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Research Article

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Evaluation of the Maturity of Composts Made from Poultry Droppings and Phosphate Waste from Togo Using UV-Visible Spectroscopy

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Abstract: During the recovery of poultry droppings (FV) and phosphate waste (Phosphate sludge: BP and Screen waste: RC) from Togo into biofertilizer, four (4) composts (A: 170 kg of FV + 85 kg of BP; B: 170 kg of FV + 85 kg RC; C: 170 kg of FV + 42.5 kg of BP + 42.5 kg of RC and D: 255 kg of FV) were developed. The maturity of these four composts (A, B, C and D) was evaluated by the UV-visible spectroscopy method. Analysis of the UV-visible spectra of these composts shows the loss of organic matter in favor of aromatic compounds signifying the formation of humic substances. Calculations of absorbance ratios show that the Q_4/Q_6 absorbance ratios of all composts exceed 5 (between 5.375 and 9.576) and show the characteristics of mature humic acids. From all the above, it can be deduced that UV-visible spectroscopy allowed the maturity of the composts produced to be assessed.

Keywords: Compost, Phosphate waste, poultry droppings, UV-visible spectra.

1. Introduction

Composting is a natural and biological process of stabilizing organic waste. The material obtained after stabilizing organic matter is called "compost". Indeed, compost is a biofertilizer that has a high organic matter content and can easily increase the level of organic matter in the soil [1]. However, unripe compost applied to soil has phytotoxic effects on plants. Several methods such as empirical, physical, chemical, spectroscopic and analytical methods are often used in the literature to assess the maturity of composts. Empirical methods consist of observing the color of mature compost which should be "dark black" without unpleasant odor [2,3]. Physical methods consist of observing the evolution of temperature within the windrow compared to the ambient temperature [4] in addition to the odor, color and appearance [5]. Chemical methods involve the study of some chemical parameters such as: pH [6], C/N ratio [7], analysis of easily biodegradable substances (sugars, amino acids, phenols etc.) and fibers, total organic carbon (TOC) and total Kjeldahl nitrogen ([8], [9], [10]]).etc. Spectroscopic and analytical methods include: UV-visible spectroscopy, infrared (IR) analysis ([11], [12], [13], [14]), nuclear magnetic resonance (NMR) [15], gas chromatography (GC), mass spectroscopy (MS) and X-ray analysis [5]. These latter methods are very interesting because they provide a lot of information on the degradation of compounds during composting ([11], [12], [13]) and allow the characterization of humic substances ([16], [17]). For this, the present study aims to evaluate the maturity of four (4) composts made from poultry droppings and phosphate waste from Togo by UV-visible spectroscopy. Indeed, the principle of this method consists of studying the excitation of a molecule subjected to UV-visible radiation, that is to say the passage of an electron from a stable orbital to an unstable orbital in the UV (200-400 nm) and visible (400-800 nm) region.

2. Materials and methods

Composting of poultry droppings and phosphate waste

The composting trial was conducted from April to August 2022 on the agronomic valorization platform for poultry by-products of the Regional Center of Excellence for Avian Sciences (CERSA) of the University of Lomé (UL). The geographical coordinates of a point on this platform are: 6°10'36" North longitude and 1°12'36" East longitude with an altitude of -2 m.

The poultry droppings used in this work come from CERSA chicken coops and the phosphate waste comes from the Togo natural phosphate washing plant in Kpémé located 40 km east of Lomé, the Togolese capital. Indeed, these phosphate wastes (phosphate sludge and screen rejects) are produced and are dumped into seawater on the one hand or piled up on the factory site on the other hand. Some chemical characteristics of these wastes (poultry droppings, phosphate sludge and screen rejects) are recorded in Table 1. In total four (4) composts (A, B, C and D) were developed with the mixtures of phosphate waste and droppings. The proportions of each compost in these different wastes are listed in Table 2.

