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Ecological Restoration of Forest Soils Case of the Forest "Aioun Branise" Saida Algeria

Borsali Amine Habib[1,2*], Zadi Fatima Zohra[2]

[1]University Dr Moulay Taher, Saida , Algéria
[2]University Aboubekr Belkaid, Tlemcen, Algéria
Email: *rhizobiologie@yahoo.fr

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Abstract

In order to preserve the environment, various treatment processes of wastewater discharges are used. Anaerobic digestion is part and allows among other things the production of sludge. The use of sewage sludge in semi arid, characterized by a binding climate, anthropozoogenic pressure and erosion, more increasingly important, is a solution for the restoration of degraded forest lands. In this study, the effect of an intake of composts from urban sewage sludge on soil quality has been studied *in-situ* soils degraded in semi arid area. The research followed in this work methodology is the first to evaluate the effectiveness of contribution of compost over time on the restoration of the physico-chemical quality of forest soils, then to evaluate the effectiveness of compost quality depending on the state of disturbance of the ecosystem to restore the chemical quality of these soils. Our results show a significant effect of sewage sludge on soil's physical and chemical characters that have been processed. This effect was delivered by the holding capacity increase, ammonium ions, inorganic phosphorus, total nitrogen, the carbon and the organic matter in these soils. This research is to show that sewage sludge are rich in easily mineralizable organic matter and are supposed to be the most suitable for the restoration of soil most impacted by the antropozoogene action. These contributions would quickly revitalize these soils by labile resource inputs.

Keywords

Forest Degraded, Soil, Residual Mud, Spreading and Ecological Restoration

1. Introduction

Currently the global forest cover in Algeria is 4.1 million hectares at a rate of afforestation of 16.4% for the

*Corresponding author.

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North of the Algeria and 1.7% only if the Saharan regions are also taken into consideration. However, only 1.3 million hectares are real natural forest. Like countries around the Mediterranean, the Algeria attends intense degradation of its forest heritage (Benabdeli, 1996). This total area consists of poor organic matter, rocky soil, soil degraded by water and wind, more erosion havoc caused by fire repeated during the summer period and illicit overgrazing (cattle and goats).

Human activities can overturn deeply and lastingly forest ecosystems in semi arid. The degradation of these natural environments, being physical or chemical, translates to profound changes in the composition and the structure of these soils. These changes in the soil can deeply modify the business processes involved in the functioning of ecosystems and in turn alter the ecological services that ecosystems provide to humans.

The soil is a living and fragile environment. It is the support of intense exchanges of biological and physicochemical transformations. It is a biological and geochemical interface decisive in maintaining the functioning of ecosystems (Robert, 1996). The ground, although can be restored and more or less reconstructed, remains a non-renewable resource because of the long period required for its formation processes.

In 2004, the society for ecological restoration (SER) defines ecological restoration as "the likely process to assist the regeneration of an ecosystem status degraded, damaged or destroyed". Ecological restoration is an intentional activity which aims to accelerate or to restore a historic ecosystem in relation to the specific species of origin, the structure of the communities, the ecological functioning, the capacity of supporting living organisms and connect them with the landscape surrounding (Aronson et al., 1993).

The mud application to soil appears therefore as one of the most environmentally friendly and economically viable options (Grenier et al., 1989). Sludge must be regarded as a raw material that can be used. As if serving as fertilizer forest, we reach two objectives, or the use of a product currently seen as junk and the production of more than timber. In addition, all fits well in the new current of thought that directs our society to the recycling and recovery (Grenier et al., 1987).

The spreading on non-agricultural soils practice on forest soils or on degraded soils (quarries, mines, forests nearly, etc.) for a revegetation or recreation areas. Revegetation is a mode of recovery particularly important in Sweden where more than 20% of sludge is concerned. It is practised also in Finland, Spain and Great Britain. The sludge of printing is also used in this area (Fierro et al., 1999). The spreading forests have been practiced for more than 20 years in the United States, mostly in the Southeast and West Coast States (Hue, 1995).

