CONTRIBUTION TO VALORIZATION OF OLIVE MILL WASTEWATER TREATMENT SLUDGE BY THE CO-COMPOSTAGE PROCESS

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Abstract

Olive mill waste water OMWW stimulate environmental problems in olive oil producing countries. They are highly phytotoxic and contain phenolic compounds, lipids and organic acids. Their treatment by biomethanization generates large quantities of sludge. The latter contains percentages of organic matter and plant nutrients that could be reused as fertilizer for sustainable agricultural practices.

The study aims to valorise the sludge from the treatment of the marble beds by biomethanisation by co-composting in an aerobic environment; and on the other hand, to evaluate the quality of the compost produced from this sludge. For this purpose, two windrows were carried out with the same starting substrates: one was used as a control and the second one, the sludge from the treatment of the water features was added to it with well-studied proportions. The biological degradation of the two mixtures was monitored by weekly measurements of physico-chemical (pH, electrical conductivity, temperature, C/N ratio and polyphenols), biological (phytotoxicity test) and spectroscopic parameters (E2/E3, E2/E4, E4/E6) until their stabilization.

After about 3 months of digestion, the products obtained are rich in fertilizing elements, especially the one with sludge, and have a composition in accordance with the French standard for organic amendments NFU-44-51. They are characterized by a C/N ratio of 11.52 for the swath with sludge against 15.2 for the control, a reduction of polyphenols of about 60%. This proves that the incorporation of sludge into the composting mixture increased the rates of degradation of organic matter, polymerisation of humic acid and degree of maturity and reduced the duration of the composting process by one week.

Keywords: Sludge, recovery, composting, mineral elements, humic substances.

I. INTRODUCTION

The biomethanization of OMWW and these treatment residues is accompanied by a significant production of waste sludge. This sludge is rich in organic matter, nitrogen, phosphorus and trace elements, and is recognized by their fertilizing power. Nevertheless, the sludge of the biomethanization may also contain trace metallic elements (Cr, Zn, Cd, Hg, Pb ...) (mikdame et al., 2019). This sludge is the origin of the genotoxic and cytotoxic power of sludge [8]. To this, it is added the richness of traitement sludge in pathogenic germs and parasites, namely protozoa such as Amoeba, Toxoplasmagondii, Giardia lamblia and Cryptosporidiumsp., As well as helminths such as *Ascaris, Capillaria, And Taenia* (El Fels et al., 2014). The most commonly used sludge treatment or disposal processes is the stabilization (dehydration, liming), incineration; which remain excessive for the Moroccan context; Direct landfill, landfill disposal (Lahlou et al., 2017). But this sector is legally banned in many countries. Other methods are less well known or Still the study, like the incorporation of sludge in the manufacture of cements and concretes (Naamane et al., 2014; 2016), packaging (bioplastic), regeneration of degraded sites, the production of biological insecticides, and bio-fungicides and herbicides. At present, no sludge treatment system is used in Morocco. Nevertheless, several studies have proven effective results when using sludge in agricultural spreading (Lahlou et al. 2017), composting in a mini-reactor, the composting process and the metallic transformation and the organic pollutants (Abdelhadi et al., 2013).

The aim of this study is to evaluate the sludge generated by the biomethanization of OMWW and these treatment residues in the composting process. For this purpose, we developed two types of composts: the first with sludge and the second one without sludge who served us as a witness.

The direct use of these residues presents many risks and constraints related to their handling and use, due to the possible presence of pathogens. These residues must therefore be chemically and/or biologically conditioned before any use in agriculture.

According to several experiments, composting is a simple biological technique, which allows the use of these wastes in agriculture under certain conditions.

II. MATERIALS AND METHODS

II.1. Raw materials

In this study, compost was prepared by mixing the sludge of biomethanization, mixture of aromatic and medicinal plant, poulty manure and the green waste. the mixture of aromatic medicinal plant leaves obtained from a cooperative in the Taounate region, mainly treating thyme, oregano, lavender and rockrose. These residues were left in the open air several days after undergoing hydro distillation to extract essential oils. This mixture is manually removed from residues that are difficult to shred (about 30%); the green waste was gathered from markets located in Taza (Morocco). They are composed mainly of fruit and vegetable residues and the poulty manure was collected from farms in the Taza region.

The physico-chemical characteristics of the defined raw materials are presented in the table 1.

Table 1 : Physico-chemical characterization of the substrates

Parameters	Methanazation sludge	Medicinal plant waste	Green waste	Poultry manure
pH	5.8 ± 0.01	5.10 ± 0.01	7.01 ± 0.03	6.93 ± 0.01
CE (mS/cm)	5 ± 0.01	26.8 ± 0.01	34.86 ± 0.01	3.75 ± 0.5
Density	ND	ND	0.25 ± 0.01	0.33 ± 0.02
Salinity (g/l)	ND	ND	24.01 ± 0.02	46 ± 0.1
Humidity (%)	ND	ND	16.8 ± 0.36	72.88 ± 0.5
MS (%)	95.6% ±1.19	ND	80.22% ±0.2	71% ±0.5
MO (%)	63,05%	95.08%	49.5%	75.7%
Matière grasse (%)	3.1%	12.03%	52%	17.64%
C org (%)	0.43±0.02	55.15	0.09	0.2
NTK (%)	0.008 ±0.003	1.85	0,008 ±0.001	0,02 ±0.004
C/N (%)	53.75	29.81	11.25	10
Polyphenols (g /L)	1.05±0.88	ND	ND	ND
Al (mg /L)	528.3	ND	ND	ND
Fe (mg /L)	7,8	ND	ND	ND
Zn (mg /L)	6	ND	ND	ND
Cr (mg /L)	3,4	ND	ND	ND
Na (mg /L)	353,4	ND	ND	ND
Mg (mg /L)	509	ND	ND	ND

II.2. Compost development

The raw materials were mixed to be co-composed in the open air, using 2 windrows. These windrows differed in their initial composition (windrow B with sludge and windrow T is a control). The proportions of the raw materials were calculated according to the methods described by Proietti et al. and Majbar et al. (2017; 2018) to obtain a physico-chemical characterisation of the initial mixture for the start of the composting process. The composition of the mixtures obtained is such that 25% of each of the substrates for windrow B and 33% for the control. The moisture content was adjusted to approximately 50-60% (optimal moisture content for composting); this operation was carried out during the turning of the windrows. Representative and homogeneous samples were taken during the composting procedure from the windrows for analysis. Each sample was obtained by mixing 6 sub-samples taken from 6 different points in the windrows according to ISO 8633 (ISO 8633, 1992).

