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RED MUD AS CONSTRUCTION MATERIA BY USING BIOREMEDIATION

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Abstract: Worldwide 120 million tons of red mud/bauxite residue is generated annually which poses a very serious and dangerous environmental problem. Red mud is a by-product which is produced in the process of extraction of alumina from bauxite. The process is called Bayers Process. It insoluble product and is generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure. The aim of the project is to describe the characteristic properties of Red Mud and possible use as a geotechnical material. The most important barrier to remediation, re-use and long term sustainability of bauxite residue management is its high alkalinity. Many researches are still being carried out on the neutralisation of red mud in various ways. This report is one of the parts of utilizing the red mud in a very better and economic manner. In this project the red mud is used as an alternative construction material after remediation by Biological process. This gives a cost effective neutralization method as well as abundant material which can use in construction. This research Provides examples of how microbiological conditions and processes may influence engineering properties and behaviors of earth materials.

1. INTRODUCTION

Red mud is a hazardous waste created in the Bayer procedure of alumina generation (Al_2O_3) from bauxite mineral which contains elevated amounts of lingering alkalinity and lethal overwhelming metals viz. silica, aluminium, press, calcium, titanium, and in addition a variety of minor constituents, specifically: Na, K, Cr, V, Ni, Ba, Cu, Mn, Pb, Zn. They involve a huge zone of land which does not bolster any sort of vegetation as a result of their unfriendly nature vegetation development. On account of the enormous volume of the red mud being created as a side-effect from the alumina business it makes them about hard to contain them and in this way causes genuine transfer. In this way advancement and actualizing its stockpiling and its remediation programs stays fundamental as stock develops around 120 million for each annum. Subsequently the red mud can be effectively diverted and dissolved by wind and substantial storm from the dumping site to the close-by local locations. Contact of the red mud with skin and eyes causes serious complexity and wellbeing dangers to individuals. They make genuine danger the ground water by leakage and furthermore cause different ecological perils. Table 1 demonstrates a composition of red mud and Table 2 indicates Chemical composition of Indian red muds.

Table 1 Typical composition of red mud

Composition	Percentage
Fe2O3	30-60%
Al2O3	10-20%
SiO2	3-50%
Na2O	2-10%
CaO	2-8%
TiO2	trace-25

Table 2.Chemical composition of Indian red muds

Company	Al_2O_3 %	Fe_2O_3 %	SiO_2 %	TiO_2 %	Na_2O %	CaO %	LOI%
BALCO Korba	18-21	35-37	6-7	17-19	5-6	2-3	11-14
HINDALCO Renukoot	17-19	35-36	7-9	14-16	5-6	3-5	10-12
HINDALCO Muri	19-21	44-46	5-7	17-19	3-4	1-2	12-14
HINDALCO Belgaum	17-20	44-47	7-9	8-11	3-5	1-3	10-14
MALCO Metturdam	18-22	40-26	12-16	3-4	4-5	1-3	11-15
NALCO Damonjodi	17-20	48-54	4-6	3-4	3-5	1-2	10-14

Red Mud is created amid the procedure for alumina generation. Contingent upon the crude material prepared, 1–2.5 tons of red mud is created per ton of alumina delivered. In India, around 4.71million tons/annum of red mud is created which is 6.24% of world's aggregate red mud generation.

