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Do it Yourself: Humic Acid

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ABSTRACT

The humic substance consists of humic acid, fulvic acid, and humin. Humic acid is a useful metal complexing agent, a good dispersant, and a redox agent. Humic acid showed an auxin-like activity and thus promoted root growth and development. It positively affected soil's physical, chemical, and biological properties. Hence, humic acid indirectly improved plant growth by chelating nutrients to the plant. However, humic acid converted carcinogen compounds in chlorinated water. Still, humic acid is a good compound for agricultural purposes. Humic acid can be produced in thermophilic composting, vermicomposting, and Bokashi. The humification process can occur with decomposers such as black soldier fly. Those methods can be made in farmland and even in the housing area. Extraction of humic acid is required from those production methods. However, it is not easy to extract by farmers on a small scale. Full compost and Bokashi or its tea also showed much humic acid alone. Humic acid extraction may be optional but good as crop tonic. Nonetheless, further study should be carried out. Bokashi tea and leachate with decomposer should be further studied to obtain more evidence of their benefits. With the benefit of composting and fermentation, further study on treating is required for food security.

Keywords: Bokashi, compost, humic acid, soil amendment, vermicompost

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INTRODUCTION

Characteristics of Humic Acid

Humic substances are an important component of the earth, especially soil organic matter. They are vital for soil's physical and chemical processes (Gautam et al., 2021). Humic substances consist of at least half chemical-resistant organic carbon

(Gautam et al., 2021; Hayes et al., 1989; Lal, 2004). The humification process is mainly contributed by plant and microbial biomass (Gautam et al., 2021). Humic substances are not easily decomposed or degraded and are used by microbes due to the complex compounds forming cell membranes and walls (Gautam et al., 2021; Kögel-Knabner, 2002). They provide brown-black color to soils but depend on composting raw materials and their concentration (Gautam et al., 2021).

Humic substances are formed in the mixture of humic acids (insoluble below pH 2), fulvic acids (soluble at any pH), and humin (insoluble in water) (Figure 1) (Frimmel & Christman, 1988; Gautam et al., 2021). They are a valuable metal complexing agent, good dispersant, and redox agent (Schnitzer, 1991). In a strong base, the extract is acidified, and the complex macromolecular organic substance of humic acid is coagulated, whereas fulvic acid remains soluble (Bleam, 2017; Schnitzer, 1991). As pH is reduced, humic acid, a weak acidic electrolyte, turns hydrophobic (Singh, 2015) and decreases negative charge (Kinniburgh et al., 1998). It is a redox-active compound in soil and the aquatic system. Humic acid comprises a heterogeneous mixture of polymerized acids (not easily separated and analyzed) and phenolic radicals in a state of advanced decay.

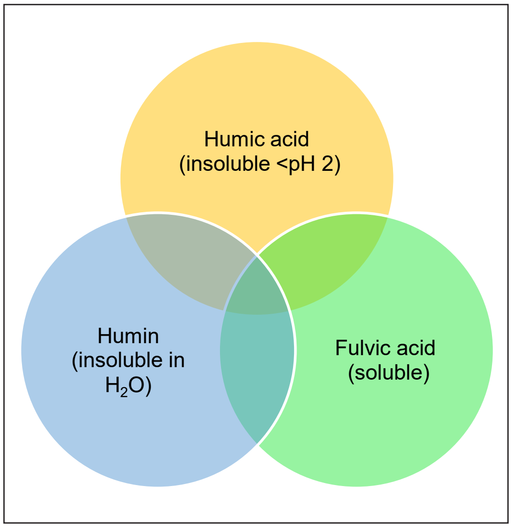

Figure 1. The humic substance consists of humic acid, fulvic acid, and humin

Humic acid can naturally occur in nature. It is found in the intermediate state after passing through the stages of compost and peat and before becoming lignite. Lignite coals are used in developed countries as a power supply source, whereas developing countries use them as agricultural humic acid-rich products (Susic, 2016). Therefore, they are important as the precursors of peat, asphalt, kerogens, petroleum, bitumen, and coal (Achard, 1786). The pathways and rate of a redox reaction are depended on the solution chemistry, material type, and microbial activity.