Table 1: Some chemical characteristics of composting raw materials [6]

Raw material	Poultry droppings (FV)	Phosphate mud (PM)	Screen Refusal (RC)
pH	8.44 ± 0.30	7.05 ± 0.11	6.84 ± 0.42
EC conductivity (µS/cm)	1896 ± 3.69	17270 ± 4.84	4510 ± 3.36
Humidity level (%H)	24.17 ± 2.55	18.18 ± 1.22	4.92 ± 0.56
Ptot (%P_2O_5)	1.1 ±0.1	11.3 ±0.3	13.10 ±0.40
Pass (mg/g)	0.24 ±0.03	0.021 ±0.002	0.026 ±0.005
CaO (mg/g)	57.57 ±1.53	312.06 ±1.17	416.75 ±1.67
MgO (mg/g)	4.93 ±0.38	6.13 ±0.37	5.39 ±0.55
Na2O (mg/g)	5.86 ±0.42	7.41 ±0.10	4.09 ±0.18
K_2O	4.22 ±0.48	6.65 ±0.52	3.66 ±0.28
%MO	61.37 ±1.05	-	-
%TOC	35.6 ±1.77	-	-
%NTK	2.45 ±0.15	-	-
C/N	14.53	-	-

Table 2: Waste composition of each type of compost [6], [18]

	Poultry droppings (FV)		Phosphate mud (PM)		Screen Refusal (RC)	
Swath	m (kg)	P (%)	m (kg)	P (%)	m (kg)	P (%)
HAS	170	66.7	85	33.3	0	0
B	170	66.7	0	0	85	33.3
C	170	66.7	42.5	16.7	42.5	16.7
D	255	100	0	0	0	0

Study of UV-Visible spectroscopy of composts during 120 days of composting

In this study, UV-visible spectroscopy analysis was carried out on the 15th, 50th, 80th, 100th and 120th day of composting on the 4 composts prepared according to the following protocol: 50 ml of 0.5 N sodium hydroxide (NaOH) solution is added to 1 gram of each compost. After 2 hours of stirring using a back and forth stirrer, the solution is left to stand for a few minutes and the supernatant is collected. The supernatant collected in the case of each compost is subjected to centrifugation at 3000 rpm for 25 min. The new supernatant from the centrifugation was subjected to absorbance measurement at 200 nm, 230 nm, 280 nm, 472 nm, 664 nm, 700 nm, 750 nm and 780 nm using a UV-visible spectrometer, after having made a blank with the reference solution. The reference solution consists only of the 0.5 N sodium hydroxide (NaOH) solution. Indeed, the different absorbance values at 280 nm (Q_2), at 472 nm (Q_4) and at 664 nm (Q_6), obtained allow the calculation of the absorbance ratios Q_2/Q_6, Q_4/Q_6 and Q_2/Q_4 [15], [19]. The flowchart in Figure 1 summarizes the protocol of UV-visible spectroscopy.

