Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2017, 7(4), 668–674, doi: 10.15421/2017_178

ORIGINAL ARTICLE *UDC 631.879.41*

Agroecological aspect of the valorization of enriched compost household fermentable refuse production: cases of the town of Tiaret (Algeria)

M. Berrayah[1], M. Maatoug[1], M.E. Azzaoui[1], N. Hadidja[1], D.T. Wendatta d'Aquin[1], A. Ganete[1], O.V. Zhukov[2]

[1]Agro Biotechnology and Nutrition in Semi-Arid Zones Laboratory, Faculty of Science of Nature and Life, University Ibn Khaldoun Tiaret, Algeria.
[2]Oles Honchar Dnipro National University
Gagarina Prospekt 72, Dnipro, Ukraine, 490102
E-mail: zhukov_dnepr@rambler.ru
Tel.: +380985079682

Submitted: 31.10.2017. Accepted: 01.12.2017

Composting is a process for the biological treatment of waste. This work consists of the valorization of the fermentable fraction of the household waste (FFOM) of the city of Tiaret by the production of enriched compost and its physicochemical characterization. In this context, 50 kg of selectively collected FFOM were composted by the Andean composting technique with mechanical turning and oxygen supply by aeration. Two enrichment treatments were applied. The first consists of the addition of ash on the waste to be compacted and the second, the addition of urea on the 25^{th} day of the process. After two months of composting, the screening gave a mass of 2.06 kg of which, 4.12% of the initial mass. The physico-chemical analyzes concerned pH, electrical conductivity, salinity, moisture, dry matter, organic matter, mineral matter and total organic carbon. The enrichment treatments carried out also made it possible to improve the agronomic value of the compost from the category of organic amendments to that of organo-mineral fertilizers.

Key words: Composting; material recovery; enrichment; agronomic value; Tiaret

Introduction

According to the FAO (2009), the world's population will reach 9.1 billion by 2050. This situation would result in a significant waste production and consequently lead to numerous health and environmental problems. This situation is all the more worrying in the developing countries.

The search for a rational approach to waste management is part of a sustainable development approach in the basic principles, which emphasize a viable environment, maintaining natural capital and biodiversity (Alouemine, 2006). In this sense, composting of household waste becomes imperative and is at the crossroads of agronomic, environmental, social and economic issues. In fact, composting is a process for the biological treatment of organic waste intended to transform it into an organic amendment, the incorporation of which on the soil improves both the physico-chemical and biological properties (Soltener, 2003), (Goldberger, 2008). Nevertheless, the composts obtained have a low content of mineral elements which does not allow their use as a fertilizer, thus limiting their prospects for use in agriculture. In order to overcome this situation, enrichment operations are recommended by many authors in particular (*Gueye et al.,* 1986, *Misra et al.*, 2005, Sérémé and Mey, 2008, Bouzou, 2009).

The objective of this work is to target two objectives:

- the production of a compost enriched from the fermentable waste of the town of Tiaret;
- the confirmation of its fertilizing value through a series of physicochemical analyzes.

Material and method

Production of enriched compost

The study was carried out at the plant ecology laboratory of the University of Tiaret. We used the technique of Andean composting with mechanical reversal where the supply of oxygen was assured by a forced aeration (Use of a fan).

Site preparation

Since the climatic conditions were not favorable, it was necessary to set up a device with a view to establishing optimum conditions for a smooth operation of the composting process. The transactions carried out are summarized as follows:

- The construction of a hangar 2 m long, 1 m wide and 1.8 m high with a slope of 0.5% based on planks and plywood. It was installed inside an electrical circuit consisting of four lamps to generate heat and an exhaust fan.
- Delimitation of the composting zone: an area of 0.80 m^2 was delimited by 4 stakes (1 m x 0.8 m). A 10 cm thick substructure was left. It consists of a layer of wood and a layer of straw to allow aeration downwards.
- Placing a plastic cover.

Collection and preparation of waste

The waste collection consisted of a selective collection of the SWOT. The sampling sites are the university restaurant and two fruit and vegetable markets of the city of Tiaret. Their mixing was subsequently carried out. They are made up of oranges, tomatoes, lemons, courgettes, banana peels, potato peelings, onions, carrots, lettuce, cabbage, green beans, parsley, spinach, bread pieces, eggshells etc.).