II.3. Physicochimicals analysis

Raw materials and composts were characterized by temperature, conductivity (EC), moisture content (% H), organic matter (% MO), Kjeldahl nitrogen (NTK) and C/N ratio.

The composition of the metals was determined by the ICP-AES (Inductively Coupled Plasma Atomic Emission Spectroscopy) method.

II.4. Maturation tests

The maturation tests of composts T and B were carried out by determining the ratio E2/E3, E2/E4, E4/E6 and calculating the germination index (GI).

The ratio E2/E3, E2/E4 and E4/E6 were obtained by the spectroscopy method which uses the property of a body that absorbs light at different frequencies. The E2/E3 index was determined to assess the intensity of the humification process. This ratio represents the absorbance ratio at 250 and 365 nm (Rigobello and al., 2017). The absorption ratio at 250 nm and 472 nm is E2/E4 and the light absorption ratio of a humic acid solution at different frequencies of 465 and 665 nm is the E4/E6 ratio (Lahlou and al.; 2017).

The plant test was carried out on watercress with compost. Ten cress seeds were spread on the surface and covered with a glass plate. Daily monitoring up to the fifth day was carried out all the time of germination, then the germinated seeds were cut and weighed (Lahlou and al.; 2017). The germination test was performed on watercress with an aqueous compost extract (compost juice) in Petri dishes with filter paper. Ten cress seeds were distributed on filter paper and incubated at room temperature (28°C) in the dark for 48 hours (Miyuki and al.; 2006). The number of germinated seeds was counted and the length of the roots was measured. A control for each treatment was performed with 10 mL of distilled water. The GI parameter was calculated using the Zucconi formula (Bustamante and al.; 2008).

II.5. Statistical analysis

The data were submitted to variance analysis using Portable IBM SPSS statistics version 19. All analyses were performed in triplicate. Principal component analysis (PCA) was used to examine multivariate relationship between the physico-chemical and biological parameters progress during composting. Pearson's correlation coefficient (R) was used to evaluate the linear correlation between two parameters at a confidence level of 95% ($p < 0.05$).

III. RESULTS AND DISCUSSION

III.1. Composting process

III.1.1. Temperature evolution

During composting, temperature is highly correlated with microbial activity and is considered to be one of the main parameters used to monitor the effectiveness of the composting process (Wang and al., 2017). The study of the temperature evolution during the composting process of the two composts (B and T) made it possible to highlight the 4 classical phases of composting (Figure1): mesophilic, thermophilic and maturation.

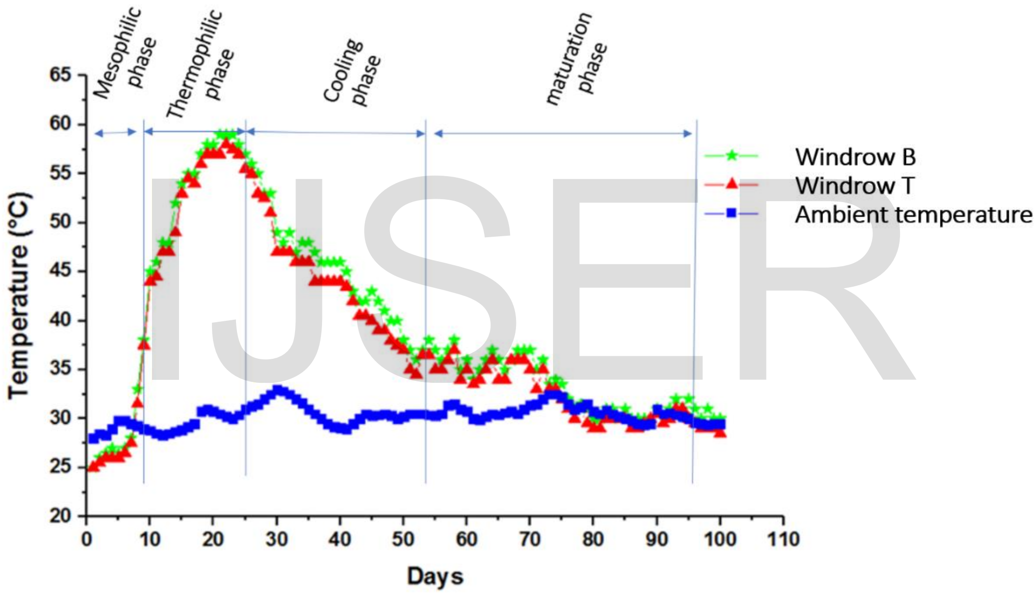

Figure 1 : Evolution of the temperature of mixtures T and B

According to the figure 1, The mesophilic phase is the initial phase of composting where the raw materials is invaded by mesophilic microorganisms (bacteria and fungi), absorbing simple molecules (simple sugars, amino acids, alcohols ...) and transforming some of the polymers Proteins, nucleic acids, starch, pectin, hemicellulose, cellulose, etc.). Their activity has engendered a rise in temperature of 25° C to 28° C for the B windrows and 25 ° C to 27.5 ° C for the T windrows. This difference is due to the difference in the development period of the two composts. The mesophilic phase lasted almost one week for both composts.

The thermophilic phase is characterized by an increase in temperature up to 59 ° C. and 58 ° C for B and T respectively and lasted for about 16 days for B and 13 days for T. Indeed, the increase in temperature is the result, on one hand, of an intense microbial activity which results from the degradation of the simple molecules present in the substrates (Majbar and al., 2018); And on the other hand, the inertia of the compost mass, which gives it a self-insulating capacity and maintains a high temperature inside the windrow.

