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CHANGES IN SEVERAL SOIL CHEMICAL PROPERTIES FOLLOWING AMENDMENT WITH OLIVE MILL WASTE WATER SLUDGE

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Abstract

Olive oil extraction produces large amounts of waste water, known as olive mill waste water (OMWW). This sludge has a high chemical oxygen demand and contains high level of phenolic compounds and is therefore a cause of environmental pollution. The exploitation of this waste without preliminary treatment is very limited considering its toxicity for soils and plants. In Tunisia, 700,000 tons of OMWW, produced annually, are generating many types of pollution. They are dried in special basins and then put in heap to be used as compost while an important fraction of the product is poured directly in the natural channel. It is within this framework that this work has been carried out aiming at finding new technologies or processes for the treatment and the valorization of this effluent. The spreading of Margines on sandy soil in Southern Tunisia represents an interesting alternative for this sewage. The aim of this work is to assess the short term effect of OMWW (olive mill waste water) application on chemical soil properties. In fact, the application of 50 (T1), 100 (T2) and 200 (T3) m^3/ha of this wastewater resulted in a significant improvement of soil fertility due to its richness in organic matter such as N and P. Application of three doses: 50, 100 and 200 $m^3 \cdot ha^{-1}$ of OMWW increased the soil electrical conductivity significantly with the increase of OMWW rates at the depth 0 - 25 cm. The pH variations were not detected during the experience. Furthermore, soil sodium, chlorides and sulfates values were substantially affected by OMWW salinity. The ratio C/N increased from 9.45 observed for the control sample to 12,91, 18,25 and 22,5, respectively, with the increase of OMWW rate in the top layer (0 - 25 cm). The both exchangeable and total potassium increased gradually with the OMWW application dose

Key words: *OMWW, ratio C/N, pH, electrical conductivity, Sodium, Chloride, Sulfates, Total Potassium, Exchangeable Potassium*

Introduction

Olive mill wastewater (OMWW) is the liquid by-product generated during olive oil production Mekki et al. (2013).

The OMWW annual production in Mediterranean countries reached 30 million cubic meters and 700 000 cubic meters in Tunisia alone (Dhouib et al., 2006 ; Kapellakis et al., 2006). The production of such a high amount of OMWW in a short period (3-5 months), its pollution load of high biological oxygen demand (40-80 $g \cdot L^{-1}$), high chemical oxygen demand (50-150 $g \cdot L^{-1}$), and its phytotoxic properties are serious problems for OMWW disposal (Mahmoud et al., 2012 ; Namara et al, 2008).

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The difficulties in disposal of OMWW arise mainly from the short period in which they are produced (4-5 month) and the high load of recalcitrant organic matter it contains. The OMWW is dumped on farm lands at the risk of severe ground and surface water pollution.

This practice is often made more difficult and expensive due to hilly landscape and the wet condition of the soil during winter.

The agronomic use of these wastewaters on soils may enhance their fertility, considering the fertilizing properties of the waste, as organic matter, P, K and N (Paredes et al., 1999). Significant increases were observed in TOC (total organic carbon), WSOC (water soluble organic carbon), humic and fulvic acids when soil was amended with olive mill husk with high water content from 2-phase decanter at the rate of 30 t/ha (Pineiro et al., 2007) It was reported that HS (humic substances) composted OMWW are similar in their chemical characteristics to those in native soil (Senesi et al., 2007). This would indicate that quality and quantity of organic matter and fertility can be enhanced in soil by the addition of compost made with OMWW (Pineiro et al., 2002).

On the other hand, OMWW spreading on top soil may have beneficial effects such as nutrient availability for plant growth (Parades et al., 1987; Alburquerque et al., 2007; Altieri et al., 2005). Field experiments showed comparable yields when a mineral fertilizer and OMWW compost were used independently at rates of 60 T/ha and 80 t/ha respectively, in maize, lettuce and spinach (Tomati et al., 1996). Although positive effects have been reported even for the application of OMWW to annual crops (Garcia et al., 1994) which are more susceptibles to toxicity, its effectiveness on olive trees is still controversial, and in most cases refer to trees of younger age. Subtoxic effects on young olive trees with high doses were observed (Bricoli and Lambardou, 1990) however; even with high OMWW doses the growth of young olive plants was not reduced (Marsilio et al., 1991). With high doses the application was phytotoxic and plants died (Ben Rouina et al., 1990).