Before they were deposited on the site, we sort out small plastic bags, pieces of metal, twine that would have escaped during the selective collection. We measured the moisture which proved to be very high and inadequate for good composting. To do this, we recommended a sun drying (5 days for waste soaked in water and 2 days for those less moistened).

The waste was subsequently cut into small pieces so as to have dimensions between 5 and 10 cm as recommended by Bayard and Gourdon (2003) and Morocomp (2008) to increase the surface area of contact between waste and microorganisms and therefore increase biodegradation kinetics.

Enrichment treatment n ° 1

We have incorporated two kilograms of wood ash in order to enrich the waste with mineral elements such as calcium, magnesium, potassium and phosphorus. The ash is used as basic (pH > 10) quick-acting amendments, regulated by French Standard NF U42-001 (Marcovéchio, 2010). On this mixture, 2.5 kg of well chopped wheat straw were added as a structuring agent. Culot (2005) shows that the addition of structuring agents makes it possible to contain moisture, to improve the porosity of the waste pile and to avoid settlement and the formation of zones of anaerobiosis during the process.

Implementation of the process

We have embedded on the previously erected base four layers of the mixture (waste - ash - straw). Each layer was topped with a thin layer of bovine manure from the university's pilot farm. Finally, a final operation consisted of covering the pile with a layer of mud made from garden soil and water in order to avoid thermal losses.

Follow-up of the process

The follow-up of the process consisted of:

- regular measurement of temperature;
- ventilation control using two different techniques: mechanical ventilation (turning) and forced ventilation (use of a ventilator);
- control of humidity after each turning.

Enrichment treatment n ° 2

After 25 days of composting, we added 500 g of urea composed of: Nitrogen: 46.64%, Oxygen: 26.64%, Carbon: 19.99% and Hydrogen: 6.73%. The urea was dissolved beforehand in 250 ml of water, to facilitate its incorporation into the waste without, however, causing the windrow to be too moist.

Maturity test and screening

Two techniques were used to estimate the maturity of the compost. A first empirical method based on observation (the absence of foul odors, the color of the compost). The second consists of the E4 / E6 Physical Test. It allows the confirmation of the maturity of the compost (Duval, 1993). It is the subject of humic acid extraction and the measurement of the absorbance at wavelengths between 465 and 665 nm. The smaller the ratio is, the more compost is ripe.

It was carried out after the maturity tests using a square mesh sieve of size: 4 × 4 mm. The physico-chemical analyzes involved a series of parameters to characterize and appreciate the qualities of compost. They concern pH, electrical conductivity and salinity, moisture and dry matter, organic matter and raw ash, total organic carbon, certain mineral elements (N, PK) and trace elements metal including zinc and copper.

Results and discussions

Inherent results in compost production

Humidity

The results show that the waste initially had a very high humidity (86 ± 1.01%). After drying, it rose to (68 ± 1.56%), then an average loss of about 18%.

A high moisture content reduces the porosity of the swath which hampers microbial activity. Culot (2005) Gourdon (2010), Humeau and Cloirec (2013) agree on a maximum humidity of the order of 65%.

Evolution of the temperature

The average temperature of the swath initially 10 ° C grows rapidly during the first eight days to reach a maximum of 57 °C (fig. 1). After the first turning over on the tenth day, the temperature drops on the eleventh day at 29 °C., then it rises to 38 °C during the 15th day and then begins to descend.

The second turn (17^{th} day) resulted in a drop-in temperature to 21 °C followed by a slight rise and stabilized at 28 °C on the 21^{st} day. The third turnover generated low variability and the temperature stabilized between 21 and 24 °C.