The objective of this study was to determine the effectiveness of composts in the form of sludge to promote the restoration of disturbed soil quality supply. This work addresses these issues by combining descriptive field and experimental approaches in the laboratory. It relies on a dozen parcels of land identified and it is characterized by a certain degradation or repeated fires, and erosion is anthropic action.

This work of ecological restoration of degraded forest soils in semi arid zones is the first experience at the level of the common Aioun Branis forest in Ouled Brahim, wilaya of Saïda and Western Algeria.

Pending a spontaneous restoration of these ecosystems and mitigating their degradation and associated services (production of wood, production of a quality water resource), the waste sludge may represent a solution to give the soil necessary nutrients for plants and the restoration of ecosystems. The objectives of these forced restoration efforts are to restore the physicochemical quality to sustainably improve the state of health of forest stands, but also to restore biodiversity and the functioning of semi arid ecosystems.

2. Material and Methods

2.1. Presentation of the Study Area

The wilaya of Saïda (**Figure 1**) is located Northwest of the Algeria and across geographic Highlands, it is limited to North by the wilaya of Mascara, South of El Bayadh, on the East by the wilaya of Tiaret, and on the West by Sidi bel Abbès wilaya. It is composed of five districts (the District of Ouled Brahim, Daira de Hassasna, Daira de Sidi Boubkeur, Daïra of Ain El Hadjar, Daïra of Youb). The Ouled Brahim district covers an area of around 9341 km^2. It is limited; On the North by the wilaya of Mascara, to the South by the municipality of Tircine, has the West by the municipality of Ain Soltane, North-East by the wilaya of Tiaret (Takhmaret). The Daïra of Ouled Brahim is a model more or less representative of the other districts. It has a very important geographical location, with heterogeneous aspect of the physical environment (presence of mountains, Plains, foothills etc.) (D.P.A.T, 2010). Our study area (**Figure 1**) covers an area of 570.7 ha it has an ecological role of protection of slopes against the phenomenon of erosion and the valorisation of agricultural land. (Saddouki, 2009), this massif is continually subject to human pressures increasing and uncontrolled, which constitute a direct threat to the renewal of bio-

