Journal of Recycling of Organic Waste in Agriculture Research
Vol. 1, No. 1, September 2013, PP: 01 -08
Available online at http://acascipub.com/Journals.php

Research article

Olives mill wastewaters spray: An interesting alternative of management of the agriculture garbage and wind erosion reduction in the south of Tunisia

a) Mounir ABICHOU,
ALI RHOUMA

a Institut de l'Olivier, Tunisia; ; email : abichoumounir@yahoo.fr

b) Mohamed LABIADH ,

b Institut des Régions Arides 4119 Médenine, Tunisia; email : Mohamed.labiadh@ira.rnrt.tn

---

Abstract

The use of waste water in agriculture is widespread and its impact on the environmental and human health had been widely investigated. In Tunisia, the olive oil extraction process, both by the traditional or the press system and the three-phase decanter system produces a large quantity of Olive Mill Wastewaters (OWM) or "margine". The quantities of the OMW that accumulate from one year to the next constitute a real environmental problem because, in the more part of case, the physicals and chemicals treatments are limited by some technical and economic requirements. On the other hand, in the Tunisian arid zones, where the soils are sandy and very poor in organic and mineral matters, wind erosion process is very active and triggered the departure of the thinnest elements of the soil and the apparition of dune building. Facing to these situations, many simple and efficient practices for combating desertification had been tested since many years in the Tunisian arid zones. The mulching of the olive mill wastewaters is one of these techniques. Otherwise, an olive mill wastewaters spray experimental device, with these respective doses of 50 m3/ha, 100 m3/ha and 200 m3/ha next to a witness parcel without OMW, has been putted in place since 1995 in the Chammakh –Zarzis, Tunisia. The mulching of the OMW in the southern Tunisian regions constitutes an interesting alternative for the controlled and rational evacuation of this polluting sewage on the one hand and for the soil cohesion improvement by : (i) the increase of the organic matter rate which raised, in proportion to the dose, from 0.06% to 1.27% after 10 years of OMW mulching, and (ii) the improvement of the soil structural stability or "the mean weight diameter" where the aggregation rate superior to 2 mm is increased until 34 % with the dose of 200 m3/ha. Therefore, that treatment will bind the sand particles and thereof control of sandstorms is gained. Indeed, the results in wind tunnel tests on the soil treated with these different doses of OMW showed that the threshold friction velocity u_{*t} was raised from 8.5 m/s to 12 m/s for 50 m3/ha and 200 m3/ha, respectively. **Copyright © acascipub.com, all rights reserved.**

Key words: olive oil wastewater, organic matter, wind erosion

---

Introduction

In many countries where the olive oil is produced (Spain, Italia, Greece, Tunisia, Marroc, Syria, etc), the olive oil extraction process produces large quantities of solid and liquid waste. The liquid waste fraction is called the

Journal of Recycling of Organic Waste in Agriculture Research
Vol. 1, No. 1, September 2013, PP: 01 -08
Available online at http://acascipub.com/Journals.php

"margine" or the Olive mill Wastewater (OMW). In Tunisia 700.000 tonnes of OMW is produced yearly. Indeed, the traditional system produces 400 litrs of "margine" for 1 tonne of olives and the tree-phase system produces 1000 litrs of OMW per 1 tonne of olives (Bonari and Ceccarini, 1990). Therefore, the quantities of 'margine' accumulating each year and dumped in open reservoirs and lakes, constitute also a real environmental problem in Tunisia. The ominous effect of the OMW results, particularly, in an elevated saltiness and very complex organic load (sugar, proteins, lipids and phenolic compounds which are very toxic) (table 1).

