Application of Natural Dolomite for Soil Upgrading

Jakapan Pimolrat, Kreangkrai Maneinr*, Pinyo Meechumna
Carbon Capture, Storage and Utilization Research Group, Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand.

*Krengkrai.M@chula.ac.th

Abstract. Soil degradation is the conditions with low-soil quality. It can result in low fertility, in soil. To overcome this problem, soil-quality upgrading should be applied. For this study, the acidic soil from Nan, Thailand is used to upgrade the soil conditions to fit well with the agricultural activities by using natural dolomite as a waste from the industries. It is blended with the acidic soil in various ratios from 5-30 % by weight. The optimal conditions for various soil properties such as pH, electrical conductivity (EC), bulk density and soil texture are investigated. From the results, the higher amount of dolomite can improve the soil properties. Acidity is lowered from 4.832 to 6.047. Bulk density is decreased at 1.1114 g/cm³. Particle size distribution is sharply increased with the amount of dolomite. EC values are raised up to 4.25 dS/m. The natural dolomite can increase the soil quality from Nan province.

1. Introduction
Soil, the mixture of disintegrated rocks, organic matters, water, gas and some biological life forms, has been using for agricultural activities to serve foods for mankind [1]. However unwell management and improper usage of soil in the agriculture are greatly impact to its quality as can be affected as soil degradation which can decline crops productivity approximately 20% from 1998 - 2013 [2].

The soil degradation is definite that the decline of soil properties in term of physical, chemical and biological properties. In physical of soil, reducing pore structure as compaction, soil erosion on top layer soil and laterization on ironic soil are alarmed for decreasing of volume of water in the soil [3]. Lacking fertilizer is the major cause in chemical soil property along with soil pH as acidity and alkalinity and also the high rate leaching of cation [4]. The decline of biological property can be described in lowering rate of humus in soil. To reduce the soil degradation rate, the soil amendment should be applied to improve all soil conditions by adding some nutrient organic and inorganic matters [5].

Thailand, agricultural country, has been also facing the soil problems which pull down soil productivity on crops plant [6]. The main land using type in Thailand is 53.69% for rural [7] and 26% of total area in Thailand requires treatment immediately to be maintained sustainable production [8].

In this study, soil from Nan, Thailand is collected from agricultural area. Its characteristic tends to be unacceptable in growing crops as it is moderately acidic, very silt texture, high bulk density. Upgrading the soil by blending natural dolomite in various ratios would regain suitable soil conditions for sustainable usage in agriculture.
2. Methodology

2.1. Sample preparation
The acidic soil and natural dolomite were dried at 115 °C for 12 hours to remove moisture then the soil was screened by sieve no. 10 (2000 µm) to remove the coarse size. The passed sieve no. 10 soil was mixed by natural dolomite in 5, 10, 15, 20, 25 and 30 percentage by weight.

2.2. pH measurement
The soil, natural dolomite and blended samples were selected by 10 g Adding 25 ml distilled water and sample in the 50 ml beaker and stirred for 5 minutes then leave for 10 minutes for settling the samples.
Firstly the pH meter, Benchtop pH/Water Quality Analyzer LAQUA F-74, must be calibrated with buffer pH 7 and 4 respectively. After that all samples were measured for 3 times each.

2.3. Electrical conductivity (EC) measurement
The 10 g of dried soil, natural dolomite and blended samples were diluted with 50 ml distilled water into 100 ml beaker then stirred for 30 minutes and allowed the settling for 30 minutes. Afterward the settling samples were poured top layer liquid into the new beaker.
Calibrating Benchtop pH/Water Quality Analyzer LAQUA F-7, electrical conductivity with std. 0.01 N KCl then measured the samples for 3 times.

2.4. Specific gravity and particle density measurement
The 100 ml cylinder was filled by 50 ml distilled water. 20 g dried sample was added into the cylinder and the different of volume was measured. This different was replaced in formula as mentioned below.

\[
\text{Specific gravity (g/cm}^3\text{)} = \frac{\text{Weight of sample (g)}}{\text{Water volume changed (cm}^3\text{)}}
\]

More over the particle density could be calculated by using the above information and substituted into below formula.

\[
\text{Particle density} = \frac{\text{Dry weight of soil (g)}}{\text{weight of soil + water (g) – weight of soil (g)}}
\]

2.5. Bulk density measurement and soil porosity
The cylinder with diameter 5.94 cm and height 5.87 cm was used for this measurement. The 200 g dried samples were packed into the cylinder. The packable amount of each sample was taken out and measured its weight. The weight was calculated by following formula.

\[
\text{Bulk density (g/cm}^3\text{)} = \frac{\text{oven dry weight of soil in cylinder (g)}}{\text{Volume of cylinder (cm}^3\text{)}}
\]

\[
\text{Soil porosity} = 1 - \frac{\text{bulk density (g/cm}^3\text{)}}{\text{sample’s particle density (g/cm}^3\text{)}}
\]