 The maturation phase is distinguished by a decrease of temperature to the ambient in the two windrows where the microbial flora is dominated by the mesophilic organisms. The decrease in temperature is due to the depletion of the medium in easily metabolizable organic compounds; and persistence of compounds resistant to degradation (lignin, cellulose ...) (Lahlou an al., 2017). It is dominated by humification reactions which consist in the polymerization of organic compounds towards more stable compounds called "Humus". The maturation of control compost T began at the 7th week while B sludge compost started only at the 6th. So, the presence of sludge in composting extended the thermophilic phase by 1 weeks.

III.1.2. pH evolution

During the co-composting process, the pH value for both mixtures tended to stabilize around neutrality 7.2 and 7.3, respectively, for Mixture B and Control T (Figure 43). A slight decrease in pH was noted in the control compost in the second week. This is explained by the production of acids and the dissolution of organic carbon in the medium where degradation of simple carbohydrate and lipid molecules occurs (Barje et al., 2010; Lahlou et al., 2017). The increase in pH from 7.33 and 7.25 for control T and compost B is due to ammonification and ammonia production from the degradation of amines (proteins, nitrogen bases, etc.) (Lahlou et al., 2017), and may also be due to the release of existing bases in organic waste. An increase in pH indicates degradation of organic acids or oxidation of phenolic compounds (Gigliotti et al., 2012). The pH stabilizes from week 8 for control compost and week 7 for sludge compost. This means that the sludge accelerates the function of thermophilic microorganisms for amine degradation. Finally, the stabilization of the pH around 7 for both composts proves the buffering capacity of humus during maturation (Abdelhadi et al., 2010; Lahlou et al., 2017).

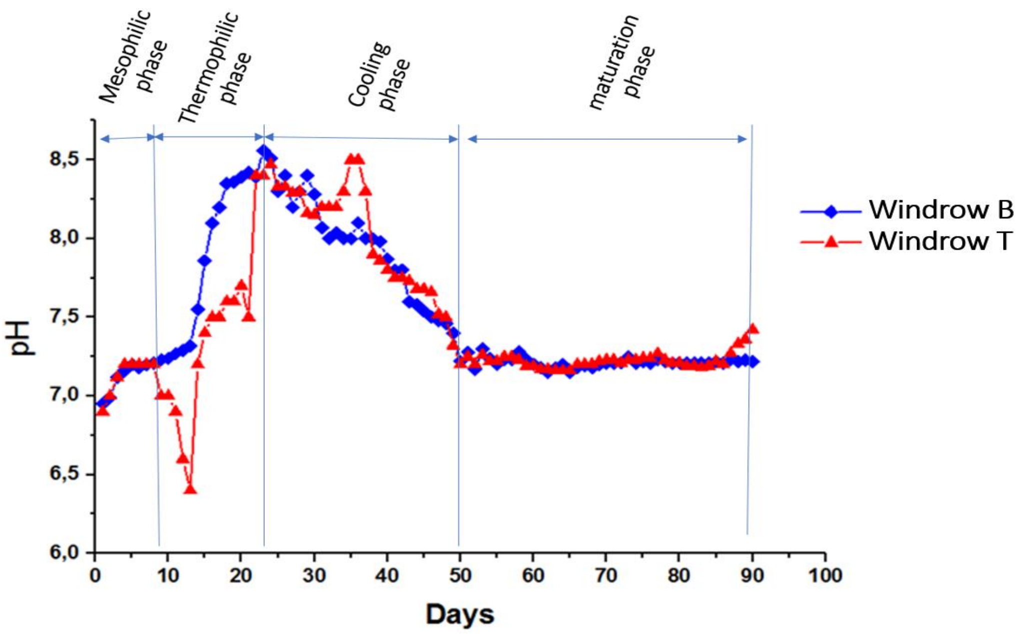

Figure 2 : Evolution of the pH of mixtures T and B

III.1.3. Evolution of electrical conductivity

The electrical conductivity (EC) is the reflection of soluble salts present in the composting mixture. The EC of both windrows T and B increases from the first weeks, showing the mineralization of the organic matter (Figure 3). In the maturation phase, the conductivity of compost T tends to decrease and stabilize at 1.72 $mS.cm^{-1}$. While that of compost B stabilizes at a value of 0.72 $mS.cm^{-1}$ at the end of the composting process. This difference could be explained by the fact that compost B is rich in fermentable elements that release more heat per unit mass and slightly inhibits the activity of microorganisms due to the reduced space in the compost. Although the conductivity values obtained at the end of the process can be explained by the theory of Avnimelech et al. (2003) which states that a reduction in conductivity is due to good aeration of the compost; this affected the concentration of salts and conductivity. According to the standard, the maximum allowed EC limit is 4000 mS/cm (Abu Khayer Md et al., 2013). This means that the two composts (Compost B and Compost T) could be applied as organic fertilizer to various crops.

