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Nadjla Lassoued, Essaïd Bilal, Mohamed Nejib Rejeb, Saloua Rejeb

IMPACT OF HEAVY METALS IN SEWAGE SLUDGE ON SOIL AND PLANTS (COLZA and WHEAT)

Najla LASSOUED[1], Essaid BILAL[2*], Mohamed Nejib REJEB[1], Saloua REJEB[1],

[1] Laboratoire de recherche Gestion des Risques Environnementaux en Agriculture Irriguée à l'Institut National de Recherche en Génie Rural Eaux et Forêts (INRGREF), Soukra, Tunis. lassoued_najla@yahoo.fr, rejeb.nejib@iresa.agrinet.tn, rejeb.saloua@iresa.agrinet.tn

[2*] Département Géosciences et Environnement, Ecole Nationale Supérieure des Mines de Saint Etienne, France. bilal@emse.fr

Abstract We are testing the impact of heavy metals in sludge from urban and industrial wastewater treatment plants. We try to understand their influence on plant growth and their bioaccumulation. We chose two plants: the wheat and rapeseed to their specific characteristics; wheat is a herbaceous low accumulator of heavy metals, however rape (colza) is a plant of the family Brassica napus, is an excellent bio-accumulator of heavy metals.
The mean levels found in the soil are organized in the following order: Fe >> Mn> Zn> Pb> Cu> Ni> Co> Cd The contents of heavy metals in the sludge is made very high and exceed European values allowed for that type of use but remain in the standard NT106 Tunisia.
The effects of the contribution of sludge are manifested by a significant increase in the weight gains of the whole plant, these results in a variation of the ratio between the aerial part and roots of the plant; this ratio tends to increase with dose of mud brought in soil increase. The roots of both plants show high levels of Zn even on the ground untreated control. The contents of Ni, Pb and Zn compared to Cu and Co are higher in the roots of rape than wheat.

Keywords: Mud, urban, industrial, heavy metals, rape, colza, wheat, bio accumulator, wastewater treatment plant, Tunis, Nabeul.

1. Introduction

The main objective of this study is to evaluate the wheat and canola the effect of two types of sludge (urban sludge / industrial sludge) containing heavy metals especially lead and chromium. These mud is made at different doses (5, 25, 50 and 100 t / ha). We are therefore interested in the growth and absorption of heavy metals by plants (Durum wheat and rapeseed Colza) and follow the fate of the latter in the ground to prevent pollution events and toxicity.

2. Materials and methods

The experimental protocol was installed in the field to the Agricultural Experiment Station of Oued Souhil - Nabeul, situated about 60 kilometers from Tunis (Fig. 1) and belonging to the National Institute for Research in Rural Engineering Water and Forest.

The urban mud used in this study is taken from the wastewater treatment plant in Korba with a treatment system at low load activated sludge followed by maturation. Sludge from this station underwent a stabilization in aerobic followed by drying on beds. The dry sludge is removed from the drying bed.

The mud is from the industrial wastewater treatment plant Bou Argoub which hosts two industrial zones, companies in the Refrigeration and Brasserie Company of Tunis (SFBT) specialized in the food industry, and Assad specialized in the electrical industry. Sludge from this station underwent a stabilization in aerobic followed by drying on beds. This sludge is loaded with heavy metals especially lead and chromium.

The plant material used in this experiment is the Wheat, herbaceous, monocot genus Triticum of the grass family and rapeseed (Brassica napus) is an annual plant with yellow flowers of the family Brassicaceae. These two species were chosen for their ability to levy metals. Wheat is a small accumulator of heavy metals while rape is an accumulator of these elements.