The present study was aimed at evaluating under field experiment, the short and long term effects of different application rates of olive mill wastewater on several chimical soil properties. Also, the assessment of the effects on different soil layer's will be addressed.

Materials and Methods

Experimental site

Experimental work was carried out in field experiment in the CFRA farmer located at the IRA (Institute of Arid Areas) in southern Tunisia (governorate of Medenine). North latitude: 33° 16′ 21″, East longitude: 10° 19′ 30″ (Fig. 1). The climate of the region is typical Mediterranean, semiarid to arid, with an average rainfall of 150 mm and average annual temperature of 18-20 °C.

Soil

It is an isohumic soil, mollic epipedon (Soil Taxonomy - Soil Survey Staff, 2014), typical soil for the arid southern Tunisia which is characterise by a low content or-

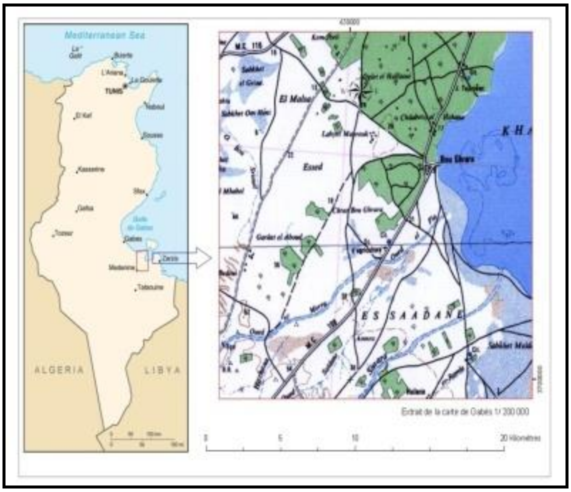

Figure 1
Study area location (Remote Sensing Unit – IRA Medenine)

ganic matter and a sandy texture. The soil is also characterized by a high level of the electrical conductivity which increases with the depth. Indeed, this parameter increased from 5 dS/m in surface layer to more than 8 dS/m in depth (Table 1). This salinity increase can be clay and gypsum at the horizon 70-80 cm.

Table 1. *The main physical and chemical characteristics of soil*.

Depth	**Clay**	**Silt**	**Sand**			**Initial EC**	**$CaCO_3$ total**	**Gypsum**	**Organic matter**	**pH**
			Very fine	**Fine**	**Coarse**					
cm	%	%	%	%	%	ds/m	%	%	%	
0-25	3.57	5.20	69.4	17.8	6.65	5.67	5.55	0.37	0.92	7.11
25-50	3.77	6.20	63.8	5.13	5.43	7.99	8.33	1.50	0.88	7.23
50-75	4.88	7.25	53.5	29.5	6.79	8.79	8.33	3.45	0.54	7.15
75-100	4.07	6.21	62.2	24.1	6.29	7.48	7.40	1.77	0.78	7.16

OMWW

The fresh OMWW was taken from a three-phase continuous extraction factory located in Saadane-Tunisia southern Tunisia. The physicochemical characteristics of this sludge are summarized in Table 2 and correspond to the mean values of 3 analyses.
OMWW application was done at rates equivalent to 50, 100, and 200 m^3·ha-1. Also SC plots were not amended and served as control. All the treatments were done in triplicate, distributing the plots alternatively. The experimental design consisted of 48 plots according to a randomized block design with three replicates.

Soil Sampling and Parameters Analysis

In order to evaluate the length and the range of OMWW spreading effects, we choose two sampling times: short-term and highest expected effects (time1): 1day after spreading; long-term and residual/lowest expected effects (time 2): 4 months

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after spreading. Soil samples were collected at different layers 0 – 25 cm, 25 – 50 cm, 50 – 75 cm, 75-1 m for each plot. The field-moist soil samples were sieved (<2 mm), delivered and then stored at 4˚C prior to analysis.