Table 1: Chemical characteristics of OMW (average values for five years)

Characteristics	Value
Humidity (%)	**87,9**
pH water	**5,5**
CE (mS/cm)	**18,6**
DCO (g/l)	**105,0**
DBO_5 (g/l)	**55,0**
Organic matter (g/l)	**107,0**
Reducing sugar (g/l)	**11,4**
Glucose (g/l)	**3,9**
Phenols (g/l)	**5,8**
Greasiness matter (g/l)	**4,5**
Mineral matter (g/l)	**13,7**
Nitrogen (g/l)	**1,4**
Phosphates (g/l)	**0,32**
Potassium (g/l)	**7,5**
Magnesium (g/l)	**0,65**
Sodium (g/l)	**1,31**
Calcium (g/l)	**0,71**
Chlorures (g/l)	**0,56**
Actif chlore	**Absent**
Sulfures	**Absent**

On the other hand, soil degradation especially with regard to detoriation of the soil physical properties is a common feature in southern Tunisia. It results in surface crust formation, reduction of vegetative cover leading to water and wind erosion. To find a remedy for these soils changes, the Mulching of Olive Mill Wastewater as an organic amendment seems be a simple and possible method to improve the organic matter content particularly rare in arid environment. The objectives of this study are to evaluate the impact of 10 years of successive 'margine' sprays on the surface properties of sandy soils in olive orchards in southern Tunisia. In this work three paramaters will be studied: the evolution of organic matter rate in the soil, the structural stability and the threshold friction velocity after 10 years of Olive Mill Wastewater spray with different doses. Materials, results and discussion

1. Field applications

The Chammakh-Zarzis olive orchard is situated in southern Tunisia (figure 1) in an environment with an arid Mediterranean climate with a mean annual rainfall of 180 mm, as long term average for the period of 1923-2004. The soil is moderately deep with a sandy texture and poor in organic matter (Taamallah, 2007).

The 'margine' is pumped from a pit cistern in a tank and brought by tractor to the field (photo 1). Then it is sprayed homogeneously on the sandy soil surface, previously tilled to a 10-15 cm depth. (photo 2) Since 1995 until 2006 'margine' was sprayed during December-January period at a yearly rates of 0 $m^3.ha^{-1}$ (control), 50 $m^3.ha^{-1}$ (treatment 1), 100 $m^3.ha^{-1}$ (treatment 2), 200 $m^3.ha^{-1}$ (treatment 3). The four one hectare parcels were selected as shown in figure 2, each containing 16 olive trees between 60 and 70 years old, planted at intervals of 25 meter. The parcels were separated by 2 non-treated olive tree rows (50 m distance).