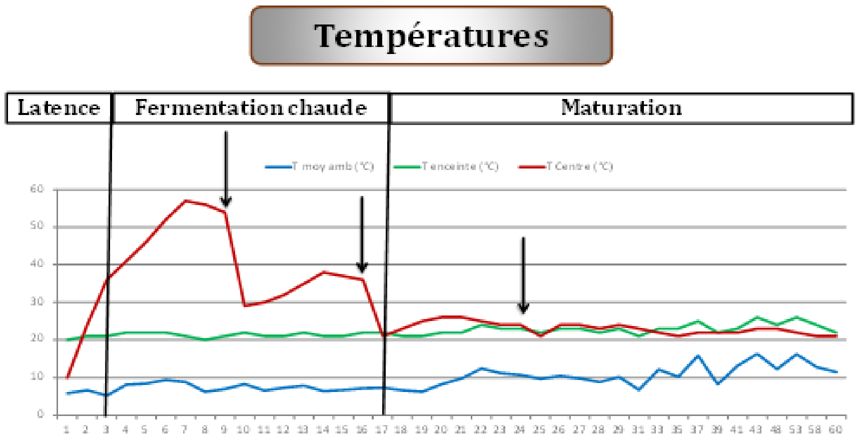

Fig. 1. Evolution of temperature during composting

It is important to note, however, that temperatures were variable at the various locations of the swath. Those in the center were higher than those on the sides, which implies a much greater degradation in its central part.
Kuztner (2000), Epstein (2011) and Stentiford (2013) recommend a temperature of 60 ° C for complete degradation of pathogens and germs. For our protocol, we have obtained just 57 ° C, nevertheless (Mesnil and Baguenier, 1967), Kahren (1967) report that a temperature higher than 55 ° C for a few hours could ensure the destruction of common pathogens and parasites.

Maturity of compost

Maturity is an organic and chemical condition that indicates the stability of compost and hence its safety to plants (Epstein, 2011).
The results of compost maturation by the empirical method were conclusive after only two months of composting. To ensure this maturity, we performed the E4 / E6 test. It is a spectrometric method, that is to say, which uses the property of a body, a solution to absorb light at different frequencies. The light absorption ratio of a humic acid solution at frequencies of 465 and 665 nm is referred to as E_4 / E_6 ratio. The results are shown in Tab. 2.

Table 1. Results of the E4 / E6 test

SampleNumber	E_4/E_6
1	2.21
2	2.61
3	2.47
Mean	2.43
White	0.66

Like white (absence or presence of fulvic acid), for all three repetitions, ratios of less than 5 are observed. As a result, the compost is very rich in humic acid, which characterizes a stable organic matter. This test ensures the maturity of the compost. One could even say that composting was relatively fast. This is due, on the one hand, to the optimization of the composting parameters Diaz and Savage (2007), Le Cloirec (2013) and on the other hand to the various enrichment treatments that have favored the development of the microbial population (Sérémé and Mey, 2008).

Screening

The screening yielded 2.06 kg of compost, which corresponds to 4.12% of the initial waste mass and 3.7 kg of screening refusal, which represents 7.4%. This low composting efficiency is due to the significant reduction in waste mass during fermentation (Bayard and Goudron, 2010). This reduction is due to a loss of the organic matter by mineralization, in particular that of the carbon which is lost in the form of CO_2 and a loss of water in view of its evaporation when the windrow temperature is raised. *Gueye and all.* (1983) observed a loss that can go up to 70% of the initial weight during the composting of corn straw with watering.
It should also be noted that no foreign matter was found in the compost after screening, thanks to the selective collection and careful sorting prior to composting.

Physico-chemical characterization

The results of the determination of the various parameters are recorded in Table 2. The pH value of 9.92 obtained at the end of composting is basic. (Diaz and Savage, 2007) report that an optimum pH at the end of composting is between 7 and 8.5. This basic pH could be explained by the presence of ammonium (NH_4^+) ions during composting (Tang et al, 2006); (*Charland et al.* 2001). This could be the result of a high concentration of exchangeable bases such as potassium K^+, magnesium Mg^{2+}, limestone Ca^{2+}), sodium Na^+. These bases emanate from the enrichment treatment with wood ash, valorised in agriculture as a basic amination at pH > 10 (Marchovechio, 2010).

Electrical conductivity is rarely mentioned or cited in the literature on compost, although it is directly related to salinity and reflects a phytotoxic potential. Fuchs et al., 2001; Francou, (2003) give a maximum value of 4 mS/cm for the compost. A value greater than 4 would lead to the inhibition of germination of cress seeds (*Garcia et al*., 1992).
The obtained values of electrical conductivity and salinity, 4.92 mS/cm and 3.44 g/l respectively for this study, are relatively high for a growing substrate. Meantime, they provide information on the availability of mineral elements (*M 'Sadek et al*., 2012).

