INFLUENCE OF THE URBAN SLUDGE USED AS FERTILIZER ON THE CHEMICAL COMPONENTS OF SOIL AND LEAVES OF IDARED APPLE.

Mihail Iancu¹, Dorin Sumedrea¹, Mihail Dumitru², Eugenia Gament³, Cristian Predescu³, Mihaela Ulmeanu³, Mirela Socaciu³, Iulian Togoe⁴, Laurenţiu Tudor⁴

¹-Research Institute for Fruit Growing – Pitesti, Romania
²-National Research Institute for Soil science, Agrochemistry and Environmantal Protection Bucharest, Romania
³–University Politechnica, Bucharest, Faculty of Science and Materials Engineering, Proc. Mat. and Ecometal Speciality, Splaiul Independenţei 313, Sector 6, Bucharest, Romania
⁴–University of Agronomic Sciences and Veterinary Medicine Bucharest, Faculty of Veterinary Medicine, Dept. of Preclinical Sciences, Bucharest, Romania

Abstract

It is known that the urban sludge resulted from clearing of the waste waters has a complex and various composition due to several factors. The utilization of sludge as fertilizer in agriculture has to prevent the pollution of environment which is primarily caused by some pathogens infestation or by the increased content in chemicals beyond the maximum limits admitted by the legislation. To determine the effects of such sludge on the chemical compounds in soil and plant some investigations were carried out at the RIFG Pitesti in 2006. The experiment involved Idared apple grown in large pots (0.785 m³). The following experimental scheme was organized:

A factor = depth of planting substrate for applying the organic matter on it, with two graduations: a₁ = 0 - 30 cm; a₂ = 0 - 60 cm;

B factor = type and amount of organic matter applied (g/l substrate), with the following graduations: b₁ = 0; b₂ = manure 340 g/l; b₃ = sludge 170 g/l; b₄ = sludge 340 g/l; b₅ = sludge 510 g/l; b₆ = sludge 680 g/l;

C factor = soil sampling depth with two graduations: c₁ = 0 - 30 cm; c₂ = 30 – 60 cm. The soil samples were collected from pots in about 5 months after tree planting to determine the contents of organic matter and of major macro and microelements. The same macro- and microelements as well as some heavy metals were found in the water samples drained at the pot bottom. From the leaves collected from the middle of annual shoots, the macro- and microelements were also determined. The chemical compounds, except the total soluble salts from the soil samples showed no significant differences. In the case of a₂ = (0 - 60 cm - planting substrate), the total soluble salts were significantly higher by 126% vs. a₁ = (0 - 30 cm - planting substrate. The manure application (340 g/l) did not show a significant increase in total salts versus the unfertilized control, but the sludge rates (b₂-b₆) led to a significant raise by 172-238% vs. unfertilized control (b₁). In case of waters drained at the pots bottom and also of leaves, the chemical compounds did not significantly vary. Of the total chemicals from the waste waters (Fe, Ca, N, B, Zn, Cd, Cr) only the Zn content of 4 samples had higher values than those stipulated in NTPA 001 regulation. At the c₂ = (30 – 60 cm) soil depth. the total salts content was significantly higher by 132% versus c₁ = (0 -30 cm).

Key-words: depth of planting substrate, type and amount of organic matter applied

1. Introduction

It is known that the urban sludge resulted from clearing of the waste waters has a complex and various composition due to several factors. The utilization of sludge as fertilizer in agriculture has to prevent the pollution of environment which is primarily caused by some pathogens infestation or by the increased content of chemicals beyond the maximum limits admitted by the legislation. To determine the effects of such sludge on the chemical compounds in soil and plant, some researches were carried out at the RIFG Pitesti in 2006.
2. Material and methods

The investigations involved Idared apple grown in large pots - 0.785 m³ (Foto.1). The following experimental scheme was organized:

**Factor A** = depth of planting substrate for applying the organic matter on it, with two graduations: a₁ = 0 - 30 cm; a₂ = 0 - 60 cm;

**Factor B** = type and amount of organic matter applied (g/l substrate), with the following graduations: b₁ = 0; b₂ = manure 340 g/l; b₃ = sludge 170 g/l; b₄ = sludge 340 g/l; b₅ = sludge 510 g/l; b₆ = sludge 680 g/l;

**Factor C** = soil sampling depth with two graduations: c₁ = 0 -30 cm; c₂ = 30 – 60 cm.

Soil samples were collected from pots in about 5 months after tree planting to determine the contents of organic matter and of major macro and microelements. The same macro and microelements as well as some heavy metals were determined from the water samples leached out of the pot bottom. From the leaves collected from the middle of annual shots, the macro and microelements were also determined.

