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Humic Acid Extraction from Fecal Sludge Compostable Materials in Gicumbi Landfill

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Abstract

People who live in urban areas increase day by day. All biodegradable and non-biodegradable wastes collected from households in Gihembe refugee camp are transported to Gicumbi landfill. The wastes either solid or liquid contain an organic fertilizer named Humic acid which is one of the two classes of natural acidic organic polymer which contains high concentration of carbon content that can be derived from humus in the soil sediment or aquatic environment and compost. The humic acid has been extracted from human wastes deposited in Gicumbi Landfill. The results indicate that the obtained humic acid has the same composition as the existing one.

Keywords:* *Humic acid; Compostable waste; Landfill; Organic fertilizer

Introduction

Organic matter applied to the soil favors the development and growth of plants because it supplies macro- and micronutrients, reduces soil toxicity through heavy metal complexation, improves the physical and chemical characteristics of the soil and prevents nutrient loss by leaching. Organic fertilization of soil reduces or even precludes the need for agrochemicals and mineral fertilizers, the extensive use of which results in economic and environmental imbalances. Whenever possible, organic fertilization relies on the use of manure, culture alternation, green fertilization, composting and biological control of pests and diseases.

About 80 to 90 wt% of the organic matter found in the earth's crust is constituted of Humic Substances (HSs). HSs play important roles in plant development. Among HSs, Humic Acids (HAs) play the most part as organic fertilizer. They reduce the hydric stress in plants. Due to their dark color, they contribute to heat retention in the soil which is beneficial for seed germination. Besides, they interact with the cellular metabolism of plants, facilitating the absorption of nutrients and enzymatic activity. They change the physical structure of the soil, stimulate microbial activity and promote the solubilization of complexes [1].

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Initially, Schulten and Schnitzer proposed a structure for Humic Acid formed by alkyl benzene moieties attached through covalent bonds (FIG. 1). Later, Piccolo proposed that it is a self-assembled superstructure with relatively small heterogeneous molecules held together primarily by hydrophobic dispersive forces and hydrogen bonds. These forces determine the conformational structure in the HA molecule. Given its superstructure, HA is a complex mixture in which there can be small, large, and polydisperse molecules. Many authors think that Humic acid has no precise and well-defined structure and properties, which depends on the source that generated them and the specific extraction conditions.

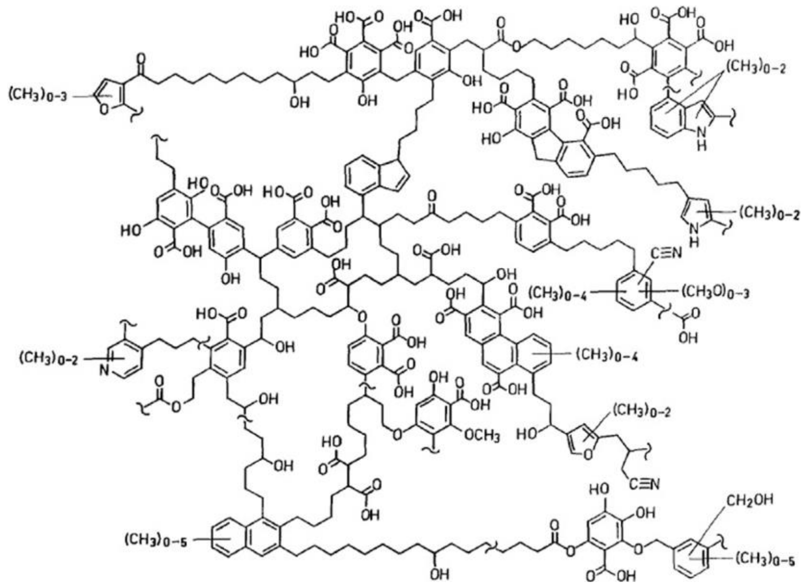

FIG. 1. **Superstructure proposed for humic acids.**

The progress of humification processes is related to numerous factors, such as the nature of the starting materials, time and the oxidative conditions of treatment that influence microbialactivities and thus the degradation of the composted material. A lot of studies showed that the relative increase in the degree of aromaticity and unsaturation of the humic acids vary as a function of time and of the treatment used for sewage sludge (drying, anaerobic digestion, or composting with or without wood chips). Additionally, they demonstrated that during composting the unstable organic compounds such as aliphatic and protein materials are transformed through intense microbial activities to more stable humic compounds with more polycondensed, oxidized, olefinic or aromatic structures which is similar to the progressive aromatization, mainly the increase in oxidized aromatic structures during native humification processes occurring in soil, that has been evidenced by numerous authors [2].