Even though the input of many biodegradable materials via composting, the percentage of extractable humic acid was low. Composting biodegradable materials via thermophilic compost, vermicompost, and Bokashi produced different percentages of extractable humic acid, from 8.4±1.1% to 22.9±2.6% (Epelde et al., 2018). The humic acid to fulvic acid ratio is generally high in most composting methods (Epelde et al., 2018). Humic acid will obtain very slowly if not composted. However, composting can be done easily without extra care and cost.

Effect of Humic Acid on Soil

Humic substances affect the nature and content of soil organic matter. Hence, it has an important role in the soil structure and function (Khaled & Fawy, 2011; Yang et al., 2004b). Furthermore, humic acid enhances soil nutrient availability and soil water holding capacity (Khaled & Fawy, 2011). Therefore, humic acid extracted from pulverized weathered coal was suitable to apply in the field since it decreased the ammonia (NH_3) volatilization and carbon dioxide (CO_2) emissions (Pang et al., 2021). In addition, humic acid significantly decreased water evaporation and enhanced water use efficiency by plants in low clay content and water holding capacity soils (e.g., sandy and arid soils) (Khaled & Fawy, 2011).

Humic acid significantly improved soil macroaggregates and could efficiently reduce soil salinity (M. Liu et al., 2019). By boosting up the cohesive forces of very fine soil particles (<0.002 mm), humate reduced soil erosion (Khaled & Fawy, 2011). Humic acid could affect the soil microbe community; for instance, fungal and bacterial community structures in the different growth stages were enhanced soil critical nutrient level and plant nutrient sufficiency range (M. Liu et al., 2019), where humic acid promoted nutrient chelate and made nutrients available to plants (Khaled & Fawy, 2011). Soil urease and sucrase activity enhanced after applying humic acid (Pang et al., 2021).

Furthermore, humic acid had the potential to act as a washing agent for the soil's toxic elements, including arsenic (As), cadmium (Cd), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn) in the *in-* or *ex-situ* remediation mechanism (Mosa et al., 2021). Biochar-humic acid-wood vinegar acted as a radiation material to immobilize nickel (Ni) metal in soil effectively (Zhu et al., 2021). In addition, the role of wood vinegar was to increase the oxygen-containing group (Zhu et al., 2021). Humic acid is extracted from fast-growing plants, such as corn (16 days). Stover anaerobic digestion had higher heavy metal adsorption ability for copper(II) ion (Cu(II)), cobalt(II) ion (Co(II)), and nickel(II) ion (Ni(II)) than livestock manure anaerobic digestion, such as chicken (X. Wang et al., 2021b). Perhaps, the co-remediation of humic acid and phytoremediator can be increased the remediate power in the polluted area, including the factory area.

In short, humic acid can improve soil properties and microbial activity and remediate contaminated soil.

Effect of Humic Acid on Plant

Humic acid is important for enhancing plant growth and development, nutrient and water retention, and suppressing diseases (Guo et al., 2019). Humic acid showed an auxin-like activity (Bottomley, 1917; Canellas et al., 2002) and the presence of interchangeable auxin groups in the macrostructure (Canellas et al., 2002). Humic acid accelerates cell division (Khaled & Fawy, 2011), promotes lateral root development, increases root surface area (Malik & Azam, 1985; Schnitzer, 1991), and decreases stress deterioration (Khaled

& Fawy, 2011) with the presence of auxin group in humic acid. Its size-fractions altered the root structure and thus affected root growth patterns, including providing more branched roots, size, and hairs to increase surface area (Canellas et al., 2010).

Humid acid promotes the expression of proton pump (H^+-ATPase) (Canellas et al., 2002). Auxin stimulates plant growth by increasing the amount of plasma membrane H^+-ATPase, acidifies the apoplast, and thus slackens the cell wall, promoting cell elongation (Frías et al., 1996; Hager et al., 1991). The increase in root hair enhanced the nutrient uptake and activation of the H^+-ATPase. It improves plant nutrition by improving the electrochemical proton gradient that makes ion transport across the cell membrane through secondary transport systems.

