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CHARACTERIZATION OF WASTE POND SILT AS AN ALTERNATIVE FOR PLANTING MEDIA

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Abstract

In planting, top soil is commonly used as a vital component of planting media. However, the price is quite high in the market due to its potential and good demand. Waste of silt soil with zero cost is highly potential to replace the top soil due to its natural composition and properties. In this study, silt soil is being characterized to determine its potential as alternative of planting medium. Three types of soil (silt, top soil and clay) were used to compare their composition and real top soil was taken as comparative reference. The samples were taken to evaluate pH analysis, FT-IR analysis, Elemental Analyzer and ICP-OES analysis. Silt has pH of 6.58 while top soil and clay are 6.57 and 6.58 respectively. Silt, top soil and clay have functional groups such as stretching of O-H in several groups, vibrations associated with several groups and out-of-plane with some groups. Silt, top soil and clay have carbon percentage of 0.84%, 1.38%, 0.17%, hydrogen percentage of 1.09%, 1.74%, 1.35%, nitrogen percentage of 0.39%, 0.63%, 0.52% respectively while sulphur percentage only contains in silt which is 2.40%. Silt, top soil and clay were also found to have metal elements such as K, V, Cr, Mn and Zn. Therefore, the similarities on important properties between silt and top soil have become paramount indication that waste pond silt has potential to become an alternative soil for planting media especially in agriculture activity.

Keywords: Silt, Characterization, Planting Medium, Clay, Topsoil

1.0 INTRODUCTION

Plants need a few basic things to grow, commonly water, sunlight, air, nutrients and soil. A plant is always looking for the balance of these elements. Usually out there in the wild, plants have evolved over thousands of years to find the perfect balance. Soil is one of the most important elements in planting and soil can be derived into several types such as topsoil and silt. Organisms living in soil such as earthworms and fungi help provide additional nutrients to plants and these nutrients are absorbed through the roots and produced healthy root system. The plant is generally healthier and able to repel against pathogens and if the plant has healthy soil, roots will be healthier and the plant's immune system will be stronger. In order to give the best medium for planting, top soil was being used as medium for replacing the common soil.

Top soil is usually seen as dark colored and lush where plants root themselves and they are the top two to seven inches of soil that contains microorganisms and great number of organic matter content. Top soil is made up of carbon and nitrogen, microbes and larger creatures such as worms, beetles and insects and organic matters that are left from plant roots, stems and leaves that decompose. Top soil contains several concentrations of nutrients such as potassium, phosphorus and iron and varies towards top soil with other geographic region and climate as well as human activity. Top soil provides nutrients to growing plants because this region of soil does the main biological nutrients cycling, providing the needed carbon and nitrogen molecules for plants to grow healthy.

There is presence of nitrogen (N), phosphorus (P) and potassium (K) which is very important to the plant and this usually comes from the ground such as silt, clay and top soil. Nitrogen is used by plants mainly for leaf growth and good green colour. Besides that, phosphorus is used by plants to help for new roots, make seeds, fruits, as well as flowers. It is also used to help fight diseases so that plant does not wilt. Then, potassium can help plant in producing strong stems and keep the plant growing fast and it also fights diseases. However, limited of and excessive of nitrogen in plants will likely increase the presence of pathogen and severity as plants will have to take nitrogen from their own cells causing the plant to be weak and unable to mount an adequate defence. Besides that, deficiency of phosphorus can reduce root development, weakening a plant and leaving it vulnerable to biotic and abiotic stressors in certain plants such as rice (Oryzasativa L.), bean (Phaseolus spp.), corn, soybean (Glycine max L.), and wheat (Triticum spp.). High levels of P in soil also have been associated with increases in some foliar diseases. Then, too much Potassium can be detrimental to crop yield and should be balanced with proper rates of N and P fertilization [1].

Conventional planting refers to farming which includes the use of synthetic chemical fertilizers, pesticides. Conventional planting is usually highly resource and energy intensive, but very productive in planting. It usually will cause environmental burden, health risk, and will produce plant with fewer nutrition. In India, studies show that soil was used for agricultural purposes and it gave good outcome which is planting using clay. Clay is a good planting medium because it can retain moisture because it can maximize the efficiency of water supply.

Silt is an intermediate in size and contains chemical and physical properties between clay and sand. Silt particles have limited ability to retain plant nutrients, or to release them to the soil solution for plant intake. Silt usually has soapy or slippery feeling when rubbed between fingers when wet and it also has the ability to retain a large amount of water. It is considered very fertile for growth of plant, largely due to their water characteristics and ease of cultivation. It usually has the size range of 0.002 to 0.05mm and has surface area of 2,100 and it is only visible in electron microscope [2].

