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Carbide lime in acid mine drainage treatment

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ABSTRACT

The objective of this study is to find a suitable quantity of carbide lime in acid mine drainage (AMD) treatment. Carbide lime, which is a waste of acetylene gas process was used as neutralisation material in AMD treatment. This study used carbide lime, because it has high calcium content that can increase pH value of AMD. Carbide lime also has the capability to reduce certain heavy metals in water sample such as cadmium, lead, zinc etc. Water sample used in this study was collected from a tailing pond of an active tin mine and its pH was around 2.6–2.8. Jar test was used in the laboratory to investigate the capability of carbide lime in treating acid mine drainage. The optimum quantity of carbide lime obtained in treating AMD is 1.5 g which can increase pH value and reduces certain heavy metals that comply with Standard A and B of Environmental Act 1974. Other quantities such as 2.0 g and 2.5 g carbide lime were capable to reduce heavy metals and semi heavy metal but pH values obtained were higher compared to both standards of Environmental Act 1974. Generally, the experiment results show that carbide lime is suitable to be used to treat AMD.

1. Introduction

Carbide lime or lime sludge is a waste of acetylene gas process when calcium carbide reacts with water through the hydrolysis process [1,2]. Carbide lime contains ≈85–95% $Ca(OH)_2$, ≈1–10% $CaCO_3$ and 1–3% unreacted carbon and silicates [2–4]. The equation that produced carbide lime is shown in Eq. (1) and its chemical formula is equal to calcium hydroxide, $Ca(OH)_2$. Friedrich Wohler had realised that calcium carbide can react with water to produce acetylene gas and carbide lime in 1962 [1].

Previous study shows that carbide lime has high impurities caused by the reactants and reaction processes. Carbide lime can be classified as not hazardous or dangerous but in Malaysia is considered as schedule waste that needs proper managing and disposal. Carbide lime has pH > 12 and also contains metals such as Mg, Br, Sr, Cd, Cu, Pb, Fe, Mn, Ni and Zn [2–4] and it is soluble in glycerol and dilute acid [1].

$$CaC_{2(S)} + 2H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(s)} \quad (1)$$

Carbide lime can be used in many purposes such as agriculture, sewage, water treatment and in certain industrial processes [2–6]. Carbide lime also suitable to be used in building material such as soil stabilization, pozzolan activation, asphaltic paving mixes, in cement-lime mortars [2,3,7–10], in peat soil stabilization [11] and as a cementing agent for stabilization of soft Bangkok clay [12] and silty clay [13]. Up until now, basically no literature or study has been reported to indicate that carbide lime is used in acid mine drainage treatment except one study reported that carbide lime was used for water treatment [14].

Previous study showed that carbide lime can treat waste water effectively. It has the capability to increase pH value and also can treat heavy metals for example at pH ranges 10–11 for zinc, 9.2–11.6 for lead, 4–11.8 for iron and 7–11.8 for copper [14]. In another study, it showed that carbide can be used to treat effluent from dairy farm using coagulant technique and the results indicated that suspended solids, organic matter, nitrogenous and phosphated compounds were reduced [15].

Every year global mining industry activities produce billion tonnes of solid inorganic wastes or by-product and effluent caused by its mineral processing to produce metals [16–18]. Acid mine drainage (AMD) is caused by oxidation of sulphide minerals such as pyrite (FeS_2) when exposed to oxygen and water in the presence of sulphide oxidising bacteria (SOB) [19,20]. AMD can be classified as acidic water that has pH below than 5.5, high concentration of sulphate, contains heavy metals and semi heavy metals such as Fe, Cu, Pb, Zn, Cd, Co, Cr, Ni, Hg, As and Sb [21]. The reactions for