In a recent study, alkamides, secondary metabolites, were found in humic acid and positively affect root growth, similar to auxin (Zandonadi et al., 2019). Alkamides alter particular root signal transduction cascades that change root growth, but the differentiation is still unknown (Morquecho-Contreras et al., 2010). It was confirmed that the involvement of cytokinin receptors and nitric oxide production during root development (López-Bucio et al., 2007). Many Gram-negative bacteria produce alkamide-related substances such as N-acyl-L-homoserine lactones. The plant received N-acyl-L-homoserine lactones to alter root architecture and senescence-related processes by intermingling with jasmonic acid signaling (Morquecho-Contreras et al., 2010).

Root growth of marigold, strawberry, and pepper significantly increased by substituting 250 to 1,000 mg humates kg^{-1} dry weight of commercial soilless potting medium (Metro-Mix®360, Sun Gro Horticulture, USA) (Arancon et al., 2006). In addition, the co-application of 10 mM K and 2 h kg^{-1} humic acid allow 100 mM sodium chloride (NaCl) salt-stressed salt-sensitive wheat plant root to grow (Abbas et al., 2022).

Humic acid also showed positive effects on the growth of beneficial microbes in the compost. For example, humic acid-enriched vermicompost improves arbuscular mycorrhizal fungi colonization, root nodulation, and plant growth maximally and eventually improves plant growth and soil health (Maji et al., 2017). In addition, the application of vermicompost suppresses soil-borne plant pathogen of mung bean (Saxena et al., 2015).

Humic acid can enhance the corn yield in salinized soil by enhancing nutrient absorption in different growth stages (M. Liu et al., 2019). Nitrogen (N) nutrient absorption in the corn vegetative growth period and phosphorus (P) and potassium (K) nutrient absorption in the reproductive growth period, especially the tasselling and harvest stage, was improved with the presence of humic acid (M. Liu et al., 2019).

Moreover, applying humic acid to plants allows the plant to cope with environmental stress. For example, the co-application of K and humic acid allows salt-stressed salt-tolerant wheat to shoot dry matter and nutrients (K, Fe, Zn) accumulated as non-stressed ones (Abbas et al., 2022). In addition, the co-application of K and humic acid reduced the Na accumulation in salt-stressed wheat plants significantly in both root and shoot (Abbas et al., 2022).

Humic acid application (54 mg L^{-1}) allowed 22% of seedling N uptake and shoot dry matter improved (Malik & Azam, 1985). Humic acid-enhanced N accumulation and thus improved chlorophyll content in the plant; however, the concentration of the humic substance is the matter (Malik & Azam, 1985; Xu et al., 2012). Also, humic acid application significantly increased the soil plant analysis development (SPAD) reading of the snap bean plant (El Sheikha et al., 2022). In addition, humic acids relieve adjusting plant chlorosis, strengthen plant enzyme systems, and enhance the permeability of the plant membranes (Khaled & Fawy, 2011).

Fulvic acid significantly promotes high chlorophyllase *a* activity than either humic acid or humin (Yang et al., 2004b). Humic acid significantly promotes the activity of chlorophyllase *b* than either humin or fulvic acid (Yang et al., 2004b). However, humin does not significantly affect the activity of chlorophyllase *a* and *b* (Yang et al., 2004a). Some of the phenolic acids, the important component of humic substances (Cheshire et al., 1967), such as *p*-coumaric acid, ferulic, and *o*-hydroxyphenyl acetic, showed an antagonistic effect on Mg-chelatase, the chlorophyll biosynthetic enzyme (Yang et al., 2002). Nonetheless, those compounds synergistically affected the activities of Mg-dechelatase *a* and *b* and chlorophyllase *a* and *b* in paddy seedlings (Yang et al., 2004a). Therefore, other factors also affected the chlorophyllase activity (Yang et al., 2004b).

Humid acid-enhanced our taste buds and economic value to selling the crop. For instance, total soluble solids, ascorbic acid content, dry matter contents, fruit characteristics (e.g., fruit height, diameter, weight, and fruit number per plant), and the yield of tomatoes have remarkably improved by humic acid (Yildirim, 2007). Also, humic acid has significantly improved the number of flowers and fruits (Arancon et al., 2006). Furthermore, it can resist plant disease (Khaled & Fawy, 2011) and thus improve food and nutrient security. The humic acid applied to time for fruit and vegetable crops can be further studied in the future and thus ensure the plant has fully utilized the resource.

