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Article

Evaluation of the potential for recovery of sludge from the Sidi El Khattab (Relizane) wastewater treatment plant in agriculture

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Abstract: The studies of valorization of the resources resulting from the treatment of waste water are directed more on the use of the treated water. Our study aims to evaluate the potential of valorization of the sludge of wastewater treatment plants in agriculture. This study was conducted to evaluate the effect of the waste sludge obtained from the water treatment plant of Sidi El khattab (Relizane) on the growth of tomato and soil biology. The sludge was characterized, then applied in the soil at different doses: 1, 2.5, 5, 7.5 and 10%. Morphological parameters (shoot height and dry biomass) were analyzed after using the sludge as fertilizer. The soil microorganism respiration test was performed to measure the impact of the sludge on the soil. Low levels of heavy metals were detected in the sludge (zinc: 20.19, lead: 09.12, copper: 9.12 and cadmium: 2.37 mg/kg DM), an organic matter content of 62.4 % and a total nitrogen content of 1.2 %. Application of sewage sludge to the soil improved tomato dry biomass from the 2.5% rate and shoot height from the 10% rate. Measurement of CO_2 release rate by soil microorganisms showed no negative effect of sludge on soil microbial respiration. The results obtained showed that the sludge from the sewage treatment plant of Sidi El khattab (Relizane) are rich in fertilizing elements usable by crops and harmless for soil biology.

Keywords: sludge, fertilizer, soil biology, tomato, microbial respiration.

1. Introduction

Plant development is dependent on the availability of organic matter in the soil. The lack of organic matter in the soil requires an external intervention, the recourse to amendments of different types, organic or chemical, becomes necessary. The use of waste rich in organic matter, especially sludge produced during the treatment of municipal wastewater is currently attracting a lot of interest. Some wastes, such as sewage sludge, have been shown to help maintain soil fertility and improve plant growth [1, 2].

Soils amended with sewage sludge retain their relative moisture longer and their vegetation develops a deeper root system than untreated soils. In fact, the amendment of agricultural soils with sewage sludge can improve crop productivity [3].

At present, several Algerian agricultural regions producing tomato are experiencing problems of soil degradation, fertility and even disappearance of fauna [4].

In this context, our study was oriented towards the evaluation of the potentialities of the sludge from treated domestic water in this city as a fertilizing material. We chose the use of bio-indicators to evaluate the impact of sludge use on plants and soil.

Bioindicators are species that, by their presence, absence or rarity, can give us information on the state of the environment. They are likely to detect disturbances that have occurred even if they are no longer present at the time of sampling [5, 6, 7].

Terrestrial bioindicators are defined as organisms that allow the identification and quantification of soil disturbances and the resulting impacts, and therefore monitor the sustainability of agricultural production systems [8].

Our study consists, on the one hand, in characterizing the sludge and, on the other hand, in carrying out vegetative vigor tests on tomato and soil micro-oragnism respiration tests to evaluate the impact of the use of sludge as a fertilizer material on plants and soil.

2. Materials and Methods

1.1 Sludge characterization

In order to characterize the sludge and the control soil used, the following parameters were determined: pH [9], organic matter [10], total nitrogen [11], heavy metals (cu, cd, zn, pb) [12] and soil particle size analysis [13].

1.2 Effect of sludge on tomato and soil

The Sidi El Khatab wastewater treatment plant treats urban wastewater and uses the activated sludge process. It has a treatment capacity of 21,600 cubic meters for the benefit of the 180,000 inhabitants of the commune of Relizane.

To evaluate the effect of mud on tomato (Solanum lycopersicum), mud inputs of 1%, 2.5%, 5%, 7.5% and 10% were added to the control soil.

Two morphological parameters (shoot height and dry biomass) were assessed after 21 days after emergence of 50% of the seedlings in the control group [14].

The soil (20 g) was incubated in a centrifuge tube suspended in a wide-necked flask into which 20 ml of sodium hydroxide solution was previously pipetted. The flask is tightly closed and incubated for 24 h in a thermostatically controlled room (22 °C ± 1 °C). The CO2 produced is absorbed into the sodium hydroxide solution. After back titration of the unconsumed solution, the amount of CO2 produced is calculated [15].

3. Results

2.1. Characterization of the sludge

Physico-chemical analyses of the sludge and the control soil used for tomato cultivation were carried out (Table 1). Then we evaluated the content of metallic trace elements (Cu, Zn, Cd, Pb, Iron) in the soil used (figure 1) and in the sludge (figure 2), the results were compared with the thresholds in trace elements according to the French standard (Absence of a legal framework which regulates the use of the residual sludge after treatment) (table 2).

