Development of annelids in some agricultural soils amended with dry sludge from the wastewater treatment plant of Ain Bouchekif (Tiaret region in the northwest of Algeria)

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Abstract

This study aims to determine the characteristics of sludge from the wastewater treatment plant of Ain Bouchekif (Tiaret region), as well as to be able to study the influence of this sludge on living beings (oats and earthworm). The results obtained show that the sludge did not have a significant effect on the plant (oats) but on the animal (earthworm), these results are more convincing and show a highly significant influence of the sludge on the development and growth of the earthworm with an average dose of 15%. Thus, the preferred dose for good worm development was found to be the average dose of 15% (15% mud + 85% soil). It can be seen that these slurries can be used as fertilizer with a recommendation of nitrogen and potassium fertilizers.

Key words: sludge, oats, sewage plant, earthworm.

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1. Introduction

Sludge from wastewater treatment in the region of Tiaret is generally stabilized in an aerobic digester and then dried in drying beds before being used or released into the natural environment. The increase in sludge production from urban wastewater treatment plants is a direct consequence of industrial development and population growth in cities.

Urban sludge can be rich in organic matter and elements useful for plant growth such as nitrogen, phosphorus, potassium and magnesium, which favors its use as agricultural fertilizer [1].

Earthworms are considered as indicators of a healthy soil, in fact they play an important role in soil fertility and structure. This fauna improves the soil structure and participates in the degradation of organic matter [2]. In addition, these soils can be amended by nutrients of diversified origin such as sludge from sewage treatment plants. They dig temporary horizontal to sub-horizontal galleries very branched by feeding on mineral soil more or less rich in organic matter, they have an important organic interest [3].

It is in this context that this study is conducted to know the development of earthworms and oats in an agricultural soil amended with different doses of dry sludge from the wastewater treatment plant of Ain Bouchekif road (Tiaret region).

2. Material and methods

This study was carried out in the plant protection laboratory of the Agronomy Department of Ibn Khaldoun University of Tiaret.

The sludge came from the Ain Bouchekif sewage treatment plant of Tiaret, after undergoing physico-chemical analyzes in the wastewater treatment plant.

The agricultural soil sample comes from the Ibn Khaldoun university of Tiaret and underwent pedological analyzes after drying in the open air and sieving with a 2mm mesh sieve, they concern two categories: physical and chemical analyzes.

2.1. Physical analyzes

2.1.1. Granulometry

This analysis gives us the percentage of the different granulometric groups (clay, sand, silt) in a soil sample inferior to 2mm. This last one was realized according to the **BOUYOUCOS** method [4].

Moisture measurement

A sample of 10g is taken and placed in an oven at 105°C for 24 hours; Moisture (%) is calculated by the following relationship:

Moisture (%) = $[(W_1-W_{2)}/W_1] \times 100$

W_1: weight of the test sample (10g) (the fresh weight)

W_2: weight after drying at 105°C (dry weight)

2.2. Chemical analyzes :

2.2.1. Total limestone:

The total limestone content is obtained by calcimetry using the calcimeter of Bernard. Its determination is basedon the characteristic reaction of calcium carbonate in contact with hydrochloric acid. It is calculated as follows:

$CaCO_3$ (%) = (W'. v) / (w.V) ×100

W': weight of $CaCo_3$

w: weight of the sample

V: volume of Co_2 released by the sample

v: volume of Co_2 released by $CaCo_3$

2.2.2. Active limestone:

The determination of active limestone is based on the property of limestone to combine with oxalates to precipitate as calcium oxalate [5].

2.2.3. Determination of organic matter:

According to the [6] method **(1945)**, Carbon is oxidized by potassium dichromate in the presence of sulfuric acid. The excess of dichromate is titrated by the MOHR salt in the presence of diphenylamine.

The dichromates will be fixed with the carbon molecules, the remaining dichromates will be oxidized by the MOHR salt.

C%= (Y-X). 0.615P

Y: the amount of Mohr's salt that oxidized all the dichromates in the blank test

X: the amount of Mohr's salt that oxidized all the dichromates in the soil sample

P: the test sample

- Organic carbon content is related to organic matter by the following relationship:

OM% = C% 1,72

The classification of the richness or poverty of the soil in organic matter was made according to [7].

2.3. Cultivation management

Plastic jars were filled with a mixture of agricultural soil and mud with the doses:

C0: 100% soil + 0% mud; **C1:** 95% soil + 5% mud; **C2:** 90% soil + 10% mud; **C3:** 85% soil + 15% mud; **C4:** 75% soil + 25% mud; **C5:** 65% soil + 35% mud. Regarding the control, 100% agricultural soil was used. In each jar, five earthworms were inoculated with the mixture. Each dose was performed in five repetitions. Oat seeds were placed in pre-germination before sowing them in the jars. Irrigation was carried out with tap water every 4 days.