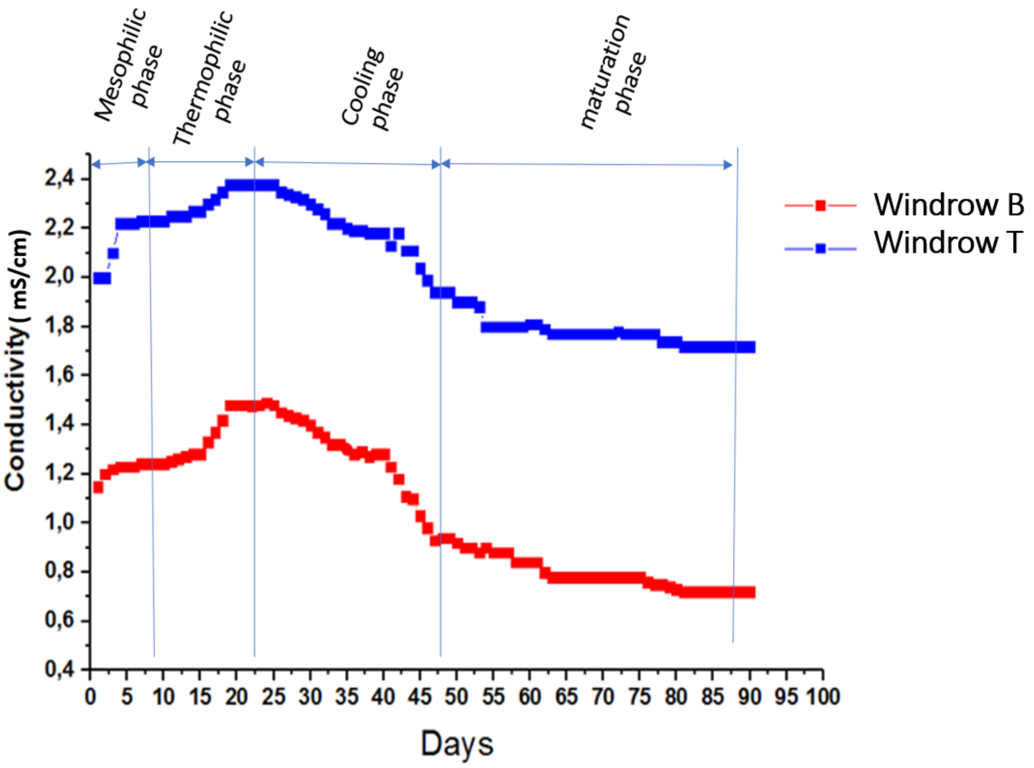

Figure 3 : Evolution of the Electrical conductivity of mixtures T and B

III.1.4. Evolution of the C/N ratio

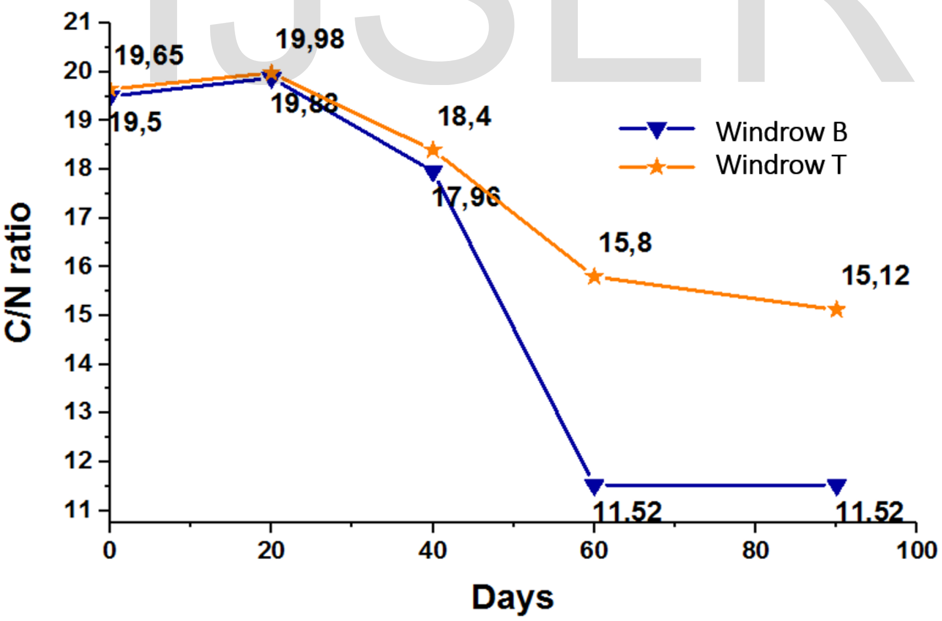

Figure 4 : Evolution of the ratio C/N of mixtures T and B

The evolution of the C/N ratio is directly related to the biodegradation of organic matter, resulting in the lowering of the total carbon rate associated with the increase in nitrogen concentration.

The C/N ratio increases from 19.65 and 19.5 to 15.12 and 11.52 for T and B composts respectively at the end of co-composting (Figure 4). The decrease in this ratio is closely related to the loss of organic carbon through biodegradation of organic matter and the evolution of gaseous CO_2. The decrease in this ratio is mitigated by the loss of ammonia nitrogen during the thermophilic phase (Abdelhadi and al., 2103). The final values achieved with C/N, after 3 months of co-composting, show a good maturity of the final compost. Indeed, according to too many authors (Michailides et al., 2011 ; Tortosa et al., 2012 ; Agnolucci et al., 2013), a compost is considered mature if it has a C/N ratio between 10 and 15. These variations depend mainly on the nature of the nitrogen molecules and their capacity to be mineralised and on the other hand, on the nature of the carbon compounds present in the substrate to be composted (Altieri et al., 2011 ; Lahlou et al., 2017).