Most of the soil waste in construction area, will be dumped and cause environmental impacts. Therefore, the objective of this study is to evaluate the characterization of waste pond silt as a potential of planting medium to replace the top soil. Lastly, there is a continuing interest in using various agricultural by products as an organic nutrient source for plants due to rising consciousness of environmental issues, including the need to manage and make use of increasing quantities of waste [3].

2.0 EXPERIMENTAL

2.1 Sample Preparation

The sample of top soil and silt are obtained from the plantation site located in Gelang Patah, Johor, meanwhile clay was obtained from Perak. All the samples were washed and dried into the oven at 105°C for 24 hours and cooled at the room temperature. After that all the samples were crushed using a grinder, then were sieved to 250 μm particle sizes and stored in a closed container.

2.2 pH Determination

About 20 g of the three soils samples were weighed and mixed with water to prepare the ground water. These samples then, were immersed into pH meter to determine their pH solution.

2.3 Characterization for Fourier Transform Infra-Red (FT-IR) Analysis

FT-IR Spectroscopy was analysed on a Bruker Vertex, 70. About 0.1 g from each sample were used for FT-IR analysis. The FTIR spectra was recorded and scans at resolution of 4 cm^{-1} and within a spectral range of 4000-400 cm^{-1}. All the samples were observed on the graph of transmittance against wave number to determine the functional group of the sample. The analysis was performed in a room temperature and the same condition for all samples.

2.4 Elemental Analysis

The elements that presented in the soils were determine by subjected the three samples into Elemental Analyzer. About 0.1 g of these three samples were taken and run into Elemental Analyzer Perkin Elmer, 2400 Series III, to detect the element of nitrogen, sulphur, oxygen, hydrogen and carbon that existed in the samples.

2.5 Inductive Coupled Plasma (ICP-OES) Analysis

0.1 g samples of top soil, silt and clay were digested respectively in an open vessel digestion with concentrated acids: HNO_3 + HF with the ratio of 3:2 and heated at 150°C. After the digestion process, each digest was transferred quantitatively with pure water to a 100 mL volumetric flask. These solutions were analysed by ICP-MS Perkin Elmer, DSC6000 model after corresponding dilution using external calibration standard. The heavy metals such as Phosphorus, Potassium, V, Cr, Mn, Co, Ni, Zn, Pb, U in soils were determined by this technique [4].

3.0 RESULTS AND DISCUSSION

3.1 pH Analysis

Table 1. pH analysis

Type of Soils	pH
Silt	6.58
Top Soil	6.57
Clay	6.58

This analysis was conducted to determine the pH of all the samples. From the data, all types of samples which are silt, top soil and clay pH is nearly to the neutral. The sample pH in the range of 6.57-6.58 are common pH for plant and are the best for most crop [5]. Silt has a closest value to the neutral pH which is 7 than the reference soil, top soil. It also determines that silt can be a planting medium and suitable for agriculture. Fruits and vegetables such as melon, corn, onion, spinach and many more can be implemented with this kind of pH soils [6]. In India, silt is proven that it can be an alternative to planting medium [7]. Soil with silt give a huge impact in a production of cotton, chillies and turmeric by increasing the result of products.

3.2 FT-IR Analysis

Soil analysis by FT-IR was performed to characterize soils and study the chemistry of the organic matter (Parolo et al., 2017). Fig.1 shows the FT-IR spectra corresponding to silt, clay and topsoil.

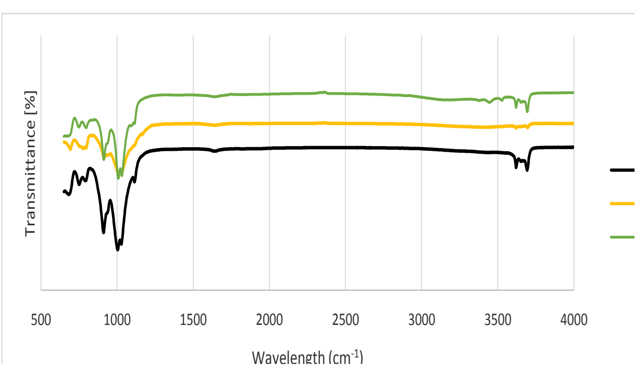

Fig. 1. FTIR spectrum of soil

The absorption bands observed resembles the main organic and inorganic components and are persistent with those reported previously from other journals. Table 2 shows functional group allocations for the absorption bands observed in the spectra of this study and those reported in the literature [8]. The position of each peak remained within the expected for all analysed samples.

