Agro-environmental assessment of composting plants in Southwestern of Morocco (Souss Massa Region)

Azim, K.[1*]; Komenane, S. [2] and Soudi, B.[2]
(1) Laboratory of Agronomy & Quality. INRA Centre Régional de la Recherche Agronomique (Agadir), BP : 124 Inzegane CP : 80350, Morocco.
(2) Department of Environment and Natural Resources. IAV Hassan II-Rabat. B.P. 6202. Madinat Al Irfane.
*Corresponding author: azim.khalid@yahoo.fr

Abstract
The region of Souss Massa generates important quantities of organic wastes estimated up to 955416 tonnes year^{-1} in 2011. These agricultural wastes can lead to serious sanitary and environmental impacts. The present study evaluated the quantitative and qualitative status of the organic wastes and the composting units operating in this region. The analysis of organic wastes macro elements (NPK) revealed an economic loss of to more than 6 M€ per year; what constitutes for soils a source of important fertilization backup. Only 11% of composting units were operated on impervious surfaces. The test of circular chromatography used for the determination of the maturity degree showed that 80 % of sampled composts are immature. A lot of effort is to make to control and to optimize the composting process within platform specialized to this activity.
Keywords: organic waste; composting; environment; pollution; horticulture

---

Introduction
In the Souss Massa region (Southwestern of Morocco), the production of plant by-products has reached 406 045 tonnes year^{-1} [1]. These agricultural wastes which are not well managed, can lead to serious sanitary and environmental impacts such as soil, air and groundwater pollution. A good management of those wastes would provide organic amendments which might serve as a source of carbon and thus improve depleted soils. However, the application of immature compost into soils may produce several negative effects, such as phytotoxicity, competition for oxygen between microbial biomass and plant roots/seeds or nitrogen starvation of plants [2]. In spite of the increasing interest in this type of organic waste processing papers related to the composting process evaluation in Sous Massa region are lacking. Besides, regulations preventing negative impacts on the environment due to the management and recycling of organic wastes are missing. Therefore, the objectives of this study were to (i) evaluate the quantitative and qualitative potential of crops residues and to (ii) compare the performance of composting method technologies used by farmers in terms of agronomic and economic issues.

Materials and Methods
Survey method
Data was collected while visiting 9 compost plants selected randomly from a total of 13 compost plants in the region studied. The nine appointed compost plants were named respectively A, B, C, D, E, F, G, H, and I were visited (Table 1) and a questionnaire was completed in cooperation with the plant operators in charge.

Sampling method
During the survey, samples were taken from input materials for composting and from the supposed mature compost. A composite sample of 2 kg of each type of input material was taken. For a composite sample of mature compost, three subsamples thereof were obtained from the shaded side of a pile at a depth of at least 70 cm. The dry matter content of all samples was determined after drying at 105°C during 48 hours [3]. Dried samples from input material and mature compost were used for laboratory analyses. Sampling from compost plants C and F were not completed because of the absence of raw material and mature compost.

The questionnaire (Table. 2) included questions related to the origin and the type of the used raw materials, their proportions of the total of feedstock processed, the size of the plants and the measures for preservation of natural resources such as soil, water and air quality as regulated according to international standards (NFU 44-051; BSI-UK-PAS 100, USCC, Compost Council of Canada…).

Table 1 Input materiel and type of compost

Composting plant	Input materiel (Tones.year^{-1})	Type of compost produced
A	7000	Manure and olive mill waste
B	2160	Tomato waste
C	780	Manure and olive mill waste
D	340	Tomato waste
E	20880	Manure and olive mill waste
F	2400	Tomato waste
G	4698	Tomato waste
H	744	Manure and olive mill waste
I	276	Manure and olive mill waste

Table 2 Consistence of the questionnaire

Nature of the question	Number of questions
Description farms that generate organic wastes	11
Description of the organic wastes	14
• Composting plant description and size	72
• Imperviousness of the operating surfaces	3
• Reception, sorting and control area	12
• Raw material storage area	10
• Composting area (thermophilic process)	20
• Composting area (curing)	11
• Sifting area	10
• Drainage system	6
Operational details	10
Certification	8
Total number of questions	**72**