2.6. Particle size distribution analysis
40g Sodium hexametaphosphate 68% is diluted with 1,000 ml distilled water as a dispersion agent. The sample is placed into 500 ml beaker, add 125 ml dispersion agent and distilled water then soak it for 16 hours. Next, sample is poured to 1,000 ml cylinder then apply distilled water to reach 1,000 ml volume. Cover the cylinder with film and shake it for 1 min. The hydrometer in 0.995 – 1.038 in 0.001 divisions at 68 °F (20 °C) is used in order to measure the specific gravity of water, dropped gently into cylinder to detect the specific gravity at time 0, 1, 2, 5, 10, 15, 30, 60, 120, 250, 420 and 1,440 minutes, respectively. Meanwhile the temperature of water is measured in the same time.
For the next step, the sample is analyzed the coarse size by wet sieve in 10 (2,000 µm), 40 (400 µm), 80 (177 µm), 120 (125 µm) and 200 mesh (74 µm). All retained samples are dried in oven with
115 °C and measured the weight. All the obtained data has been replaced in the following formulas in order to find out size and cumulative percentage of passing of particle.

3. Results and discussion
According to the figure 1, the increasing of bulk density depends on among of natural dolomite blended in samples. There is 1.2119 g/cm³ from original soil into 1.114 g/cm³ on 30% dolomite which is requirement for ideal bulk density of plants growth [9]. It can represent that the higher volume of natural dolomite could raise slightly space for some water and gas in the soil. This evidence is also supported by higher volume of porosity in Figure 2.

In soil texture, 50% size distribution of particle (d50) in original soil is around 12. The trend of size distribution of particle seems to dramatically grow for high ratio of dolomite, there are 82, 94, 97, 110, 130 and 200 µm for 5, 10, 15, 20, 25 and 30% dolomite respectively. As the result, the increasing of grain size from silt loam to sandy loam can reflect the better drainage management in soil.

![Figure 1. Bulk density of samples in percentage.](image1)

![Figure 2. Porosity in samples.](image2)
As can be seen from figure 3, the acidity of original soil has been solved. The sample which has removed freely cation from uptaking and harvesting, resulted as acidic soil can be reduced acidity by dolomite. The chemical reaction of adding dolomite can create $\text{Ca}^{2+}$ and $\text{Mg}^{2+}$ to reach soil health standard. pH of samples has moved from pH 4 in acidic zone into 6.0487 for the highest ratio of dolomite. The blended sample is optimising suitable pH for crop growth in Thailand which is required pH 5.5-7.0 [10].

The electrical conductivity can represent to salinity of soil. All samples significantly increase EC especially 30% dolomite which is 4.25 dS/m as shown in figure 4. However, the significantly increasing of EC seems to damage the plants growth. Over 2.00 dS/m EC can reduce potato crops yield for 20% [11] and also over 7.00 dS/m extremely affects for all crops growth [12].

4. Conclusion
To upgrading the acidic soil from Nan, Thailand, blending natural dolomite can resolve the soil degradation in term of both physical and chemical properties. The high among of dolomite blending into the soil could recover the soil to gain capacity of air and water containing from higher porosity and improving soil aggregation, pH problem moreover has been adjusted for suitable with many type of crops. However raising ratio of dolomite can turn the soil to be salty which may need other soil amendments combined to reach the best solution.
Acknowledgments
The authors would like to acknowledge the Malaysia-Thailand Joint Authority (MTJA) for financial support of this project.

References
[1] Richard Y, Stefano O and Ian F 2015 Soil Degradation: A Major Threat to Humanity 1
[2] United Nations Development Programme 2019 Combatting Land Degradation Securing A Sustainable Future 1
[3] Pagliai M and Vignozzi N 2003 The Soil Pore System as an Indicator of Soil Quality Available from: https://www.semanticscholar.org/paper/The-Soil-Pore-System-as-an-Indicator-of-Soil-Pagliai-Vignozzi/81a867b7dbe23b8c08eb7d778b3515a5377a364c
[4] McCauley A, Jones C and Olson-Rutz K 2017 Nutrient Management Module 8 1
[5] Clements D P and Bihn E A 2019 Safety and Practice for Organic Foods 321
[6] Tonmanee T and Kanchanakool N 1999 Water Science & Technology 39 61
[7] Land Development Department of Thailand Land 2012 Use Types of Thailand in 2009-2012 Available from: http://www.ldd.go.th/ldd_en/en-US/land-use-types-of-thailand-in-2009-2012/
[8] Moncharoen P, Vearasilp T and Eswaran H 2001 Sustainable for Global Farm 179
[9] Cliffie W, Sagona J, Kachala O, Matete S and Jenya H 2016 Universal Journal of Agricultural Research 4 155
[10] Food and Agriculture Organization of the United Nations 2017 Final Report National Agro-Economic Zoning for Major Crops in Thailand (NAEZ) (Project TCP/THA/3403) NAEZ Model Implementation and Results 41
[11] Reis Jr R A, Fontes P C R, Neves J C L and Santos N T 1999 Science Agricola 56 993
[12] Maas E V and Hoffman G J 1997 Journal of the Irrigation and Drainage Division 103 115