Table 1: Physico-chemical characterization of sludge and soil

Parameters	**Soil**	**Sludge**
pH	8.27	6.69
OM %	2	62.4
Total nitrogen (%)	0.2	1.2
Grain size	sandy-silty: clay (8%), silt (25.571%), sand (73.629%)	/

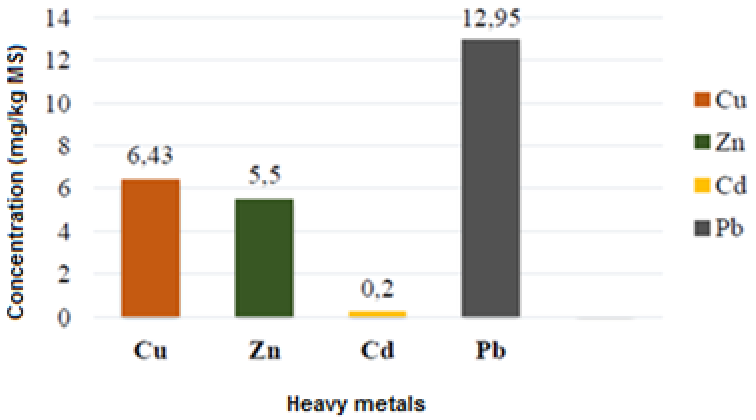

Figure 1: Trace metal content (Cu, Zn, Cd, Pb) in soil

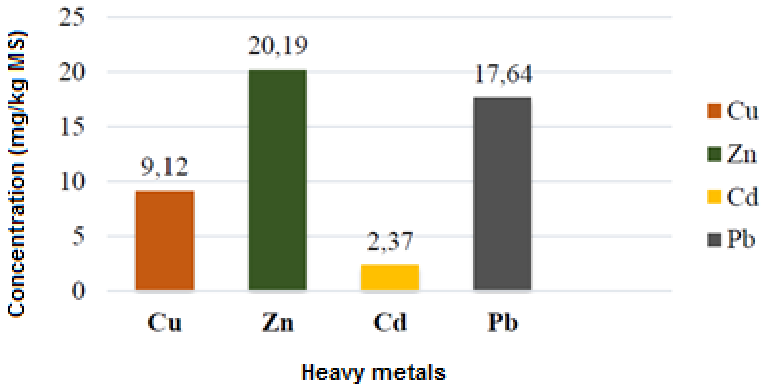

Figure 1: Trace metal content (Cu, Zn, Cd, Pb) in soil

Table 2: Trace element thresholds according to the French standard [16].

Thresholds (mg/kg DM)	Soil	Sludge
Cu	100	1 000
Zn	300	3 000
Cd	2	10
Pb	100	800

The soil is characterized by an alkaline pH of 8.27 while the sludge is slightly acidic at 6.69. The soil has an ordinary organic matter content (2%). The sludge is considered rich in organic matter 62.4 %. The results show that the soil is poor in nitrogen with 0.2%, while the sludge is six times richer in nitrogenous matter with 1.2%. The results of the physico-chemical parameters of the soil and the sludge show that the soil used in this study is sandy-silty, moderately alkaline, not salty, with a poverty of organic matter, whereas the sludge applied is neutral, extremely salty and very rich in organic matter. The soil is poor in nitrogen unlike the mud. According to the analyses carried out, the sludge and the soil have low TME contents and respect the limit values. The highest values were obtained by analyzing the zinc contents in the sludge which are respectively (5.5 20.19 mg/kg MS and 17.64 mg/kg MS).

2.2 Impact of sludge use on the plant and soil microorganisms

We performed an ANOVA analysis using F-tests to make a comparison of the means of the effect of sludge on the height of the aerial part of tomato (Figure 3), the effect of sludge on the dry biomass of the aerial part of tomato for 21 days (Figure 4) and the effect rate of CO2 production by soil microorganisms (Figure 5).

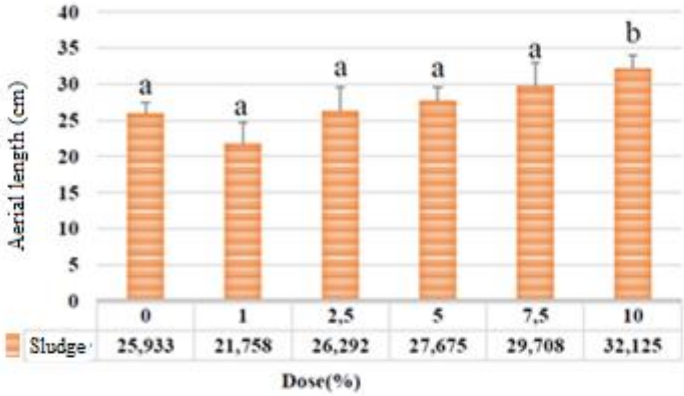

Figure 3: Effect of mud on the height of the aerial part of the tomato for 21 days

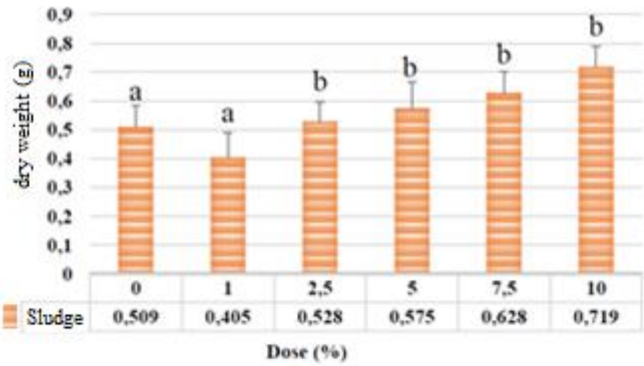

Figure 4: Effect of sludge on the dry biomass of the aerial part of tomato for 21 days

