & Fino, 2019; Cuenca, Rodríguez, Martín-Morales, Sánchez-Roldán, & Zamorano, 2013; Figueiredo, Chagas, da Silva, & Paz-Ferreiro, 2019; Florentino et al., 2019; Głąb et al., 2020; Głąb et al., 2018; Hazrati, Farahbakhsh, Cerdà, & Heydarpoor, 2021; Kończak & Oleszczuk, 2018; Markowicz, Bondarczuk, Cycoń, & Sułowicz, 2021; Martínez-Lage et al., 2016; Matalkah, Soroushian, Ul Abideen, & Peyvandi, 2016; Nagrockienė & Daugėla, 2018; Omran, Soliman, Xie, Davidenko, & Tagnit-Hamou, 2018; Poggere et al., 2019; Rojo-López et al., 2020; Sahin et al., 2020; Skowrońska et al., 2020; Teixeira, Camões, Branco, Aguiar, & Fangueiro, 2019; Urra et al., 2019; van den Berg, Huerta-Lwanga, Corradini, & Geissen, 2020; Velay-Lizancos et al., 2017; Wang & Baxter, 2007; Wang, Llamazos, Baxter, & Fonseca, 2008; Wang, Miller, Llamazos, Fonseca, & Baxter, 2008; Wu et al., 2021; Zhang et al., 2021; Zoghlami et al., 2020)

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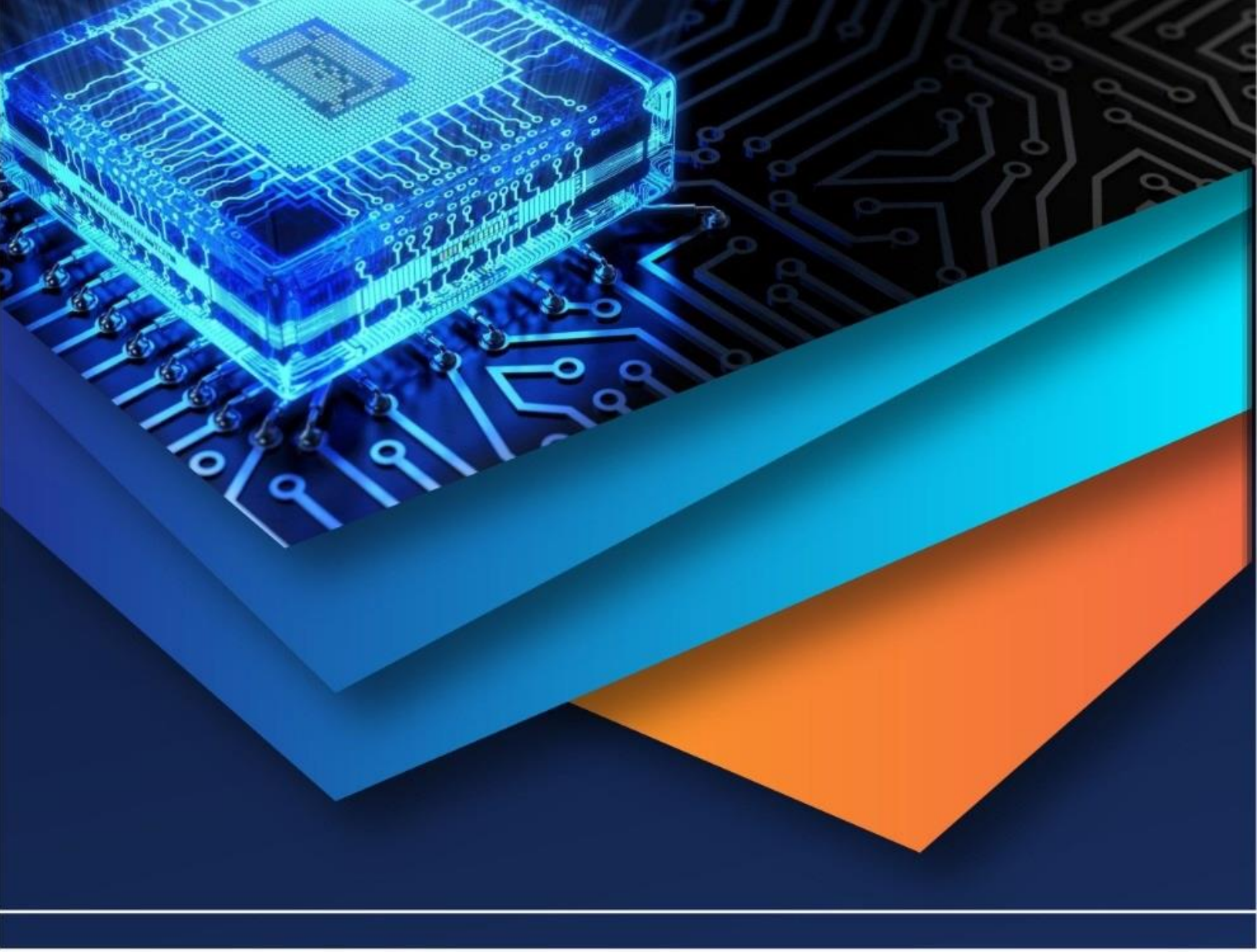

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