Natural Silt as the Alternative of Fertilizers in Agriculture

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Abstract

Many studies have addressed on various agriculture management measures to reduce chemical uses in plant. However, the main objective of this study was to analyse the minerals that contain in the silt and fertilizer. It is to observe the ability of silt as an alternative of fertilizer that can be used in agriculture which can reduce environmental impact. In addition, silt soil is enriched with organic matter, macronutrients, micronutrients, nitrogen and phosphorus which have potential as fertilizer supplements to stimulate the plant which can improve plant nutrients. This issues was investigated in two differently methods which are using Fourier Transform Infrared Spectrometer (FTIR) and Inductively Coupled Plasma (ICP) to observe chemical properties and minerals that contain in the silt. The results illustrate that silt have a potential to be an alternative for fertilizer in plants. Through the pH analysis, the silt is acidic and not suitable to be an alternative of fertilizer as the difference between the findings for pH of the silt is quite far from fertilizer. The silt can through a modification by adding lime in order to reduce soil acidity that will increase the pH level of silt. The silt also contain high concentration of potassium which is suitable for agriculture soil that are needed by most plant to growth. The absent of lead which is type of heavy metal in the silt indicates that the silt also suitable to become an agriculture soil. To conclude, the silt have a potential to be an alternative of fertilizer in the agriculture.

Keywords: agriculture uses, loess, silt, soil nitrogen

1. Introduction

In agriculture, essential nutrients are needed in growing process for plants. There are two categories of nutrients which are macronutrient and micronutrient. Macronutrient is element that relatively large amount in fertilizer such as potassium (K), phosphorus (P) and nitrogen (N) (Cole et al, 2016). Potassium is very important for plant to increase photosynthesis, activates enzymes and controls their reaction rates and improve the plant quality (Prajapati & Modi, 2012). Phosphorus involved in photosynthesis, increases the plant height under certain condition, respirations, energy storage and transfer, cell division and cell enlargement and also for improves quality of fruits, vegetables and grains. Nitrogen is the most important nutrient that absorbed by most plant (Cheng 2014). Nitrogen being used for increasing the crop yield of plant and also increase the quality of the plant. Nitrogen not only increases the crop yield but also increase the quality of the food. Those nutrients have a big role for plants growth which is easy to obtain in fertilizers.

Micronutrient is element that required only small amount in fertilizer (Cole et al, 2016).Excessive of micronutrient will cause problem of soil fertility exhaustion (Govindaraj, Kannan & Arunachalam, 2011). The higher concentration of micronutrients will give the acidic pH value (Eskandari, 2011). So that, the required concentration of micronutrient needed only small amount to maintain the pH value near to neutral. Micronutrients mostly available when pH value is below 7 (Cole et al., 2016) The examples of micronutrients are iron (Fe), zinc (Zn) and manganese (Mn) (Eskandari, 2011). The required amount that needed of micronutrients for 1 bushel of corn is about 0.2 pounds for iron (Fe) about trace (small amount detected) for zinc (Zn) and about 0.03 pounds for manganese (Mn)

Fertilizer is commonly used in agriculture as a medium that provide nutrient needed for the plant. The production and application of fertilizers has reducing the hunger worldwide in the world. Fertilizer is divided into two categorize which are natural fertilizer and synthetic fertilizer. The natural fertilizer is materials that derived from plant and animal parts of residues such as compost, worm-castings and manure.

The organic material inside the organic fertilizer basically gives the benefits for the plant, soil and also for the environment (Massri & Labban, 2014). The synthetic fertilizer is 'man-made' organic compound that derived from by-products of the petroleum industry ammonium nitrate, ammonium phosphate and potassium sulfate (Mercy, Mubsira Banu & Jenifer, 2014). Synthetics fertilizer also familiar as natural fertilizer which human used for modern agriculture which increased the crop yield, easy to use and easy to obtain at store but it have long term of negative effect that turn the dead human and plant into nutrient-rich organic matter (Lu & Tian, 2013). Synthetic fertilizer also can cause groundwater more toxicity and the decreasing of the soil quality and also give harmful effect towards the soil organisms because of the chemical that been used inside the synthetic fertilizer (Rai, Ashiya & Rathore, 2014). Most of fertilizers are expensive and most of the predominantly poor areas are unable to buy fertilizer.