The scoring of the results was done on the following parameters:

- **Stem height:** This measurement was taken with a graduated ruler.
- **Leaves number:** This measurement was made by eye with a digital camera.
- **Earthworm size:** This measurement was made with a graduated ruler.

2.4. Data analysis

Statistical differences for Physico-chemical analyzes ofsoil, sludge, plants, earthworms and soil between sludge-amended soil treatments and control were assessed through analysis of variance ($p<0.05$, ANOVA test) and the least-significant differences (LSDs) multiple range test at $p<0.05$.

3. Results

3.1. Physical and chemical analyzes of the soil

The physico-chemical characteristics of the soil are shown in **Table 1**. The soil used in this study contains silt and sand more than clay, which is poor in organic matter.

Table 1: Physico-chemical analyzes of the soil

<table>
<tr><th colspan="2">Characteristics</th><th>Results</th></tr>
<tr><td colspan="2">Moisture (%)</td><td>17</td></tr>
<tr><td colspan="2">Active limestone (%)</td><td>O.87</td></tr>
<tr><td colspan="2">Total limestone (%)</td><td>5.91</td></tr>
<tr><td colspan="2">Organicmatter(%)</td><td>0.54</td></tr>
<tr><td colspan="2">Organiccarbon (%)</td><td>0.31</td></tr>
<tr><td rowspan="3">Granulometry</td><td>Clay</td><td>9.84</td></tr>
<tr><td>Fine silt</td><td>21.31</td></tr>
<tr><td>Coarse silt</td><td>31.15</td></tr>
</table>

	Fine sand	23.21
	Coarsesand	14.49
	Silty-sandy texture	

3.2. Physical and chemical analyzes of the sludge

The physico-chemical characterization of sewage sludge **(Table 2)** shows a high organic matter content (7.91%), a neutral pH (7.20) and rich mineral elements content such as Iron, Nitrogen, Potassium, Copper, Zinc (Phosphorus and Carbon in high proportion).

Table 2: Physico-chemical characterization of the sewage sludge used in this study

Parameters	Residualsludge
pH	7.20
Electrical conductivity mS/cm	3.34
Total limestone (%)	32
Active limestone (%)	15
Organicmatter (%)	7.91
C (%)	4.6
N (%)	0.13
C/N ratio	35.38
Total P (ppm)	290
Total K (ppm)	0.19
Cu (ppm)	143.12
Zn (ppm)	850
Mn (ppm)	177.12
Fe (ppm)	94.33

3.3. Stem height

The effect of the different doses of mud on the height of the stemsis shown in the **Table 3**; there was no effect on the development of the plant. The different doses of mud witchare considered, as a supply of mineral matter for the plant did not have an effect on the height of the plant.

Table 3: Analysis of variance of the effect of the different doses of mud on the height of the stems

ANOVA Table for Hight by Dose					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	65.6198	5	13.124	0.41	0.8400
Within groups	776.427	24	32.3511		
Total (Corr .)	842.047	29			

Degrees of Freedom (DF); Sum of Squares (SS); Mean Square (MS); F-Ratio; p-Value<0.05

3.4. Leaves number

The effect of the different doses of mud on the number of leaves is shown in **Table 4**, the different doses of the mud added to the soil did not have a significant effect on the plant regarding the number of leaves factor.

Table 4: Analysis of variance of the effect of the different doses of mud on the number of leaves

ANOVA Table for Number by Dose					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	1.86667	5	0.373333	0.77	0.5790
Within groups	11.6	24	0.483333		
Total (Corr .)	13.4667	29			

3.5. Size of the worm

The result **(Fig. 1)** shows a highly significant influence of the mud on the development and the growth of the worm **(Table 5)**.

Table 5: Analysis of variance of the effect of the different doses of mud on the size of the earthworms

ANOVA Table for Size by DOSE					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Batween groups	16.936	5	3.3872	4.56	0.0046
Within groups	17.836	24	0.7483167		
Total (Corr.)	34.772	29			

Regarding the study of homogeneous groups **(Table 6)**, There are four groups which are Group 1: C0; Group 2: C1 - C5; Group 3: C2 - C4 and the final group C 3. C0 being the control, in which the worm developed normally as in the normal state.

The 5% and 35% doses of mud added to the agricultural soil allowed better development than a control soil. The 10% and 25% doses of sludge added to the agricultural soil allowed a remarkable development compared to the other doses. While the 15% dose was found to be the best dose for a better worm development. An average dose of 85% agricultural soil plus 15% sludge was found to be the suitable dose for good worm development.