Photo 1: **"**Margine" spray from tank and tractor

Photo 2: **"**Margine" treated parcel

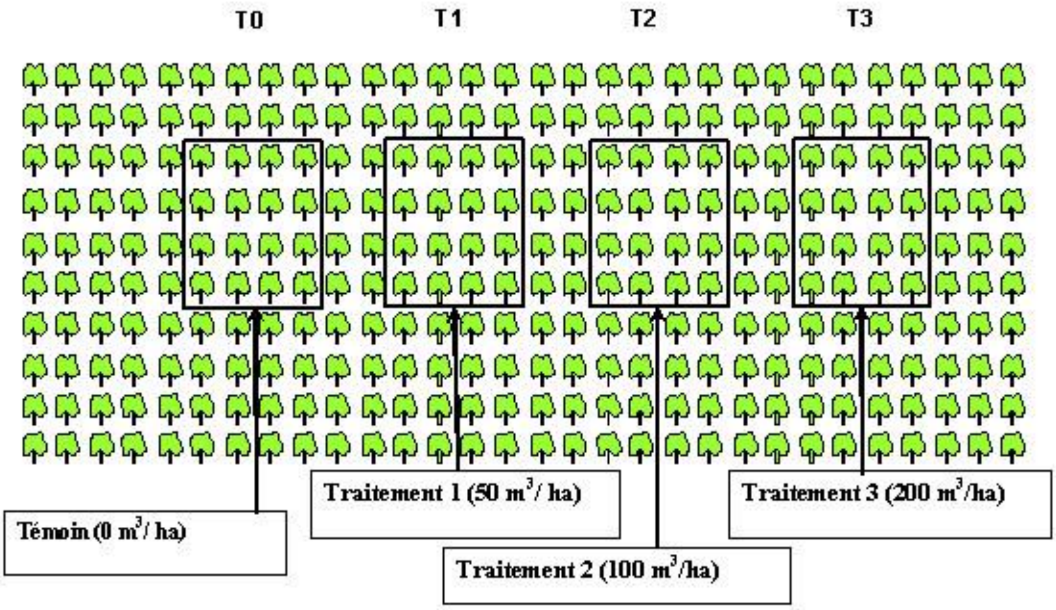

Figure 2: Schematic plan of Chammakh-Zarzis experimental parcel

2. Experiment results and discussion

2.1. Organic matter content

The organic matter rate was determined by Walkley and Black methods which consisted on cold oxidization with bichromate of potassium ($K_2Cr_2O_7$) in acid environment and titration with ferrous sulfate ($FeSO_4$ $7H_2O$). The organic matter rate was calculated by the fellow equation 1:

$$MO\% = C\% \times 1.725 \qquad \text{(eq 1)}$$

Soil samples for organic matter content determination were taken in 2006 on each parcel and this after 10 years of 'margine' application. The organic matter content is listed in table 2:

Table 1: Organic matter content of the upper sandy soil layer after 10 years of 'margine' application

Rate ($m^3.ha^{-1}$)	Organic matter content (%)
0 (control)	0.06
50	0.41
100	0.71
200	1.27

Rich in organic substances (107 kg/m^3), the mulching of OMW improved the soil organic matter rates. Indeed, the differences observed could be explained by the kinetics of the organic matter mineralization process which depended on the abounding, in number and quality, of micro-organisms in the treated soil. Similar results were obtained by Cabrera and al. (1996) who showed that after three successive years of "margine" applications rate of 37 l/m² (370 $m^3.ha^{-1}$) and 61 l/m² (610 $m^3.ha^{-1}$) organic matter content up to 1,62% and 1,98% respectively. Organic amendment supply represented the principal cohesion factor between the soil aggregations. This observation is in agreement with results given by Oades, 1993, Angers and Cover, 1996.

2.2. Aggregate formation and stability

Disturbed surface samples were taken and brought to the laboratory. Previously air dried samples were sieved and the dry aggregate distribution determined. It was only at rates of 200 $m^3.ha^{-1}$ that differences in aggregate formation could be found. As at lower rates of applications (50 and 100 $m^3.ha^{-1}$) only 10 % of the aggregates had diameters larger than 2 mm, at the 200 $m^3.ha^{-1}$ rate 35 % of the aggregates had diameters larger than 2 mm. The same samples were then subjected to a under water sieving test and allowed to break down. When aggregates are submerged in water and gently sieved under water (wet sieving), their status will change compared to their initial status (dry aggregates). Hence, the difference in mean diameter of the aggregates before (dry) and after (wet) sieving can be used as the in stability index IS. The difference of the areas under the curves of dry and wet aggregate distribution describes this stability.

Generally, the inverse of IS, the stability index SI is taken as a measure for the stability of the soil aggregates. The higher is the value, the more stable are the aggregates.

To determine the structural stability we should:

1. Calculate the mass of the rain drop.
2. Calculate the mean weight diameter after dry MWD_d and after wet MWD_w sieving

$$MWD = \frac{\sum_{i=1}^{i=n} m_i d_i}{\sum_{i=1}^{i=n} m_i} \quad \text{(Eq 2)}$$

Where m_i = mass of aggregate fraction i,
d_i = mean diameter of fraction i,

3. calculate the instability index (IS) using following expression :

$$IS = MWD_{dz} - \mathrm{MWD}_{nz} \quad \text{(Eq 3)}$$

4. calculate the instability index (*IS*) using following expression :

$$si = \frac{1}{IS} \quad \text{(Eq 4)}$$

5. plot the aggregate size distribution after dry and after wet sieving.

Once more the 200 $m^3.ha^{-1}$ rate showed marked differences compared to the lower application rates, where now only 5% of the aggregates had diameters larger than 2 mm. The 200 $m^3.ha^{-1}$ application rate on the other hand still resulted in 25 % of aggregates with diameters larger than 2 mm, reflecting also a higher aggregate stability (figure 3).

