



## تأثير الكومبوست الناتج عن المخلفات الصلبة المدنية المستخدم لمدة 15 عاماً في تراكم العناصر الثقيلة في التربة

### Effect of 15 Year Application of Municipal Solid Waste Composts on The Heavy Metals Accumulation in Soil

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#### الملخص

يتعلق الاستخدام البيئي الآمن للكومبوست بنوعية المخلفات الصلبة ونوعية الكومبوست المنتج، ومن أجل اختبار تأثير الكومبوست الذي سيتم إنتاجه في المعامل المزمع إنشاؤها في سورية، أجريت دراسة في كلية الزراعة بجامعة دمشق (سورية)، تم من خلالها اختبار تأثير منتج معمل الكومبوست في دمشق المستخدم لمدة 15 عاماً في تربة ريف دمشق.

صُممت التجربة بشكل قطاعات عشوائية، إذ تم اختيار خمسة أزواج من الحقول المتشابهة، وحدد حقل من كل زوج بشكل عشوائي ليكون معاملةً، وتم تسميده بالكومبوست على عمق 15 سم، والثاني لم يتم تسميده بالكومبوست ليكون شاهداً، وتم اخذ ثلاث عينات ترابية من كل حقل على عمق 30 سم، كما تم تحليل كل عينة لمعرفة تركيبها الكيميائي.

أظهر تحليل النتائج ارتفاع نسبة العناصر الثقيلة مثل: Pb، Cu، Fe، Zn... الخ في الترب التي أضيف لها الكومبوست، إذ تراوح تركيز الزنك بين 18.19 مغ/كغ في حقل المعاملة (5)، و4.22 مغ/كغ في الحقل الشاهد (3). أما تركيز الحديد في التربة فتراوح بين 17.10 مغ/كغ في حقل المعاملة (2) و8.92 مغ/كغ في حقل الشاهد (3)، وتراوح تركيز المنغنيز بين 15.70 مغ/كغ في حقل المعاملة (5) و8.30 مغ/كغ في الحقل الشاهد (5). أما الرصاص فبلغ 9.53 مغ/كغ في الحقل الشاهد (3) و29.41 مغ/كغ في حقل المعاملة (5). في حين تراوحت قيم عنصر الكاديوم بين 2.00 و4.71 مغ/كغ في حقل الشاهد (5) وحقل المعاملة (1) على التوالي. أظهرت الدراسة أن إضافة الكومبوست للتربة بشكل دوري وبالكمية التقليدية يؤدي الى زيادة تركيز المعادن الثقيلة فيها بشكل تصاعدي، ويتعلق معدل هذه الزيادة بتركيب الكومبوست وطريقة معالجته. كما أظهر التحليل الاحصائي وجود فروق معنوية بالنسبة للمعاملات فيما بينها ولكل معاملة على حدة.

تقترح الدراسة استمرار العمل لإيجاد مواصفة خاصة بنسبة المعادن الثقيلة في الكومبوست المعد للتسميد.

**الكلمات المفتاحية:** الكومبوست، العناصر الثقيلة، التربة، المخلفات الصلبة، Fe، Zn، Cu، Mn، Pb، Cd.

#### Abstract

The environmental and safety usage of the compost as an organic fertilizer depends on the quality of the solid waste and the quality of the produced compost. In order to investigate the impact of the compost to be produced from the compost plant in Syria, a study was made in the Faculty of Agriculture, Damascus University. This study investigated the 15 year

usage of the compost produced from compost plant of Damascus on the soil in Rural Damascus.

A randomized block (RB) design was made. Five pairs of similar fields were located. In each pair, one field was randomly assigned to receive compost from the Damascus compost plant, set about 15 cm deep (the treatment) , and the other received no compost (the control). Three subsamples were taken from depths down to 30 cm from each of the ten Fields. Each soil sample was analyzed in order to determine its chemical composition.

The results of the analysis showed that the soil in which compost was used has a higher concentration of heavy metals like , Pb, Cu, Fe, Zn...etc.

Content of Zinc element in soil has ranged between 18.19 mg/kg in field No.(5) and 4.22 mg/kg in control field No. (3) .

The content of Fe in the soil ranged between about 17.10 mg/kg in the treatment field No. (2) and 8.92 mg/kg in the control field No. (3).

The values of Mn in the studied soil have ranged between 15.7 and 8.30 mg/kg in the treatment field No.(5) and control field No.(5) respectively.