Table 2. Physico-chemical parameters of compost (mean±st./error)

Parameters	Average
pH	9.92±0.005
Electrical conductivity (mS/cm)	4.92±0.006
Salinity (g/l)	3.44±004
Humidity (%)	21.55±0.08
Dry matter (% MS)	78.45±0.08
Organic material (% MS)	49.94±0.265
Total organic carbon(% MS)	28.96±0.155
Mineral matter (% MS)	50.10±0.321

These results support the assumption made above about the concentration of exchangeable bases. Moisture dropped from 67% at the beginning of composting to 21.55% at the end of composting. Canet and Pomares (1995) and Albrecht (2007) measured similar moisture drops, respectively, from 60 to 21% after 3 months. According to Francou (2003), the calorific energy released during the composting process, more precisely during the hot fermentation phase, causes this evaporation, causing the drying of the materials.
The proportion of organic matter determined according to the dry matter is of the order of 49.94% DM. This value conforms to the French standard NFU 44051 which stipulates that the organic matter content of a mature compost must be greater than 30%. This value also conforms to the standards (AFNOR, 2005) and the work of Zdanevitch (2012).
Carbon is one of the major constituents of composted organic waste (Francou, 2003). It is composed of total organic carbon which, according to Garcia et al., 1992, represents between 25 and 50% of household waste and inorganic carbon.
The total organic carbon content decreases during composting (Francou, 2003). This decrease is mainly due to the use by the microorganisms of the medium of the organic matter essential to their metabolism, which leads to its mineralization in CO2 in well-ventilated media and CH4 methane under anaerobic conditions (Saviosi et al. 2002, Lornage, 2002, Provenzano, 2014).

Agronomic value of compost

The agronomic value of an amendment or fertilizer is assessed by its content of major fertilizing elements nitrogen, phosphorus and potassium and to a lesser extent minor nutrients such as calcium, sodium, And magnesium (Hubert and Schaub, 2011). Table 3 summarizes the contents of these elements contained in the compost as well as the C / N ratio. Agronomically, the nitrogen content of compost is probably one of the most important factors to consider when talking about its quality. With an average of 4.62%, the nitrogen content of our compost is relatively high compared to other similar work. Indeed Znaidi (2002) found grades varying from 1.21 to 1.5%; For Bouzou (2009), 0.83%; 2.6% for M'Sadek et al. (2012); 1.10 to 1.36% for Zdanevitch (2012) and 1.6% for Ulrich (2013).
In view of these results, it can be seen that the contribution of urea has considerably influenced the nitrogen content of the compost obtained.
It should be noted, however, that the volatility of the urea during its dissolution makes the period of incorporation of this element decisive for the quality of the finished product. The addition of urea during the maturation phase gave convincing results, contrary to the study by Sérémé and Mey (2008) where the addition of urea at the beginning of composting resulted in a content In relatively low nitrogen (1.07 and 1.16%).
The C / N ratio is frequently used as an indicator of the maturity of compost as well as to evaluate the process of mineralization of organic matter. The ratio C / N obtained is 6.27. This value is in line with the work of certain authors, notably Sérémé and Mey (2008) and Arslan et al. (2011), which report values between 05-07 and 04-12. In general, a wall compost must have a C / N ratio of less than 15. The value obtained with our compost is indicative of the high nitrogen content and therefore of its agronomic quality. Organic or organo-mineral fertilizers must have a C / N of less than 8 (Constant, 2001).
In contrast to the nitrogen content, phosphorus (P_2O_5) is relatively low (1.29% DM). This can be explained by the fact that the enrichment treatments carried out during the composting process did not contain sufficient phosphate or the composted substrate was not rich (ADEME, 2005; Marchovechio, 2010). Nevertheless, the recorded content is slightly higher than those of certain simple composts such as Soumaré et al., (2001) which is between 0.37 and 0.43%; Of Cofie et al., (2009) which is 0.46%; Of Zdanevich (2012), 0.5 to 0.77% or Etsé et al., (2014) ranging from 0.37 to 0.88%.
In general, we can say that our results are in agreement with those of Tittarelli et al., (2007), which states that a FFOM compost must contain on average 0.6 to 2% DM of phosphorus.