3. Results

3.1. Influence of the urban sludge application on some chemical components in the planting substrate and the water drained out from the plant pots

3.1.1. Influence of the urban sludge application on some chemical components in the planting substrate

On average, in the six fertilization treatments and both sampling depths, no significant differences in the humus, total N, pH and K contents in the planting substrate were observed related to the depth of the fertilizers application. However, the fertilization at 0-60 cm depth determined a significant increase in P content by 133% and in soluble salts content by 126% vs. the 0-30 cm depth. The manure application at a rate of 340 g/l substrate for both depths induced a higher P content by 215% and soluble salts by 126%, a significant decrease in the K content by 1.2. times, but not an important change in humus, total N and pH contents vs. the untreated control.

The urban sludge application at rates from 170 g/l to 680 g/l substrate increased by 163% the K content, by 188% the soluble salts and decreased significantly by 1.03 times the pH, but did not change the humus, total N and K contents.
The manure application (340 g/l) determined an increase in P by 147% and a decrease in pH by 1.03 times, in K by 1.28 times and in soluble salts by 1.37 times vs. the same rate of sludge. The humus and soluble salts content was not significantly modified.

The effects of fertilizers (b1-b6 treatments) on the chemical components were more evident at 0-60 cm depth (a2) vs. 0-30 cm (a1), (table 1).

### Table 1. Influence of urban sludge application on the chemical components from the planting substrate

<table>
<thead>
<tr>
<th>Chemical component</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
<th>c1</th>
<th>c2</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humus %</td>
<td>583</td>
<td>621</td>
<td>NS</td>
<td>577</td>
<td>648</td>
<td>591</td>
<td>608</td>
<td>608</td>
<td>520</td>
<td>NS</td>
<td>580</td>
<td>614</td>
<td>NS</td>
</tr>
<tr>
<td>PH (H2O)</td>
<td>8.13</td>
<td>810</td>
<td>NS</td>
<td>8.29</td>
<td>8.27</td>
<td>8.15</td>
<td>8.05</td>
<td>7.96</td>
<td>7.94</td>
<td>0.08</td>
<td>8.18</td>
<td>8.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.39</td>
<td>0.37</td>
<td>NS</td>
<td>0.38</td>
<td>0.38</td>
<td>0.35</td>
<td>0.39</td>
<td>0.40</td>
<td>0.38</td>
<td>0.05</td>
<td>0.39</td>
<td>0.37</td>
<td>0.02</td>
</tr>
<tr>
<td>Phosphorus (ppm)</td>
<td>18</td>
<td>24</td>
<td>2.49</td>
<td>13</td>
<td>28</td>
<td>17</td>
<td>19</td>
<td>25</td>
<td>24</td>
<td>3.19</td>
<td>21</td>
<td>21</td>
<td>NS</td>
</tr>
<tr>
<td>Potassium (ppm)</td>
<td>28</td>
<td>31</td>
<td>NS</td>
<td>30</td>
<td>25</td>
<td>29</td>
<td>32</td>
<td>31</td>
<td>30</td>
<td>5</td>
<td>29</td>
<td>29</td>
<td>NS</td>
</tr>
<tr>
<td>Total soluble salts (mg/100 g soil)</td>
<td>66.6</td>
<td>83.8</td>
<td>18.6</td>
<td>45.8</td>
<td>57.7</td>
<td>59.8</td>
<td>78.8</td>
<td>96.9</td>
<td>109.2</td>
<td>18.7</td>
<td>64.5</td>
<td>84.9</td>
<td>7.5</td>
</tr>
</tbody>
</table>

5%LSD, 1= between graduations of C factor at A,B constant, 2= between graduations of factor B at AC constant; 3= between graduations of factor A at BC constant, NS= non significant

The significance of experimental factors graduations is shown in the text at chapter „Material and methods.

On average, the fertilization on both depths and in all 6 treatments (b1-b6) showed some differences in soil sampling, higher in the 0-30 cm depth vs. 0-60 cm, the pH was higher by 102%, total N by 105%, but the total soluble salts were lower by 1.32 times and no significant modifications in P, humus and K contents were observed (table 1).

