Optimization of Soil pH by Using Calcium Carbonate ($CaCO_3$) Obtained from Seashell Waste

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Abstract

Calcium carbonate ($CaCO_3$) represents as a by-product from seashell waste. The synthesis of $CaCO_3$ from seashell waste basically can reduce the environmental burden around the seashore in terms of disposal issue. The $CaCO_3$ from seashell waste can be used to stabilize the soil pH when used as a liming agent. Therefore, this study aimed to determine the effect of $CaCO_3$ on soil pH. In this study, seashell wastes were used to obtain the $CaCO_3$ compound. The seashell wastes were washed by using household detergent and were crushed using a mortar and pestle to produce powder form. The powder then was analyzed using Fourier Transform Infrared Spectroscopy (FTIR), and Thermogravimetric analysis (TGA) to determine the presence of $CaCO_3$ in seashell waste. Then, soil samples were divided into portions and different amount of $CaCO_3$ from seashell wastes were added based on weight of soil. In this study, 10% to 50% by weights of $CaCO_3$ have been applied on each soil sample. This study found that 50% weight of $CaCO_3$ was the best amount of liming agent because it will stabilize the pH of soil about 7.16. Nevertheless, it should be noted that a comprehensive study is required for more evaluation on soil acidity and effectiveness of seashell waste.

Keyword: calcium carbonate, optimization, pH, seashell, soil

INTRODUCTION

Agricultural activities contribute to soil acidification. Indeed, since the industrialization; water, soil and air pollution by heavy metals or organic contaminants have been boosted up (Dhyèvre et al., 2014) which comes from the usage of large amount of agricultural fertilizer and pesticide (Zhang et al., 2012). According to Czinkota (2010), acidic soils that consumed low pH contribute to more problems in agriculture and influenced other soils component in both pest control and soil fertility. Thus, it is important to stabilize the soil condition in order to increase the plant growth.

Calcium carbonate ($CaCO_3$) is one of the basic inorganic and inexpensive materials that were applied in oil, paint, plastics and agricultural industries to stabilize the pH (Hait et al., 2012). About 95% of $CaCO_3$ can be obtained from shellfish and the rest is organic matter and other compounds (Hamester et al., 2012). Shell wastes are acceptable to prepare high purity $CaCO_3$ powder since it becomes the richest source of biogenic $CaCO_3$ (Lu et al., 2015). Reusing shell wastes might possibly reduce the issue of dumping unwanted or unused seashells, thus useful to maintain the soil pH (Barats et al., 2007; Lu et al., 2015).

Soil acidity might be recovered by liming activity to correct the soil pH up to the required levels for improving the crops growth. **Figure 1** indicated how $CaCO_3$ act as lime work in order to neutralize acidic soil. It shows that the acidity on the particles of soil surface have been neutralized as lime were applied on the soil. Calcium (Ca) will be transferred on the soil surface particles in order to replace the acidity of soil. Then, carbonate (CO_3) will take place and reacts with the acidity to form water and carbon dioxide (Anderson et al., 2013). Hence, the resulting soil become less acidic with higher pH value.

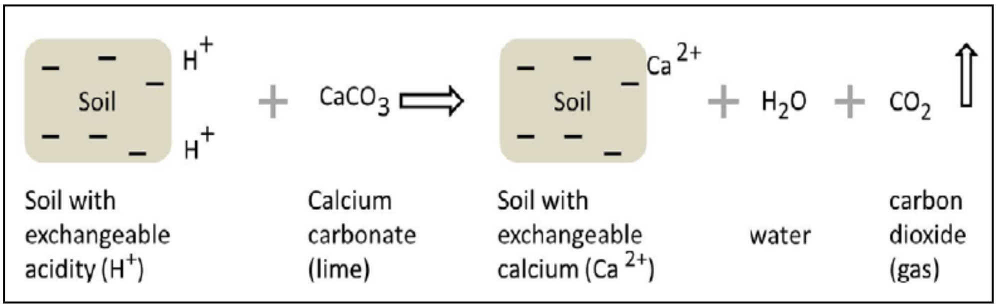

Figure 1 Mechanism of how $CaCO_3$ neutralize acidic soil modified from Anderson et al. (2013)

Thus, this study aimed to determine the effect of $CaCO_3$ on soil pH. Soil sampling site that was chosen for this study was soil samples at an agricultural area near UiTM Jengka as a pilot study.