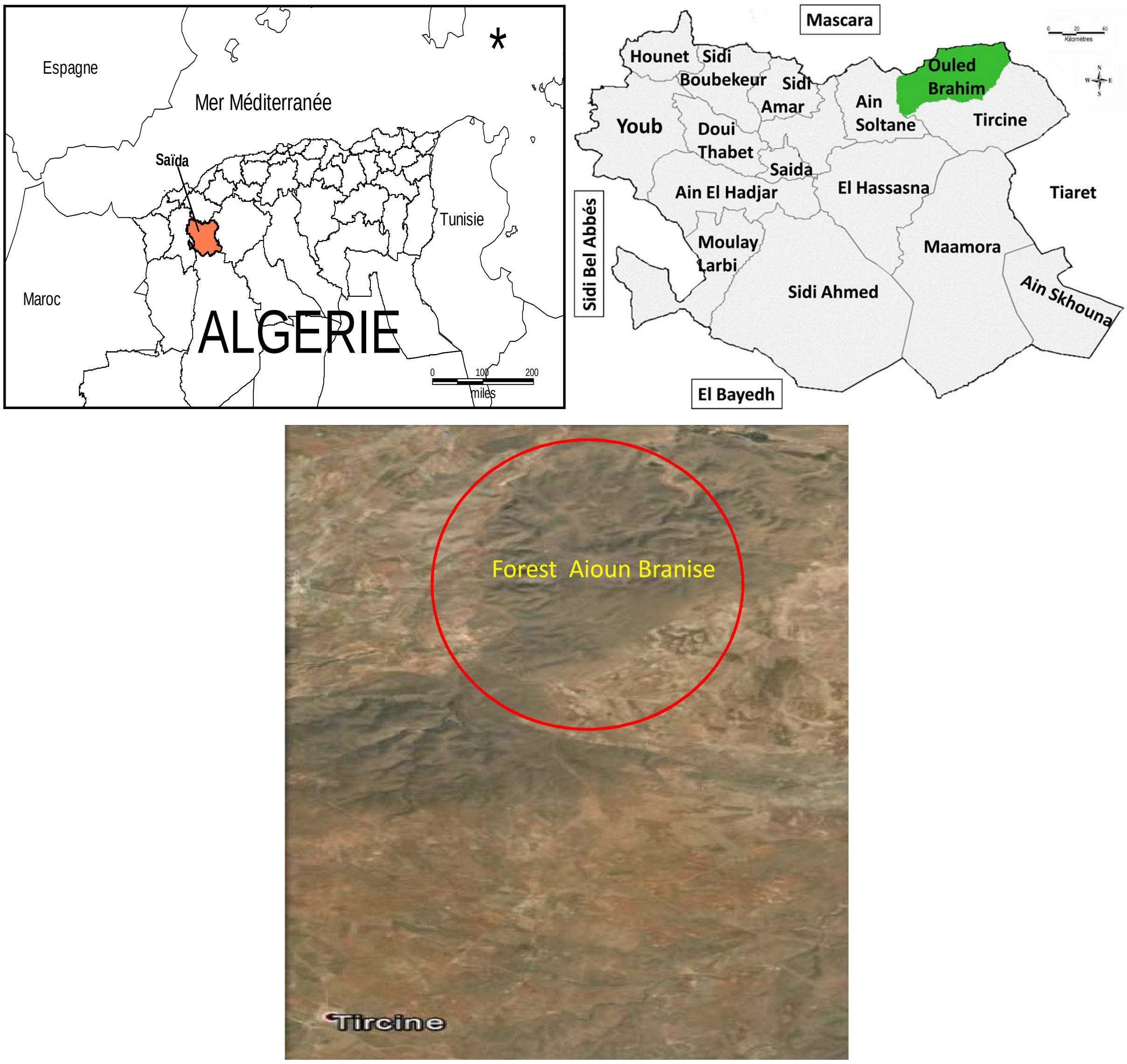

Figure 1. Location of the study area.

logical resources and the ecological balance of the region. The study area that it has chosen is subject to intense degradation of forest cover; illegal logging and firewood collection; a permanent herds, ovine, bovine, and goat grazing that threatens the renewal of biological resources.

2.2. Choice of Stations

In this study the selection of study sites was imposed by the degraded areas that characterize an ecosystem which the soil quality is poor so directed sampling.

We selected ten (10) experimental sites (**Figure 2**) in the forest of Aioun Branis on an estimated 800 m^2 area and divided into two equal parts spaced at least 2 metres on a flat surface. The first five sites to have left such stands without any application (station 1temoin). The other five sites of sustained application of mud residuaires (station 2).

2.3. Origin of Composts

Composts used in this study are of compost of sewage sludge from the treatment of wastewater. These composts