Salicylic acid and humic material could act as a cut flower postharvest preservative, where they decrease the lipid peroxidation and delay the aging process (Khandan-Mirkohi et al., 2021). In addition, the activity of the antioxidant enzymes is enhanced by salicylic acid and humic material in cut flowers (Khandan-Mirkohi et al., 2021). Perhaps, this concept can be further applied in stem cutting, selling, and big tree transplanting (to preserve the root ball) to extend the shelf life for shipping and storage time.

Humic acid has many positive effects on plant growth and development, even in the postharvest stage. However, the effect of humic acid is highly dependent on the nature of humic substances, including composition, concentration, and pH (e.g., growth medium, culture condition, and plant species) (Schnitzer, 1991).

Effect of Humic Acid on Water Bodies

Modified humic acid significantly remediated the water bodies from heavy metals. Humic acid had superior heavy metal (e.g., Cd, Cu, Pb, and Zn) wash out capacity than artificial sweeteners such as acesulfame and sucralose in lake sediment remediation (Y. Liu et al., 2020b). In addition, the low adsorption capacity of humic acid had enhanced the affinity of magnetic nanoparticles with oxidizing and ferrous ferric oxide (Fe_3O_4) coating to treat drinking water (Xue et al., 2021).

Nevertheless, humic acid brings many benefits to agriculture and the environment. On the flip side, humic acid is recommended to remove from water for drinking and swimming water use purposes. Humic acid is converted to carcinogenic compounds such as trihalomethanes and haloacetic acids after chlorinating in drinking and swimming water (Satheesh Ananda & Mehendale, 2005; Shi et al., 2020).

Humic molecular are vulnerable to being attacked by chlorine as they are electron-rich with aliphatic side chains and phenolic structures (Liao et al., 1982; Richard, 1982). Therefore, they have the potential as the precursor's toxic disinfection by-products with the carbon attached (Rook, 1976). The by-products can be classified into volatile hydrophobic and non-volatile hydrophilic. The specific by-product of humic acid depends on its molecular structure, pH, and chlorine to carbon ratio (Richard, 1982). High chlorine to carbon ratio can produce a non-volatile hydrophilic humic acid by-product (Richard, 1982; Rook, 1977). Humic acid changes the unchlorinated watercolor and affects the aesthetic value.

Spot of Humic Acid

Humic acid is an organic matter found in the sediment, terrestrial soil, and natural water (de Melo et al., 2016). Also, humic acid can be formed through human activity such as thermophilic composting, vermicomposting, and fermenting. Therefore, it is easy to be made by ourselves. Various ways can form the humus substance, such as thermophilic composting, vermicomposting, fermenting (Bokashi), and even decomposer (i.e., black soldier fly). The concentration of humic acid in different recipes of thermophilic compost (e.g., chicken manure-based or green waste thermophilic compost) and vermicompost (e.g., fresh, aged chicken manure-based or food waste vermicompost) is in the range of 2.9 to 11.5 g kg^{-1} dry weight (Pant et al., 2012b).

Thermophilic Compost. Compost generally undergoes mesophilic, thermophilic, and stable phases. Among the phases, the thermophilic phase has the peak temperature, from 45 °C up to 70 °C; however, there is no specific temperature (Miller, 1996). During the transition phase from mesophilic to thermophilic, the microbial activity will be reduced (Day et al., 1998). Thermophilic compost is a product that undergoes the process to achieve a sanitary and stable compost with a controlled biological decomposition of biodegradable materials such as agricultural and kitchen waste, mainly under aerobic conditions, and allows the development of thermophilic temperatures biologically (Walters, 2009).

A good quality compost has moist, fine-textured, pathogen-free, and comprises high beneficial microbes, soluble mineral nutrients, phytohormones, humic substances, and low phytotoxic organic acids and heavy metals. Humic substances can be used as an indicator of the maturity of compost (Wei et al., 2007). Manipal solid waste compost had significantly higher extractable humic acid (22.7±1.8%) than composts (Epelde et al., 2018). Compost tea is the water extract from compost substrate soaked with recirculated water in aerobic conditions (Riggle, 1996). Therefore, the compost tea quality depended on the compost quality (Milinković et al., 2019; Naidu et al., 2013; Pant et al., 2012b). Compost and manure are widely used for plant disease management, whereas compost tea has recently been used as a crop tonic (Walters, 2009).