#### 3.1.2. Influence of urban sludge application on the heavy metals content in the planting substrate

The two depths of fertilization, did not significantly influence the heavy metals content in all the six treatments. As for cadmium, the fertilization at 0-60 cm increased its content by 154% vs. 0-30 cm depth (table 2A). Anyway, there were some significant differences in lead, cadmium and cobalt contents (interaction of A/B/C factors) at soil sampling at the same depth and fertilization treatment.

The manure application (340 g/l) did not lead to a significant increase in the heavy metals content vs. the unfertilized control. On average, at both depths of fertilization and soil sampling, the sludge application (170 g – 680 g/l) increased the Cu, Zn, and Cd contents at the highest rate, but as for lead, Mn, Co, Nickel contents, the values were not so high vs. the unfertilized control (table 2).
Table 2. Influence of urban sludge application on the heavy metals from planting substrate, Mărăcineni, 2007

A. Average values of the experimental factors (A, B, C)

<table>
<thead>
<tr>
<th>Chemical component</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
<th>c1</th>
<th>c2</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coper</td>
<td>19.4</td>
<td>20</td>
<td>NS</td>
<td>19.5</td>
<td>19.0</td>
<td>19.4</td>
<td>19.4</td>
<td>20.0</td>
<td>20.8</td>
<td>1.1</td>
<td>19.2</td>
<td>20.2</td>
<td>0.68</td>
</tr>
<tr>
<td>Zinc</td>
<td>80.8</td>
<td>83.6</td>
<td></td>
<td>79.4</td>
<td>72.9</td>
<td>77.2</td>
<td>91.7</td>
<td>87.2</td>
<td>84.7</td>
<td>7.8</td>
<td>82.1</td>
<td>82.2</td>
<td>NS</td>
</tr>
<tr>
<td>Lead</td>
<td>6.77</td>
<td>7.21</td>
<td></td>
<td>6.28</td>
<td>7.02</td>
<td>6.76</td>
<td>6.54</td>
<td>7.80</td>
<td>7.53</td>
<td>6.64</td>
<td>7.33</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Cadmin</td>
<td>0.24</td>
<td>0.37</td>
<td>0.08</td>
<td>0.225</td>
<td>0.25</td>
<td>0.35</td>
<td>0.322</td>
<td>0.324</td>
<td>0.352</td>
<td>0.089</td>
<td>0.315</td>
<td>0.292</td>
<td>0.062</td>
</tr>
<tr>
<td>Manganese</td>
<td>639</td>
<td>627</td>
<td></td>
<td>620</td>
<td>607</td>
<td>629</td>
<td>639</td>
<td>664</td>
<td>640</td>
<td>48</td>
<td>628</td>
<td>639</td>
<td>NS</td>
</tr>
<tr>
<td>Cobalt</td>
<td>9.8</td>
<td>9.3</td>
<td></td>
<td>10.0</td>
<td>9.3</td>
<td>9.8</td>
<td>9.0</td>
<td>9.6</td>
<td>9.8</td>
<td>9.0</td>
<td>10.1</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>20</td>
<td>20</td>
<td>NS</td>
<td>18.9</td>
<td>19.9</td>
<td>19.8</td>
<td>20.6</td>
<td>21.1</td>
<td>19.8</td>
<td>20.1</td>
<td>20.0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

