A Study on Utilization Potential of Microbial Biopolymer treated Wastes in Civil Engineering

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Submitted by

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CHAPTER- 5

CONCLUSIONS AND FUTURE SCOPE

5.1 Conclusions

Biopolymer stabilization of soil and waste has been introduced in the field of construction and geotechnical engineering, with biopolymers serving as a binder for soil/waste strengthening and ground improvement. In this study, bauxite residue and coal mine overburden waste were stabilized using two environmentally friendly biopolymers (xanthan and guar gum) to enhance shear, hydraulic properties, and durability characteristics (Freezing and thawing cycles).

The specific conclusions that have resulted from the current research are listed below:

1. The use of biopolymers, xanthan, and guar gum (1.5% concentration), on the compaction characteristics of bauxite residue and CMO, has shown a higher maximum dry density and optimum moisture content. However, the dry mixing method does not influence the dry density of bauxite residue.
2. The shear strength parameters increase with the curing time for samples stabilized with biopolymers, individually and with composite. However, the increase is more with composite biopolymer.
3. With composite biopolymer, the more significant improvement in strength, over individual biopolymers, is due to the formation of cross-link networks of two biopolymers that bind the bauxite residue and coal mine overburden waste particles; resulting in a stable matrix.

4. The biopolymer treatment with xanthan or guar gum at a minimal concentration could improve the strength characteristics of bauxite residue due to inter-particle strength enhancement resulting from the formation of thick particle coating and hydrated gel formation.
5. The biopolymer amended bauxite residue sample show a substantially higher increase in UCS compared to 10% cement treatment; with an additional advantage of a reduced CO_2 footprint. Therefore, the use of biopolymer can be a beneficial and environmentally friendly option in Civil Engineering construction.
6. The compressive strength of biopolymer stabilized bauxite residue samples (without thermal treatment) increased with biopolymer concentration and curing time. Thermal treatment showed a higher compressive strength and durability enhancement than without thermal treatment.
7. With or without thermal treatment, the unconfined compressive strength of the stabilized bauxite residue decreases with an increase in freeze-thaw cycles. However, the sample with a higher biopolymer concentration (at m_b/m_w= 1.5%) and longer curing period (28 days) showed a lower loss in strength.
8. The maximum recovery of strength, post Freeze-Thaw cycle, was observed till 14 days of curing time. Thus, biopolymer stabilized bauxite residue can be a beneficial option in various applications of civil and geotechnical engineering construction, especially in cold regions where F-T phenomenon is common.
9. Addition of 0.25% xanthan gum and 0.5% guar gum to the bauxite residue sample decreases its permeability by approximately 10 times than the permeability of untreated bauxite residue sample mixed with tap water. Also, addition of 1% composite (XG+GG) gum changes the hydraulic conductivity from 7.65×10^{-6} to 4.67×10^{-8} cm/sec, which is less than 10^2 times.

10. Addition of 0.15% xanthan gum to coal mine overburden waste sample reduces its coefficient of permeability to almost half of the initial value. However, the influence of 0.15% XG on coefficient of permeability was not observed after about 60 days, possibly due to the very low content of biopolymer remaining in the sample. Addition of 1% xanthan gum changes the coefficient of permeability from 5.4×10^{-4} to 5.32×10^{-8} cm/sec, which is less than 10^4 times.
11. The concentrations of the all the biopolymers in the effluent water were less than 0.25g/lit, indicating that a large percentage of biopolymers (XG, GG, and XG+GG) had been retained in the bauxite residue sample. However, the mechanism of retention is unclear and still need to be explored.
12. Colorimetry of several permeability tests indicates that less than 2 percent of total biopolymer content was washed out over two months.

Therefore, it can be concluded from the above findings that biopolymer stabilization shows promise as a tool to modify the bauxite residue and coal mine overburden waste characteristics to have considerable strength in terms of ductility or stiffness. Hence, due to the efficacy of biopolymer, it can be a sustainable substitute material to cement and lime.

5.2 Scope of future work

Future research should focus on resolving some limitations of biopolymer application. The characteristics of biopolymer stabilized soil can change under natural environmental conditions such as pH, temperature, wet-dry cycles, and ultraviolet radiations. Also, a field permeability test should be performed on untreated bauxite residue and coal mine overburden waste and compared with the permeability of biopolymer treated bauxite residue and coal mine overburden waste. Further research on the utilization of various other biopolymers and their composite and their effect on different waste materials should be explored.