Characteristics		Average value
pH		4.8 ± 0.2
EC	dS/m	10.0 ± 0.52
COD	g/L	98.0 ± 2.1
BOD	g/L	66.0 ± 2.4
Total organic carbon	g/L	26.0 ± 2.4
Total nitrogen kjeldahl	g/L	1.6 ± 0.1
Carbon/Nitrogen	g/L	16.25 ± 0.48
Phenolic compounds	g/L	8.8 ± 0.3
Potassium	g/L	6.1 ± 0.2
Calcium	g/L	1.1 ± 0.1
Phosphorus-Olsen	g/L	0.35 ± 0.02
Mangesium	g/L	0.42 ± 0.01
Sodium	g/L	1.57 ± 0.01
Chlorides	mg/L	0.65 ± 0.4

Table 2
Characterization of OMWW used in spreading **(***values after represent ± standard deviation).*

***EC** : Electrical conductivity*
***COD** : Chemical oxygen demand*
***BOD** : Biological oxygen demand.*

Chemical Soil Analysis

The following parameters were monitored in the soil layer (0 cm- 1 m): pH and EC25 (1:2.5 aqueous extracts), TOC (Total Organic C) was determined by Dichromate oxidation, total N by the Kjeldahl method (1883), Na^+, total K^+ and sulphates contents were determined by fire Spectrophotometer by Chapman and Pratt (1961) method; Chlorides ions was estimated using method of titration with Chlorhydric acid by the Mohr method (Skoog et al., 2015). All determinations were made in three replications.

Statistical Analysis

All results were subjected to analysis of variance. Data were analyzed using the ANOVA procedure. A probability level of $\alpha = 0.05$ was chosen to establish the statistical significance among treated and control samples. Variance and standard deviation were determined using SAS 9.3 (version for windows).

<u>Results and discussions</u>

Effect of OMWW spreading on chemical soil properties

Compared to the control, OMWW land spreading determined differential short and long-term impacts on soil chemical parameters such as: ration C/N, pH, EC, exchangeable K^+, total K^+, sodium, chlorides and sulfates contents (Table 3). The studied soil was initially poor in OM (0.92%). Results show that OMWW application significantly increased the ratio C/N in the upper layer of soil with respect to the control, during the experiment (Table 3). This increase is proportional to the OMWW spread quantities. The rate of organic matter increases with the doses administrated. Indeed, the ratio carbon/nitrogen increased from 9 in the control to 12, 18 and 20 with OMWW gradual doses application 50, 100 and 200 m^3 ha^{-1}, respectively.

Many researchers have established that these wastes have a high fertilizer value when applied to the soil; OMWW is known to increase soil organic matter and the concentrations of essential inorganic elements for plant growth resulting in enhanced soil fertility (Bonari et al., 1993; Cabrera et al., 1996; Paredes et al., 1999). This is of the greatest importance in semiarid conditions where agricultural soils poor in organic matter are dominant, and are being subjected to intense processes of degradation (Sierra et al., 2007). Moreover these results are consistent with previous reports indicating that olive mill waste application increases soil organic C (Madejon et al., 2003; Pineiro et al., 2002; Taamallah, 2007).

Table 3. *Soil chemical parameters at different sampling times after olive mill wastewater (OMWW) addition, one day and four months, in comparison with controls (unamended soils).*

	First time: after one day			**Second time:** after four months		
	Treatment (*m³/ha*)	Value		Treatment (*m³/ha*)	Value	
C/N	SC	9.46 ±0.54	A	SC	12.0 ±0.87	A
	S50	12.9 ±0.69	A	S50	17.0 ±0.45	B
	S100	18.3 ±0.96	B	S100	21.2 ±0.81	C
	S200	22.5 ±0.36	C	S200	23.9 ±0.39	D
pH	SC	7.12 ±0.23	A	SC	7.89 ±0.35	A
	S50	7.14 ±0.52	A	S50	7.83 ±0.39	AB
	S100	7.44 ±0.58	A	S100	8.06 ±0.86	BC
	S200	7.61 ±0.92	A	S200	8.16 ±0.59	C
EC (ds/m)	SC	4.83 ±0.58	A	SC	5.46 ±0.94	A
	S50	5.45 ±0.59	A	S50	5.62 ±0.87	A
	S100	6.67 ±0.47	B	S100	6.84 ±0.36	B
	S200	7.30 ±0.72	B	S200	7.57 ±0.72	C
Exchangebale K+ (mg/Kg)	SC	301 ±0.95	A	SC	301 ±0.35	A
	S50	1354 ±0.98	B	S50	939 ±0.85	B
	S100	1628 ±0.76	C	S100	1321 ±0.69	C
	S200	1988 ±0.81	D	S200	1576 ±0.52	D
Total K+ (mg/Kg)	SC	1236 ±0.23	A	SC	1022 ±0.61	A
	S50	1808 ±0.36	AB	S50	1584 ±0.65	A
	S100	2441 ±0.88	BC	S100	2087 ±0.87	B
	S200	3266 ±0.74	C	S200	3041 ±0.89	C
Sodium (mg/Kg)	SC	5663 ± 0.74	A	SC	5273 ±0.92	A
	S50	6908 ± 0.78	A	S50	6652 ±0.88	A
	S100	7838 ± 0.32	B	S100	7038 ±0.63	B
	S200	10640 ± 0.44	C	S200	9823 ±0.67	C
Chlorides (mg/Kg)	SC	378 ±0.63	A	SC	258 ±0.35	A
	S50	364 ±0.41	A	S50	317 ±0.47	AB
	S100	389 ±0.89	A	S100	288 ±0.82	AB
	S200	399 ±0.38	A	S200	218 ±0.28	B
Sulfates (mg/Kg)	SC	1099 ±0.28	A	SC	773 ±0.38	A
	S50	1174 ±0.55	A	S50	954 ±0.62	AB
	S100	1218 ±0.69	A	S100	1128 ±0.43	BC
	S200	1224 ±0.97	A	S200	1088 ±0.93	C