The values of Pb in the studied soil have ranged between 29.41 and 9.53 mg/kg in the treatment field No.(5) and control field No.(3) respectively.

The values of Cd in the studied soil have ranged between 4.71 and 2.00 mg/kg in the treatment field No.(1) and control field No.(5) respectively.

Statistical analysis showed significant treatment effect for all five pairs combined and also for most pairs individually.

The study recommends continuing the research to establish a standard for the quantitative and qualitative content of heavy metals in the compost used for fertilizer .

**KeyWords:** Compost, Accumulation, Solid waste, Heavy metals, Soil, Fe, Zn, Cu, Mn, Pb, Cd.

## Introduction

The topic of treating the solid wastes is one of the priorities taken by Ministry of Local Administration in Syria (MLA) which is trying to reach an integral mechanism for separating the solid wastes to their components, recycling them and safely disposing of the refused elements resultant from the separation operations in suitable sanitary landfill sites .

Damascus City and Aleppo City are considered the biggest resources for wastes generation in which the quantity of the resultant wastes exceeds one thousand tons per day in each. In general, it is estimated that each person generates about half a kilo per day (Alboukhari, 2002).

Compost can be produced as the case in the solid wastes treatment plant in Damascus Countryside which produces 700 tons per day and where the received garbage are separated to its organic and inorganic material, and where part of the inorganic materials can be used in recycling while the other parts (refused elements) go to the landfill. The organic part is treated by aerobic fermentation for the purpose of producing compost which is used in turn in fertilization (MLA, 2004).

The strategic plans applied in treating the solid wastes in Syria, within this framework, a national work plan and environmental strategy have been achieved that included special instructions regards the collection, removal and treatment of the solid wastes (UNDP, 2003) and the directive plan for the solid wastes through which in 2005 a several study scenarios have been studied related to the treatment and landfill of the solid wastes in a safe and environment friendly way. There has been an accreditation to the scenario that recommends the generalization of the bio-mechanical methods as an efficient and appropriate style in the solid wastes management by the administrative units in Syria, and within which there has been a suggestion to establish 24 plants for solid wastes treatment and compost production to be used in farming, in addition to the determination of the administrative units need to the sanitary landfill sites by 40 landfill sites distributed on the various Administrative Units in proportion to the wastes volume and extension limit. (MLA, 2004).

## Research Justifications:

Some of the farmers have been using the Compost produced by the solid wastes plant for many years (may reach 15 years) in their fields in Damascus Countryside. No accurate scientific evaluation has been made for the effects resultant from such use. Bio-mechanical methods have been used in treating the wastes, and the experience of the solid wastes treatment plant in Damascus Countryside in the production of the compost from the municipal wastes have to be generalized in the future to all the Syrian Cities, in accordance with the directive plan for the solid wastes management, which in turn means that the use of the compost resultant from the municipal wastes will be generalized to all the regions of agricultural investment in Syria, particularly when all the administrative units in Syria will be provided with plans for the solid wastes treatment and production of compost. Therefore, and through this research, it is useful to evaluate the effect of using the compost on the change of farming soil content related to the heavy metals, in soils used compost for long times in organic fertilization as the case is in Damascus Countryside.

The compost produced from the municipal wastes led to the increase in the concentration of the heavy metals in soil such as Cu, Zn and Cd (Achiba, *et al.*, 2009). Woodbury (1992) showed that the use of compost led to the transfer of those heavy metals to the plants grown in those soils. Epstein *et al.* (1992) showed that the use of compost from the municipal wastes reflects negatively on the health and the environment due to its content of heavy metals.

The importance of observing the compost's content of heavy metals comes from the purpose of enriching the soil with those elements on one side, and of preventing the pollution of soil thereby in case of the increase of those elements over the permitted limits, on the other side. (Smith, 2009).

In a more definite way, (Wang *et al.*, 2007a,b) showed that each of Zn and Cu has a poisonous effect on soil bacteria, in case their rates increase over the permitted limit, and their effect on soil microbes. Their effect differs according to the textural composition of the soil, where it increases in the loamy soil more than in the clay soils (Olaniran, *et al.*, 2011), they also affect negatively on the organic carbon in soil with the increase in their rates (Wang, *et al.*, 2007a,b). In general, the subject of the contamination coming from the trace elements concentrations in soils is important due to recent interest in contamination potential and toxic effect of these elements on people and environment (Slagle, 2004).