Table 6: Homogeneous groups study

Multiple Range Test for Size by Dose					
Method: 95.0 Percent LSD					
Dose	Count	Mean	Homogeneous Groups		
C0	5	7.34	X		
C1	5	7.8	XX		
C5	5	8.06	XX		
C2	5	8.6	XX		

C4	5	8.66	XX		
C3	5	9.7	X		

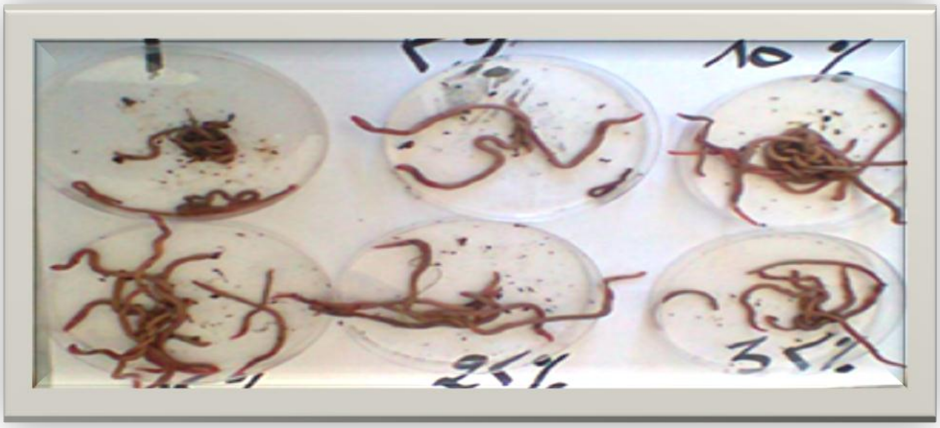

Fig1. The effect of different doses of the mudon the earthworm

4. Discussion

The mud is considered as an agricultural amendment, the doses that we added to the agricultural soil allowed enriching the soil in mineral matter, all for the plant that is oats and for the animal, which is the earthworm.

Regarding the plant, the measurements carried out duringthe stemming showed that the mud did not have a significant effect on the size and the number of leaves. This is probably because the plant's needs are not high enough during this period, and it is only at the time of heading and grain filling that the plant needs more mineral matter. A testin Canada on white spruce (*Piceagluca*) with a dose of 560 Kg/ Ha of mud showed a height growth gain of 40% [8]. and that biomass production increased with repeated sludge applications (compared to a massive application).

Regarding the animal, which is the earthworm, the statistical treatment (ANOVA) by the analysis of variance shows a highly significant influence of the mud on the development and the growth of the worm. This leads us to the study of different groups, the first group is the control an agricultural soil without added mud, the worm has developed normally with a slow growth compared to other worms in the amended soils. The second group with doses of 5% and 35% sludge, this is the lowest dose with the highest dose allowed a better development than the control but less compared to the average doses.

The worm is blind and feeds on the soil and mud without making a choice for its diet, so a very low dose and a very high dose did not allow a high enough development compared to the average dose of sludge added to the soil. While the 10% and 25% doses of sludge allowed a more remarkable and higher development compared to the extreme doses (lower and higher) of sludge added to the soil. The preferred dose for worm development was the average dose C3l:15% neither too high nor low for a good worm development.

Organic matter is rich in polysaccharides, amino acids, mainly liguin and other products of the metabolism of microbial bodies, which will be used mainly by soil biology animals.

Annelids promote good structure and texture of agricultural soils, especially those enriched by sludge. According to [9] sludge can cover, in part or in totality, the needs of plants in nitrogen, phosphorus, magnesium, calcium and sulphur, as well as correcting deficiencies except for potassium.

Trace elements such as copper, zinc, chromium and nickel in sludge are also essential for the development of plants and animals [10]. Therefore, sludge can be used as a fertilizer to improve the physico-chemical characteristics of the soil.

5. Conclusion

The use of sewage sludge in agricultural soils promotes the improvement of the potential of their productions by providing of organic matter and mineral salts to satisfy the various needs of the soil.

The results obtained during this experiment showed that the different doses of mud used had no significant effect on the height and number of leaves of oats, probably due to the low needs of the plant at the beginning of its development.

On the other hand, the enrichment of the soil with mud revealed significant effects on the earthworm development.Optimum worm development was observed at 15% of the mud supply in the soil. At lower and higher doses, their development is less important.

It would be interesting in future worm development in amended soils studies , to take into account the parameter weight of worms, and to study the effect of sludge input in agricultural soils on the rapid growth of a plant, taking into account some of its development parameters such as the weight of a thousand grains, the number of grains formed.

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