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At second sampling, a light increase of C/N ratio was demonstrated for all OMWW rates application. In agreement, increases were observed in the short-term period by several authors (Sierra et al., 2007 ; Mechri et al., 2011).

This increase was attributed to mineralization or immobilization process (Javis et al., 1996) suggested that C/N characteristics of organic materials provide an indication of whether net mineralization will occur when organic materials are added to soil.

When a substance entering soil has a low C/N ratio, net mineralization occurs because there is enough N in the substrate to be assimilated for the microorganisms in converting all the C into their biomass and the excess N accumulates in soil. On the other hand, when a residue with a high C/N ratio is added to soil, net immobilization occurs because there is not enough N available in the substance to meet the N requirement of microorganisms to convert all of the C into biomass, so soil microbes will take up nitrogen from the soil mineral nitrogen pool, or attack simultaneously soil organic matter, which has a low C/N ratio to release more available nitrogen, or degradation will be slowed until death of a part of the microbial population.

In first time sampling day, the soil pH indicated no significant difference with the application of increasing OMWW doses. Indeed, the pH variation (7–7.5) for treated soil showed no difference compared to the soil taken as reference. The soil pH remains unchangeable despite the pH acidic of OMWW (Table 1:4.8) mainly due to the presence of organic acids (Mekki et al., 2009).

Indeed, in spite of the initial OMWW acidity, the follow-up of this parameter during 4 months showed that these OMWW provoked a weak incease in the soil pH. It is probably due to the substantial ability of the $CaCO_3$ soil compound to neutralize such OMWW as given away by (Sierra et al., 2001; Dakhli et al., 2013); Zenjari et al., 2009).

Besides, the variability in pH values can be attributed to the transformation of the substrate form reduced to oxidized material during anaerobic mineralization and to the intense liberation of CO_2 predominantly during aerobic mineralization.

Similarly, OMWW application increased soil EC and this increase was proportional to the added OMWW quantity (Table 3).

One day after OMWW spreading, the EC value for the untreated soil registered was 4.8 ds m^{-1}. For the treated soil, these values were 5, 6 and 7 ds m^{-1} for each doses applied respectively 50, 100 and 200 m^3/ha (Sierra et al., 2001) showed the raise of soil EC with increasing OMWW rates and the highest OMWW dose applied almost duplicate the control salinity.

The increase in soil EC was related to the high salts concentration in the OMWW which presented an EC value about 10 ds/m (Table 2).

On the other hand, regarding the deviation of the soil salinity determination, the Chlorides, Sodium, Sulfates and total K concentrations also increases with OMWW rates application (Table 3). The increase of the soil salinity involved the alteration of the CEC (cation exchange capacity) and could affect the soil fertility. So as a consequence, this application might affect negatively the most sensitive crops. The raise in the soil salinity could result from the main ionic species (Na, Cl and SO_2), which came from OMWW. Dakhli et al. (2013) reported that the OMWW acidity was due to the presence of phenolic and fatty acids, subsequently the application of this effluent to soils could accumulate salts and phytotoxic compounds, change pH and leach nutrients that could contaminate the ground water source (Zenjari et al., 2001).