Humification also allows lignin degradation (Burges et al., 1964; Steelink, 1964). Lignocellulose degradation improved by adding humic acid-modified oyster shell to the digestate (obtained through aerobic fermentation) composting; however, the synthesis of nitrate (NO_3^-) decreased (Lu et al., 2021). Humic substances formed from red mud composting promote lignin degradation and laccase-producing microbes' growth (Jiang et al., 2021). The addition of manganese dioxide (MnO_2) fastened the organic matter degradation and enhanced the humification degree of fulvic acid in the co-composting of chicken manure and rice straw (Qi et al., 2021).

Animal-based manure thermophilic compost significantly suppressed disease in livestock production and controlled powdery mildew disease in crop production than plant-based thermophilic compost (Pant et al., 2012b; Weltzien, 1990). In contrast, green waste thermophilic compost and its tea showed significantly high humic acid than manure-based compost (Pant et al., 2012b). In addition, the co-application of N fertilizer, humic acid, and plant-based (rice straw) compost significantly enhanced the wheat growth performance and yield (Antoun et al., 2010).

Vermicompost. Vermicompost is the product of speeding up the biodegradation of organic matter, such as agricultural, industrial, and urban waste, using fauna such as earthworms without a thermophilic stage (Hervas et al., 1989). Up to 50% of the organic fraction total weight in the vermicompost are sterols, proteins, polysaccharides, fatty acids, alkanes, and enzymes; however, humic acid was in the range of 4–17% of the total weight (Epelde et al., 2018; Hervas et al., 1989).

Vermicompost has higher phosphorous (P), potassium (K), magnesium (Mg), sulfur (S), calcium (Ca), and carbon (C) than thermophilic compost (Hervas et al., 1989; Tognetti et al., 2005). Due to the presence of phytohormone, auxin, in humic acid, flowering and fruiting significantly improved in the food waste vermicompost humic acid treated crop compared to commercial humic acid (Arancon et al., 2006). Furthermore, the application of humic acid (100 mg L^{-1}) significantly improved plant morphology (leaf area, length, and branch diameter) and yield (cluster weight, number of fruits per cluster, and fruit weight) (Pakkish et al., 2022). In addition, vermicompost and humic acid significantly improved secondary plant metabolites (e.g., flavonoid and phenolic) (Gholami et al., 2018) which is good for food and nutrient security.

Compost and vermicompost tea can be produced by brewing with water. The dilution from 1:10 to 1:20 can obtain optimum plant growth (Pant et al., 2012a, 2012b). The tea and humic acid positively affected plant growth, yield, quality, and nutrition (El Sheikha et al., 2022). Besides, vermicompost tea can be produced by leaching the solution during the composting process, which also contains micronutrients, fulvic acid, and humic acid to improve plant growth (Gutiérrez-Miceli et al., 2008). Vermicompost tea might be allowed insignificant changes in transamination and deamination reactions in the amino acid profiles (El Sheikha et al., 2022). Vermicompost tea contained more humic acid than vermicompost (Pant et al., 2012a). Vermicompost leachate also has the potential to substitute for P and K deficiency (Arthur et al., 2012).

Bokashi. Fermentation is an anaerobic process with microbes to form peat where the breakdown of plant remains is terminated by bathing in water (H_2O) with a very low oxygen (O_2) content plus the presence of various organic acids, including humic acid (Merfield, 2012). Bokashi is one example of organic matter fermentation. Bokashi is fermented organic matter (e.g., cooked and raw plant and animal-based materials) made by fermenting with effective microorganisms, molasses, and water for about two weeks and sun-dried within two days (to avoid secondary fermentation) (Christel, 2017). The receipt is versatile to change with the preference of raw materials. It brings many benefits to plant growth.

Bokashi improved seedling survival rate and height during transplanting (Jaramillo-López et al., 2015) and showed the greatest positive effect on initial plant growth and development (Bócoli et al., 2020). In addition, humic acids extracted from Bokashi demonstrated positive effects on the initial corn growth performance and development (Baldotto & Baldotto, 2016) and chlorophyll content (Prisa, 2020; Santos et al., 2020), and photosynthetic capacity (Olle, 2021). Amendment of Bokashi enhanced plant height of *Alibertia edulis* (Santos et al., 2020), onion (Álvarez-Solís et al., 2016), and jalapeño pepper plants (Álvarez-Solís et al., 2016).