III.1.5. degradation of organic matter

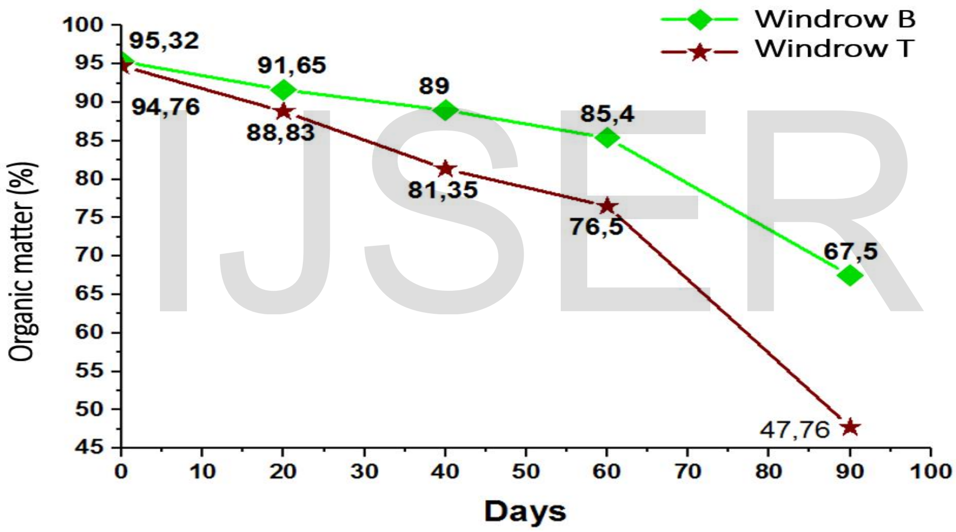

Figure 5 : Evolution of the OM of mixtures T and B

the evolution of the organic matter content of the mixture during the composting process is considered as an essential parameter of biodegradation and transformation of organic matter during composting. Figure 5 presents the organic matter contents of the both mixtures at the beginning and end of the composting process. these results show that all the experimented windrows were characterized by a high rate of organic matter at the beginning of the composting process. It could be noticed that the windrow T has the highest organic content. During the composting process, the organic matter content gradually decreased, resulting in a degradation rate exceeding 40% for the both mixtures. This degradation is highlighted during composting by a mass loss of the initial mixtures or even a remarkable reduction in the volumes of co-composted waste. The organic matter decomposition was the result of the microbial activity, allowing the transformation of the organic matter into stable humic substances (Majbar et al., 2018). The similar results were observed by El Fels et al., indicating a good degree of compostability of the mixtures (El Fels et al., 2014). Furthermore, no significant difference was shown by Student's t-test between the both windrows. So, one can conclude that the degradation of organic matter does not depend on the composition or nature of the co-composted waste.

III.1.6. Degradation of phenolic compounds

the degradation of phenolic compounds during the composting process is necessary to assess the phytotoxicity of the composts produced. Figure 6 shows the degradation of phenolic compounds during the co-composting process in the two windrows.

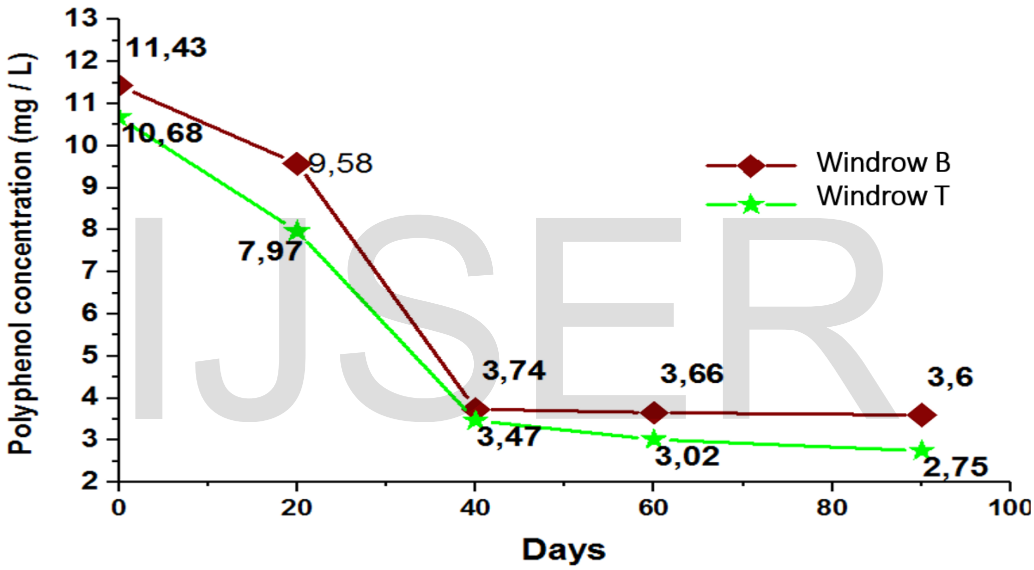

Figure 6 : degradation of phenolic compounds of mixtures T and B

According to Figure 6, the decrease in the concentration of phenolic compounds started in the first phase of composting but was greater during the second phase (mesophilic phase). According to Abu Khayer et al (2013), fungi are the main agents of polyphenol degradation in compost because they use polyphenoloxidase, especially during the thermophilic phase. However, they discovered that polyphenoloxidase can also be active during the initial activation phase of composting or after the thermophilic phase. Abu Khayer and colleagues (2013) also reported on the ability of redox enzymes, including laccases, peroxidases and tyrosinases, to remove polyphenolic compounds from the marble by polymerization and oxidation reactions. As a result, oxidoreducing enzymes in microorganisms or plant tissues act on phenolic compounds to produce highly reactive substrates that react with each other or with other substrates, such as sugars, proteins and fatty acids, resulting in the formation of comparatively less toxic and bioavailable substances. Therefore, the reduction in polyphenol concentration observed in composting is likely coupled with the formation of humic substances (HS), which incorporates both degradation and condensation reactions. It should be noted that the precise mechanism of humification remains largely unknown, although it is assumed that the monomers are converted to polymers with high molecular weight and low solubility and that these polymers are highly resistant to biological degradation (Ait Baddi et al., 2009).

III.2. Phytotoxicity

Figure 7 : Evolution of germination index of composts T and B

During the composting process, the phytotoxicity of the two windrows of the different samples collected from the two composts was evaluated by monitoring the germination index in relation to the maturity of the product.

During composting, the watercress seeds will germinate after 90 days. It should be noted that for the first 40 days (Figure 7), the GI is relatively low, reflecting an immature compost. This composting period coincides with the mesophilic and thermophilic phases during which the degradation of organic matter and the release of low molecular weight organic acids occur, with the existence of high concentrations of ammonia, considered a phytotoxic substance (Zhang et al., 2014). Therefore, the presence of polyphenols are considered to inhibit seed germination would eventually be present (Hachicha et al., 2009; El Fels et al., 2016).

From the 2nd month of composting, the germination index gradually increased, indicating the reduction of toxic compounds and the elaboration of stable humic substances, during the cooling phase (El Fels et al., 2014 and 2016). The final GI value of about 99% in compost B reflects the maturity of the compost and the absence of phytotoxicity (Sellami et al., 2008; Zhang et al., 2014; Cui et al., 2017).