However, this soluble salts can be effectively mobilized, transported and eliminates from the soil both by infiltrating rain water accumulated during the experimental period (150 mm) and the quantities of water deliberated by irrigation, as can be seen by the decrease of the soil salinity through the experimental period (especially four months after OMWW spreading for all the parameters following as: EC, Chlorides, Sodium Sulfates and total K concentrations.

K exchangeable was significantly affected by the OMWW treatment just after OMWW disposal values were found to be 10 to 13 fold higher than the observed ones in the control (Tables 3).

This increase is directly caused by the high content of K in the OMWW. This is keeping with the remarks of Mekki et al. (2011) and the results of (Achak et al., 2005; Sierra et al., 2008; Chartzoulakis et al., 2010; Kawadias, 2010) confirming that residues applied directly to the soil could be used as an alternative supply of K in low K soils. It is important to emphasize that adequate K fertilization allows better tolerance to drought, which is very frequent under our Mediterranean conditions Dakhli (2015). These K increases are beneficial for crop productivity and health according to the different plant requests and uptake efficiency Dakhli (2015) and (Granades et al., 2004).

However, it is not uncommon for the plant to take up more potassium than needed if a potassium-containing OMWW is applied at a rate greater than that recommended. This phenomenon is known as "luxury consumption," (www.clemson.edu) a condition that may cause an imbalance at the cation exchange complex therefore a nutritional disorders in plant yield and quality will be induced. In addition, due to luxury consumption, a considerable amount of potassium will be removed if the entire plant is harvested. Therefore, for a following crop, more potassium than what might be expected will need to be applied Dakhli (2015) and (Granades et al., 2004).

By contrast, at second sampling time, low decreases were recorded. Indeed, four months after spreading, soil K exchangeable values were decreased by 400 mg/Kg for each rate application than the values observed at first sampling time 1 (Table 3). K losses can be induced by leaching process due to rainfall/irrigation conditions.

Evolution of chimical soil properties under OMWW application at different layer's C/N ratio and exchangeable K progress.

The rate of organic matter increases with the doses adminnistrated. C/N ratio increase was proportional to the increasing of OMWW doses application (Figure.1). Because of it's binding and hydrophobic effects, the application of

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OMWW resulted in a more stable soil and created mulch reducing the losses of water evaporation. C/N ratio on top layer increased from 14 in the control to 20, 25 and 31 with OMWW gradual doses application 50, 100 and 200 $m^3 \cdot ha^{-1}$, respectively. The highest level was recorded at plot S100 and S200 on layer 0 - 25 cm, with a slight migration towards the lower layers compared to the control. These results suggest that agronomic application of OMWW had a greater effect on the organic carbon (OC) content than on the nitrogen(N) content of the soil.
Dick (1983) indicated that the lower soil C/N ratio is due to the greater mineralization rates of OC vs. N. The main constituents of the organic fraction of OMWW are proteins and sugars that are easily biodegradable and, to a lesser degree, organic acids, polyalcohols, fats, polyphenols, and others (Fiestas, 1996).