MATERIALS AND METHODS

Soil Sampling and Preparation

Soil samples were collected from the humus horizon (0-20 cm) depth using a soil probe with a diameter of 5 cm. The sample were sieved with 2 mm sieve to remove unwanted things such as leaves, roots and stones. The collected soil samples were air dried at room temperature for 5 days. About 10g of sample was weighed by using analytical balance. Three replications were used for each treatment. Then, the soil was placed into a beaker with addition of 10 ml of 0.01M calcium chloride ($CaCl_2$) solution into each beaker. Test that has been carried out by using $CaCl_2$ considered more accurate than using distilled water, since it reflects what has been experienced by plant in the soil. The sample was mixed thoroughly and left for one hour at room temperature before the pH of each sample been taken.

Preparation of $CaCO_3$ powders

The shell wastes were obtained from commercial freshwater shellfish (*Anadara granosa*). Then the shells were washed thoroughly with household detergent, and crushed with a mortar and pestle followed by sieving through 180 µm sieve (Lu et al., 2015). About 0.001 g of powder was analyzed using Fourier Transform Infrared Spectroscopy (FTIR), and Thermogravimetric analysis (TGA) to determine the presence of $CaCO_3$ in seashell waste.

Determination the effect of $CaCO_3$ on soil pH

Five beakers that contain 10g each of soil samples were prepared. In this study, 10 to 50% weights of $CaCO_3$ from weight of soils have been applied on each soil samples. All the samples have been left for a week to allow $CaCO_3$ mixed well with each sample before the pH value was measured. Three replication of pH reading were taken to avoid cross contamination.

RESULTS AND DISCUSSION

Characterization of $CaCO_3$ from seashell waste

Development of $CaCO_3$ crystals was proved by FTIR spectroscopy as carbonate group display a strong vibration at 1,456 cm^{-1} (Ghadami & Idrees, 2013). The absorbance of IR spectrum was obtained at range 400 to 4000 cm^{-1}, by using typical 32 scanning and 4 cm^{-1} resolutions (Srivastava et al., 2015). Spectrum obtained from FTIR analysis had showed the presence peak of carbonate (CO_3) group at 1600 to 1400 cm^{-1} with a broad peak. The presence of CO_3 group was indicated by C-O stretching and proved that the $CaCO_3$ powder obtained from shell waste was calcium carbonate (Bharatham et al., 2014).

Comparisons between presences of $CaCO_3$ in this study with previous studies are shown in **Table 1**. IR spectrum in this study was slightly higher than previous study by Bharatham et al., (2014) and Hariharan et al., (2014). This may be due to the different types of seashell waste. They used the *Strombus canarium, Oliva sayana, Terebra dislocate* species of seashell waste while in this study used *Anadara granosa* species. Even though Hariharan et al., (2014) also used the Anadara granosa species same as in this study, the physical type was different which is in nano powder.

Table 1 Comparison of wavelength reading of FTIR with previous study

Species of seashell waste	**Wavelength reading (cm^{-1})**	**References**
Anadara granosa	1452.19	This study
Anadara granosa	1456.39	Hariharan et al., (2014)
Strombus canarium	1463.51	Bharatham et al., (2014)
Oliva sayana	1465.10	Bharatham et al., (2014)
Terebra dislocate	1465.30	Bharatham et al., (2014)

TGA (thermogravimetric analysis) is a thermal analysis method which had changes in chemical properties of materials and its physical properties were measured as a function of temperature increased with function of time or as a constant heating (Atifah et al., 2014). **Figure 2** shows the TGA thermogram of $CaCO_3$ from shell waste which illustrates one significant weight lost curve which occurred at 600 until 800◦C. The total weight loss of the sample was 39.85%. From the thermogram, it can be seen that the weight seemed to be constant when the temperature reach at 900°C and the sample that was left were recognized as ash (Mohamed et al., 2012).