As the alternative of the fertilizers in agriculture, silt or also known as sediment can be used in agriculture. It is naturally can get from the soil and it also eco-friendly that are not cause a pollution to environment. Silt is one mineral components of soil which is a sedimentary material be made up of very delicate particles intermediates in size between sand and clay. The particle size of silt is about 0.002 until 0.05 mm (Al-hamed et al., 2014). Silt may occur in a body of water of lakes, wetlands and harbor. Silt will be formed at the bottom of the pond because the accumulating of organic matter (OM) that comes from the green and animal manures in the large amount (Mizannur, Yakupitiyage & Ranamukhaarachchi, 2004). The fact that silt is closely packed together makes it easier to keep nutrients and moisture in place for long period of time which are not easier to dry. The tightly packed of soil prevents water from leaving it when it is used for plants. This lead to rich number of nutrient such as nitrogen (N), phosphorus (P), and potassium (K). This three nutrients are the nutrient that have inside the fertilizer (Mizanur, Yakupitiyage & Ranamukhaarachchi, 2004).

Based on the previous study, Rita M. F Fonseca (year) stated in her study that the silt or sediment have a neutral or near neutral value of pH which in range 5.5 to 7.2. The range of pH value is most advantageous for availability of the nutrients that needed by plant. Rita M. F. Fonseca also stated in her study that the organic matter which is Nitrogen and also Potassium have high level in her sediment sample. Basically, acid pH of sediment is not appropriate for the solubilization of phosphorus (Fonseca, Barriga & Fyfe, 2003). When the pH value is more acidic, the value of iron (Fe) and also zinc (Zn) are also higher while when the pH value is more to neutral, the value of iron (Fe) and also zinc (Zn) will decrease (Fonseca, Barriga & Fyfe 2003).

Thus, the main objective of the study was to identify the elements inside the silt such as macronutrients and micronutrients. Other than that, to substitute natural silt as an alternative way to substitute the chemical fertilizer used in agriculture that could cause environmental pollution and human health damage (Trujillo-Tapia & Ramirez-Fuentes, 2015).

2. Methodology

2.1 Pre-Treatment

A bulk of raw silt was mixed with water then the mixture was poured into a container. The method of oven drying was adopted for this analysis. The mixture was prepared for analysis by drying in an oven for approximately 47 hours and 45 minutes at the temperature of 90°C (O'Kelly, 2005). The dry silt medium was crushed into smaller pieces using pestle and mortar to facilitate the sieving process. The shredded silt was sieved using 63 μm sieve. The refined silt then was stored for further process.

2.2 pH Analysis

The pH analysis was conducted to determine the pH value of the silt sample. The silt sample need to be diluted with distilled water because the pH meter can only detect a reading of the silt sample in liquid state. 20g of silt was weighted and placed inside a 100 ml beaker. 40 ml of distilled water was added into the beaker and stirred well with a glass rod (Virtual Amrita Laboratories, 2013). The electrode of the pH meter was taken out from its storage solution and was rinsed with distilled water. Before being used,the pH meter need to be calibrated with pH 4 and pH 7 buffer solutions. After the calibration was done, the electrode was dipped into the silt solution and reading of the sample was identified. The pH value of the silt was recorded.

2.3 Fourier Transform Infrared Spectrometer (FTIR) Analysis

FTIR was used to identify the organic matter and minerals contain inside the silt (Raphael, 2011). The result of the FTIR was in a graph that has a peek. Every peek show the different organic matter based on the range of the wavelength.

2.4 Inductively Coupled Plasma (ICP-OES) Analysis

2.4.1 Preparation of standard solution

The standard solution of potassium was prepared using 1000ppm stock potassium solution. From the stock solution of 1000ppm,100ppm of potassium was prepared through dilution with distilled water (Gaudino et al., 2007). The same procedures are repeated to produce 1 ppm,0.8ppm.0.6ppm.0.4ppm and 0.2ppm standard solutions of potassium. The multi – elements standard solution was prepared the same.

Dilution formula:

$$M_1V_1 = M_2V_2$$

2.4.2 Digestion method

Open vessel and hot plate procedure was introduced. A test portion of silt about 0.1 g was weighted using electronic balance. The weighted silt was digested with 3ml of nitric acid and 2 ml of hydrofluoric acid in an open beaker and heated at 150 °C using a hot plate for 15 minute (Rm & Technologies, 2011).The sample was allowed to stand for several minutes before being filtered to remove any impurities for the ease of ICP analysis. Finally, the sample was diluted with distilled water to 100ml.

