“EVALUATION OF PROPERTIES OF FRESH AND WASHED RED MUD”

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ABSTRACT: Red Mud is a waste generated by aluminium industry, which poses great challenge for disposal. Red mud has been investigated widely for its possible use as a construction material, stabilizing agent. The red mud deposited in disposal sites - generally known as red mud ponds, needs to be sprinkled with water, so that particles do not get blown away by wind. Besides, the red mud ponds are also subjected to seasonal rainfalls leading to leaching effects. Therefore, an attempt is made in this paper, to investigate the characteristics of fresh and leached red mud. The repeated washing of red mud is done in the laboratory to simulate the field leaching conditions. The investigations on fresh and leached red mud samples indicate the reduction in alkalinity with number of washes. Consistency limits and compaction characteristics indicate the optimum values between third and fourth washed samples.

Key Words: Red Mud, Leachate, Washed Red Mud, Alkalinity.

1 INTRODUCTION

Significant changes in the environment are due to industrialization and urbanization. There is need for developing methods for managing the wastes in such way that sustainable development is achieved without causing any damage to ecosystem (Abdel, M. et al 1998).

Red Mud (Bauxite Residue) is a by-product of Bayer’s process. Red Mud is highly alkaline and poses number of environmental and health risks (Suresh, C. et al 2010; Thakur, R. and Das, S. 1994). The annual red mud production is to the tune of 66 million tonnes in the world (Leonardou, S. 2008). This poses great threat for the safe disposal of red mud and thus its effective utilization is a challenge. In the present investigation, an attempt is made to characterize the red mud for its possible use as stabilizer.

2 LITERATURE REVIEW

Sivapullaiah, P. V. (2000) studied the effect of isolated pollutants on index properties, volume change behavior, shear strength properties and permeability of different types of clayey soils with different groups of pollutants. It is reported that, type of pollutant, amount and type of clay present influences the behavior of polluted soil matrix. Further, the macro behaviour of the clay is mainly governed by forces acting between the clay particles in addition to those caused by external loads. This depends on the mineralogical properties of the clay and physicochemical interactions of the clay water system. Different clay minerals exhibit wide range of properties (Sivapullaiah, P. V. 2000).

Tim, N. et al carried out the studies to investigate properties of red mud at a site in the United Kingdom. It is observed that the material has frictional behaviour closer to sandy soils and compression behaviour similar to clayey soils. Literature reports that the agent causing the aggregation of particles is hydroxysodalite. Exposure of the red mud to acidic conditions causes dissolution of the hydroxysodalite and loss of particle cementation. Hydration of the hydroxysodalite does not affect the mechanical performance of the material. It is observed that the size, shape and electrically charged properties of the hydroxysodalite, hematite and goethite in the red mud are causing mechanical behaviour, without the presence of clay minerals or either quartz (Tim, N. et al 2006).

The mineralogical composition of the red mud indicates the presence of gibbsite (γ-Al(OH)₃), hematite (Fe₂O₃), goethite (α-FeOOH), boehmite (γ-AlOOH), TiO₂ in the anatase polymorph, quartz (SiO₂) and hydrated sodium aluminosilicate (1.08Na₂O·Al₂O₃·1.68SiO₂·1.8H₂O); the latter resulted from the kaolinite content of the parent bauxite during Bayer’s Process (Siti, H. et al 2015).
Literature Review indicates that, there is need to study the deposited red mud in the ponds subjected to natural and artificial washing effects. Therefore, present investigation is focused on geotechnical properties of fresh and washed red mud samples.

3 MATERIALS AND METHODOLOGY

Red Mud (RM) from HINDALCO Industry, Belagavi is collected for analysis. For all the experiments, the sample of red mud is dried in an oven at 104 °C for 24 hours, then cooled and stored in airtight container prior to use. The red mud is classified as inorganic silt (ML), as the plasticity index of the red mud is less than 7 and liquid limit value is less than 35%.

3.1 Methodology

The percentage of red mud passing through 75µ sieve is 88%. Red mud slurry is prepared with varying amount of distilled water (DW). The dilution ratio of Red Mud: Distilled water (RM:DW) is varied from 1:1 to 1:10. The mixture is stirred well for 30 min to ensure thorough mixing. After stirring, the samples have been kept undisturbed for different detention periods. At the end of the detention period, the pH value of sample is analysed. Optimal pH value is identified and the corresponding RM:DW ratio is selected for further analysis.

The red mud pond is sprinkled with water continuously to keep the top surface wet and thereby avoiding blowing away of dry red mud particles. The sprinkled water percolates down the heaped red mud and is collected in the lagoon. To simulate this field condition, the fresh red mud is subjected to repeated washing in the laboratory. The geotechnical properties such as consistency limits and compaction characteristics of fresh and repeatedly washed red mud are determined as per IS 2720. The characteristics of the leachate at each wash of red mud, are investigated with special reference to pH and alkalinity. pH is measured using pH meter and alkalinity is determined by titrimetric method as per Standard Methods of American Public Health Association (APHA) and American Water Works Association (AWWA).