B. Factors interaction (A/B/C)

| Chemical component | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | c1  | c2  | 1  | 2  | 3  |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Coper              | 18.7| 19.3| 18.6| 19.4| 18.2| 20.1| 18.5| 20.4| 19.3| 20.2| 19.9| 20.3| 8.3 | 2.3 | NS  |
|                   | 20.3| 19.8| 18.6| 19.3| 19.1| 20.5| 19.6| 19.0| 19.7| 20.6| 19.9| 23.2| 14.1| 14.9| NS  |
| Zinc               | 86  | 74  | 71.3| 74.0| 65.0| 86.7| 91.7| 88.7| 78.3| 98.0| 85.3| 79.0| 5.1 | 4.9 | 4.8 |
|                   | 90.0| 68.3| 72.3| 74.0| 69.0| 88.3| 102.7|91.7| 80.7| 91.7| 93.3| 81.0| 62.4| 586 | 599 | 614 | 628 | 643 | 612 | 634 | 650 | 629 | 662 | 644 |
| Lead               | 6.0 | 5.3 | 6.7 | 8.4 | 6.6 | 7.0 | 4.7 | 6.4 | 8.9 | 8.5 | 5.8 | 5.9 | 19.0 |16.0 |19.8| 20.7| 20.0| 22.6| 19.1| 20.5| 19.4| 22.7| 22.1| 20.7|
|                   | 6.2 | 7.6 | 7.2 | 5.8 | 7.1 | 6.2 | 7.5 | 7.6 | 8.8 | 8.9 | 8.1 | 9.3 | 9.0  | 10.3 | 10.2| 9.2 | 8.7 | 9.7 | 8.8 | 10.3 | 9.1 | 11.0| 9.6 | 11.0| 2  | 2.7 | 2.8 |
| Cadmin             | 617 | 654 | 585 | 629 | 627 | 617 | 644 | 667 | 653 | 723 | 635 | 622 | 76  | 86  | NS  |
|                   | 624 | 586 | 599 | 614 | 628 | 643 | 612 | 634 | 650 | 629 | 662 | 644 | 10.2 | 9.7 | 6.2 | 11.7| 10.6| 10.0| 7.0  | 8.6 | 9.8 | 8.7  | 9.0 | 8.8 | 7.9 |
| Manganese          | 19.0| 16.0| 19.8| 20.7| 20.0| 22.6| 19.1| 20.5| 19.4| 22.7| 22.1| 20.7| 6.9 | 7.1 | NS  |

5%LSD, 1= between graduations of C factor at A,B constant, 2 = between graduations of B factor at AC constant; 3= between graduations of A factor at BC constant, NS= non significant

The significance of experimental factors graduations is shown in the text at chapter „Material and methods”

3.1.3. Influence of urban sludge application on some heavy metals in water drained out from the plant pots

In the six fertilization treatments at the two depths of soil sampling, the depth of fertilizer application did not significantly change the content of four from the five heavy metals analyzed. In the case of Zn, the planting substrate at 0-60 cm increased its content by 198% vs. 0-30 cm depth. The manure application of 340 g/l determined a significant increase by 226% in the Nickel content, a decrease by 2.1 times in the Cu content, and there was not an important modification in Zn, lead and Mn contents versus the unfertilized control (table 3).
Table 3. Influence of the urban sludge application on the heavy metals from the drained water, Mărăcineni, 2007

A. Average values of the experimental factors (A,B)

<table>
<thead>
<tr>
<th>Analized heavy metal %</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>15.6</td>
<td>11.9</td>
<td>NS</td>
<td>24.8</td>
<td>11.9</td>
<td>10.8</td>
<td>7.0</td>
<td>13.7</td>
<td>11.6</td>
<td>7.29</td>
</tr>
<tr>
<td>Zinc</td>
<td>15.9</td>
<td>31.5</td>
<td>7.2</td>
<td>23.0</td>
<td>27.3</td>
<td>31.7</td>
<td>10.8</td>
<td>20.5</td>
<td>29.0</td>
<td>11.59</td>
</tr>
<tr>
<td>Lead</td>
<td>26.5</td>
<td>32.0</td>
<td>NS</td>
<td>29.2</td>
<td>34.8</td>
<td>24.9</td>
<td>24.5</td>
<td>35.4</td>
<td>26.8</td>
<td>NS</td>
</tr>
<tr>
<td>Manganese</td>
<td>16.2</td>
<td>29.0</td>
<td>NS</td>
<td>26.2</td>
<td>25.6</td>
<td>22.2</td>
<td>20.2</td>
<td>11.5</td>
<td>29.8</td>
<td>16.6</td>
</tr>
<tr>
<td>Nickel</td>
<td>14.7</td>
<td>20.4</td>
<td>NS</td>
<td>12.2</td>
<td>27.6</td>
<td>12.0</td>
<td>19.4</td>
<td>22.8</td>
<td>11.5</td>
<td>11.84</td>
</tr>
</tbody>
</table>