Table 3. Content of compost in nutrients

Items		Units	Values
Total nitrogen Kjeldahl (TNK)		mg/kg MS	46256.98± 151.99
		% MS	4.62 ±0.015
		% MB	3.63±0.011
C/N			6.27±0.056
Phosphorus	P	Mg/kg MS	5599.11±142.399
		% M	0.56±0.014
	P_2O_5	% MS	1.29±0.032
		% MB	1.014±0.012
Potassium	K	Ppm	826.67±28.867
		% MS	12.40±0.433
	K_2O	% MS	14.88±0519
		% MB	1.02±0.012
[N + P_2O_5 + K_2O]		% MB	16.31±0.436
Calcium	Ca	Ppm	200
		% MS	3
	CaO	% MS	2.1
Sodium (Na)		Ppm	263.33±11.547
		% MS	3.95±0.173

The compost produced is highly rich in potassium (14.88 %). Compared to others, work, the average K_2O content obtained is one of the highest. Indeed, Pfiter et al. (1981), Bouzou (2009), M'Sadek et al., (2010), Zdanevitch (2012), M'Sadek et al. Order of 0.6%, 2.84%, 1.86% 1.12% and 1.03%. Thus, the effect of enrichment No. 1 was strongly influenced by the potassium content of the compost obtained. The same is true of bovine manure, as both are rich in potassium.

The calcium Ca content of the compost is 2.1%. This rate is relatively high compared to the results of Chausson (1999), Soumaré et al. (2001) and Etsé et al. (2014), where the contents obtained are: 1.9%, 1.34% % And 0.13%. However, the content obtained remains in line with the work of M'Sadek et al. (2011), which obtained values between 2 and 2.5%.

The high calcium content is the effect of the enrichment treatment No. 1 because calcium is the major constituent of the ash (ADEME, 2005, Marchovechio, 2010, Godbout, 2011). This high content is very interesting from an agronomic point of view because calcium makes the environment favorable to microorganisms, agents of organic matter decomposition, humification, mineralization and symbiotic fixation (M'Sadek et al., 2012).

Trace elements

Zinc and lead were determined in the compost obtained. They are shown in figure 2, with their tolerance thresholds according to the NF U 44 051 standard.