4 RESULTS AND DISCUSSIONS

Results of Table 1 indicate that, the pH of leachate decreases with increase in the detention period. The pH of the leachate seems to stabilize for a detention period of 5 days, for all the dilution ratio greater than 1:5. Therefore, dilution ratio of 1:5 is adopted for further analysis.

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Detention Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min</td>
</tr>
<tr>
<td>1:1</td>
<td>12.00</td>
</tr>
<tr>
<td>1:2</td>
<td>11.78</td>
</tr>
<tr>
<td>1:3</td>
<td>11.64</td>
</tr>
<tr>
<td>1:4</td>
<td>11.60</td>
</tr>
<tr>
<td>1:5</td>
<td>11.58</td>
</tr>
<tr>
<td>1:6</td>
<td>11.56</td>
</tr>
<tr>
<td>1:7</td>
<td>11.50</td>
</tr>
<tr>
<td>1:8</td>
<td>11.40</td>
</tr>
<tr>
<td>1:9</td>
<td>11.40</td>
</tr>
<tr>
<td>1:10</td>
<td>11.40</td>
</tr>
</tbody>
</table>

Table 1 Variation of pH value for different detention period

<table>
<thead>
<tr>
<th>Red Mud</th>
<th>pH</th>
<th>Total Alkalinity</th>
<th>Hydroxyl</th>
<th>Carbonates</th>
<th>Bicarbonates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Wash</td>
<td>10.70</td>
<td>1650</td>
<td>0</td>
<td>1044</td>
<td>606</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Wash</td>
<td>10.50</td>
<td>1220</td>
<td>0</td>
<td>440</td>
<td>780</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Wash</td>
<td>10.40</td>
<td>918</td>
<td>0</td>
<td>296</td>
<td>622</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Wash</td>
<td>10.30</td>
<td>644</td>
<td>0</td>
<td>212</td>
<td>442</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Wash</td>
<td>10.20</td>
<td>530</td>
<td>0</td>
<td>204</td>
<td>326</td>
</tr>
</tbody>
</table>

Table 2 Characteristics of Red Mud Leachate

Results of Table 2 indicate that, repeated washing of red mud causes decrease in pH and alkalinity of the leachate. The pH of the leachate is greater than the permissible range of 5.5 to 9.0 as specified by Central Pollution Control Board (CPCB), effluent standards.

As caustic soda (NaOH) is used for digestion of alumina in Bayer’s process, it was expected that the alkalinity of red mud might be due to the traces of caustic soda. On the contrary, it is observed from the analysis that, the alkalinity due to hydroxyl ions is zero in the leachate. The alkalinity is entirely due to carbonates and bicarbonates.

Two forms of sodium present in red mud (total soda) are bound soda and free soda. Free soda (NaOH,
NaAlO) is the entrained liquor in the red mud slurry which gets incorporated during digestion process and remains with red mud in spite of repeated washings (Rai, S. et al 2013).

Fig. 1 Variation of Liquid Limit for washed red mud samples

Fig. 2 Variation of Plastic Limit for washed red mud samples

Fig. 3 Variation of Shrinkage Limit for washed red mud samples

Fig. 4 Variation of Maximum Dry density for washed red mud samples

Fig. 5 Variation of Optimum moisture content for washed red mud samples

Fig. 1 indicates the variation of liquid limit of red mud with number of washes. The decreasing pH or alkalinity results in decrease in liquid limit. This behaviour is probably due to the presence of kaolinites in red mud, as decreasing pH and alkalinity causes decrease in the liquid limit of Kaolinites (Sivapullaiah, P. V. 2005).

Fig. 2 and 3 indicate the variation in plastic and shrinkage limit of red mud with number of washes. The optimum values of consistency limits are observed for third and fourth wash of red mud. However, the magnitude of change is not substantial.

Fig 4 and 5 indicate the variation of Maximum dry density (MDD) and Optimum Moisture Content (OMC) of fresh and washed red mud samples. The MDD and OMC also indicate an optimum value between third and fourth washed samples.
5 CONCLUSIONS

1. The seepage of water through red mud, alters the geotechnical characteristics of red mud.

2. The pH value of leachate decreases with increasing dilution ratio for the detention period of four days. It stabilizes for all the dilution ratios greater than 1:5 for detention period of five days.

3. The pH of the leachate is greater than the permissible pH range of 5.5 to 9.0 as specified by Central Pollution Control Board (CPCB), effluent standards.

4. The alkalinity in the red mud samples is due to presence of carbonate and bicarbonates ions. Alkalinity decreases with increase in the number of washes.

5. Optimum values of Consistency limits and compaction characteristics are observed to be between third and fourth wash of red mud.

6. The presence of kaolinite in red mud probably brings about changes in liquid limit with changes in the alkalinity.

REFERENCES


Sivapullaiah, P.V. (2000), ‘Pollution effects on soil geotechnical properties, Geo-engineering in Arid Lands’.