III.3. Spectroscopic analysis:

III.3.1. E2/E3 ratio

The E2/E3 ratio is related to the molecular size and the degree of aromaticity of organic matter, increasing when aromaticity and the molecular size of humic substances decrease (Rigobello et al., 2017). An increase in the E2/E3 ratio of the two composts is observed until the 3rd week (Figure 8) and then there is a stability of the ratio until the 40th day, reaching an E2/E3 ratio value of 5.26 for compost B and 11.05 for the control compost, after which the ratio increased slightly until the end of composting. The final values reflect the decrease in the molecular size of the humic substances, especially in compost B.

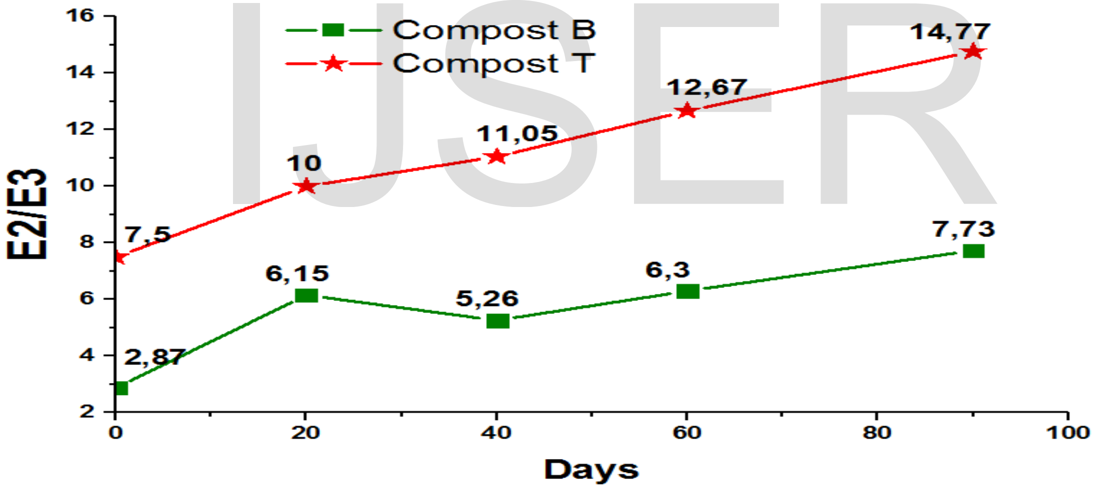

Figure 8 : E2/E3 of composts T and B

III.3.2. E2/E4 ratio

The E2/E4 index has been used as an indicator of the relative proportions of lignin and the rest of the material at the beginning of humification (Guo et al., 2017). It indicates the relationship between weakly and partially moistened organic molecules (Cerdán et al., 2016). After a slight increase in the E2/E4 ratio during the first weeks of co-composting, the ratio decreased in compost B (Figure 9). The observed decrease in the E2/E4 ratio in compost B reflects intense depolymerization and microbial degradation of phenolic compounds (Lim and Wu, 2015). Subsequently, the increase in the E2/E4 ratio would be explained by the formation of carboxylated benzene groups in humic substances (Guo et al., 2017).

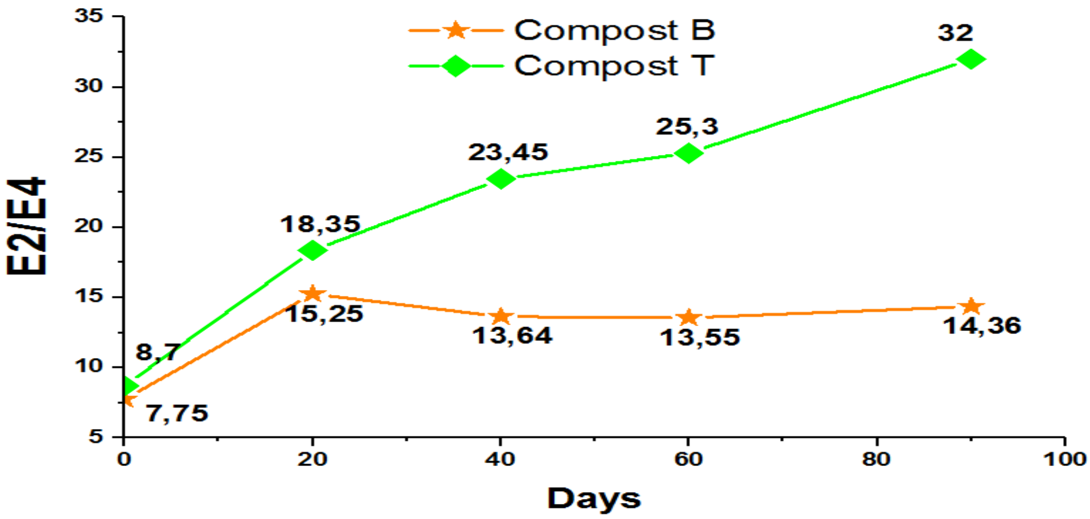

Figure 9 : E2/E4 of composts T and B

III.3.3. E4/E6 ratio

The E4/E6 ratio is the most indicative parameter related to the degree of humification, with a value below 5 for humified material indicating the predominance of humic acids (Bhat et al., 2017) and a value above 5 indicating the predominance of fulvic acids. Indeed, the report provides information on the size and molecular weight for E4 and the degree of aromatic condensation and polymerisation for E6 (fuentes et al., 2016).

During the first 21 days of composting (Figure 10), E4/E6 increased and then decreased in compost B due to humification of organic matter and synthesis of humic substances (Zbytniewski and Buszewski, 2005). After 40 days of composting and following windrow turns, the E4/E6 ratio increased again, eventually decreasing at the end of the process. Wang and al. (2013) also found a reduction in the E4/E6 ratio during the active phase of composting sludge from wastewater treatment plants, and a slow increase afterwards. More recently, Haddad et al. (2015) also found a final E4/E6 ratio value of 6 during the composting of olive pomace and cattle manure. They considered this ratio as an indicator of the intensity of humification. Thus, when the value of the E4/E6 ratio is reduced, the compost is mature and the humic substances formed are complex.