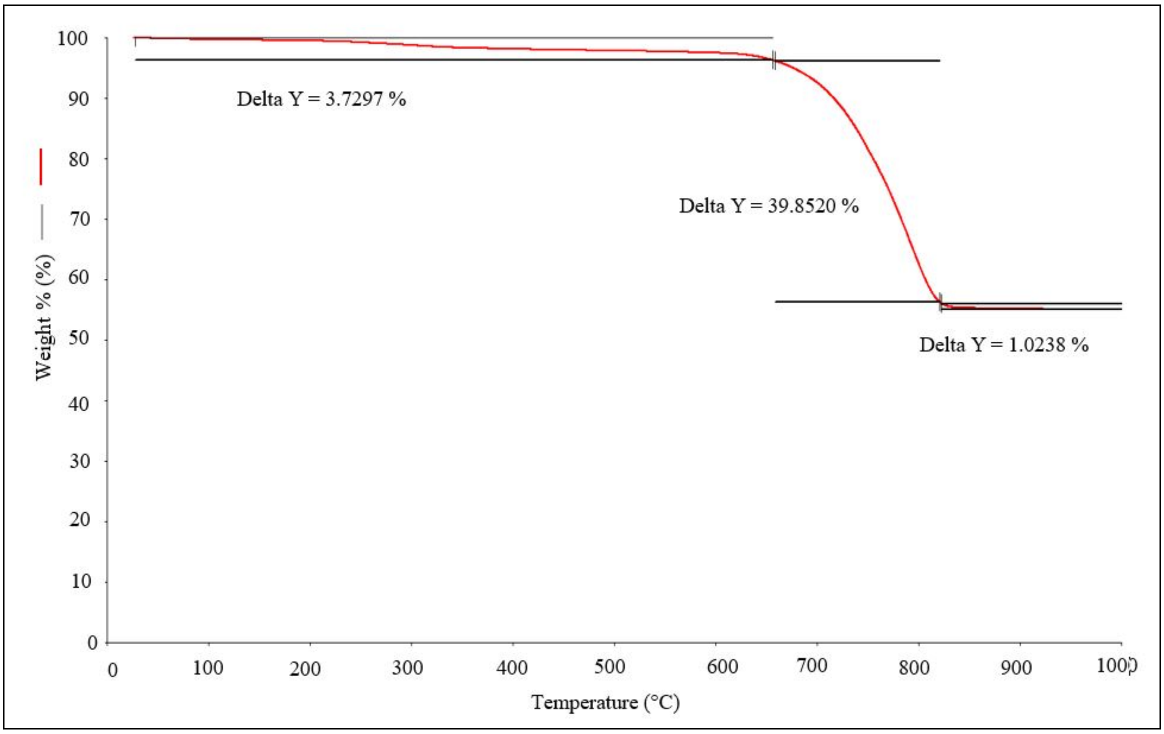

Figure 2 TGA thermogram of $CaCO_3$ from seashell waste

Determination the effect of $CaCO_3$ on soil pH

The effectiveness of $CaCO_3$ on soil pH has been observed by applying 10%, 20%, 30%, 40% and 50% of crushed $CaCO_3$ by weight of the soil on each samples. The expected soil pH of this study was to optimize the soil pH up to required pH level which is seven, means that the pH of soil need to be optimized from acidic soil to neutral or alkali soil. From the laboratory works, the increasing amount of $CaCO_3$ had given an effect on soil pH for each sample. From the observation, the amount of $CaCO_3$ that has been applied from 10% until 50% has shown some increases on the soil pH. The study only used 10 to 50% and not continue further because the pH reading at 50% showed the required pH reading which is about 7.16. Data for each samples collected were recorded in **Table 2**.

Table 2 Effect of $CaCO_3$ on Soil pH

Percentage weight of $CaCO_3$ added based on weight of soil (10g)	**Average reading of Soil pH**	
	Before added	**After added[a]**
10%	4.79	6.52 ± 0.02
20%	4.79	6.60 ± 0.01
30%	4.79	6.62 ± 0.01
40%	4.79	6.95 ± 0.01
50%	4.79	**7.16** ± 0.02

[a]Results represented in mean ± standard deviation (SD)

By comparing the five values percentage of $CaCO_3$, it showed that 50% weight of $CaCO_3$ was the best amount of liming agent since the pH reading reached seven (**Table 2**). It is important to achieve pH 7 for soil because mostly nutrients can be found in that pH and to ensure plant growth (Anderson et al., 2013). $CaCO_3$ can be used as a liming agent to optimize the soil pH (Barats et al., 2007) as it will help in reducing the acidity of soil and increase the alkalinity (Anderson et al., 2013).

CONCLUSION

Based on all the observations and results obtained, it can be concluded that $CaCO_3$ from seashell waste was effective to act as lime agent with the purpose to optimize the soil pH. This study found that 50% weight of $CaCO_3$ was the best amount of liming agent because it will stabilize the pH of soil about 7.16. Further study should focus on the evaluation of more soil properties, soil acidity and effectiveness of seashell waste in details.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

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