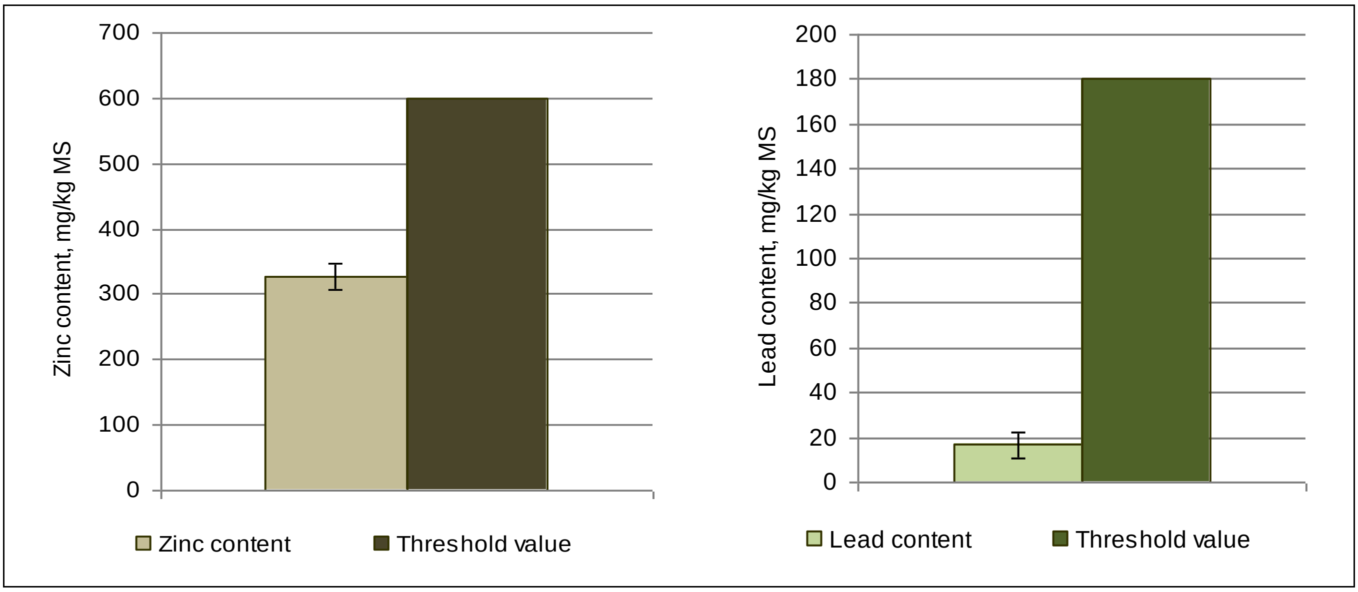

Fig. 2. Zinc and Lead Content

Referring to the standard, the compost produced has a concentration rich in zinc which demonstrates its safety. This can be explained by a low contamination of household waste. Moreover, this content makes zinc a micro-element for living microorganisms.

The lead content also meets the standard and demonstrates the absence of toxicity of the compost product.

Conclusion

Our study focused on the production of compost enriched from the fermentable fraction of household waste collected in the town of Tiaret selectively. The compost obtained was subjected to two enrichment treatments, one with wood ashes and the other with urea. The windrow composting technique with mechanical turning was used.
Although having obtained a relatively low yield of the order of 4%, the physicochemical analyzes carried out on the products were quite conclusive. In fact, the results showed that the compost produced has a dry matter and organic matter content that perfectly fits with the French NF U 44 051 standards.
The pH and electrical conductivity are well above the threshold values. This demonstrates that enriched compost is likely to improve the physicochemical parameters of soils poor in mineral salts.
The proportion of compost in fertilizers, with the exception of phosphorus, is significantly higher than that reported in the literature on compost. It emerges that the enrichment treatments have greatly improved its value.
In general, the results obtained show that the compost obtained is of superior quality to organic amendments. It may be considered as an organo-mineral fertilizer.

Acknowledgements

The authors would also like to thank The General Directorate of Scientific Research and Technological Development (DGRSDT) of Algeria and Algeria water of Tiaret (ADE)