a
b

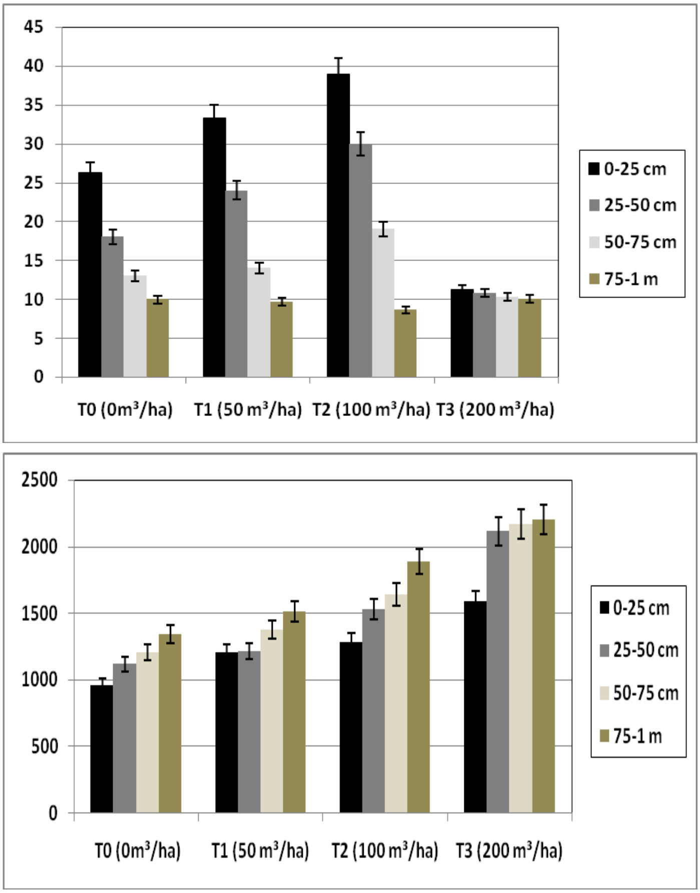

Figure 1

Effect of OMWW on C/N (a) and Exchangable K^+ (b) at four soil layers (0–25 cm, 25–50 cm, 50-75 cm and 75 – 1 m). Error are represent ±3.

pH, EC and mineral Elements evolution

Throught the four layer's, soil pH indicated no significant difference with the application of increasing OMWW doses. Indeed, the pH variation (7.8 – 8.4) for treated soil showed no difference compared to the soil taken as reference. This result could be explained as mentionned by (Chartzoulakis et al., 2010) by the buffering capacity of the soil which counterbalance the negative effect of OMWW. Results showed that, EC values decreased with depth due to the infiltration by precipitation that induced a transfer of ions to the groundwater (Sierra et al., 2007). Although, potassium (K^+) is not considered as polluant, it is present in OMWW with a high concentration about 6.1 g/l. Table 2 displayed the evolution of K^+ after OMWW spreading on the soil, K^+ level increased on layer (0 - 25 cm) for plot T 50, T 100 and T 200, referred to control. Whereas, the highest level of K+ (was registered on top layer at plot T 200 (2700 ppm).