Laboratory analysis

Oven dried samples of raw material and compost were sieved (Ø=2 mm) and analyzed for pH in 1:10 soil/water (w/v) suspensions using a glass electrode pH-meter (BioBlock pH-mètre Microprocessor 99621) at room temperature [4]. EC was measured using an electrical conductivity meter (WTW Inolab-Cond Level-2P, Germany [at 25°C]) in 1:5 soil/water (w/v) solutions. Total Organic Matter content (TOM) was determined by calcination of a dry sample with known moisture content at 480°C during 6 hours. Total nitrogen (TN) content analysis was performed using the standard Kjeldahl procedure (Gerhardt: Kjeldatherm-Vapodest 20, Germany) [5]. Total phosphorus, total potassium, calcium and magnesium were analyzed by the atomic absorption spectroscopy detection (Varian Spectra AA 220FS, USA) [6]. Qualitative test of compost samples was performed by the circular chromatography test using silver nitrate as reagent [7].

Results and Discussions

Composting plant description and size

The description of the composting plants and their position within their environments are shown in Table 3 . The assessment showed that 67% of the composting plants have an area equal or higher that 1 ha (average of 1.24 ha), and are completely separated from the production farm reflecting the awareness of the producers with respect to a contamination risk due to inappropriate process management. The sizing of the composting units didn't respect the logical work flow of the composting process, mainly due to confusing between fermentation and maturing phase. The high proximity between the raw material and the maturation piles in 55.5% of cases could result in a high degree of contamination by phytopathogenes and nematodes inoculum. Additionally, only 11% of the

surveyed units had impervious surfaces and drainage facilities to collect compost leachates. Two management approaches have been identified:

- High quality compost production: 56% of composting plants are oriented to produce compost using sheep manure and olive mill wastes;
- Organic waste management: 44 % are oriented to turn tomato waste into an acceptable organic amendment. The produced compost is amended on citrus orchard fearing pathogens and nematodes that couldn't be suppressed trough composting (due to the low level of sanitization).

Table 3 Description of the composting plants environment

Compost plant	Total area of the farm (ha)	Compost plant surface	Distance from the well	Distance from the habitation	Soil type
A	1 ha	1 ha	5 m	≈ 10 m	Sandy loamy
B	1 ha	1 ha	> 500 m	≈ 50 m	Sandy loamy
C	6 ha	2000 m²	> 500 m	> 500 m	Sandy loamy
D	4 ha	150 m²	> 500 m	> 500 m	Sandy loamy
E	220 ha	1 ha	> 500 m	> 500 m	Sandy
F	1 ha	1 ha	≈ 500 m	≈ 25 m	Sandy loamy
G	1 ha	1 ha	> 500 m	> 500 m	Sandy loamy
H	22 ha	700 m²	≈ 5 m	≈ 25 m	Sandy loamy
I	45 ha	600 m²	0 m	≈ 1,5 km	Sandy loamy

Agronomic performance of the raw material and the produced compost

Table 4 reveals that the C/N ratio of different final composts is above the optimal value of 12-15. It turned out that 40% of the final composts are not mature. The content of total nitrogen of the compost derived from OMW (Olive Mill Waste) + SM (Sheep Manure) and SM are higher than the compost of TW. This is mainly due to the fact that an appropriate composting of pure TW is difficult to achieve with because of its high C/N ratio and its low moisture content. Concerning the agronomic value, the nutrient content of all final compost comply with the recommendations of a quality assessment [8].

Table 4 Physical and chemical analysis of input material and final compost

	Input material						Compost					
	OMW+SM		**SM**		**TW**		**OMW**		**TW**		**SM**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Moisture	36%	17%	26%	16%	40%	18%	37%	6%	47%	3%	37%	4%
pH	9.40	0.28	7.69	1.05	8.14	0.48	9.40	0.582	8.93	0.06	8.63	0.20
EC (ms/cm)	5.86	0.08	2.98	2.51	2.85	1.17	3.77	0.287	2.92	0.32	4.32	0.56
TOC	67.01	1.41	71.63	23.30	77.55	9.11	63.25	5.596	60.25	1.32	56.47	2.74
TMM	32.99	1.41	28.37	23.30	22.45	9.11	36.75	5.596	39.75	1.32	43.53	2.74
C/N Ratio	39.79	9.60	50.24	11.65	29.92	7.18	23.92	0.767	22.94	0.44	32.41	3.33
TN	0.87	0.19	0.78	0.41	1.36	0.37	1.33	0.145	1.31	0.03	0.88	0.08
P2O5	2.50	1.84	2.00	0.10	1.21	1.35	1.62	0.801	0.73	0.05	1.61	1.09
K2O	1.74	0.25	0.99	0.56	1.19	0.12	1.58	0.454	1.57	0.08	0.98	0.76
Na2O	0,44	0.41	0.27	0.26	0.24	0.20	0.29	0.259	0.16	0.01	0.09	0.05
CaO	6.78	1.66	4.58	3.12	3.77	1.35	5.30	2.403	7.67	0.67	5.35	3.27
MgO	0.79	0.32	0.42	0.14	0.51	0.14	0.81	0.378	0.74	0.03	0.38	10

Legend: OMW (Olive Mill Waste); SM (Sheep Manure); TW (Tomato Waste); SD (Standard Deviation) and TMM (Total Mineral Matter).