These results are in concordance with the Mellouli's results who concluded that it is possible to improve the stability of an unstable soil (loamy soil). Indeed, in presence of water, the soil could be structured but it is stability depended on it is contain of clay and loam both considered as an enduring cohesion factors (Hartmann et De Boodt, 1974). The same results are obtained by Gabriels and al (1975) on the sandy soil treated by the compost. This technique of Mulching could improve the soil stability and reduce the evaporation.

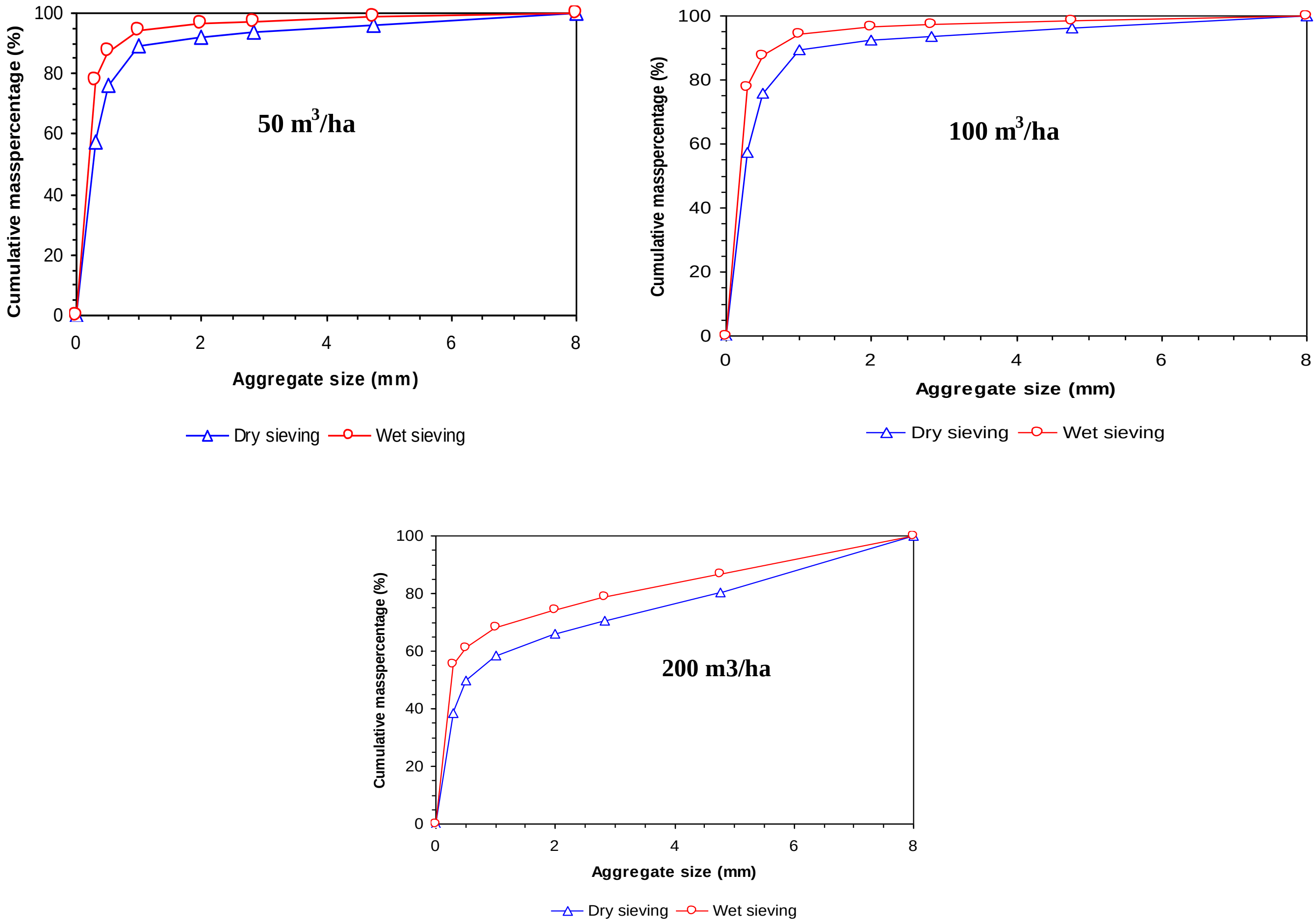

Figure 3: Mulching effect of OMW in structural stability

2.3. Threshold friction velocity for initiating particle movement

Bulk samples of the upper sandy soil layers were shipped to the Department of Soil Management of Ghent University, Belgium to be tested in the wind tunnel of the International Center for Eremology (ICE). The wind tunnel of ICE is described in detail by Gabriels et al. (1997) and Cornelis et al. (2004). The boundary layer was set at about 0.60 m using a combination of spires and roughness elements (Cornelis, 2002). The samples were placed in 0.95 x 0.40 x 0.02 m trays and put at a distance of 6.00 m downwind from the entrance ofthe wind tunnel working section. To ensure wind tunnel profile equilibrium with the roughness of the sample surface, the test section was covered with commercially available emery paper with the sarne roughness length as the surface ofthe sample, as determined experimentally from measured wind velocity profiles (Cornelis et al., 2004) Wind at different reference velocities u_{ref} (recorded at a height of 1.00 m at the entrance ofthe test area) were introduced in the test area and wind velocities u were monitored at a 1-Hz frequency with 13 mm diameter vane probes mounted at heights of0.05m, 0.lOm, 0.15m, 0.20m, 0.30m, 0.40m, 0.50m, 0.60m and 0.70m. The shear velocity u_* of the sand surface could be calculated from the wind profile and the roughness length z_0 and the Von Karman constant k 0.4 (eq 5).

$$u_z = \frac{u_*}{k} \ln \frac{z}{z_0} \qquad \text{(eq 5)}$$

The initiation of particle movement was determined by continuously recording particle transport with a ‘saltiphone’. The ‘saltiphone, described by Spaan and van den Abeele (1991), is an acoustic sensor that records the number of saltating particles that bounce against a microphone at a frequency of 0.1 Hz.