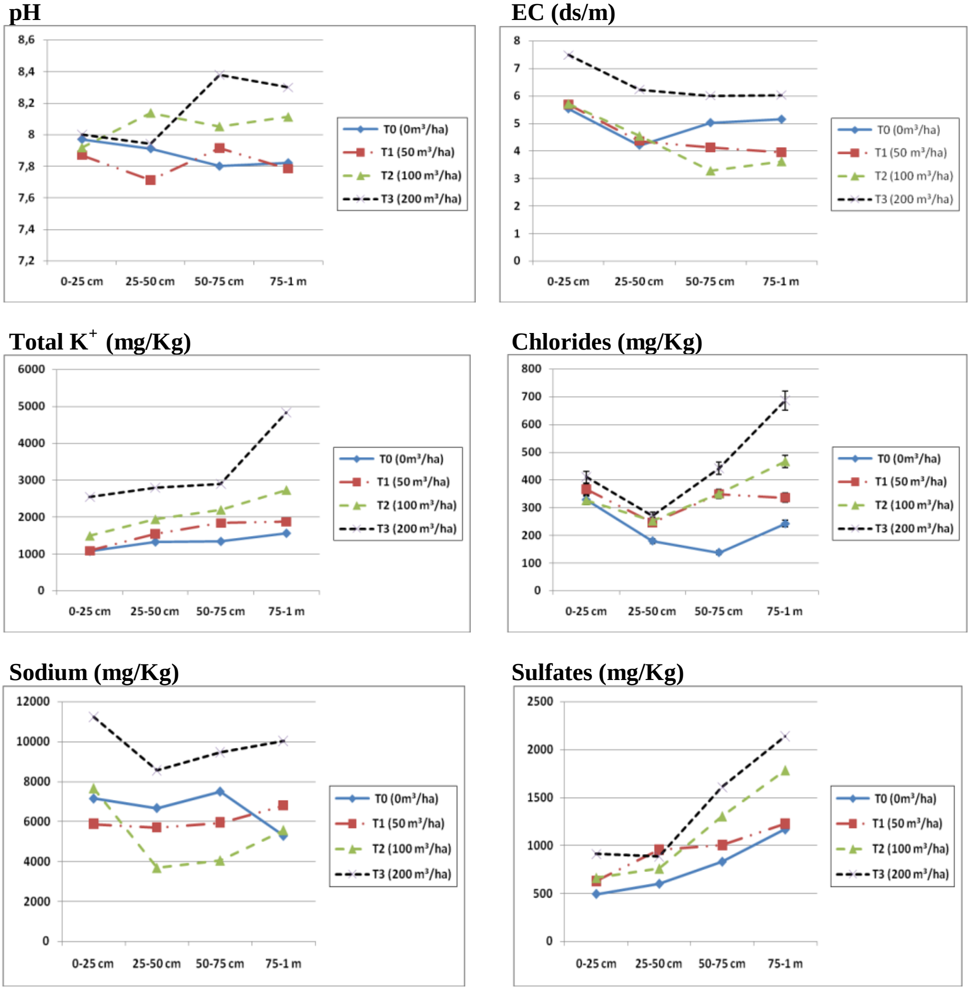

Figure 3. *Effect of OMWW on several chemical properties at four soil layers (0–25 cm, 25–50 cm, 50-75 cm and 75 – 1 m).*

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This level was almost 3 times higher than the control. Whereas, K^+ level recorded no difference between treated plots and the control from layer 25 – 50 cm to 75 - 1 m. Dibene et al. (2013) and Fahd (1990) mentioned that K+ levels were found to be four to 10 folds higher than the control. Generally, K^+ is affected by the soil equilibrium conditions (drying and wetting) and subsequent loss by leaching. Potassium is an essential element for development, plant growth and many plant functions (Masser et al., 2002; Zhang et al., 2010). Potassium availability in soil has a major role in estimating fertilization requirements.Hence, the sodium (Na^+), Chlorides (Cl^-) and Sulphates ions (SO_4^{2-}) showed the same evolution recorded for K^+ (Figure3).
Three elements level's in the soil amended with 50 and 100 $m^3{\cdot}ha^{-1}$ registered no difference from layer 0 - 25 to 50 - 75 cm and 1m. Notably, the raise in deeper layers of T200 is related to leachining by infiltration. In addition, the Na^+ excess on soil solution was neutralised by $CaCO_3$ or $CaSO_4$, both naturally present in the soil (Gupta et al., 1990). The neutralisation caused a decrease of Ca^{2+}, and since the soil particles tend to repel each other causing clay dispersy and the collapse of the soil structure (Chaari et al., 2015).

Conclusion

This study investigated the effects of OMWW application on selected chemical soil properties. Results presented here show that several chemical of the investigated soil changed in response to OMWW application. Compared with the control, soil pH was slightly affected by the addition of OMWW. Therefore the OMWW acidity was neutralized by carbonates present in the soils.
Taking into consideration the deviation of the soil salinity determination, the electrical conductivity, Chlorides, Na and Sulphates also increase with OMWW rates. All these parameters increased as a function of depths compared to the control soil which suggests the leaching of OMWW from the surface to the deeper layers of soil (concentration of ionic species especially Na, Cl and SO_4).
Parallel, the fertilisation with OMWW led to a significant increase in the C/N ratio in the upper soil layer with respect to the control, during the experiment. This increase is proportional to the OMWW spread quantities which are most important especially for the two highest rates (S100, S200). Similarly, both the exchangeable and available K in the upper layer tended to increase throughout the experimental period in the OMWW treated soils, independently of the rate application of amendment received, this increase is most significant especially for the higher doses applied such as (S100, S200) compared to the control.
The results of this study seem to confirm that the impact of the OMWW residues on soil properties is the result of opposite effects, depending on the relative amounts of beneficial and toxic organic and inorganic compounds present.
OMWW in sandy soils in arid conditions of southern Tunisia can be considered as an attractive alternative to implement with caution for the rehabilitation of poor organic matter soils. For this reason, agronomic application of OMWW and its

effects on soil properties, soil phosphorus availability and on soil microbial communities should be examined in future studies to reach an affirmative answer.