With regards to the nutrients content from the final compost samples, results showed that for 100 g of compost, means of nutrient values can be estimated as follows: 0.958g of potassium, 0.5g of phosphorus and 0.82 g of nitrogen. The qualitative test (circular chromatography) of final compost

showed that only 20% of the produced compost are mature, whereas 80% were not. It's likely that immature compost could spread phytopathogene germs and nematodes; especially root knot nematodes that could result to up to 90% of tomato yield loss.

Assessment criteria of the composting plants in Souss Massa

The activity of composting presents a positive effect on the environment especially for the good management of produced waste. However there are some failures in the management of the process (Table 5), the mechanization and especially the quality of the produced compost.

Table 5 Summary of the assessment criteria of the composting plants in Souss Massa

Compost plants	Environmental impact	Process handling	Mechanization	Quality of compost
A	+ + + +	+ + +	+	+
D	+ + + +	+ + +	+ + + +	+
E	+ +	+ + + +	+ +	+
F	+ + + +	+ + +	+ + + +	+
G	+ + +	+ + +	+ + + +	+
H	+	+ + +	-	
I	+	+ + +	-	+

Legend: absence (-); slightly high (+) ; medium high (++) ; high (+++); very high (++++)

Conclusion and perspectives

The lack of regulation related to the composting activity at Moroccan level, results in anarchy in the sizing and the location of composting plants but also problems of control and monitoring the process and the quality of the produced compost. The activities related to composting induced problems regarding water pollution, but the effects on the soil are not defined. The management policy of waste should favor its valorization, either in term of recycling, or in term of energy valuation. The development of the composting is actually limited, and has to be supported by scientific research activities to allow a better knowledge concerning the real impacts of compost on the agriculture, the environment and on the public health.

References

[1] ORMVA/SM (2009). « Etude de la gestion des déchets agricoles dans la zone d'action de l'ORMVA/SM comprise à l'intérieur de la province de Chtouka Ait Baha ». Office Régionale de la Mise en Valeur Agricole du Souss Massa Agadir. Rapport définitif de consultation du Groupe EDIC-SEGU, Pp : 83.

[2] Gómez-Brandón, M., Lazcano, C., Domínguez, J., (2008). The evaluation of stability and maturity during the composting of cattle manure. Chemosphere 70, 436–444.

[3] Pétard, J. (1993). Les méthodes d'analyse Tome1 analyses de sols. L'institut français de recherche scientifique pour le développement en coopération centre de Nouméa.

[4] Rhoades, J.D. 1982. Cation exchange capacity. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.) Methods of soil analysis. Part 2. Agron. Monogr. 9, Am. Soc. Agron., Madison, WI. p. 149-157.

[5] JacksonM.L. (1967). Soil chemical analysis. In: Karlen D.L.,Varvel G.E., Bullock D.G. and Cruse R.M. (1994). Crop rotations for the 21st century. Advances in Agronomy,pp. 1-45,53.

[6] Mehlich (1953). Determination of P, Ca, Mg, K, Na and NH4. North Carolina Soil Test Division , Publ. 1-57, North Carolina Dept. of Agriculture, Raleigh.

[7] Brinton, W.F., Jr. (1983). A qualitative method for assessing humus condition. in Knorr, D. (Editor). 1983. Sustainable food systems. AVI Publishing, Westport, Connecticut. 416 pages.

[8] Soudi, B. (2005). The composting of cattle manure and crop residues from greenhouse production system. Bullet Transfer of Technology in agriculture, PNTTA N°129, June 2005.

Acknowledgment

This study is co-financed by the INRA (National Institute of Agronomy Research), IAV (Agronomic and Veterinary Institute of Hassan II) and the APEFEL (Association of Producers and Exporters of Fruits and Vegetables). We thank without exception all the persons in charge of the farms and the composting plants, who helped us to succeed this study.