Humic acid extracted from Bokashi tea significantly increased dry matter accumulation up to 41% at 45.70 mmol/L humic acids compared to control (Baldotto & Baldotto, 2016). Bokashi had significantly low extractable humic acid (8.4±1.1%) than composts (Epelde et al., 2018). Tomato seed soaking with Bokashi tea enlarged transplants' stem diameter, promoting plant nutrient absorption (Olle, 2020). Bokashi leachate as a seed priming agent also positively affects seed germination and dormancy breaking (Phooi et al., in press).

Black Soldier Fly Larvae

The decomposer of the black soldier fly (*Hermetia illucens* L.) could allow the easy biodegradable organic matter, including soluble microbial by-products and proteinaceous substances, to convert to humic substances (Q. Wang et al., 2021a). Raw livestock manure such as chicken, cow, and pig manure as black soldier fly larvae feed can increase the humic-like and fulvic-like substance (Q. Wang et al., 2021a). It can alter the structure and composition of animal manure (e.g., cow, chicken, and pig) (Q. Wang et al., 2021a). As a bonus, it also makes the manure more aroma due to the aromatic protein formation (Q. Wang et al., 2021a). It can be used as a post-composting agent to boost the level of the humic substance. It can improve the maturity of compost (T. Liu et al., 2020a).

Black soldier fly is known as environment cleaner. It can clean the organic waste and reduce the spread of disease (Bradley & Sheppard, 1984). Biotransformation from black soldier fly larvae can suppress pathogens such as *Salmonella* and *Escherichia coli* in livestock manure, control horsefly breeding, and reduce manure waste (Erickson et al., 2004; Q. Li et al., 2011). *Escherichia coli* count in the diary manure was significantly reduced by black soldier fly at the constant temperature of 27 °C (Q. Liu et al., 2008). Copper (Cu) and zinc (Zn) mobilization can be improved with the presence of black soldier fly larvae (T. Liu et al., 2020a) and thus positively affect plant growth.

Extraction Method of Humic Acid

Humic acid extraction needs alkaline extraction, humic acid separation, and fulvic acid separation (Lamar et al., 2014). The sample should be crushed and sieved with 60 mesh.

The following extraction method was described by (Canellas et al., 2002; Schnitzer, 2015). A 1:10 ratio (v/v) of sample and 0.5 M sodium hydroxide (NaOH) needed to mix under nitrogen (N_2) atmosphere for 12 hours. First, the suspension was centrifuged at 5,000 × *g* and then acidified to pH 1.5 using 6 M hydrochloric acid (HCl). The third solubilized and precipitated humid acid pallet was then mixed with 10 volumes of a diluted mixture of hydrofluoric acid (HF) and HCl solution (5 mL L^{-1} of 12 M HCl + 5 mL L^{-1} of 48%, v/v HF). A negative test against silver nitrate ($AgNO_3$) was obtained by repeatedly washing with H_2O after centrifugation at 5,000 × *g* for 15 minutes. Then, purifying against deionized H_2O using a 12-14 kD cut-off membrane is required. Next, the dialysate was lyophilized to form a powder and characterized chemically. Then, the humid acid powder was solubilized with 50 to 100 mL of 0.05 M NaOH, and the pH was adjusted to 5.5 with 0.1 M HCl.

Humic acid extraction was a long process with intensive chemicals and was unsuitable for small-scale extraction. Not only that but the HF and HCl are also required in this method. However, HF and

HCl are highly toxic to human beings and the environment. Moreover, the use of a flame hood is required to protect the experiment conductor, and thus it is impossible to conduct by the small farmer. Besides, humic acid is also extracted through the fungal liquefaction of coal, and also the bioactivity is also improved compared to commercial products (Ghani et al., 2021).