References

Ademe (2005). Management and valorization of ash from wood boilers - agriculture - small boilers.
Afnor (2005). NFU44-051. Organic amendments and culture media - denomination, specification and marking.
Albrecht, R. (2007). Co-compostage de boues de station d'épuration et de déchets verts, nouvelle méthologie du suivi des transformations de la matière organique. Thèse de doctorat de l'Université Paul Cezanne Aix-Marseille III. Faculté des Sciences et Techniques.
Alouemine, S. (2006). Methodology for the characterization of household waste in nouakchott (mauritania) Thesis of Doctoral Dissertation. limoge University.
Arslan, E., Unlu, A., and Topal, M. (2011). Determination of the effect of aeration on composting of vegetable - fruit wastes. CLEAN – Soil Air Water, 39(11), 1014–1021. DOI10.1002/clen.201000537
Bayard, R., de Araujo Morais, J., Rouez, M., Fifi, U., Achour, F., Ducom, G. (2008). Effect of biological pretreatment of coarse MSW on landfill behaviour: laboratory study Water Science and Technology, 58(7), 1361–1369.
Bouzoui, M. (2009). Evaluation of the effect of compost enriched with hygienic urine on the cultivation of millet. Agricultural technology brief, abdoumoumouni university, Niamey.
Canet, R. and Pomares, F. (1995). Changes in physical, chemical and physico-chemical parameters during the composting of municipal solid wastes in two plants in Valencia. Bioresource technology, 51, 259–264.
Chausson, P. (1999). Use of composts in agriculture. Synthesis of the tests – vitrines. 1989–1998.
Culot, M. (2005). Agricultural valorisation of organic matter, university of gembloux.
Diaz, l. F. and Savage, G.M. (2007). Factors that affect the process. Compost science and technology, 8, 49–66.
Duval, J. (1993). Méthodes d'évaluation de la maturité des composts. Projet pour une agriculture écologique. Publications Agro-Bio, 310-02. Available from: http://www.eap.mcgill.ca/Agrobio/ab-310-02/ Accessed on 20.10.2017
Eisted, R., Christensen, T.H. (2011). Characterization of household waste in greenland. Waste management, 31, 1461–1466.
Etsé, A., Sanonka, T., Kokou, S., Magnoud, B.B. (2014). Study of the availability of assimilable phosphorus from municipal waste compost in two different soils. Esj, 10(6), 1857–1881.
FAO (2000). How to feed the world in 2050.
Fuchs, J.G., Galli, U., Schleiss, K., Wellinger, A. (2001) ASCP Guidelines 2001: Quality criteria for composts and digestates from biodegradable waste management. Published by the Association of Swiss Compost Plants (ASCP) in collaboration with the Swiss Biogas Forum, 11 pp.
Garcia, C., Hernandez, H., Costa, F., and Pascualj, A. (1992). Phytotoxicity due to the agricultural use of urban wastes. Germination experiments. J. Sci. Food. Agri., 59, 313–319.
Goldberger, J.T. (2008). Diffusion and adoption of non – certified organic agriculture: a case study from semi-arid makueni district, kenya. J. Sustain. Agric., 32(4), 597–609.
Gueye, F., Canry, F., Sinth, T. (1986). Development of a compost enriched in phosphate by natural phosphate: agronomic study.
Hubert, G., Schaub, C., (2011). Soil fertility: importance of organic matter. Environmental service - innovation.
Humeau, P., and Cloirec, P. (2010). Gaseous emissions and air treatment in composting, 1, 17.
Kahren, L. (1967). Composting of household waste in hot countries tech. Sci. Munich, 211-216.
Kutzner, H. J. (2000). Microbiology of composting, Ober-Ramstadt, Germany.
Marcovéchio, F. (2010). Ashes from biomass recovery. Departmental laboratory of Aism.

Morocomp, G. (2008). Deign and application of innovating composting unit for effective treatment of sludge and other biodegradable organic wast in Morocco, 5, 39.
M'sadek, Y., Elouaer, M., and Kamel, R. (2012). Evaluation of the chemical behavior of silvicultural composts in sieves and mixtures for the design of culture substrates. Nature and technology, 6, 59–70.
Saviosi, A., Cardelli, R., Levi-Minzi, R. and Riffaldi, R. (2004). Evolution of biochemical parameters in the composting of urban waste. Journal, compost sciences & utilization, 12, 153–160.
Sérémé, A., and Mey, P. (2008). Agricultural valorisation of household waste in the sudano-sahelian zone. Case of the town of bobodioulasso. Rev. Cames, A, 5, 64–71.
Soltener, D. (2003). The basis of plant production. Volume 1. The soil and its improvement.Collection science et techniques agricoles. 23rd ed. Paris.
Soumare, M., Demeyer, A., Tackf, M.G., and Verloo, M. G. (2001). Chemical characteristics of malian and belgian solid waste composts. Biosource technology, 81, 97–101.
Stentiford, E. (2013). Composting and compost. Environmental science and technology, 37, 187–204.
Tang, J.C., Maie, N., Tada, Y., and Katayama, A., (2006). Characterization of the maturing process of cattle manure compost, 41, 380–389.
Tittarelli, F., Petruzelli, G., Pezzarossa, B., Civilini, M., Benedetti, A., Sequi, P. (2007). Qualité and agronomic use of compost. Compost science and technology, 119–157.
Ulrich, G. (2013). Analysis report for compost and digestate. Tera nova, environmental consulting sarl. Breitenbach.
Zdanevitch, I. (2012). Comparative study of the quality of composts and digestates from the fermentable fraction of household refuse. Study report ineris – drc, 12, 124.

Citation:
Berrayah, M. Maatoug, M., Azzaoui, M.E., Hadidja, N., Wendatta d'Aquin, D.T., Ganete, A., Zhukov2, O.V. (2017). Agroecological aspect of the valorization of enriched compost household fermentable refuse production: cases of the town of Tiaret (Algeria)
Ukrainian Journal of Ecology, 7(4), 668–674.