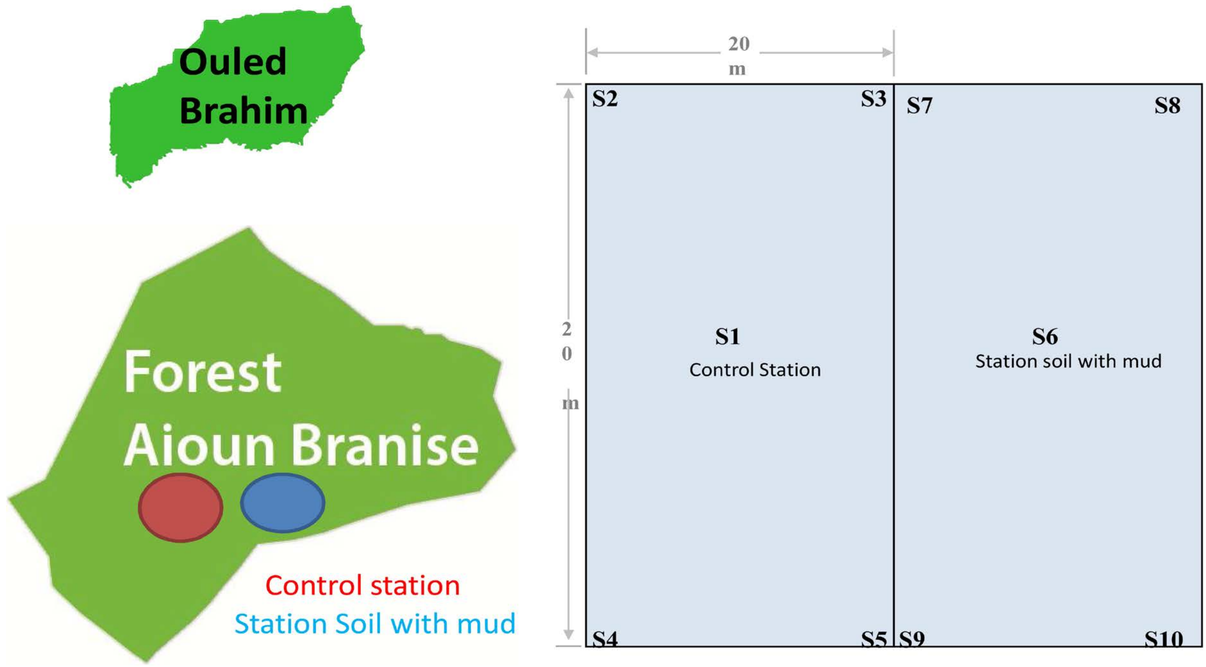

Figure 2. Location of the study sites.

were provided by the centre of composting (STEP) of the wilaya of Saïda. We have thus retained old compost from 3 weeks of maturities physico-chemical and microbiological, selected on the basis of the work of Rémy Albrecht thesis (2007), which suggests that age of maturity for best results.

In September 2012, 3 fresh composts 40 mm-ridden were made in mulch (surface deposit) to the equivalent dose of 70 tons per hectare of dry matter on these plots of 1 m^2 (7 kg of dry plot equivalent compost) (Guénon, 2010).

Analysis of sewage sludge (**Table 1**) shows that they contain significant amounts of organic matter and nutrients (nitrogen, phosphorus, etc.) which justify their use for the restoration of degraded soils. Indeed, if the sludge has a real value as organic amendment, they can thus compensates for humus soil.

2.4. Type of Sampling and Sampling of Soil

Soil samples were taken in October 2013 respectively 13 months after intake of composts. The samples were taken at 0 - 5 cm depth 5 amended sites, other samples were taken on the control sites. Soils were screened immediately to 2 mm and kept waiting for analyses.

2.5. Physico-Chemical Analyses of Soil

2.5.1. Particle Size Analysis

Particle size distribution (%) of 3 fractions (sands 2000 µm to 50 µm, coarse silts from 50 µm to 2 µm, clays < 2 µm) of fine soil was determined by sedimentation under the pipette Robinson and sieving method (Aubert, 1978).

2.5.2. Holding Capacity

The water retention capacity was determined by the Bouyoucos method. The sample is dampened for 12 hours by capillary rise in a sintered glass filter of Buchner. Then the filter is placed on a flask vacuum connected to a trunk water to eliminate the water in the pores of less than 8 µm in diameter. The difference between the wet weight and dry weight (after drying at 105˚C) allows knowing the capacity of water in (%) retention of dry weight (Soltner, 2006).

2.5.3. The pH

Soil pH was measured in a suspension of soil:distilled water (1:2.5). The measurement was made after 2 h of

Table 1. Characteristics of sewage sludge of sewage treatment of wastewater of Saida.

Parameters	Humidity %	pH water	CE mS cm^{-1}	NT %	PT %	K %	MO %
Average values	75	7.5	2	4.02	6.30	0.8	60.56

EC: electrical conductivity (mS cm^{-1}), MO: organic matter (%), NT: total nitrogen (%), PT: total phosphorus (%), K: potassium (%).

stabilization at room temperature using a pH meter Métrom (Herisau, Switzerland).

2.5.4. Measurement of the Levels of Calcium Carbonate

Calcium carbonate levels were determined by Bernard calcimetre (Aubert, 1978). In a flask for Bernard calcimetre was introduced in the finger 5 ml of HCL 1/2 with a straight pipette, then were weighed 10 g of finely ground soil that have been inserted into the vial, then on moistened the Earth with water demineralised without excess. After closure of the flask connecting it to the calcimetre, it is sure that the liquid level reaches up to the zero mark.