Another alkaline extraction, humic acid, was much simpler. First, the water mixed sample and 1:1 ratio of potassium hydroxide (KOH) and potassium pyrophosphate ($K_4P_2O_7$) were stirred at room temperature. Then, the liquid was separated from the solid to obtain the humic acid extractant (Stevenson, 1994). Still, it was not easily extracted by farmers. Potassium pyrophosphate ($K_4P_2O_7$) is a type of food additive, and thus it is nontoxic to use. However, KOH is very high in pH (base) and harm human if not handled carefully. Therefore, the use of KOH is only recommended in laboratories and industries.

Soil Humus Composition Determination

Soil humus composition determination is generally separating the substances. After applying the humus to soil, humus composition can be analyzed following the method described by (Ndzelu et al., 2021; Zhang et al., 2020). A 5 g of air-dried soil was extracted with 30 mL of 0.1 M alkali solution [NaOH + tetrasodium pyrophosphate ($Na_4P_2O_7$)] under constant shaking at 70 °C for an hour. The mixture was centrifuged for 15 minutes at 548 x *g* and filtered with quantitated fast flow filter paper. The remaining soil residue was humin, and the solution, which was a humic extractable substance, was acidified to pH 1 to separate humic acid from fulvic acid. The C contents of humic extractable, extracted humic acid, and humin are determined using potassium dichromate ($K_2Cr_2O_7$)- sulfuric acid (H_2SO_4) oxidation followed by titration with iron (II) sulfate ($FeSO_4$) (Nelson & Sommers, 1982). Fulvic acid carbon was computed as the difference between humic extractable and humic acid-C. Humification degree was calculated as humic acid-C/(humic acid-C + fulvic acid-C) × 100.

Nevertheless, it is complicated with the condition (constant shaking temperature) and chemicals needed. Thus, it is impossible to run small-scale farming. Humification can be determined by the naked eye with its color changing.

FUTURE PROSPECT

Compost significantly improved plant growth and slightly altered the rhizosphere microbe community density (e.g., total numbers of bacteria, actinomycetes, and fungi) in tomato plants and thus exhibited antagonistic effects toward the soil-borne root pathogen (de Brito et al., 1995). Compost enhanced cucumber and summer squash (Rashwan et al., 2021). Vermicompost and compost significantly increase aerial and root biomass and plant morphology (e.g., the greater leaves number and leaf area and improved root volume and branching) of the tomato plants (Lazcano et al., 2009). Vermicompost made nutrients available by increasing soil microbial activity (dehydrogenase activity) and soil respiration, whereas vermicompost tea enhanced soil and foliar nutrient uptake (Pant et al., 2012a).

Bokashi is considered easy to make and fast to get end products among the soil amendments. On the other hand, compost and vermicompost take months to obtain the end product and require basic knowledge to obtain a good compost-like C/N ratio. Also, Bokashi can be Do It Yourself (DIY) with recyclable organic waste such as food waste from family farming, as it is low cost in the production of both the Bokashi and the extraction of humic acid (Baldotto & Baldotto, 2016). However, the study of humic acid extracted from Bokashi, and its leachate is insufficient scientific evidence to prove its benefit to soil and plant growth; however, it is widely used among home gardeners.

Humic acid showed a positive effect on saline soil (Khaled & Fawy, 2011; M. Liu et al., 2019), and hence it may be applied to other infertile soil, such as urban soil and high polluted soil. Urban soil is associated with human being health (G. Li et al., 2018). Urban soil such as Hong Kong, Japan, Germany, the United States of America, the United Kingdom, Russia, and Australia has dumped materials (Jim, 1998; Tiller, 1992). Urban soils have great vertical and spatial variability. For example, each layer may significantly be different in physical properties (e.g., texture, pH, organic matter content, structure, and bulk density) and other associated soil properties, including soil water-holding capacity, aeration, drainage, and fertility. Moreover, urban soil restricts aeration and water drainage in the soil. Also, humic acid had the potential to remediate polluted soil such as factory nearby soil and other anthropogenic soil.

CONCLUSION AND RECOMMENDATIONS

Humic acid can be done yourself by composting, vermicomposting, and Bokashi, as it positively affects soil and plant. Tea with humic acid can be extracted from its compost, brewed with water, or leached. The solids and their tea can be extracted to obtain pure humid acid; however, it is optional since it is similar to tea. Bokashi tea and leachate should be further studied to obtain more evidence of their benefits. With the benefit of composting and fermentation, further study on treating is required for food security.

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