Table 2. Band positions in the FT-IR spectra was observed in the current study and reported in the literature, and proposed assignment

Peak position (cm^{-1})

Current study			Literature	Proposed Assignment*
Top Soil	Silt	Clay		
3693-3620	3695-3620	3692-3620	3698-3618	Stretching of 0-H bond in kaolinite
3526-3446			3600-3400	Stretching of O-H bond in water, carbonyl and hydroxyl group
	1163-1030	1114	1300-1100	In-plane bending of the aromatic ring C-H bonds; the C-O stretching vibration in alcohols, ethers, phenols, carboxylic acids and ester; stretching of C-O in polysaccharides; C-n stretching vibrations in aliphatic and aromatic amines
1007	1030-1007	1003	1100-1000	Vibrations associated with phosphate groups [PO3-]
912	937-912	910	915	Fundamental vibrations in illite
673	777-692	750-682	900-675	Out-of-plane bending of the aromatic ring C-H bonds
796	796-777	750	800-775	Symmetric Si-O stretching in quartz
796-748	796-692	769-750	800-666	Out-of-plane NH wagging in amides
796-673	796-692	769-682	900-675	Out-of-plane bending of the aromatic rings C-H bonds

*source from [8]

Topsoil was chosen as reference for the analysis of this research and was found that bands identified in the spectra correspond to the –OH groups of clay mineral structure (3693-3620 cm^{-1}), hydration water and the oxygenated groups of organic matter (3526-3375 cm^{-1}), stretching of Si-O in kaolinite present at band of 1030 cm^{-1}, vibrations associated with phosphate groups [PO^{3-}) corresponds at band 1007 cm^{-1}. Besides that, there are also fundamental vibrations inflate present at band 912 cm^{-1} and symmetric Si-O stretching in quartz at band 796 cm^{-1}. Then, it is showed that there is out-of-plane bending of aromatic ring C-H bonds at band 692 cm^{-1}.

Silt also corresponds to the –OH groups of clay minerals structure (3695-3620 cm^{-1}) and found in-plane bending of the aromatic ring C-H bonds (1163-1030 cm^{-1}). In addition, it is found that vibration associated with phosphate group [PO^{3-}] and traces of out-of-plane bending of aromatic rings C-H bonds like top soil with band of 673 cm^{-1}. Clay also corresponds to the –OH groups of clay minerals structure similar as top soil and silt (3692-3620 cm^{-1}) and detected vibrations associated with phosphate group [PO^{3-}] and the same with top soil and silt. Furthermore, it is found that there is in-plane bending of the aromatic ring C-H bonds (1114 cm^{-1}) and there is stretching of Si-O in kaolinite (1027 cm^{-1}).

Band intensity shows the quantity of functional groups responsible for IR absorption for each frequency. The analysis of these intensities reflects the physicochemical composition of these soils [8]. Among all the soils, silt presented the greatest intensity for bands at 3695-3620 cm^{-1} which shows the –OH groups of clay minerals are high.

3.3 Elemental Analysis

Table 3. Percentage of Carbon, Hydrogen, Nitrogen and Sulphur percentage present in the soil.

Soil Type	%C	%H	%N	%S
Topsoil	1.38	1.74	0.63	0.00
Silt	0.84	1.09	0.39	2.40
Clay	0.17	1.35	0.52	0.00

Topsoil, silt and clay was digested and prepared for elemental analysis to determine the composition of non-metal element as Carbon, Hydrogen, Nitrogen and Sulphur mainly. Non-metal also plays a big role in the planting medium. Table 3 shows the elements existed in the silt, topsoil and clay. Carbon percentage of top soil is the highest which is 1.38% and silt also has high carbon percentage which is 0.84% compared to clay which has the least carbon percentage at 0.17%. Besides that, top soil, silt and clay have hydrogen percentage with slight difference with the least number of hydrogen percentage is silt. Topsoil has the highest hydrogen percentage which is 1.74% and silt shows the least hydrogen percentage at 1.09%. Then, Nitrogen percentage present in topsoil, silt and clay also have only a slight difference and top soil also shows the highest percentage at 0.63% while silt has the lowest percentage of Nitrogen.

On the other hand, sulphur percentages have a huge difference between topsoil, silt and clay. Topsoil and clay have very low percentage of sulphur with nearly zero while silt has high percentage of 2.40%. It is believed that silt have excess sulphur composition and differs from reference which is topsoil. Excess sulphur in soil causes contamination and acidification [9]. If the soil contains excessively large amounts of sulphur, it increases irrigation and ensure that fertilizers being applied to the soil do not contain sulphur. The deficient nutrient can also be added to the soil provided it does not result in excess levels of that nutrient in the soil, which could result in toxicity once soil sulphur levels drop because Sulphur also plays an important role in planting.