3. Results and discussion

3.1 pH analysis

PH value was analysed using Eutech Instruments. Result for the analysis is presented in Table 1. Yash P Kalra (1995) state that generally, if the suspension of silt is more diluted, the pH value of silt will be higher. The main silt pH reflects whether silt is acidic, neutral, basic or alkaline. The acidity, neutrality or alkalinity of silt is measured in terms of hydrogen ion activity of the silt water system. The negative logarithm of the H ion activity is called pH and thus pH of silt is a measure of only the intensity of activity and not the amount of the acid present. The pH of silt tends to increase as the sample is diluted with water. Such pH changes may be caused by variables such as carbon dioxide partial pressure, salt concentration, hydrolysis, and solubility of silt constituents.

Table 1 the comparison between pH value in the silt and fertilizer

	Silt	Silt (Rita M. F. Fonseca, 2003)	Soil (McCauley, Jones & Olson-Rutz, 2017)
pH value	4.41	5.5-7.2	6.5-8

Based on Table 1, it can be concluded that this silt is not suitable to be an alternative for fertilizer as the difference between the findings for pH of the silt is quite far from fertilizer. In order for the silt to be acknowledged as fertilizer is through modification. If the pH level contains high alkaline, lowering its alkalinity level is possible with the help of Ammonium Sulphate and organic materials to lower the pH level of silt. In this study, it is proved that the pH value of the silt is below than 6 which is more acidic. Therefore, the modification that can be made for the silt is by adding lime in order to reduce soil acidity that will increase the pH level of silt.

3.2 FTIR analysis

Organic matter is being measured by using Fourier Transform Infrared (FTIR). Basically, the silt undergoes FTIR analysis to find out organic matter that contain in silt. Based on the result of FTIR analysis that is recorded in figure 1, it is show that every peak of the graph will have the organic matter that being traced as stated in Table 2.