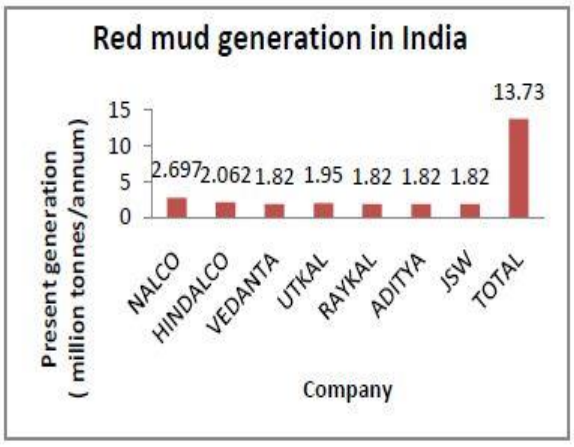

Figure 1.Red mud generation in India

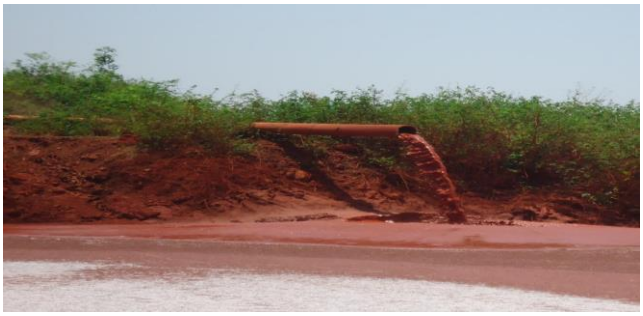

Figure 2.Discharge of Red Mud as Slurry into the Pond

Bioremediation is the utilization of microorganisms for the corruption of unsafe chemicals in soil, residue, water, or other defiled materials. It is notable that all microscopic organisms deliver exopolysaccharides under overabundance of sugars or other water solvent wellsprings of carbon over wellspring of nitrogen. In this way, such nourishment preparing squanders or sub-items as corn glucose syrup, cassava glucose syrup and molasses with C: N ratio>20 are utilized for mechanical generation of bacterial water-insoluble polysaccharides.

Microbial Geo-technology is another branch of geotechnical building that arrangements with the utilizations of microbiological strategies to land materials utilized as a part of designing. Bio-Geotechnology is a branch of geotechnical building that arrangements with the utilizations of organic strategies to geotechnical designing issues that are connected primarily to the uses of plants or vegetative soil cover for soil disintegration control and slant assurance, counteractive action of slant disappointment, and decrease of water penetration into inclines and have points of interest of low speculation and upkeep costs.

1.2 SCOPE AND OBJECTIVE OF RESEARCH WORK

The disposal of red mud is a danger to the environment due to its high alkalinity content. Researchers are trying to use and neutralize it by using physical and chemical method but the restrictions faced with physical and chemical treatment technologies will be overcome with the help of microbes.

The purpose of this research work will be utilisation of the red mud, an industrial waste in the construction of embankment and fill which can't be done due to its high alkalinity. A new perception will be used to neutralize the red mud by biological activities so that the modified red mud can be tested in the field and advantageous for construction material which will reduce the need of borrowed soil.

3. MATERIALS AND METHODS

3.1 Red mud

The red mud used in the research study is collected from NALCO, Damanjodi, Koraput in Odisha, India. About 0.8 to 1.5 tons of red mud is coming out per ton of alumina produced. The red mud is released in a slurry form to red mud pond shown in Figure 3. The area of red mud pond is around 212hectares. Due to environmental pollution of water sprinkling system to arrest dust is shown in Figure 4.

Figure 3. Red mud pond

Figure 4.Sprinkling system of red mud pond to prevent dust effect at Damanjodi

3.2 Collection of red mud sample

The red mud is collected from the red mud pond in an air dried state and characterised by various standard laboratory methods. 100gms. of red mud was kept in freezer for microbial count and isolation of pure culture.

3.3 Dairy waste

The dairy business is the most dirtying among all nourishment industry because of huge utilization of water. Diverse research was continuing for the better usage of dairy squander over around the world. The waste originating from dairy industry was appeared in Figure below.

3.4 Collection of Dairy waste

The dairy waste known as whey is made by taking OMFED milk and boiling it in induction cooker by addition of few amount of vinegar in saucepan in laboratory shown in figure below.

Figure 5. Laboratory whey

3.5 BIOREMEDIATION ANDCHARACTERISATION

3.5.1 Isolation of bacterial culture

Ten distinctive levelled Petri plates having agar and dilution of samples are incubated for the development of lactose fermenting microorganism. The outcome demonstrates four distinct provinces are framed in the Petri plates after 48 hrs. The settlements framed are utilized for acquiring pure culture which is appeared in Figure.

Figure 5.colonies formed in Petri plate

3.5.2 Pure culture

Streak plate method is the most reliable method is used for the pure culture. The 4 colonies were stroke for pure culture and incubated in incubator. Result shows that colonies are absolutely pure and no need to do more striking. The culture is saved in agar form in freezer. The culture is used for nursery trials. The pure culture is shown in Figure.

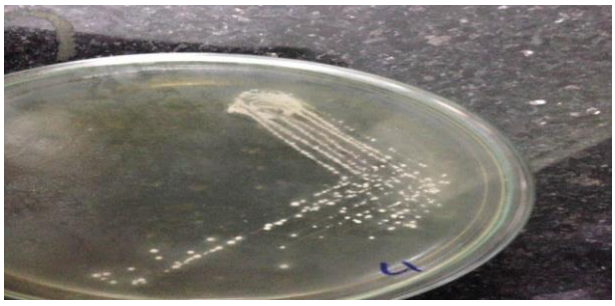

Figure 6.Pure culture obtained from red mud

3.5.3 Morphology study

The pure culture obtained is studied with esteem to their structural form. Morphological study is done with the bacterial culture by staining procedure as told in section. The result shows the 4 pure cultures are same in structure which is used for bio-neutralisation. The bacterial structure in 100 x microscopes is shown in Figure below.