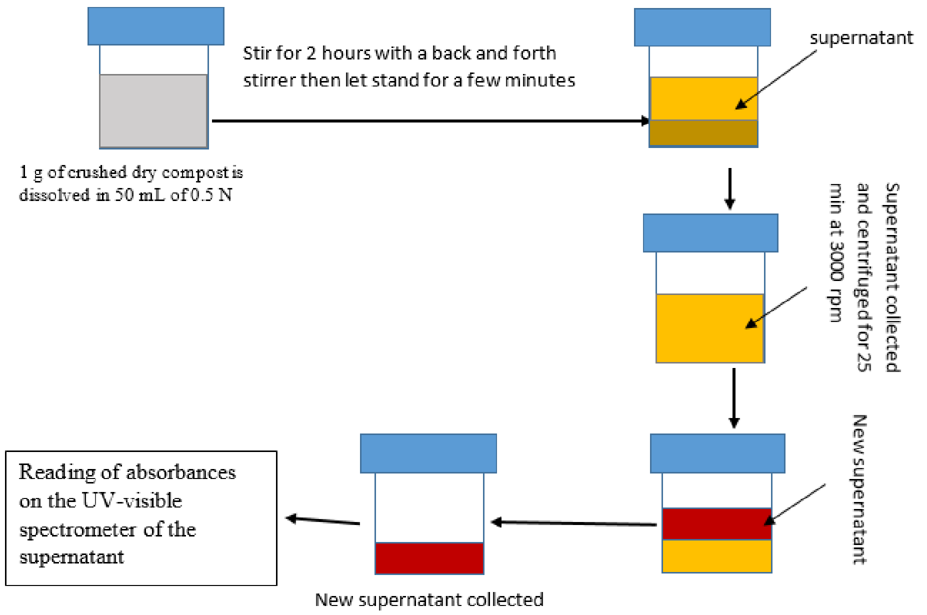


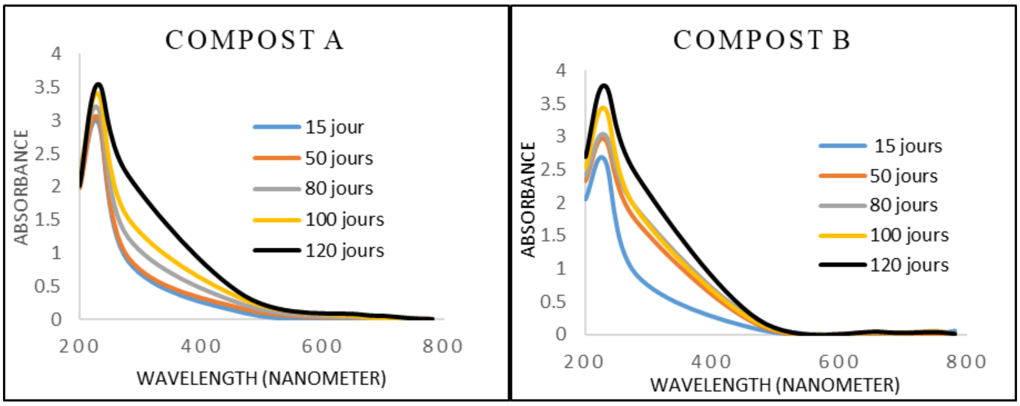
Figure 1: Flowchart summarizing the protocol for measuring absorbance using a UV-visible spectrometer.

3. Results and discussion

Analysis of the UV-visible spectra of the four composts

Figure 2 shows the UV-visible spectra of Composts A, B, C and D.

Analysis of this figure shows that the longer the wavelength, the lower the absorbance (absorption ratio). For all composts, an absorbance peak is observed at the wavelength of 230 nm. For compost A, the maximum absorbance is equal to 3.553; for compost B, this absorbance is 3.780; it is 3.647 for compost C and 3.840 for compost D. These observed peaks would be due to an absorption of radiation from small molecules such as nitrites, carboxylates, aromatic compounds as well as unsaturated compounds which absorb by the double bonds C=O, C=C and N=N [16] . It is generally observed that whatever the wavelength considered, the absorbances become greater as the composts age. This increase in absorbance with the evolution of the process is a sign of the increase in the concentration of aromatic compounds as well as the modification of the functional groups of the organic matter, where the phenomenon of polymerization is known as one of the characteristics of humification [20].



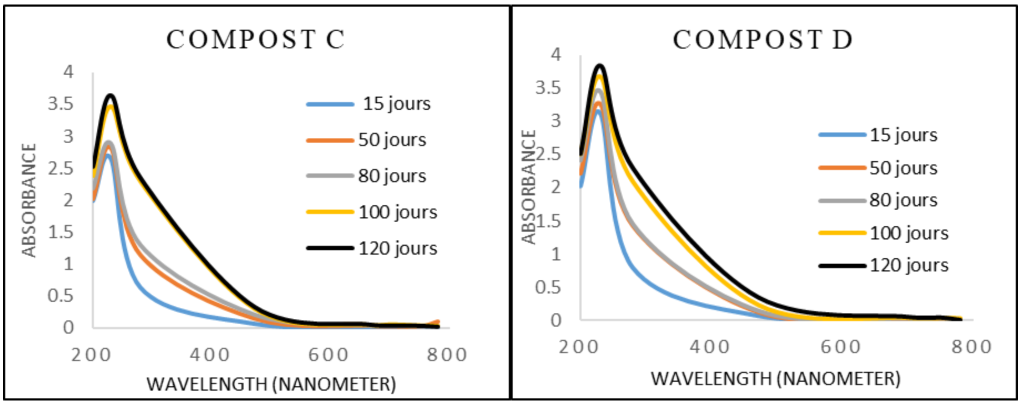


Figure 2: UV-visible spectra of the four composts produced.