To determine the threshold friction velocity u_{*t} for initiating particle movement, the u_{ref} was increased until first particles were recorded with the saltiphone (Cornelis and Gabriels, 2004). Table 3 illustrates the threshold friction velocity values for the different treatments with margine.

Table 3: Threshold friction velocities for initiating particle movement after 10 year of 'margine' application

Rate ($m^3.ha^{-1}$)	Threshold friction velocity ($m.s^{-1}$)
0(control)	8.50
50	8.65
100	10.25
200	l2.15

These results showed that the threshold velocity was raised with doses of OMW spray. These velocities are respectively 8.50 m/s and 12.5 m/s for 0 $m^3.ha^{-1}$ and 200 $m^3.ha^{-1}$ (table 3).
These results could be explained, by the augmentation of organic matter. The same results are obtained by Mellouli (1996), Ben rouina and Taamallah (1999) and Abichou (2003). They showed that OMW with it is link power improve the mulch formation which can reduce water and wind erosion.

2.4. Natural floristic composition for soil roughness improvement

The mulching effect of OMW in the vegetation cover and natural floristic composition had been investigated when we had observed a visual difference on the invading yearly species. Indeed, some species as *Chenopodia murale* and *Mesembryanthemum cristallinum* which they had never been founded in the witness parcels and those surrounding had founded for the other parcel treated with "margine". The Presence Specific Contribution (CSP) of these two species was 53% and 37% respectively (figure 4). These results could be explained by the ecological and biological feature of these species which tolerate an important quantity of nitrates and salts in soils (elevated electric conductivity in the parcel treated with 200 $m3.ha^{-1}$). Nevertheless, the density of *Diplotaxis harra* is relatively abundant (18 individual/m^2) in the witness parcel where the CSP is 11%. However, the density of this specie is nil in the parcel treated with the dose of 200 $m3.ha^{-1}$. These effects could be explained by the seeds germination inhibition caused by the high dose of "margine". Indeed, the acidic pH and the presence of phenolic composed seems be very aggressive on some sensitive species.

