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Neutralization of red mud using mine water

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Abstract

Red mud is the byproduct of commonly used Bayer process for extraction of alumina from bauxite ore. Globally, there are approximately 70 million tones of red mud being produced every year. Highly alkaline red mud, usually pH ranges from 10.5–13 and high caustic causes environmental disposal problem and their reuse. The results show that pH of red mud decreased to standard environmental level using mines water. Sodium ions dominated among the soluble cations, but the sodium ion concentration decreased with increasing duration of storage time due to leaching which causes water pollution. The acid neutralizing capacity of red mud obtained from this study was about 5.5 mol/kg. Mine water neutralization process led to many benefits, including conservation of fresh water due to less use of fresh water at the refinery, increasing settling rates at the red mud pond, reduces the pH, easy to handle and reduces the cost of waste management. The neutralized red mud can be used for other socio-economical and environmental benefits.

Keywords: Red mud; Caustic; Mine water neutralization; Acid neutralizing capacity

1. Introduction

Red mud is the main byproduct of bauxite processing for alumina extraction plant. Bayer's process is commonly used for digestion of bauxite ore in a solution of conc. NaOH at temperatures between 150-230˚C under pressure. During the digestion process, aluminum reacts with the NaOH to form soluble sodium aluminate, leaving red mud slurry. Red mud is highly alkaline, usually pH in the range of 10.5 – 13, due to presence of NaOH and Na_2CO_3 (1–6% w/w). These compounds are expressed in terms of Na_2O [1-3]. The main constituents of red mud (%w/w) are: Fe_2O_3 (30-60%), Al_2O_3 (10-20%), SiO_2 (3-50%), Na_2O (2-10%), CaO (2-8 %), TiO_2 (trace -10%). The amount of red mud generated per ton of alumina produced, varies greatly depending on the type of bauxite used, from 0.3 tons for high-grade bauxite to 2.5 tons for very low-grade [3]. Globally, there are approximately 70 million tones of red mud being produced every year[5]. Red mud typically deposited as slurries (with 15–40% solids) in red mud pond situated much above the normal ground level. The problem related to storing the slurry causes leakage of alkaline compounds into the ground water, over flow of caustic from red mud pond

during rainy season, dusting of dry surfaces during summer season, which interfere with nearby rehabilitation [1-6]. The contaminations of surrounding environment are a global environmental issue, which can be solved by neutralization of red mud and its utilization for environmental benefits. In this study, mine water was taken as a source of water for neutralization of red mud by simple addition and filtration method.

2. Materials and methods

Red mud used in this study was obtained from R & D Laboratory of National Aluminum Company Ltd. NALCO, Damanjodi, Orissa, India. pH measurements were made using a calibrated Orion pH meter. The mineralogy of powder red mud samples was determined with a Phillips X-ray diffractometer (XRD) and digital data processing. Chemical composition of major oxides was determined by Energy Disperse X-ray (EDX). The micro-morphology of materials was investigated using a JOEL JSM-6480LV Scanning Electron Microscope (SEM).The experiments were performed in 100 ml beakers. Two-gm sub-samples of each red mud were mixed with 40 ml of mines water at room temperature 22 – 25˚C and stirred the solution through a magnetic stirrer to increase the solubility of caustic. The red mud solutions were kept for 2 hr and the slurries were allowed to settle. The pH was measured on the suspension using a calibrated pH meter.

3. Results and discussion

The red mud samples are analysed after neutralization process, the composition of which are represented in Table 1. Hematite, goethite, gibbsite, calcite, rutile, sodalite, quartz minerals are the main composition of neutralized red mud.

Table 1. Major mineral composition of neutralized red mud as determined by X-ray diffraction

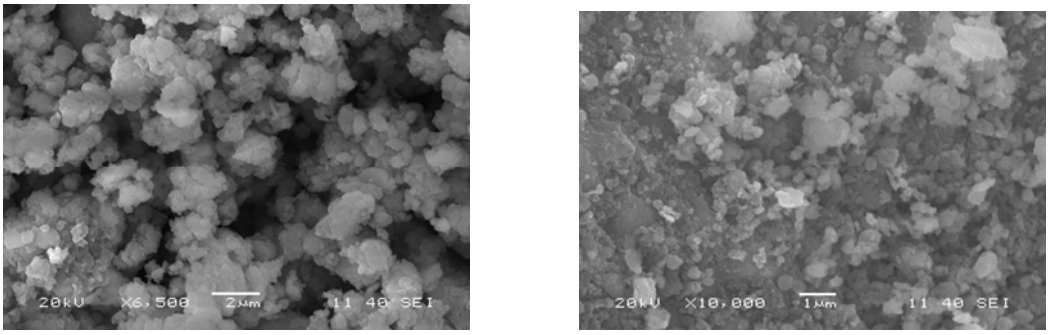
Mineral Phases	Formula
	Neutralized Red Mud
Hematite	Fe_2O_3
Goethite	FeO(OH)
Gibsite	$Al(OH)_3$
Calcite	$CaCO_3$
Rutile	TiO_2
Sodalite	$1.08Na_2OAl_2O_31.68SiO_21.8H_2O$
Quartz	SiO_2