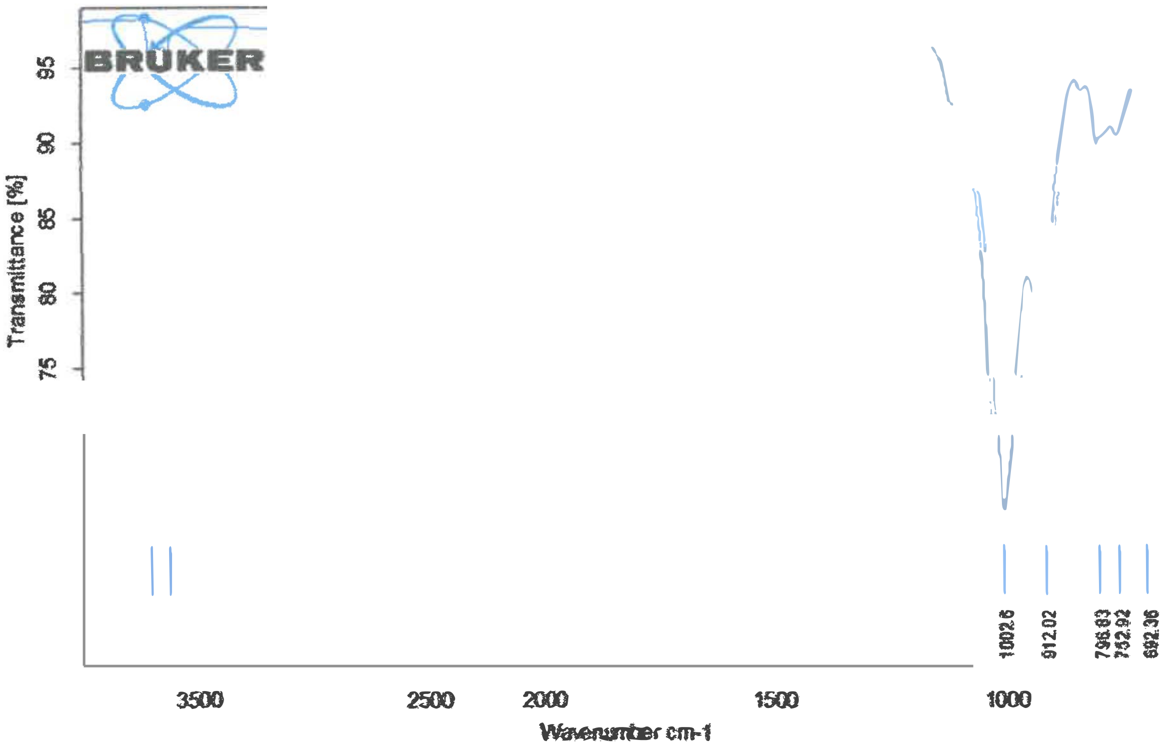

Fig 1. Result of FTIR analysis

Table 2. The current study reported in the literature and proposed assignment

Peak position (cm^{-1})		Proposed assignment
Current study	Literature	
3696.58 – 3621.07	3698 - 3622	Stretching of O-H bond in kaolinite
1002.62	1100 - 1000	Vibrations associated with phosphate groups $PO^{3/4-}$
912.02	915	Fundamental vibrations in ilite
796.83	800 - 795	Symmetric Si – O stretching in quartz
752.92	800 - 666	Out – of – plane NH wagging in amides
692.36	900 - 675	Out – of – bending of the aromatic ring C – H bonds

(Parolo, Savini & Loewy, 2017)

Based on the result, the first peaks correspond to OH groups of mineral structure (3696.58 to 3621.07 cm^{-1}). Next peak is correspond to vibration of phosphate group (1002.62 cm^{-1}) while there a peak that correspond to vibration in ilite and also correspond to stretching of Si-O which the wavelength is (912.02 cm^{-1}) and (796.83 cm^{-1}) respectively. Last two peaks are correspond to NH wagging and also CH bond which the wavelength are (752.92 cm^{-1}) and (692.36 cm^{-1}) respectively.

Basically, all the organic compounds that contain in the silt are also effect by the sources of the silt sample. The silt was gained from a pond. So, the silt may contain the OH bond from the water inside the pond while for the phosphate element is came from nearby farm which also contain nitrogen, phosphorus and potassium element.

3.3 Silt chemical characterization via ICP-OES analysis

Table 3. Experimental value and its element

Element	Measured experimental value (mg/L)
Potassium	157.3
Iron	22.32
Zinc	-0.047
Lead	-0.014

From the figure 2, it was found out that the trace element, zinc is probably absent in the silt. Potassium has the highest concentration among all elements and followed with iron. Meanwhile, lead which is a type of heavy metal was found absent in the silt as well. potassium is a vital macronutrient in plant for controlling the closing and opening of stomata as well as regulation of water in the plant (Amtmann & Rubio, 2012). The amount of potassium needed varies according to different plants. The average potassium concentration in plants should be around 81 to 120 mg/L (Kaiser & Rosen, 2016). The concentration of potassium in this silt sample is 157.3 mg/L and it is located in the high range area when compared to average concentration of potassium in soil which should be around 81 to 120mg/L (Kaiser & Rosen, 2016).

Modification need to be done which is the addition of calcium to balance out the silt. Besides, rocks presence in the silt need to be removed because minerals occurring in the rocks such as mica could slowly release potassium into the silt through weathering. Potassium deficiency in plant can contribute to substantial reduction in growth. Besides from reduction in growth, potassium deficiency will also affect the leaves where the leaves tips will start to curl up (Bradley & Hosier, 1999) as well as the presence of purple spots on the undersides of the leaves. The presence of trace element iron in the silt is crucial in plant for the production of chlorophyll which promotes the healthy green colour of the leaves (Rout & Sahoo, 2015). Iron deficiency can lead to a serious effect in plant which is known as chlorosis that will turn the leaves colour from green to yellow.

Apart from that, the absent of heavy metal in the silt indicates that the silt is also suitable to become an agricultural soil. Lead(Pb) is a toxic element to plant because lead can prohibits the growth of root due to the inhibition of cell division at the root tip (Fahr et al., 2013). Excessive uptake of lead by plant can contribute to the loss or reduction of root length especially to plants that are still growing. Zinc on the other hand is another important micronutrient that is needed by plants to play an important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome (Hafeez, Khanif, & Saleem, 2013). The deficiency of these micronutrients will lead to stunting of growth, interveinal chlorosis, brown spots on upper leaves and distorted leaves.