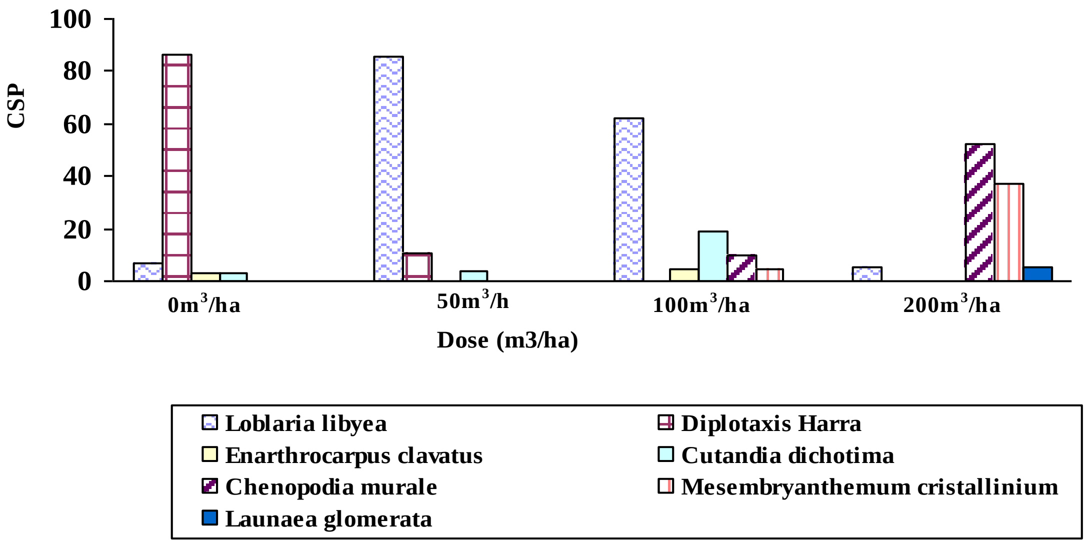

Figure 4: Natural floristic composition

According to these results, we can conclude that the mulching of OMW in the abandon and pastoral area could be beneficial to control the messicoles annual species development. In most cases, the fallow lands are dominated by *Diplotaxis harra* which is a very weak economic value species (pastoral, medicinal or other). Therefore, it seems that the "margine" could decrease the competition of this species to the profit of others which should be more beneficial as well as pastoral and industrial plan like the *Mesumbryanthemum cristallinium*, species used for soap manufacture.

Conclusion

Mulching "margine" on poor sandy soil could be an interesting alternative for increasing the organic matter content, the formation of aggregates and improving the soil structure stability.
Since 1995 a field experiment is running in an olive plantation in Chammakh-Zarzis, South Tunisia, where rates of 50, 100 and 200 $m^3.ha^{-1}$ of margine were sprayed yearly on 1 ha fields with 16 olive trees per ha. Data collected in 2006 showed an increase in organic matter content from originally 0.06 to 1.27 %, an increase in the amount of aggregates >2 mm to 45%, and an increase in the threshold friction velocity for deflation to 12 $m.s^{-1}$ for the 200 $m^3.ha^{-1}$ application. In this study, we showed the mulching effects of OMW on the natural floristic composition. According to these results, the spontaneous vegetation acts at lower scale as an erodibility factor, determining resistance or vulnerability to erosion. At contiguous but higher scale cover factors becomes erosivity factors, structurally mediating erosive energy of wind. Hence, "margine" can be an alternative and effective way to control wind erosion in southern Tunisian arid zones.

Bibliographies

[1] ABICHOU M.: Impact de l'épandage de la margine sur les propriétés physiques et chimiques du sol et sur la composition floristique naturelle des parcelles traitées. Mastère de l'INAT, option lutte contre la désertification et la gestion durable des ressources en milieu aride. (2003) , pp60.

[2] ANGERS D.A., CARTER M.R.: Aggregation and Organic Matter Storage in Cool. Humid Agricultural Soils. Advances in Soil Science, eds M.R. Carter and B.A. Stewart, (1996), 193-211.