2.5.5. Levels of Total Organic Carbon, Total Nitrogen and Organic Matter

Concentrations of total carbon (TC) and total nitrogen (NT) were measured using an elemental analyser CN FlashEA 1112 (Thermofisher). Organic carbon (OC) is obtained by subtraction of the concentrations of inorganic carbon ($CaCO_3$) at concentrations in CT. C/N ratio has been calculated. Organic matter content was measured by loss of mass of a dry sample during calcination at 550˚C for 16 hours.

2.5.6. Determination of Nitric and Ammoniacal Nitrogen

Quantities of ammonium ions (µg de N-$NH4^+\cdot g^{-1}$ dry soil) and nitrate (µg de $NNO_3^-\cdot g^{-1}$ of dry soil N) were determined by spectrocolorimetry according to (Mulvaney, 1996; Keeney et al., 1982) from the extraction of soil solution (1:10 M KCl). 5 g (dried equivalent) soil fresh have been in suspension in 50 mL of a molar solution of KCl. After a 1 hour shaking, the suspension was filtered on paper Whatman no. 5. Then, the content of ammonium (µg de N-$NH4^+\cdot g^{-1}$ dry soil) contained in the filtered solution was dosed by Colorimetry. The intensity of the emerald green color formed after addition of salicylate is measured with the spectrophotometer to the wavelength of 667 nm. The absorbance of the yellow coloration of nitrate salicylic acid is read with the spectrophotometer at 410 nm.

2.5.7. Dosages of Inorganic Phosphorus

Available inorganic phosphorus was extracted by the method Olsen & amp; Sommer (1982). 2 g equivalent dry fresh soil have been in suspension in 25 mL of standard sulphuric acid solution. After a 1 hour shaking, extracts are filtered on paper Whatman no. 5. The amount of phosphorus in the form of orthorphosphates (µg P-$PO4^{3-}\cdot g^{-1}$ of dry soil) in the extracts was assayed by spectrocolorimetry according to the Protocol described by Murphy & Riley (1962).

2.5.8. Statistical Analyses

Analyses of variance (ANOVA) to 1 factor were used to test the effects of sewage sludge on the physico-chemical properties of soils. Test post-hoc least differences of Fisher (LSD) was used to make multiple comparisons of means.

3. Results

Our results shows that all studied soils of the two stations have a limoneu Sandy texture.

Results of analyses (**Table 2**) allowed us to see that the soil of the witness station 1 is poor total nitrogen, organic carbon and organic matter; its holding capacity is low enough.

According the results (**Table 3**) Note that a year after the input of sewage sludge, any physico-chemical variables are significantly altered. We measured an increase in pH, retention capacity, inorganic phosphorus, ammoniacal nitrogen, of the levels of total organic carbon and total nitrogen, organic matter in soils amended reaching all values greater than that of soils of station 1 and the C/N ratio control.

The statistical study (**Table 4**) showed that intake of sewage sludge significantly changed 8 of 9 physico-chemical properties of soils of station 2 depending on the time. Ph ($F = 26.5$, $p < 0.001$) and water levels ($F = 1.6$, $p < 0.001$), phosphate ($F = 6.3$, $p < 0.001$), in ammonium ions ($F = 5.4$, $p < 0.05$), total nitrogen ($F = 32.5$, $p <$

Table 2. Results of physico-chemical analyses of the soil of the witness station 1.

Soil sampling sites	pH Water	Holding capacity	$P\text{-}PO_4^{3-}$ (mg/g)	$N\text{-}NH_4^+$ (mg/g)	$N-NO_3^-$ (mg/g)	NT (%)	OC (%)	C/N ratio	O M%
Site 1	7.02	25.78	08.34	11.32	2.60	0,75	0.56	0.74	0.98
Site 2	7.05	24.89	07.06	10.23	1.98	0.64	1.77	2.76	1.21
Site 3	7.11	25.67	09.50	10.88	1.67	0.99	1.67	1.68	1.43
Site 4	7.20	26.89	08.83	11.80	2.30	0.76	0.99	1.30	1.77
Site 5	7.60	26.67	07.43	12.71	1.98	0.56	1.09	1.94	1.94

Table 3. Results of physico-chemical analyses of ground station 2 with sludge.