The appearances of our ghosts corroborated those of Albrecht [15] and Swift [21] who reported that the absorption spectra of humic substances resemble a "smoothed curve" consisting of an increase in absorption correlated with the decrease in wavelengths. This appearance of the spectra would be due to the fact that these correspond to an accumulation of several chromophores [15].

Evolution of the absorbance ratios Q_2/Q_6, Q_4/Q_6 and Q_2/Q_4 of the composts during the process

The absorbance ratios Q_2 /Q_6, Q_4/Q_6 and Q_2/Q_4 of composts A, B, C and D are shown in Figures 3, 4, 5 and 6 respectively. Analysis of these figures generally shows that the 4 composts (A, B, C and D) have almost constant absorbance ratios Q_4/Q_6 and Q_2/Q_4 during the first 80 days of composting. However, these absorbance ratios show a slight decrease towards the end of the process. At the end of composting, the absorbance ratios Q_4/Q_6 of all composts exceed 5 (between 5.375 and 9.576) and show the characteristics of mature humic acids [19]. These findings indicate the progress in the maturity process of the composts [22]. Composts A and B each exhibited drastic decreases in the Q_2/Q_6 ratio from the 15th day until around the 100th day of composting where this ratio decreased from 65.5 to 35.09 for compost A and from 75 to 49.954 for compost B. For composts C and D, the drastic decreases in the Q_2/Q_6 ratio occurred between the 15th ^{and} 50th ^{day} of composting and were respectively between 125 and 48.251 and 100.941 and 51.825. All composts exhibited progressive decreases in the Q_2/Q_6 absorbance ratio. The progressive decrease began for composts C and D from the 50th day of composting while this decrease began only for composts A and B from the 100th day. The observed decreases in absorbance ratios are explained by the rapid decomposition of proteins and lipids which are easily degradable compounds [20]. Our results corroborate those of Habchi [14], who observed decreases in the absorbance ratios Q_2/Q_6, Q_4/Q6 and Q_2/Q_4 of composts made from date palms.

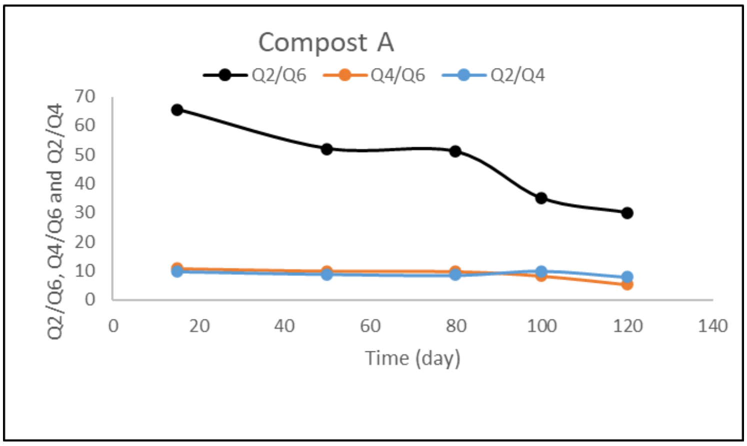


Figure 3: Absorbance ratios Q2/Q6, Q4/Q6 and Q2/Q4 of a 0.5 M NaOH solution of compost A