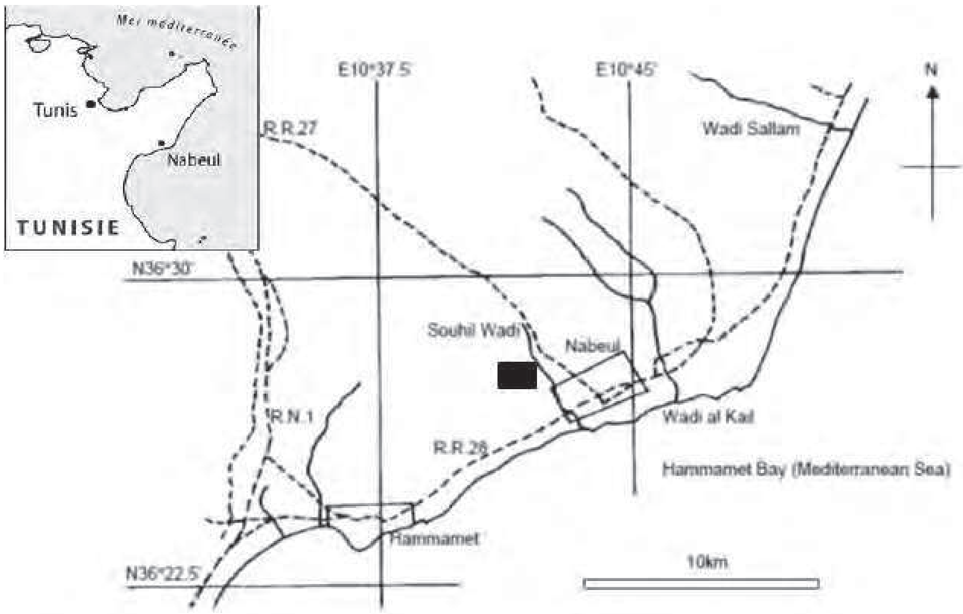

Fig. 1. Location map of Oued Souhil – Nabeul Agricultural Experiment Station (the black rectangle).

The test device is installed on two juxtaposed plots reserved for each crop (wheat or rapeseed). For each type of sludge, four doses (5, 25, 50 and 100 t / ha) were brought into play and compared to control soil without any addition.

Field work began in September 2010 with the spreading of sludge realized September 20, 2010. They were manually dug into the ground. Before application, the sludge was analyzed.
The soil was sampled twice, first before the application of sludge and the second time after harvest. The samples were taken between the lines by auger at four depths (0-10, 10-20, 20-40 and 40-60 cm).

In the laboratory, soil samples were dried in open air and sieved to 2mm or 0.2mm depending on the type of analysis required. Soil testing is in progress. The main parameters are determined particle size, total calcium, conductivity, carbon, organic matter, total nitrogen and determination of heavy metals.

For the particle size we used the method of the International pipette Robinson, it is primarily the destruction of soil organic matter using H_2O_2 and dispersion of clays by sodium hexametaphosphate. Clays and silts are measured in the suspension of land following the decay time that depends on particle diameter (NF X 31-107). The settling velocities of particles can be calculated by the formula of Stokes.

For plants, we performed the semi rapeseed (50 seeds / m²) December 29, 2010 and semi wheat (350 seeds / m²) January 5, 2011. The rapeseed harvest was performed after the formation of siliques May 25, 2011. The aerial part and the root have been weighed. The same work was done with wheat June 9, 2011. The samples were subsequently dried and crushed ore to determine the mix of metals in different parts of the plant.

3. Results

Sand is the most representative size fraction in this soil, which is a sandy loam soil texture. The analytical results show that the soil of the plot used is characterized by an alkaline pH, conductivity ranging from 1.06 to 1.52 mmho/cm resulting low salinity, soil saturation is between 30.4 and 31.8ml/100g. Limestone is a total of inherited components of soil, light and possibly modified by repeated and massive supply of amendments basic. The analysis of the limestone is needed to refine the characterization of soil constituents. Inspection of Table 1 shows the percentages of limestone in the different horizons are less than 5% so it is a non-calcareous soil, with organic matter content very low.

Contents of total nitrogen are relatively low. The C/N ratio is widely used to characterize and classify types of organic matter in soil. This ratio C/N is about 7 at the first horizon (0-10cm) indicates that organic matter will be quickly mineralized.

Concerning trace elements, iron is the most representative. The mean levels found in the soil are organized in the following order: Fe >> Mn> Zn> Pb> Cu> Ni> Co> Cd mean concentrations of heavy metals introduced by the sludge are shown in Table 1.

With the addition of sludge, there is a parallel increase in the number of ears and an increased number of grains per m². The ears and grains also increase with increasing dose of mud, whatever the type of sludge made. The increase in the number of grains with the addition of mud has the consequence of decrease in PMG this can be explained by the decrease in weight and grain quality response to stress. The numbers of feet of wheat increases dice the contribution of 5t/ha sludge, this increase is more pronounced with the addition of urban sludge.

Table 1. Chemical composition of different horizons of the soil profile and sludge:

	Soil Profile					**Sludge**		
	0-10	**10-20**	**20-40**	**40-60**	**NF U 44-041**	**BU**	**BI**	**NT 106**
Limestone	1	2,2	1,8	2,4		n.d.	n.d.	
pH	8,36	8,4	8,38	8,5		6,9	6,33	
MO %	0,64	0,24	0,24	0,14		52,6	60	
C%	0,34	0,12	0,14	0,06		30,58	34,88	
N %	0,0453	0,0561	0,0475	0,0515		4,9	6,1	
C/N	7,511	2,138	2,948	1,166		6,24	5,71	
Cd	1,6	1,6	1,4	1,8	2	3	11	20
Co	11,6	10,8	12,2	14,8		28	18	
Cu	23,4	13,8	11,8	11,2	100	158	68	1000
Fe	8628	8800	10328	11675		10700	8300	
Mn	128	118	119	131		152	81	
Ni	19	26	26	22	50	78	49	200
Pb	39	39	35	31	100	63	577	800
Zn	55	39	43	38	300	440	360	2000
Cr	n.d.	n.d.	n.d.	n.d.	150	155	8030	

NFU 44-041: French norm of heavy metals in sol.
NT 106: Tunisian norm of heavy metals in sludge
BU: Urban sludge and BI Industrial sludge
n.d.: no determined

One can see that the leaf area increases with the contribution of sludge as well as for urban or industrial sludge's. The leaf surface of this crop varies between 15.77cm^2 of the oldest leaf to 3.78 cm^2 for the youngest leaf in the control soil.