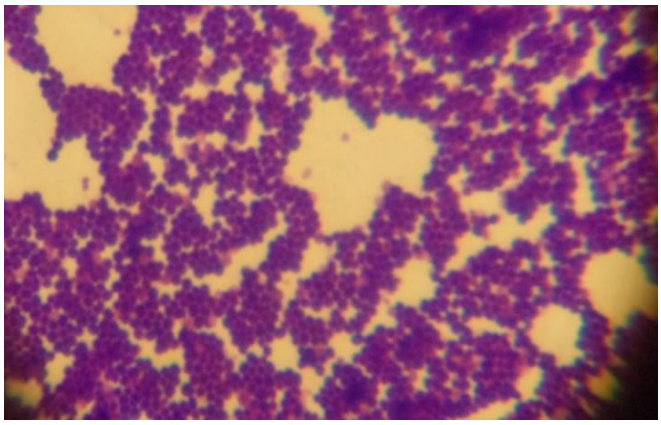

Figure 7. Bacterial cultures in microscope

The morphological study shown in above figure is Coccusin shape. The colour of bacteria culture is off white in colour which converts purple when bacterial cell absorbed the dye, which helps in staining process.

3.5.4 Nursery trials

The bacterial culture is tested for reduction of pH of lactose broth in nursery trials. The pH is shown in Table 3, which was monitored while, incubation.

Table 3 pH monitoring of lactose broth

Time of incubation	1st sample (lactose broth + bacteria)	2nd sample (lactose broth + bacteria)
0 hour	11.04	7.11
24 hour	8.82	11
48 hour	8.43	74
96 hour	5.59	4.56
After 7 days of incubation	5.56	4.77

The result which we obtained shows that the bacterial culture lactose fermenting facultative bacteria which can convert lactose to lactic acid in their metabolism process. The bacterial culture can live in the high alkaline environment as well as in the acidic environment.

3.5.5 Bio-neutralisation process

In bioremediation there is no change of pH value of red mud and inoculated cultured with red mud. There is a decrease of pH of red mud with lactose broth and inoculated culture but

it's not feasible. The pH value reduced to 8.40 and 7.40 with diluted and non-diluted diary waster when mixed with red mud with the bacteria culture. The disparity of pH was shown in table 4 and in Figure below.

Table 4 pH measurement of red mud with different Solution.

Days of incubation	Red mud & water	Red mud, Water & bacteria	Red mud, Lactose broth & bacteria	Red mud, dil. Diary waste & bacteria	Red mud, diary waste & bacteria
0 days	10.06	10.04	10.04	9.60	9.60
2 days	10.06	9.90	9.60	8.67	7.82
4 days	10.06	9.90	9.47	8.40	7.40
6 days	10.06	9.90	9.23	8.40	7.40
8 days	10.06	9.90	9.23	8.40	7.40

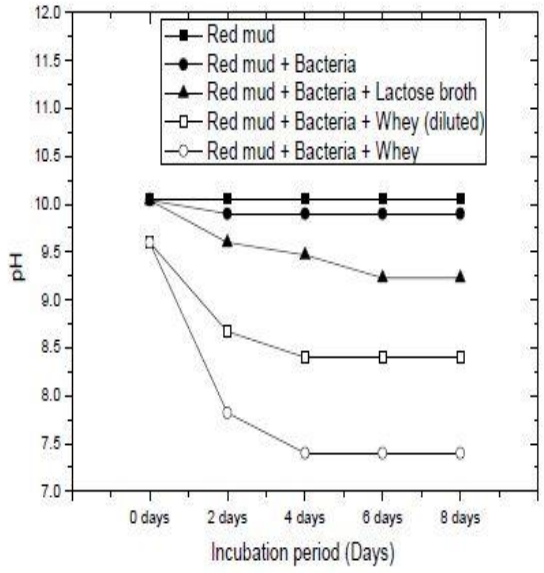

Figure 8 Dissimilarity of pH value of red mud under different conditions

3.6 CHARACTERISATION OF DAIRY WASTE

Crystal clear yellowish colored whey contains carbohydrate, protein and various minerals. The carbohydrate contains lactose and is calculated in anthrone method. The minerals are calculated in atomic adsorption machine. The content are presented in the below table 5.

Table 5 contents of dairy waste

S.No	Contents	Amount
1	Lactose	47g/lit
2	Fe (Iron)	0.455mg/l
3	Chloride	650mg/l
4	K (Potassium)	48.947mg/l
5	Mg(Magnesium)	6.604mg/l
6	Ca(Calcium)	61.865mg/l
7	Na(Sodium)	13.700mg/l

4. RED MUD CHARACTERISATION AND COMPARISON

4.1 Mineralogical study

The X-Ray Diffraction analysis of red mud is shown in Figure 4.5 and from the analysis it isobserved that Hematite, Boehmite, Gibbsite, Rutile, Goethite and Sodalite are major mineralspresent in red mud. The bio-neutralised red mud X-Ray Diffraction analysis is shown inFigure and it was observed that similar types of minerals are observed afterbioremediation qualitatively. However, some quantitative differences were observed, thoughit has not been measured.