## Objectives of the Research:

1. Evaluating the environmental effect of using the compost on the soil composition when organic fertilization is used for long periods.
2. Investigating the positive or negative effects expected from the compost used as a fertilizer that will be produced from the plants intended to be established according to the solid waste master plan in Syria.

## Material and Methods

In this research, some fields were specified in Damascus Countryside, from those which have depended in the last fifteen years on fertilization by the compost produced by a solid waste treatment Plant. Other fields were specified within the same region from those which have not used compost as a source of organic fertilization. Five fields were designated from those which used the compost (Treatment Fields) and other five fields similar to them as for the location, nature of soil, and investment (Control Fields), the annual precipitation in the region of study ranges between 200 to 225 mm, which is classified as semi-arid. The average temperature is 10C° in winter and 25C° in summer. The area of each field ranges between 0.5 to 1 hectare. The crops planted in those fields are shown in Table 1.

Soil samples were collected at a rate of three replicates from each field from the (Treatment Fields) and from the (Control Fields). The samples were taken from 30 cm deep. They were subjected to the following chemical analyses:

EC, pH, T-Nitrogen, Calcium Carbonates, Organic matter, Phosphorus and Potassium.

PH was measured by pH meter (Beckman model). The EC of soil extract was measured with conductivity meter. The total nitrate was analyzed by using Caldahl and Spectrophotometric methods. The available Phosphate was analyzed by using the Olsen method, (Olsen *et al.*, 1954) and Spectrophotometric method. The potassium was analyzed by using the flame- photometric method. The organic matter was analyzed by using the wet oxidation method (Jackson, 1958). Total heavy metals concentration such as Zn, Fe, Mn, Cu, Pb, and Cd was analyzed by treating the samples first by a mixture

of hydrochloride acid and nitric acid and second by using the atomic adsorption GPC33.

The analyses were performed in the Agricultural Research Laboratories belonging to the Ministry of Agriculture in Damascus/Syria.

The compost used in the soil as organic fertilizer was analyzed by the laboratory of Atomic Energy Agency in 1997 in Damascus. Its analyses showed that the average amount of the organic matter was 47,43% and the total amount of Nitrate was 1,19%. The total average concentration of heavy metals in the analyzed samples was: Ni 87,9 mg/kg, Cu 484 mg/kg, Zn 111 mg/kg, Cd 5,02 mg/kg Pb112 mg/kg and Mn 316 mg/kg.

Statistical analysis of the results was made by using SPSS Program by resorting the one way analysis of variance and Univariate Analysis of Variance .

There was an evaluation of the effect of using the compost (produced from the Solid Wastes Treatment Plant in Damascus) on the change in the rate of the heavy metals in the soil of the treatment fields; while there was no study for that effect on changing the rates of the major elements such as P, N, and Ca, since the rates of these elements in the soil of the control fields were not homogeneous among each other.

Table 1. shows the treated fields and controls as related to the region, the planted crops, the used fertilizers and duration of use.

**Table 1. Specifications of the studied fields and control fields.**

Field N°.	Region	Planted Crops	Used Fertilizers (m <sup>3</sup> /hectare)	Duration of Use	Accompanied Crops
T1	Murj Alsultan	Fruitful Trees	Compost 30	15 years	Barley
T2	Murj Alsultan	Fruitful Trees	Compost 30	15 years	Barley
T3	Alnashabieh	Fruitful Trees	Compost 30	15 years	Barley
T4	Deir Alhajar	Olive Trees	Compost 30	15 years	Barley
T5	Dair Alassafir	Fruitful Trees	Compost 30	15 years	Barley
C1	Murj Alsultan	Fruitful Trees	- - -	-----	Barley
C2	Murj Alsultan	Fruitful Trees	- - -	-----	Barley
C3	Alnashabieh	Fruitful Trees	-----	-----	Barley
C4	Deir Alhajar	Olive Trees	- - -	-----	Barley
C5	Dair Alassafir	Fruitful Trees	- - -	-----	Barley

T: Treatment Field, C: Control Field

The soil samples from the treatment fields and the control fields amounting to (30) samples were analyzed. Tables 2 and 3 give the results of the chemical and physical analyses. However, with the exception of Cd, the content of Zn, Pb, Mn, Fe, and Cu in the treatment fields and control fields are within the acceptable range, (Adriano,1986; Schachtschabel, 2002).