Soil sampling sites	pH Water	Holding capacity	$P\text{-}PO_4^{3-}$ (mg/g)	$N\text{-}NH_4^+$ (mg/g)	$N-NO_3^-$ (mg/g)	NT (%)	OC (%)	C/N ratio	O M%
Site 1	7.80	35.89	16.87	12.56	2.76	1.04	1.53	1.47	1.08
Site 2	7.60	34.78	14.56	11.50	1.97	0.99	2.64	2.66	2.67
Site 3	7.90	33.90	13.43	11.67	1.68	1.29	2.85	2.20	1.79
Site 4	8.02	30.90	15.87	11.78	2.31	1.12	2.90	2.58	2.47
Site 5	7.70	30.67	16.90	12.56	1.98	1.77	2.89	3.75	1.82

Table 4. Effect of sewage sludge on the physico-chemical characteristics of degraded soil.

Physico-chemical properties	**F**	**P**	**Station 1**	**Station 2**
pH Water	26.5	<0.001	7.19 ± 0.1^a	7.80 ± 0.1^b
Holding capacity	11.6	<0.001	25.98 ± 1.4^a	33.22 ± 0.7^b
$P\text{-}PO_4^{3-}$ (mg/g)	6.3	<0.001	8.23 ± 2.3^a	15.52 ± 15.5^a
$N\text{-}NH_4^+$ (mg/kg)	5.4	<0.05	11.38 ± 0.5^a	12.01 ± 0.9^b
$N-NO_3^-$ (mg/kg)	0.6	ns	2.1 ± 0.4^a	2.14 ± 0.1^a
NT (%)	52.3	<0.001	0.74 ± 0.03^a	1.24 ± 0.07^b
OC (%)	35.0	<0.001	1.21 ± 0.06^a	2.56 ± 0.03^b
C/N ratio	9.2	<0.01	1.68 ± 0.5^a	2.53 ± 0.3^b
O M%	9.1	<0.01	1.46 ± 0.05^a	1.96 ± 0.06^b

0.001), organic carbon ($F = 35$, $p < 0.001$), of matietres oraganique ($F = 9.1$, $p < 0.01$) and the C/N ration ($F = 9.2$, $p < 0.01$) increased significantly 12 months after the contribution of sludge in station 2. However have note that there are no significant effect ($F = 0.6$, ns) of sludge on nitrate nitrogen.

4. Discussion

Soils of the semi arid forests usually have levels of nutrient substances and low organic matter, indeed several authors who have worked on these soils showed that overgrazing and erosion weaken these soils under the action of climatic hazards which are quite harsh in these regions. Also, the frequency of fires in these areas causes a decrease of the elements carbon and mineral organic soils (Campo et al., 2006).

4.1. Effects of Composts on the Physical Properties of Degraded Soils

Daoud and Halitim (1994), specify that in the semi arid and arid, the soils are typically alkaline ($7.5 < pH < 8.5$). The pH of soils of the station that received sewage sludge to slightly increased after the contribution of sludge. This alkalinization could be attributed to the elevated calcium of composts; liming of sludge from sewage treatment before their composting is actually a method frequently adopted for hygièniser sludge and increase their pH (Guénon, 2010).

The incorporation of different types of sewage sludge increased retention in soil (Valat et al., 1991) and the amount of water available for plants (Khaleel et al., 1981). Our study to shown that retention capacity increased under the action of the sludge. Guénon, 2010 to shown that the contribution of compost maintained a higher humidity in soils in the summer season 10 months after are spreading on soil South of the France in the forest of the Moor, probably thanks to the high capacity of composts water retention and a limitation of the evaporation deposition surface (Serra-Wittling et al., 1995). Sludge-treated soils, keeps longer moisture (Tester et al., 1982).

According to Pfefer (1996), the mud is an element that holds lots of water and doesn't lose that very slowly, to the soil remains wet for a long time. The variability of the effectiveness of waste sludge depends on the type of soil on which it is epandee (Darwish et al., 1995). The effect of sludge will be more pronounced in soils with unstable structure as the soil silty but lesser in soils where other agents of stabilization of the aggregates are present such as clays.