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CHANGEMENT DES PROPRIÉTÉS CHIMIQUES DU SOL APRÈS ÉPANDAGE DES MARGINES

Résumé

L'extraction d'huile d'olive génère d'énormes quantités des eaux résiduaire produites lors de la trituration des olives, connues sous le nom des margines. Ces déchets sont caractérisés par une forte demande chimique en oxygène et une concentration très élevée en composés phénoliques responsable de la pollution de l'environnement. L'exploitation de ces déchets sans traitement préliminaire est très limitée compte tenu de sa toxicité pour les sols et les plantes. En Tunisie, 700 000 tonnes de margines, produites annuellement, génèrent de nombreux types de pollution. Ils sont séchés dans des bassins spéciaux puis mis en tas pour être utilisés comme compost alors qu'une fraction importante du produit est versée directement dans le canal naturel. C'est dans ce cadre que ce travail a été réalisé en vue de trouver de nouvelles technologies ou procédés pour le traitement et la valorisation de ces effluents. L'épandage de margines sur des sols sablonneux du sud de la Tunisie représente une alternative intéressante pour ce type d'égout. L'objectif de ce travail est d'évaluer l'effet à court terme de l'application des margines sur les propriétés chimiques du sol. En effet, l'application de 50 (T1), 100 (T2) et 200 (T3) m³/ha de margines a permis une amélioration significative de la fertilité du sol en raison de sa richesse en matière organique notamment en N et en P. L'application de trois doses: 50, 100 et 200 m³ · ha-1 de margines a engendré une augmentation significative de la conductivité électrique au niveau de la couche superficielle du sol (0 - 25 cm). Les variations de pH n'ont pas été détectées au cours de l'expérience. En outre, les valeurs du sodium, des chlorures et des sulfates du sol ont été sensiblement affectées par la salinité de margines. Le rapport C / N est passé de 9,45 pour le témoin à 12,91, 18,25 et 22,5, respectivement, avec l'augmentation de la dose de margines attribuée au niveau de l'horizon de surface (0-25 cm). Le potassium échangeable et le potassium total ont augmenté progressivement avec la dose d'application OMWW.

Mots clés: OMWW, rapport C / N, pH, conductivité électrique, Sodium, Chlorure, Sulfates, Potassium total, Potassium échangeable.

CAMBIAMENTI DELLE PROPRIETA' CHIMICHE DEI SUOLI AMENDATI CON ACQUE DI VEGETAZIONE DEI FRANTOI OLEARI.

Riassunto

L'estrazione dell'olio d'oliva genera grandi quantità di acque reflue prodotte dai frantoi oleari, note come acque di vegetazione. Tali rifiuti sono caratterizzati da un'elevata richiesta chimica di ossigeno e da un'alta concentrazione di composti fenolici responsabili dell'inquinamento ambientale. Lo sfruttamento di questi rifiuti senza trattamento preliminare è molto limitata a causa della sua tossicità per il suolo e le piante. In Tunisia, 700.000 tonnellate di vegetali, prodotti ogni anno, generano molti tipi di inquinamento. Essi vengono essiccati in stagni speciali e stoccati per uso come compost, mentre una parte significativa del prodotto viene colato direttamente nel canale naturale. È in questo contesto che è stato svolto il presente lavoro mirato a trovare nuove tecnologie o processi per il trattamento e il riciclaggio di questi effluenti. La diseprsione delle acque di vegetazione su terreni sabbiosi del sud della Tunisia è un'alternativa interessante per questo tipo di inquinante. L'obiettivo di questo studio era di valutare l'effetto a breve termine dell' uso delle acque di vegetazione sulle proprietà chimiche del suolo. Infatti, l'applicazione di 50 (T1), 100 (T2) e 200 (T3) m³ / ha di acque di vegetazione ha permesso un significativo miglioramento della fertilità del terreno grazie alla ricchezza di materia organica oltre ad azoto e fosforo. L'applicazione di tre dosi: 50, 100 e 200 mc · ha-1 di acque di vegetazione ha prodotto un significativo aumento della conducibilità elettrica nella parte superficiale del suolo (0-25 cm), mentre non sono stati rilevate variazioni di pH nel corso della sperimentazione. Inoltre, i valori di sodio, cloruri e solfati del suolo sono stati significativamente influenzati dalla salinità dell'acqua di vegetazione. Il rapporto C/N è aumentato da 9.45 del testimone a 12,91, 18,25 e 22,5, rispettivamente, con il progressivo incremento delle acque di vegetazione. Potassio scambiabile e potassio totale sono aumentati progressivamente in funzione dell'apporto delle acque di vegetazione.

Parole chiave: *acque di vegetazione, rapporto C / N, pH, conducibilità elettrica, sodio, cloruro, solfati, totale potassio, intercambiabile.*