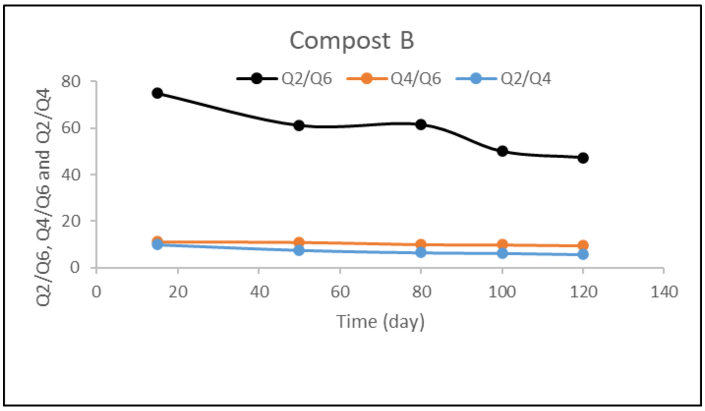


Figure 4: Absorbance ratios Q2/Q6, Q4/Q6 and Q2/Q4 of a 0.5 M NaOH solution of compost B

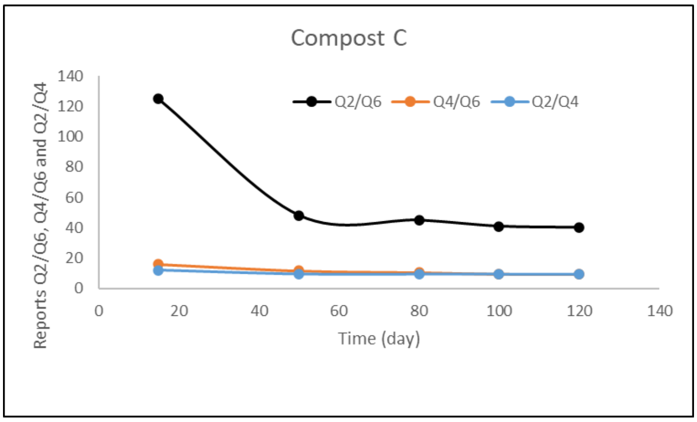


Figure 5: Absorbance ratios Q2/Q6, Q4/Q6 and Q2/Q4 of a 0.5 M NaOH solution of compost C

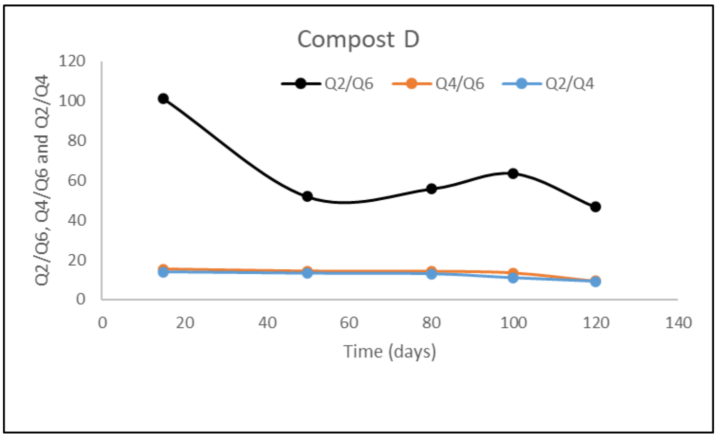


Figure 6: Absorbance ratios Q2/Q6, Q4/Q6 and Q2/Q4 of a 0.5 M NaOH solution of compost D

4. Conclusion

This study aims to monitor the evolution of the maturity of composts made from poultry droppings and phosphate waste by the spectroscopic method, in particular UV-visible spectroscopy. The UV-visible spectra of the four composts show absorbance peaks from the 15^{th} to the end of the process for wavelengths between 230 and 280 nm. The largest peaks are observed on the 120^{th} day of composting and are 3.553; 3.780; 3.647 and 3.840 respectively for composts A, B, C and D. The absorbance ratios Q 4 /Q 6 of all composts exceed 5 (between 5.375 and 9.576) and show the characteristics of ripe humic acids. UV-visible spectroscopy made it possible to evaluate the maturity of the composts produced.

Conflicts of Interest

The authors declare no conflicts of interest

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