[3] BEN ROUINA B. , TAAMALLAH H.. Valorisation biologique du grignon et des margines par le compostage. Séminaire national sur l'huile d'olive et se dérivés. Société Chimique de Tunisie. Hammamet 26-28 Nov.1999.

[4] BONARI E., CECCARINI L.,: Sugli effete dello spargimento dell acque di vegetazione sul terreno afrario: risultati di una ricerca sperimentale. Genio Rurale 5, (1990), 60-67 (in Italian).

[5] CABRERA F., LOPEZ R., MARINEZ-BORDIU A., DUPUY DE LOME E., MURILLO J.M.,. land treatment of olive oil mill wastewater. International biodeterioration and biodegradation 38. (1996), pp:215-225.

[6] CORNELIS W.M.: Erosion processes of dry and wet sediment induced by wind and wind-driven rain: a wind-tunnel study. PhD dissertation, Ghent University. (2002)

[7] CORNELIS W. M. and GABRIELS D.:The affect of surface moisture on the entrainment of dune sand by wind : an evaluation of selected models. (2003)

[8] CORNELIS W. M. and GABRIELS D.: A simple model for the prediction of the deflation threshold shears velocity of dry particles. Publication in Sedimentology (2004),N° 51; 39-51.

[9] GABRIELS D., DE BOODT M., and MAESSCHALCK D. : The evaporation process in a sandy and clayey soil as affected by treatment with a bitumen emulsion and polyacrylamide solution: a laboratory study. Med. Fac. Landbouww. Rijksiniv; Gent, 40, (1975), pp.1373-1384.

[10] GABRIELS D., CORNELIS W.M., POLLET I., VAN COILLIE T. and OUESSAR M.: the ICE wind tunnel for wind and water erosion studies. Soil Techn. 10, (1997), pp 1-8.

[11] HARTMANN R. AND DE BOODT M.,: the influence of the moisture content, texture and organic matter on the aggregation of sandy and loamy soils. Geoderma, 11, (1974), pp.53-62.

[12] KALOGERAKIS, N., GEKAS, V., DIAMADOPOULOS, E.,. Olive oil-mill wastewater management in Crete: a fresh look at an old problem. In: Tsihrintzis, V.A., Korfiatis, G.P., Katsifarakis, K.L., Demetracopoulos,

A.C. (Eds.), Protection and Restoration of the Environment (V), Proceedings of an International Conference, Thassos, Greece, July 2000, vol. II., Bouris, V., Thessaloniki-Kalamaria, (2000), pp. 761–768.

[13] KHATTELI H., 1996: Erosion éolienne en Tunisie aride et désertique : Analyse des processus et recherches des moyens de lutte.

[14] LOGIE M.: Influence of roughness elements and soil moisture on the resistance of sand to wind erosion. Catena Suppl. 1, (1982), p 161-174.

[15] MELLOULI H.J. Modifications des caractéristiques physiques d'un sable limoneux par les margines: incidences sur l'évaporation. Thèse d'état de l'Université de Gent. (1996), pp225.

[16] OADES J.M.: The role of biology in the formation, stabilization and degradation of soil structure, Geoderma, 56, (1993),377-400.

[17] SBAI, M.L., MEBIROUK, M., SKALLI, A., MA DEL CARMEN LOPEZ MARTINEZ, GONZALEZ, J.,. Phenols biodegradation in olive oil mill wastewater by Aspergillus niger/Phanerochaetae crysosporium.In: Tsihrintzis, V.A., Korfiatis, G.P., Katsifarakis, K.L., Demetracopoulos, A.C. (Eds.), Protection and Restoration of the Environment (V), Proceedings of an International Conference, Thassos, Greece, July 2000, vol. II., Bouris, V., Thessaloniki-Kalamaria, (2000), pp. 769–775.

[18] SPAAN W.P. and VAN DEN ABEELE G.D.: Wind borne particle measurements with acoustic sensors. Soil Techn. 4, (1991), p 51-63.