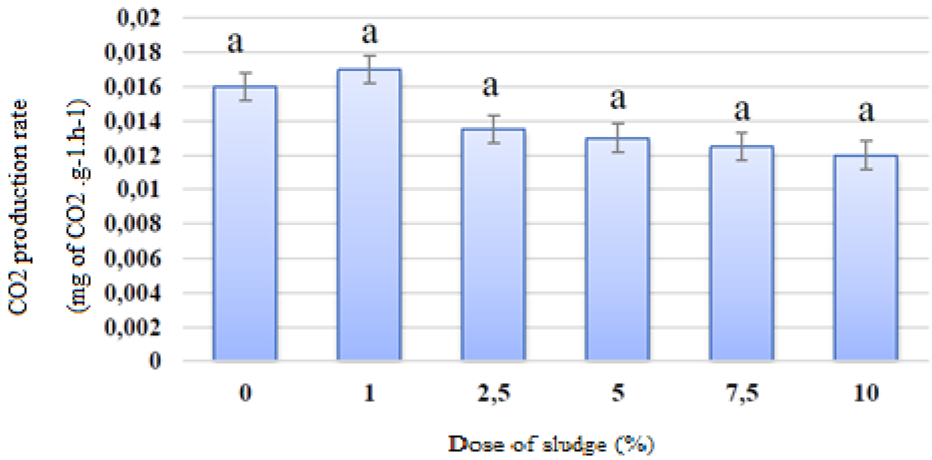

Figure 5: CO2 production rate by soil microorganisms

Our results show that the use of sludge as a fertilizer does not affect the aerial length of tomato at doses below 7.5%. On the other hand, the mixture of 10% of sludge with 90% of soil has a significant effect on the aerial length. Concerning the dry biomass of the aerial part of the tomato, it is affected if the dose of the use of the sludge exceeds 2,5 %. On the other hand, the use of sludge has no negative impact on the microbial activation. All the doses of sludge used do not have a significant inhibitory impact on the respiration of microorganisms.

4. Discussion

The sludge used contains high levels of organic matter and nitrogenous fertilizing elements that can meet the needs of crops. The results obtained show that the application of sludge could help increase the organic matter content of the soil. The contribution of this organic matter is likely to contribute to the improvement of the cationic exchange capacity and the retention of water necessary for the crop [17]. The trace element thresholds of the French standard used were compared with recent data. The toxicological values are confirmed by sufficient and good quality soil/plant transfer data [1]. The concentration of zinc in the sludge shows a remarkable increase compared to that found in the soil, but without exceeding the threshold. Indeed, zinc and Pb are among the most abundant metallic microelements in terms of concentration in urban wastewater [18]. Overall, the concentrations of trace metal elements in the studied sludge do not reveal any toxicity.

Vegetative biomass is considered a fundamental criterion for evaluating plant growth. We find that tomato would respond favorably to the input of composts. Our results are in agreement with those obtained by Sbartaiet al,[19] who showed that the dry weight of the aerial part of tomato tends to increase with the increase of organic matter supply via sludge. According to our results, the use of sludge has a positive effect on the growth of tomato. This would be due to the high rate of organic matter provided by the sludge used. Our results confirm the work of kassaoui et al,[20] who showed that the more the contribution in mud is important the more the aerial growth is remarkable.

Soil respiration is influenced by total nitrogen and organic matter content, one of the main sources of CO2 release in soil is the degradation of organic matter [21]. Microbial respiration is sensitive to metal contamination, and is therefore considered to be an indicator of anthropogenic disturbance [22]. The sandy-silty texture of the soil used allows for good aeration, which provides the soil with a large microbial population that ensures active mineralization of organic matter [23, 24]. Our results reveal that the use of the slurry does not have an effect on soil microorganisms since no significant difference was observed after the use of different doses of the slurry compared to the control crops. Good soil respiration can indicate good soil quality [25]. Therefore, the slurry used is not toxic to microorganisms and does not disturb the soil. The levels of CO2 release observed in this study are close to the levels observed in cultivated soils [26].

5. Conclusions

Our experimental study of the valorization of sewage plant sludge used as a fertilizer allowed us to draw several conclusions. Our study revealed the possibility of the valorization in agriculture of the used sludge because it contains a high content of organic matter, and it is little loaded in metallic trace elements. The sludge applied in the soil acts positively on the growth of tomato (Solanum lycopersicum). On a biological scale, the respiration of soil microorganisms was not affected by the different doses of sludge. Thus, sewage sludge has enormous potential as a fertilizer. In the future, we propose to analyze other trace metals in the sludge and to test the effect of the sludge on tomato in the field. The application of sewage sludge can replace commercial fertilizers if it is applied in the right quantities to the soil.

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