Much of the humic acid used in organic fertilizers is derived from leonardite, a material with a HAs content of over 90 wt%. Unfortunately leonardite deposits are not found in all regions of the world. One has to consider other sources of humic acid, such as mineral coal, lignite, worm compost, peat, and sewage sludge. Mineral coal is not an attractive source because it contains less than 10 wt% in HAs. Lignite recovery is not economical. Worm composts contain up to 80 wt% of HAs, but are expensive for large scale production. An attractive alternative is peat, which contains HAs in concentrations, varying between 20 and 40 wt%, and is simple to recover either from surface deposits or as a byproduct in sand mining. To the best of our knowledge no study has been conducted on extraction of humic acid from human waste. On this background, an objective study was planned to characterize humic acid from human waste from Gihembe refugee camp using elemental analysis technique. For this purpose, HA was extracted using alkaline solution. The sample was selected to represent Gihembe refugee camp and all refugee camps existing in Rwanda. It has to be emphasized that the starting material has already undergone a sludge facial treatment and a long period of aerobic-anaerobic treatment has been applied, and the obtained material was dry which was raw material in our study.

Methodology and Findings

Sample collection

Gihembe refugee camp is located on a small hill in Gicumbi District, Northern Province. The camp currently is a home to about 20,000 refugees from the Democratic Republic of Congo who fled political turmoil in their country in 1997. The process of Treatment of Human waste in Gicumbi Landfill is illustrated in FIG. 2.