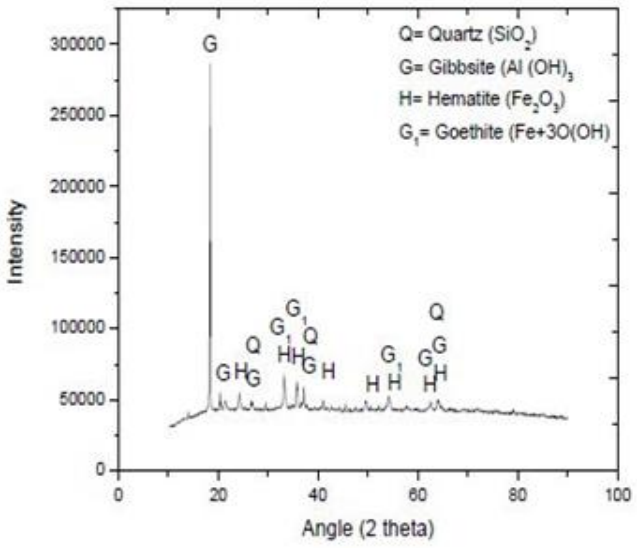

Figure 9.XRD analysis of red mud

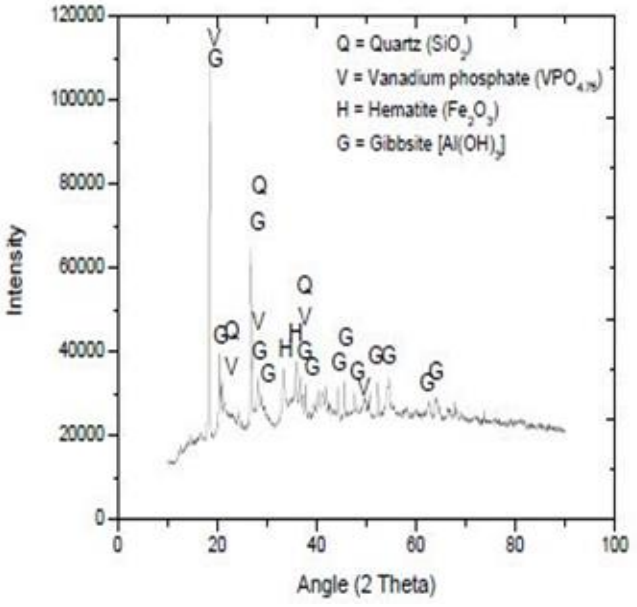

Figure 10 XRD analysis of bio-neutralised red mud

Table 6 Geotechnical properties of red mud and bio neutralised red mud.

S. No	Properties	Red mud	Neutralised red mud
1	pH value	10.06	7.40
2	Specific gravity	3.34	2.83
3	Liquid Limit	24.75	23.34
4	Plastic Limit	17.5	19.86
5	Plasticity Index	7.25	3.48
6	Unconfined Compressive Strength	57.6	41.11`

5. CONCLUSION AND FUTURE SCOPE

Production of red mud is an alarming environmental effect and for storage it needs a vast land area. The red mud production is 1.2 – 1.4 times the production of alumina which is a big issue for the world. Though, several labours have been made to use red mud an alternative material in building and alloy industries, but only 5% of red mud can be used.

1. The toxicity of red mud is the main cause for which it cannot be used. The toxicity is due to the high alkaline in nature so in this research the red mud is neutralised by microbes so that it can be used in construction material as well as lessen the environmental effect and cost for storage of red mud.

2. There is a potential to use in huge quantities as a fill and embankment material, but very little efforts have been made to neutralise and characterize neutralised red mud as a geotechnical engineering material, particularly the Indian red mud.

3. The alkalinity of red mud is high with a pH value 10.06 due to presence of NaOH and Na2CO3; these are expressed in terms of Na2O.

4. The isolated bacteria culture can reduce the pH value of red mud to 7.42 from 10.06 when red mud is mixed with diary waste product.

5. The specific gravity changed to 2.82 from 3.3 due to the presence of organic matter.

6. There is a variation of plasticity index due to slight decrease in liquid limit and increase in plastic limit.

7. The unconfined compressive strength value is decreasing to 42.22kPa from 57.6 kPa at optimum moisture content.

8. There is a reduction of plasticity index and cohesion due to the loss of apparent cohesion present in red mud.

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