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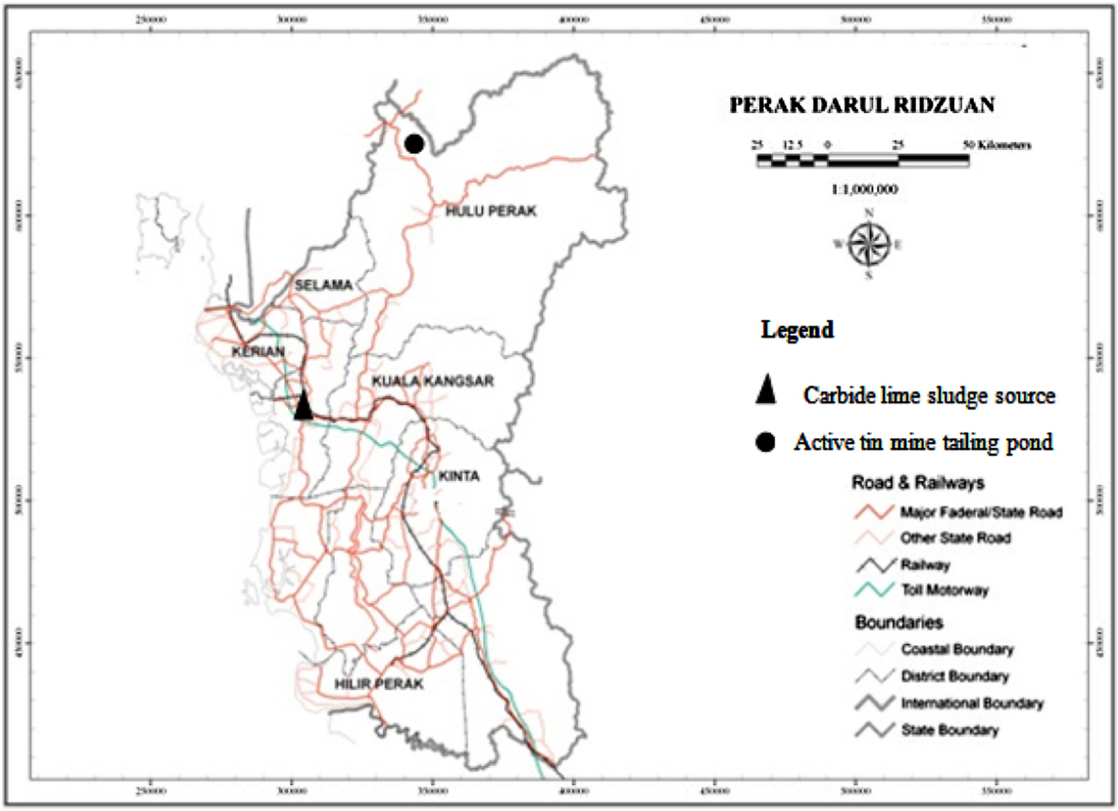

Fig. 1. Locations of tin mine and carbide lime stockpile.

AMD occurrence are shown in Eqs. (2), (3), (4), and (5) respectively [22–25].

$$4FeS_{2(s)} + 15O_{2(g)} + 14H_2O_{(l)} \xrightarrow{bacteria} 4Fe(OH)_{3(s)} + 8SO_4{}^{2-}{}_{(aq)} + 16H^+{}_{(aq)} \quad (2)$$

$$4Fe^{2+}{}_{(aq)} + O_{2(g)} + 4H^+{}_{(aq)} \rightarrow 4Fe^{3+}{}_{(aq)} + 2H_2O_{(l)} \quad (3)$$

$$FeS_{2(s)} + 14Fe^{3+} + 8H_2O_{(l)} \rightarrow 15Fe^{2+} + 2SO^{2-}{}_{4(l)} + 16H^+{}_{(aq)} \quad (4)$$

$$Fe^{3+}{}_{(aq)} + 3H_2O_{(l)} \rightarrow Fe(OH)_{3(s)} + 3H^+{}_{(aq)} \quad (5)$$

There are two methods to neutralise and to reduce heavy metals content in AMD using chemicals or biological mechanisms. The methods can be divided in two; (i) active that needs ceaseless input of material to control the process and (ii) passive that needs a small amount of material input during operation process [26]. In this study carbide lime waste was used to treat AMD as if in active treatment. By using carbide lime as AMD treatment material it can assist certain parties to cut their cost to dispose this material. Compared to other chemical materials such as hydrated lime, quick lime, limestone and others, they require certain cost to treat AMD.

The purpose of this study is to prove that carbide lime that has capability to neutralise pH and to reduce heavy metals content in AMD indirectly can assist mine operators use this material as alternative to substitute others chemicals.

2. Materials and methods

2.1. Materials

Carbide lime sludge was collected from acetylene gas plant in Perak, water sample (AMD) was collected from an active tin mine pond tailing from Perak. Both locations were situated in northern part of Perak State. The locations were shown in Fig. 1.

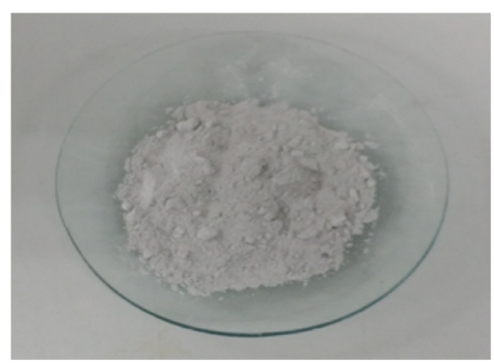

Fig. 2. Carbide lime waste.

2.1.1. Sampling

Grab sampling was used to take the samples of carbide lime and water. For carbide lime, 15 kg from stock pile of acetylene gas producer was brought to laboratory and dried in tray under the sun. Subsequently, representative sample of carbide lime was obtained using cone and quartering method. The last portion was kept in desiccator before experiment was carried out. Fig. 2 shows the carbide lime waste that was used in this experiment.

For water sample, 30–40 bottles with volume 1 L water samples were collected from tin tailing pond. Then, the bottles were kept into ice container and brought to laboratory. Subsequently, the bottles were transferred into chiller for preservation before the experiment was carried out.

2.2. Characterisaction of carbide lime

X-ray fluorescence (XRF-1700, Shimadzu, Japan) was used to determine the content of metal oxides in carbide lime before reac-