The leaf surface increases by 10cm² for 5BI and 11cm² 5BU. We noted that the young leaf appears to 5BI and 25BI, but it is not yet developed with input from 50t/ha to 100t/ha. This developmental delay may be due to toxicity effect more pronounced with industrial sludge.

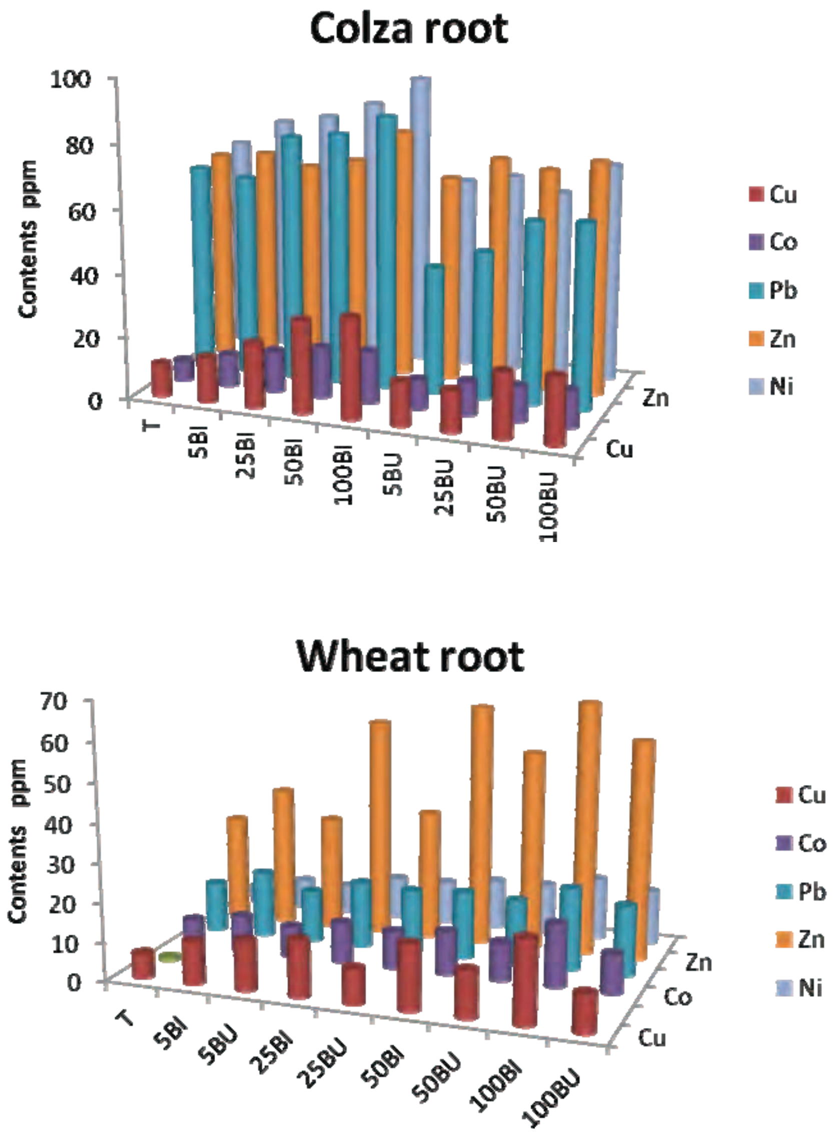

Fig. 2. Distribution of heavy metals in the roots of colza and of wheat in soils with addition (5, 25, 50 and 100t/ha) of urban (BU) and industrial (BI) sludge and control soil (T).

4. Conclusions

The effects of the contribution of sludge are manifested by a significant increase in the weight gains of the whole plant, these results in a variation of the ratio of the aerial part and root (PA / R) which tends to increase with the increase the dose sludge made. In all cases, the increase in leaf weight gain following a contribution of mud is still perceptible from the low inputs applied with a more significant effect with the provision of urban sludge. The important contribution of sludge rich in heavy metals causes stress in plants. We found a high content of Ni, Pb and Zn in these plants (Fig. 2).