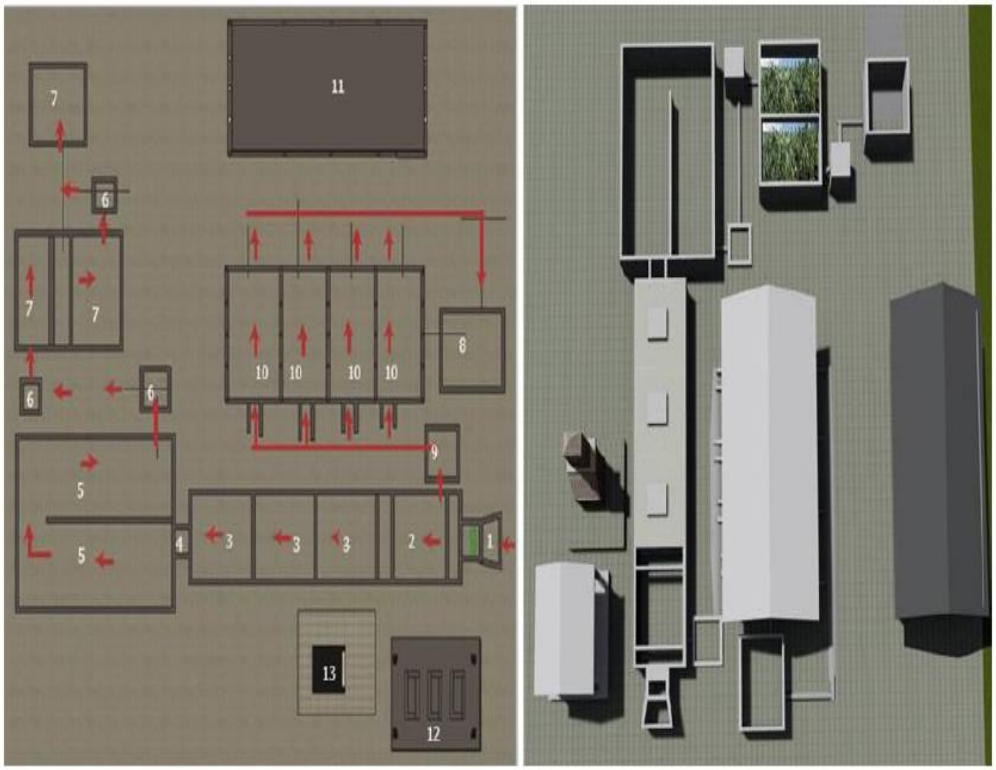

FIG. 2. **Action building of human waste treatment. (1) Reservoir channel. (2) Settling chamber. (3) Anaerobic tank. (4) Filter channel. (5) Aerobic chamber. (6) Transporter pipe. (7) Reed zone. (8) Storage tank of remained liquids. (9) Van pipe transporter. (10) Separation house. (11) Storage house of solid fertilizer. (12) Trash dryer house. (13) Incinerator.**

Extraction and purification of humic acid

The Humic Acid was extracted with alkaline solution according to the protocol described in reference. Briefly, the procedure consisted of (i) 30 g of dry human waste treated by facial sludge treatment method which was continuously stirred with glass rod manually for 10 min in 100 ml of 0.1 N NaOH at room temperature and then kept for 2 h; (ii) supernatant was filtered using Whatman No.1 filter paper and then centrifuged at different rotation speed for 30 min, at 20°C; (iii) acidified with 6 N HCl to pH 1.0 and allowed to precipitate for 24 h at 4°C; supernatant was Fulvilic Acid (FA) and the residue was Humic Acid; (iv) precipitated Humic Acid was recovered by centrifugation at 4000rpm in 35 min at 23°C, then dissolved in a small volume of 0.1 N NaOH and again precipitated at pH 1.0 for 24 h at 4°C.

This precipitation dissolution procedure was repeated four times to eliminate Fulvilic Acid; (v) after purification, the precipitated Humic Acid was dried at temperature 32-35°C in an oven for 6 days. Dried HA was kept in a sealed tube for characterization. The following FIG. 3 summarizes the process of HA extracted from human waste [3].