## Results and Discussion

The particle size analyses results of all the soils in the treatment fields were similar to a great extent as for the content of sand, clay and silt, the thing that makes it possible to compare between the treatment fields and control fields as regards the change in the rates of the heavy metals in the studied soils.

The table 3 shows the average rates of the heavy metals in the treatment fields and control fields, where the treatment fields were coded with the term (T1, T2, T3, T4 and T5) while the control fields were coded with the term (C1, C2,C 3, C4 and C5).

**Table 2. Results of the chemical and physical analyses of the studied fields.**

Samples	pH	EC (ms/ cm)	OM. (%)	CaCo3 (%)	N (%)	P available (mg/kg)	K available (mg/kg)	Mechanical analyses (%)		
								Sand	Silt	Clay
T1	7.9	1.4	2.76	65.75	0.19	139.76	118.51	26	27	47
C1	7.4	2.8	1.75	65.53	0.19	192.08	246.28	28	22.	50
T2	8.1	0.73	2.88	62.40	0.2	106.68	146.08	23	26	51
C2	7.9	1.11	1.84	63.03	0.17	101.23	122.93	28	31	41
T3	8.0	3.70	1.62	31.97	0.15	75.64	229.50	34	50	16
C3	7.8	2.42	2.03	66.6	0.16	154.03	248.85	30	18	52
T4	8.2	1.496	3.35	57.60	0.22	241.33	457.88	18	20	62
C4	8.1	0.74	3.1	61.22	0.22	366.24	143.7	15	23	62
T5	7.9	5.813	1.88	27.59	0.18	124.9	518.25	32	3 4	34
C5	8.1	5.93	0.84	30.76	0.11	47.07	266.66	30	25	45

T: Treatment Field, C: Control Field

The comparison between the content of the heavy metals in the soil of the studied (treatment) fields and in the control fields has shown significant differences. In general, the effect of using the compost was positive in increasing the rate of the heavy metals in the fields where the compost was used in comparison with the control fields where the compost was not used. In more accurate words, there has been a study of the relation between the effect of using the compost in increasing the rate of the heavy metals in the fields where used, in comparison between the treatment fields and control fields at the level of the one field; and consequently, the study of the exchangeable effect for the use of compost in increasing the heavy metals in soil among the fields, through the application of a statistical analysis program (SPSS). That is why a simple and complex exchangeable contrast analysis has been performed, for each element apart, as follows:

#### Zinc Element:

Content of zinc element in the soil was ranged between 18.19 mg/kg in field No. (5) and 4.22 mg/kg in control field No. (3). The results of the statistical analysis of zinc accumulation in the soil, have shown that there are significant differences ( $P \leq 0.05$ ). The table No. (3) shows as well the difference values in the content of the studied zinc between the treatment fields and control fields, which found high in the treatment fields No. (1), (3), (4) and (5) in comparison with the control fields; while this did not appear clearly in field No. (2), because the quantity of the used compost therein was just 30 m<sup>3</sup>/hectare.

As for the difference in the content of the total heavy metals at field level, the results of the statistical analysis of zinc have shown no significant differences among the fields No. (1), (2) and (4). This means that the fertilizer's effect in the increase of the Zn content was in a homogeneous way, and in more than half of the control fields (Table 3).

#### Iron (Fe) Element:

The results of the statistical analysis for the difference of Fe content in the treatment fields and control fields was significant ( $P \leq 0.05$ ). The content of Fe in soil ranged between 17.10 mg/kg in the treatment field No. (2) and 8.92 mg/kg in the control field No.(3), (Table 3) , where the differences in the content of this element were high in the fields (1) and (5) in comparison with the control fields. This was not at the same level for the fields (2), (3), and (4). To explain this, it is required to perform a qualitative study specific for this matter. As for the visual effect of compost addition in increasing the heavy metals at the level of the fields in total, there were no significant differences among the fields Nos. (1), (2), (3), and (4). Consequently the results came homogeneous, as shows in the table No. (3).