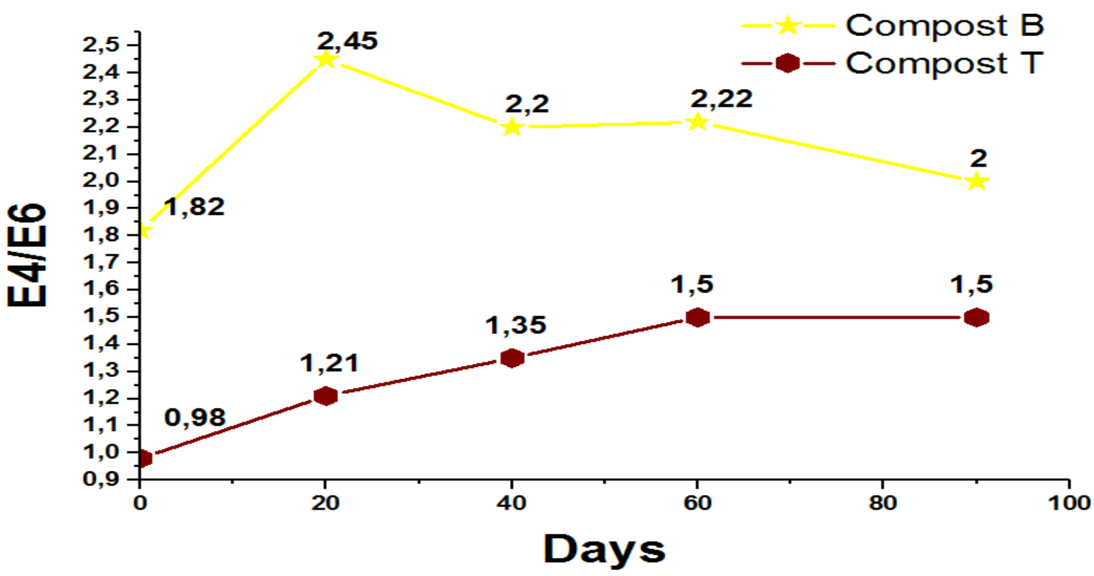

Figure 10 : E4/E6 of composts T and B

III.4. Principal component analysis of composting parameters

In order to study the influence of the different control parameters on the evolution of the co-composting process, a correlation analysis between these physico-chemical parameters of the mixtures was established. This correlation study was carried out by a principal component analysis that identifies the main factors influencing the process. This correlation between the results of the physico-chemical and biological parameters during the composting process was established on a matrix (Table 2).

The results show a significant positive correlation between temperature and pH (tending towards 1) for both mixtures and also between pH and temperature. However, during the early phases of the co-composting process (mesophilic and thermophilic), the intense activity of the microorganisms leads to an increase in temperature accompanied by mineralization of the organic matter and a release of organic acids and mineral salts reflecting a change in pH and an increase in the EC of the medium, hence the correlations observed between temperature, pH and EC.

Also, we observe a significant correlation between MO, C/N ratio and the degradation of phenolic compounds due to the fact that the activity of the microorganisms during the co-composting process condemns a decrease in the carbon level associated with the increase in the nitrogen concentration leading to the reduction of the C/N ratio and the biodegradation of the organic matter. This activity also contributes to the reduction of the phenolic compounds contained in the mixtures. On the other hand, a strong negative correlation is noted between the germination index, organic matter and C/N ratio and phenolic compounds giving the idea that this index depends mainly on the rates of phytotoxic compounds. We confirm the hypotheses that organic acids, due to the biodegradation of organic matter during the early stages of co-composting, inhibit seed germination and plant growth and that high concentrations of phenolic compounds have a phytotoxic effect (Majbar et al., 2018).

Table 2: Correlation matrix between the different control parameters of the co-composting process and the germination index for the three mixes

CORRELATIONS OF THE COMPONENTS OF COMPOSTS B AND T											
		TEMPERATURE	PH	CONDUCTIVITY	C/N	OM	POLYPHENOL	IG	E2/E3	E2/E4	E4/E6
TEMPERATURE	PEARSON CORRELATION	**1**									
PH	PEARSON CORRELATION	**,986****	**1**								
CONDUCTIVITY	PEARSON CORRELATION	**,705****	**,729****	**1**							
C/N	PEARSON CORRELATION	**,443**	**,493**	**,941****	**1**						
ORGANICS MATTER	PEARSON CORRELATION	**,289**	**,254**	**,791****	**,812****	**1**					
POLYPHENOL	PEARSON CORRELATION	**,059**	**,082**	**,630***	**,771****	**,717****	**1**				
IG	PEARSON CORRELATION	**-,101**	**-,109**	**-,750****	**-,875****	**-,927****	**-,893****	**1**			
E2/E3	PEARSON CORRELATION	**,248**	**,235**	**-,482**	**-,686****	**-,814****	**-,693****	**,898****	**1**		
E2/E4	PEARSON CORRELATION	**,667****	**,645****	**-,047**	**-,338**	**-,479**	**-,582***	**,666****	**,876****	**1**	
E4/E6	PEARSON CORRELATION	**,695****	**,649****	**,332**	**,088**	**,100**	**-,128**	**,100**	**,339**	**,601***	**1**

**. The correlation is significant at the 0.01 level (two-way).

*. The correlation is significant at the 0.05 level (two-way).

III.5. Analysis as a main component of composting parameters

The Principal Component Analysis (PCA) shows that only two components of the PCA explain almost all of the information or variability (Figure 11).