4.2. Effects of Composts on the Chemical Properties of Degraded Soils

Our results, in agreement with the work of Guénon (2010) and Kowaljow and Mazzarino (2007) performed in a semi-arid climate, have shown that the contribution of compost increases quickly (in 12 months) inorganic phosphorus levels; phosphorus in municipal sewage sludge comes to 50% - 70% poly phosphates from detergents and for 30% - 50% of the organic materials of human origin (Morel, 1978).

Liquid sludge non-flocculated phosphorus is as effective as that of the soluble phosphate fertilizers, intake of this element promotes root development and the precocity of plants and nitrate, elements most of the time limiting in Mediterranean soils (Carreira et al., 1997). Zaman et al. (2004) showed a similar increase of net nitrification of soils after injections of composts.

Addition to the elevated N-$NH4^+$, pH, and soil moisture are also major factors that can control the nitrifying activity (Krave et al. 2002, Guénon, 2010) however we note that it is not a significant difference in the levels of nitrate nitrogen in sewage sludge, nitrogen be found in two forms: organic and mineral (NH4), sludge does not contain nitrogen nitric (NO_3^-) and nitrous (NO_2) except the state of trace (Juste and Catroux, 1980). Nitrogen is assimilated by the plants form mineral, especially nitric, the fertilizing value of sludge depends on their ammoniacal nitrogen content and especially the ability of organic nitrogen they contain to be mineralized soil.

We also recorded an enrichment of soil organic carbon and total nitrogen a year after the disposal of sludge. These results are in agreement with those of Guénon (2010) and Guerrero et al. (2001) which showed an increase of carbon and total nitrogen. This result confirms therefore that the effectiveness of compost on chemical properties that would be proportional to its quality and in particular its levels of C, N. Sludge gradually release nutrients including nitrogen to put at the disposal of the plant throughout the cycle of culture. The release of nitrogen is depending on conditions climate prevalent quantities made sludge and the C/N (Jamil et al., 2006) ratio compared to a non-amended soil, nitrogen and organic carbon content increase in the presence of sludge, in the first five to ten centimeters of soil (Pekrun et al., 2003).

Our results also show a significant increase of organic matter indeed, with sewage sludge-treated soils are enriched in phosphorus and organic matter (Benmouffok et al. 2005).

The sludge contains as much organic matter as a manure. In the mud especially microbial bodies are located and the products of their metabolism; Organic matter can range from 30% to 35% (Robert et al., 1996).

Evaluation of the organic sludge is comparable to those of other organic amendments. According to Alberta (1977), the residual sludge contains a high proportion of organic matter which varies from 6% to 30% fat and 8% - 15% of cellulose.

The direct effect of the organic matter contained in the sludge designs an improvement of the physico-chemical properties of soils, the cation exchange capacity increase, improvement of permeability, stability of aggregates and density (Kirkham, 1974).

5. Conclusion

Intake of compost could prove to be an effective way to restore the quality of degraded soils mainly of semi arid and arid zones that lacks much water and nutritious substances necessary for the development of the plants.

Furthermore, amendments on degraded soil constitute a pathway of recovery of organic waste products, and integrate in setting up management reasoned from these products. However, the sustainability of this sector requires the assessment of the effectiveness of the contributions and the identification of the optimum conditions for implementation (i.e. Product maturity, stock changes nutrient) and the assurance of environmental safety of products.

The effects of supplementation of compost on soil were studied in different agronomic contexts, forestry or Mediterranean soils degraded and burned. The contribution of compost generally translates into an enrichment in carbon, nitrogen and phosphorus organic and mineral soil (Larchevêque et al., 2005; Pascual et al., 1997; Guénon, 2010). However the level of enrichment and its length depend on the quality of the used compost (Guerrero et al., 2001).

Our results, in agreement with the work of Kowaljow and Mazzarino (2007) and Guénon (2010) carried out in Middle foresters in a semi-arid climate, showed that the contribution of compost significantly increased levels of organic matter and water, elements, most of the time limiting in Mediterranean soils (Carreira et al., 1997).

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