Topsoil gave almost high percentage in nitrogen as it plays an important role in plant growth. Nitrogen is biologically combined with carbon, hydrogen, oxygen and sulphur to create amino acids, which are the building blocks of protein. Amino acids are used in forming protoplasm, the site for plant growth and development and nitrogen is also needed for all the enzymatic reactions in a plant. Deficiency of nitrogen will stun the growth of plant because of reduction in cell division. Besides that, chlorosis appearing on older leaves firstly and could result in death of older leaves [10].

Topsoil also contained high percentage of carbon. High soil organic carbon promotes soil structure with greater physical stability. Additionally, it improves soil aeration and water drainage and retention, and reduces the risk of erosion and nutrient leaching. Top soil is the top layer of soil, in which all plants grow. It usually covers a layer of subsoil, which in turn covers the rock underneath, although when the soil is very thin, topsoil and subsoil may be indistinguishable. Topsoil is so important because it contains all the nutrients that plants need to survive. Silt and clay are not commonly used as planting medium but have the potential to be alternative planting medium as they contain composition of metals and non-metals present in topsoil but differs in percentage.

Compared to top soil and clay, silt contained the highest percentage of sulphur which is 2.40%. Excess sulphur in silt has the potential to become alternative planting medium depending on the plant. Sulphur is essential in forming plant proteins because it is a constituent of certain amino acids. Then, it also aids in seed production, chlorophyll formation in legumes, and stabilizing protein structure. Plants such as legumes, cotton and tobacco uses relatively large amount of sulphur, ranging from 20 pounds an acre for 4 tons of alfalfa to about 15 pounds an acre [11].

3.4 ICP-OES Analysis

ICP-OES is used to determine any other element presented in the compound. From this study, a few important elements such as potassium (K), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), zinc (Zn) and lead (Pb) were found in all the samples which are silt, topsoil and clay. From Table 4, the results show that silt has all the additional elements which are similar to the reference sample, top soil. Although the values of the element are slightly different with the reference sample, all values are still in the closest range. From the data, element K has the higher component than the other heavy metal in each sample. Potassium, K is vital to the plant process and growth. Almost all types of plants need a higher content of K in the soils. The main role of K in the soils is for enzyme activation, photosynthesis, stomatal activity (water use), transport of sugars, starch synthesis, water and nutrient transport, crop quality and protein synthesis. All of these processes will be happened between soils and plants [12].

Table 4. Data of studied elements for silt, top soil and clay

Element	Silt (mg/L)	Top Soil (mg/L)	Clay (mg/L)
K	510.1	860.6	648.5
V	0.293	0.168	0.029
Cr	0.409	0.613	0.00
Mn	0.162	(Saturated)	0.152
Co	0.00	0.00	0.00
Ni	0.00	0.00	0.00
Zn	0.069	5.245	3.616
Pb	0.00	0.00	1.550

For vanadium, V the less amount of it in the soils is much better as it can lead to decrease in stem length, root fresh weight and fruits weight [13]. A least component of chromium, Cr in the soil is better. Cr is considered as an environmental hazard. Toxicity of chromium can affect growth and development of plants including inhibition of germination process, decrease of growth and biomass of plant [14]. Manganese, Mn is essential element in term of micronutrients for plant growth. However, an excess of this element in the soils can produce toxic for plants [15]. Element zinc, Zn involved in many physiological functions. Zn is essential for the transformation of carbohydrate in the soils. It can affect plant by stunning its growth, decreasing number of tillers, chlorosis and smaller leaves and inferior quality of harvested products [16]. Having this element in the soils can give both benefits to the soils and to the plant. Meanwhile, almost all the elements of Co, Ni and Pb is nearly 0 which are not existed in all types of soils which are silt, top soil and clay; except for Pb element, it only exists in clay.

4.0 CONCLUSION

The ability of waste pond silt to become an alternative way to the planting medium is higher. This is because waste pond silt contains almost all the components and elements with the common soil used as a planting medium which is topsoil. From the study, it is also found that this pond silt has pH number of 6.58 which is near to neutral and suitable for mostly planting medium. This waste pond silt also has functional groups such as stretching of O-H in several groups, vibrations associated with several groups and out-of-plane with some groups. In addition, silt also has carbon percentage of 0.84%, hydrogen percentage of 1.09%, nitrogen percentage of 0.39% and sulphur percentage of 2.40%. Elements such as K (510 mg/L), V (0.293 mg/L), Cr (0.409 mg/L), Mn (0.162 mg/L) and Zn (0.069 mg/L) which are the most important element s also found in the silt. In short, from the construction waste, pond silt can be more beneficial and valuable as it proves can be an alternative way of the planting medium especially in the agricultural sector.

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