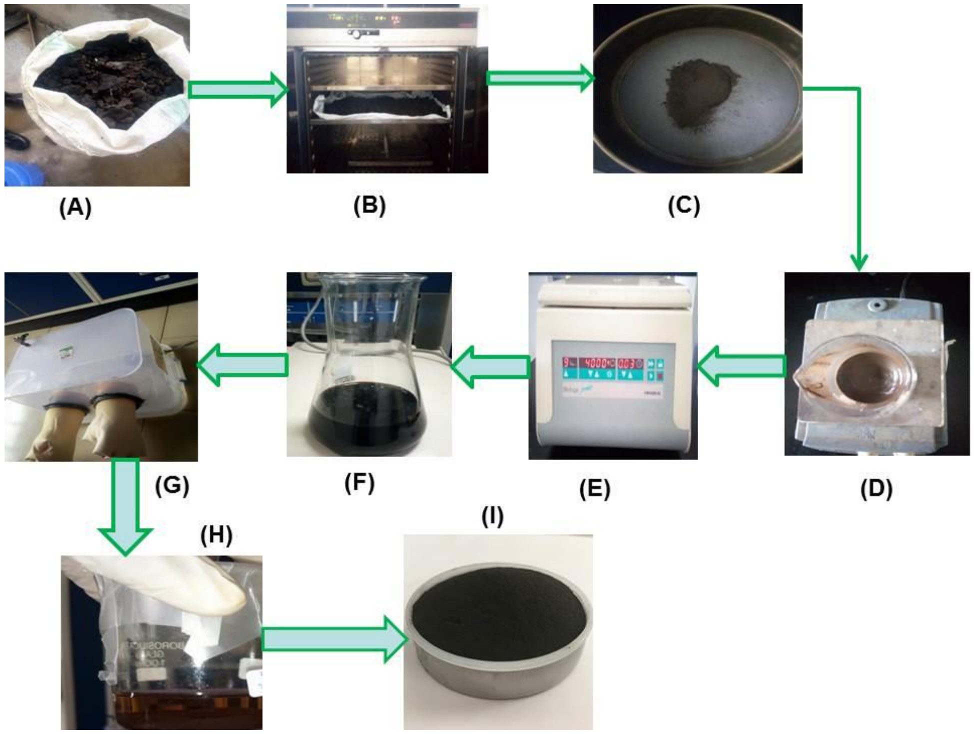

FIG. 3. **Extraction of HA extracted from facial sludge waste. Samples collected from Gicumbi landifill. (A) Preparation of sample in oven. (B) Sieved sample under sieve of 0.18 µm. (C) 30 g of sieved compost +100 ml of 0.1 N NaOH by magnetic stirrer in 250 ml of beaker during 2 hours. (D) Separating the supernant of humic substances in the centrifuge machine at 4000 rpm in 35 min. (E) Extracted humic acid of solid compost. (F) Precipitation method under nitrogen atmosphere, this process need to be carried out in the glove box. (G) Extracted solid humic acid (H and I).**

Elemental analysis

Using an AAS, Na, K, Ca, Mg, Fe, Cu, Cr, Co and Pb analysis were obtained. All samples were prepared in 100 mL volumetric flasks. For each HA sample, around 3 mg of dried HA was dissolved in 10 ml of 0.05 N $NaHCO_3$ and then diluted with Distilled Water (DW) to make total volume of 50 ml. Each HA solution was treated with concentrated HNO_3: HCl, 3:1 and covered with a glass lid. The samples were placed on a hot plate and heated to 85 ± 5°C for 10-15 min. They were then allowed to cool and 1 ml of concentrated HNO_3 was added [4]. The lid was removed and then samples were heated again for 30 min. After cooling, the volume of the sample was adjusted to 100 ml by adding DW. The digested samples were then filtered by Whatman No. 41 filter paper and were kept in a glass bottle with lid for taking the required readings. The elemental analysis for each sample has been repeated three times with the calibration of the system ($p<0.05$) and the average values were taken.

TABLE 1. **Total quantity (ppm) of Na, K, Ca, Mg, Fe, Cu,S, Cr,Al,P and Co and in HA samples.**

Samples	Na	K	Ca	Fe	Mg	Cu	S	Co	Al	P
Total quantity (ppm)	21.3	18.712	13.353	0.353	0.063	0.058	0.03	0.007	nd	10.62
Percentages	8.49 ± 0.183	5.69 ± 0.164	5.71 ± 0.195	0.33 ± 0.014	2.45 ± 0.070	0.05 ± 0.036	0.88 ± 0.057	0.08 ± 0.015	2.25 ± 0.139	4.22 ± 0.068

Discussion

TABLE 1 shows the total quantity of metal elements found in HA sample using AAS. It shows that the metals such as Na, K, Ca and P are present in larger quantity in HA sample (~62 ppm). Percentage content of element, AAS analysis elucidate that the physical and chemical compositions of HA varies as per the origin and environmental conditions. As heavy metals were found in HA samples, presence of HA can increase the level of heavy metals in the environment. Presence in excess may cause a serious threat to human health, living resources and ecological systems as they are considered persistent, bioaccumulative and toxic substances. On the other side, high organic elements and aliphatic groups present in HA samples are useful for agriculture. The aliphatic structures in soil contribute significantly to the increased sorption of organic pollutants. Therefore, the incorporation of organic molecules into the soil may significantly affect the soil structure and may have significant benefits to agriculture and environmental sustainability [5].

Conclusion

The present work provides another source (raw material) of Humic Acid and its use as solid organic fertilizer. This scientific data may help to decide the suitability of HS, of which HA is one of the constituent, as fertilizer. Pb element not present in samples is not required by the plant. HA from human waste used as a fertilizer was extracted and characterized using AAS technique. The elemental analysis data shows that HA exhibits different elemental compositions. In general, HA samples analyzed are rich in carbon and oxygen and poor in nitrogen. AAS analysis showed the presence of elements such as Na, Ca, K, Mg, Al, S, P, Cu, Fe, Cr,and Co in all analyzed samples. For further studies we do recommend to conduct SEM, EDS, XRD analysis in order to get information regarding chemical composition and molecular structure of extracted Humic Acid.

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