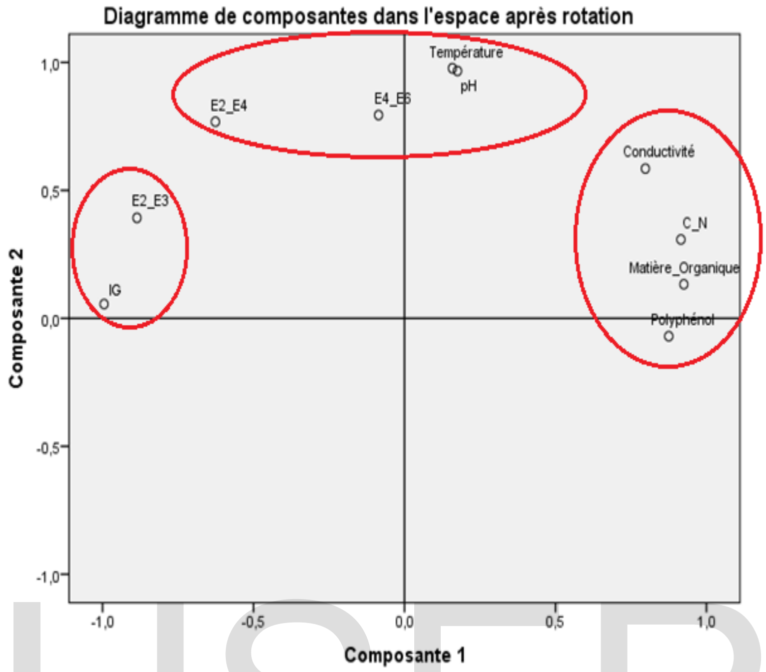

Figure 11 : Main component analysis of control parameters for both composts during the co-composting process

The projection on the plan of these variables (Figure 11), gives an affinity of the variables along each axis and it highlights three groups:

- Group 1, which is positively focused on axis 1, shows that electrical conductivity, organic matter, C/N ratio, phenolic compounds vary in the same direction.

-Group 2, located on the positive part of axis 2, consists of temperature, pH, E2/E4 and E4/E6.

- Group 3 is opposed to group 1 since it is negatively focused on axis 2 and contains the germination index and E2/E3.

The Main Component Analysis justifies the correlation results and we will conclude that the C/N ratio, the degradation of organic matter and phenolic compounds have an important influence on the co-composting process and therefore on the quality of compost produced.

III.6. CHARACTERIZATION OF MATURE COMPOST

Maturity is not described by a single property and it is therefore preferable to evaluate it by measuring two or more compost parameters. Maturity is, in part, influenced by the relative stability of the composting material, but it also describes the effect of other physical and chemical properties of compost on plant growth and development. Immature composts may contain high amounts of free ammonia, specific organic acids or other water-soluble compounds that can prevent seed germination and root development (Abu Khayer and al.; 2013). The mature compost that will be applied to agricultural land should be free of these potentially phytotoxic substances.

Therefore, the quality of the composts produced was evaluated by measuring the physico-chemical and metallic parameters represented in Table 3:

Table 3: Physico-chemical characterization of mature composts

PARAMETERS	COMPOST T	COMPOST B	STANDARDS NFU44-051 (LIMITS)
Ph	7.2	7.3	ND
Conductivity (ms.cm-1)	0.72	1.72	ND
C/N	15.12	11.52	>8
Polyphenols ($mg.L^{-1}$)	2.75	3.60	
MINERAL ELEMENTS AND FERTILIZERS (G/KG)			
P	0.5212	1.3893	ND
K	1.0533	3.4896	ND
Mg	0.7635	3.7072	ND
Ca	20.527	4.4835	ND
Fe	2.4358	0.5379	ND
Na	1.2209	0.4628	ND
Mn	0.1626	0.0701	ND
HEAVY METALS (MG/KG)			
Al	0.5930	3.2400	18
Cd	0.0851	0.0859	3
Ni	0.1179	0.1132	2
Cr	0.0388	0.0306	12
Cu	0.0445	0.0343	300
Zn	< 0.01	< 0.01	600

The Comparison between the composition of composts T and B with French standards reveals that the content of most metals has decreased compared to that of sludge (Table 3). This decrease may be the result of the leaching of these metals by the water produced during the degradation of the organic matter and by leaching during the humidification of the windrows. On the other hand, some changes in physicochemical characteristics such as pH and electrical conductivity influence the solubilisation or the transformation of these elements (Lahlou et al., 2017). It can be deduced that the decrease in the total rate of heavy metals is strongly related to a decomposition of the organic matter during the thermophilic phase and that these latter precipitates and become immobile in the presence of the carbonates. In general, heavy metals are immobilized by organic matter and the phenomenon of adsorption of the organic matrix which can contribute to the decrease of their concentration (Burkina et al., 2010). In the light of these data, the total contents of the heavy metals (Pb, Cd, Cr ...) in the final compost is lower than that in activated sludge alone. After 4 months of co-composting, the products obtained meet the standards of use (AFNOR, 1993) to the NFU 44-095 standard for sludge composts of the STEP and the French standard of urban compost NFU 44-051. As a result, the composts thus produced can be classified in category A of the composts (Burkina et al., 2010) and can be used in agriculture as an amendment for soils without risk of contamination of the soil-plant system.

CONCLUSION

the digested sludge of the biomethanization of OMWW and their sludge traitement is characterized by their richness in organic matter and nitrogen, a C/N ratio of 53.75 according to the sludge standard accepted for composting (NFU 44-095). This proves their valorisation in the composting process with other substrates (household and green waste, poultry droppings and ....). Two mixtures of different substrates and compositions were made; One with B sludge and the other without sludge T constituting the control. The mixtures of the initial substrates at t = 0 for the production of composts B and T are slightly basic, rich in carbon, in nitrogen and organic matter. The monitoring of the composting process was carried out by weekly measurements of temperature, pH, conductivity, organic matter, carbon and nitrogen for 3 months. The mesophilic phase of the two composts B and T was obtained after one week. The thermophilic phase is the longest phase; it was 16 days for the compost B and 7 days for compost T. Stabilization of the various parameters of compost B and T took place after the 6th and 7th week respectively a. The presence of the sludges in the compost accelerated the thermophilic phase.

in concluding, the prior treatment of OMWW by physico-chemical or biological methods reduces its pollutant load in non-biodegradable organic matter, in particular polyphenols; this facilitates the degradation of the remaining matter during the composting process, increases its load in fertilisers and reduces the production time of a mature compost ready for use.

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