**Table 3. Results of the chemical and physical analyses of the studied fields.**

Samples	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Cd (mg/Kg)
T1	15.41	14.56	13.66	10.26	27.74	4.71
C1	11.04	12.73	11.23	9.06	25.83	4.17
T2	10.40	17.10	11.28	6.54	22.68	4.68
C2	8.98	14.26	8.90	6.65	18.80	4.12
T3	11.76	10.65	13.11	3.92	14.96	4.01
C3	4.22	8.92	10.13	1.60	9.53	2.76
T4	10.13	15.11	11.25	5.23	15.17	4.28
C4	6.43	13.93	9.08	4.24	11.49	3.79
T5	18.19	15.13	15.70	10.07	29.41	2.63
C5	8.23	10.04	8.30	3.56	18.72	2.00

T: Treatment Field, C: Control Field

### Manganese Element (Mn):

The values of Mn accumulation in the studied soils have ranged between 15.70 and 8.30 mg/kg in the treatment fields No.(5) and control field No. (5) respectively. Moreover, a significant differences ( $P \leq 0.05$ ) appeared in all the studied fields and control fields. At the study of the table No.(3), it seems clear that the values of the differences in the content of this element between the treatment fields and control fields and which was most in field No. ( 5 ). This reveals a difference in the rate of the qualitative effect of compost as regards enriching the soil with the heavy metals, according to the kind of element and the rate of its existence in the added compost. As for the visual effect from adding the compost in increasing the heavy metals at the level of the fields in total, there were no significant differences among the fields Nos. (1), (2), (3), and (4). Consequently, the results came homogeneous as shows in the table No. (3).

### Copper (Cu) Element:

The results of the statistical analyses of Cu accumulation in soil have shown a significant differences ( $P \leq 0.05$ ). As for the effect of adding compost in increasing Cu rate in soil, which appeared distinctly in the two fields (3) and (5) but did not appear at the same level in the fields (1), (2) and (4) as shown in the table No. (3). As for the results of the statistical analyses regards the degree of the compost addition effect at the level of the fields in total, as shows in the table No. (3), the results came the same as the other elements homogeneous in the fields (1), (2), (3) and (4).

### Lead (Pb) Element:

The results of the statistical analyses of Pb accumulation in the soil have shown significant differences in the change of its content in the treatment fields in comparison with control fields ( $P \leq 0.05$ ). It can be noticed in the table No. (3) that there are distinct differences between the values the change of Pb contents in the Fields (1), (2), (3), and (5) but not in the same degree in field (4) in comparison with the control Fields. As for the degree of the non-homogeneity in the effect of adding compost in increasing Pb in the soils of the fields in total, as the case is for the other elements, the fields (1 – 4) were homogeneous in the degree of effect by compost in enriching and changing the content of heavy metals in soil (Table 3).

### Cadmium (Cd) Element:

As for Cadmium element, the study of soil samples taken from the fields that have used compost for a period of fifteen years have not shown a significant differences of Cd accumulation ( $P \leq 0.05$ ) among the studied fields. As for the interaction in the effect of adding compost at field level in total, as appears distinctly in table No. (3), there have been significant differences among the fields (1 – 4) which indicates the non- homogeneity in the effect of compost addition in all the

fields. Here the reason may be the difference in the rate of Cd used for a period of fifteen years, due to the non-stability in the rate of the substances that contain Cd in the garbage that includes the batteries which constitute the major resource of Cd in compost.

### **Conclusions and Recommendations:**

The conclusions reached through the analyses of the data obtained statistically have shown that the addition of compost to soil, periodically and with the traditional quantities, leads to the increase in the rate of the heavy metals accumulation in the soil and in an escalating way.

This expected increase in the rate of the heavy metals in soil differs in accordance with the composition of the added compost and the way of treating it. Consequently, the treatment Plants that will be established based on the recommendations of the execution plan should be upgraded with various techniques different from what is already available in the Solid Wastes Treatment Plan in Damascus Countryside, particularly in the part related to the screens and separation operations.

The permission to use compost as an organic fertilizer in farming soils safely will be given after the issuance and of a Syrian standard determining the tolerated rates of heavy metals in soil, in dependence on the farming system and the chemical and physical specifications of the soil and its horizons according to the various soil horizons.

Upgrading the standard related to compost should take into consideration the climatic condition in the region where the compost will be used, the specifications of the soil, and the crop to be planted there. The adopted standards should depend on standard thresholds not on marginal values in classifying the compost according to the regions where compost is permitted to be used.

It is recommended to proceed more experiments to evaluate the effect of the wastes plant product (Compost) on the various kinds of soils as regards to the quality, and experiments that lead to the determination of the suitable quantities to be added to soil according to the kinds of crops and kinds of soil to be used in.

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