The chemical composition of partially neutralized red mud is analyzed by EDX, the results of which are presented in Table 2.The results in Table 2 indicate that, most of oxides of partially neutralized red mud are stable and non-reactive.

Table. 2. Major oxides in mines water neutralized red mud as determined by EDX

Major oxides	Neutralized red mud %(w/w)
Fe_2O_3	51.72
Al_2O_3	11.25
TiO_2	3.17
SiO_2	6.56
Na_2O	2.87
CaO	1.45

Scanning electron microscope images, Fig. 1(a) of red mud, and Fig. 1(b) of neutralized red mud, show compositional features of the materials. Rounded shape of red mud particles is responsible for extremely high friction angles, most of minerals are cubic or prismatic shapes.



(a) Red mud (b) Neutralized red mud

Fig 1. SEM of (a) red mud, and (b) neutralized red mud

The cementing/aggregating agent is hydroxysodalite. It is only very slightly soluble in water, but becomes more soluble in alkaline conditions [1]. The dissociation of hydroxysodalite is responsible for decrease of rounded shape and aggregation of red mud Fig. 1 (a,b).

Acid neutralizing capacity (ANC)

The ANC is the amount of acid that can be added to a kilogram of red mud such that the equilibrium pH of the mixture remains above 5.5. Red mud & neutralized red mud were titrated with standardized 0.1 M HCl solutions indicates that the ANC had about 10.5 and 5.5 mol/kg respectively (Fig. 2). The ANC of red mud (pH = 11.5) was higher than that of the partially neutralized red mud (pH = 8.9).

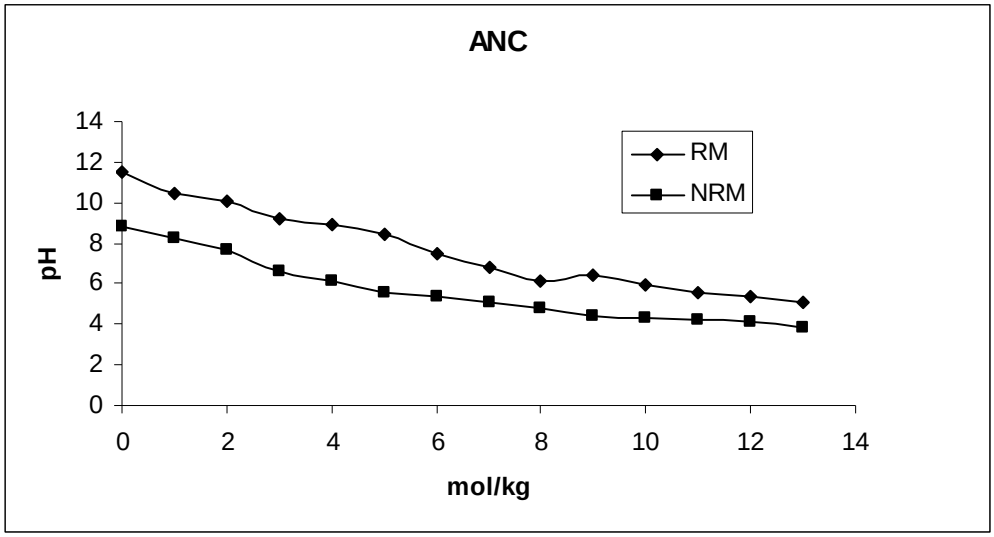


Fig. 2. ANC of red mud and neutralized red mud were obtained by slow titration with standardized 0.1 mol/L HCl solution

4. Conclusions

This experiments show neutralization of highly caustic red mud which can prevent the water pollution. The findings of this study show that mine water has some potential for neutralization of red mud. The supply of bauxite mines water into the red area of alumina plant is very difficult due to presence of large number of hilly areas. So, further work is needed to increase their neutralization capacity.

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