B. Factors interaction (A/B)

<table>
<thead>
<tr>
<th></th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>31.8</td>
<td>14.3</td>
<td>12.3</td>
<td>7.6</td>
<td>17.4</td>
<td>10.3</td>
<td>10.3</td>
</tr>
<tr>
<td>a2</td>
<td>17.9</td>
<td>9.6</td>
<td>9.4</td>
<td>6.4</td>
<td>10.1</td>
<td>13.0</td>
<td>16.39</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>21.6</td>
<td>18.9</td>
<td>16.1</td>
<td>5.7</td>
<td>16.7</td>
<td>16.6</td>
<td>16.39</td>
</tr>
<tr>
<td>a2</td>
<td>24.5</td>
<td>35.7</td>
<td>47.3</td>
<td>15.9</td>
<td>24.2</td>
<td>41.5</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>35.7</td>
<td>35.2</td>
<td>20.8</td>
<td>15.3</td>
<td>30.9</td>
<td>21.3</td>
<td>19.7</td>
</tr>
<tr>
<td>a2</td>
<td>22.6</td>
<td>34.5</td>
<td>28.9</td>
<td>33.6</td>
<td>40.0</td>
<td>32.4</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>29.9</td>
<td>16.6</td>
<td>9.7</td>
<td>6.2</td>
<td>8.5</td>
<td>26.1</td>
<td></td>
</tr>
<tr>
<td>a2</td>
<td>22.6</td>
<td>34.7</td>
<td>34.6</td>
<td>34.1</td>
<td>14.6</td>
<td>33.5</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>15.0</td>
<td>13.2</td>
<td>11.9</td>
<td>12.4</td>
<td>20.1</td>
<td>15.8</td>
<td>16.75</td>
</tr>
<tr>
<td>a2</td>
<td>9.5</td>
<td>42.0</td>
<td>12.0</td>
<td>26.3</td>
<td>25.6</td>
<td>7.3</td>
<td></td>
</tr>
</tbody>
</table>

5%LSD, 1= between two graduations of B factor at A constant, 2 = between two graduations of A factor at B factor constant; NS= non significant

The significance of experimental factors graduations is shown in the text at chapter „Material and methods”

3.1.4. Influence of sludge application on some microbiological parameters in the water drained out from the plant pots

There were taken 36 water samples from the plant pots to analyze the microbiological indicators following the sludge application. So, there were not found coliforms and *Escherichia coli* or bacteria of *Salmonella* origin.

*Pseudomonas aeruginosa* was presently in six samples of the total analyzed, but with a very low cell population of only 2-4 cells/ml. Also, the total coliforms were presently just in 4 of 36 analyzed samples, with very low values of 6-64 cells/ml sample. *Bacteria of Enterococcus genus* were presently in all 36 analyzed samples (12-64 cells/ml sample). Also, *sulphito-chlostridia* was found in most samples analyzed but into a small number (8-29 cells/ml samples).

Higher values showed the total aerobic microorganisms or anaerobic *mezophiles* (NTC), such as: 1 200 – 57 200 cells/ml. Also, the total moulds and levens varied between 7 200-12 200 cells/ml samples.

Table 4 indicates the statistical data of the experimental factors (origin and amount of organic fertilizers as well as the application depth).

On average, in the four treatments, the 0-60 cm application depth increased significantly the aerobic and or anaerobic microorganisms by 240% and the bacteria of *Enterococcus* by 140%, but did not much influence the number of reducing *sulphito-chlostridia*, levens or moulds, vs. the 0-30 cm depth.

On average, the microbiological indicators did not much vary in the three fertilization treatments at the two depths compared to the unfertilized control.
Table 4. Influence of urban sludge application on the microbiological parameters from the drained water, Maracineni 2007

A. Average values of the experimental factors (A, B)

<table>
<thead>
<tr>
<th>Macrobiological parameter</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTC (thousands)</td>
<td>9.89</td>
<td>23.73</td>
<td>10.58</td>
<td>13.88</td>
<td>15.16</td>
<td>23.23</td>
<td>14.96</td>
<td></td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Enterococi (no.)</td>
<td>26.83</td>
<td>37.50</td>
<td>5.56</td>
<td>33.8</td>
<td>25.5</td>
<td>31.7</td>
<td>37.7</td>
<td></td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Reducing sulphito – Clostridia (no.)</td>
<td>13.83</td>
<td>16.67</td>
<td>NS</td>
<td>14.0</td>
<td>13.2</td>
<td>20.2</td>
<td>13.7</td>
<td></td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Leavens and moulds (No)</td>
<td>8.25</td>
<td>9</td>
<td>NS</td>
<td>8.1</td>
<td>8.7</td>
<td>8.8</td>
<td></td>
<td></td>
<td></td>
<td>8.9</td>
</tr>
</tbody>
</table>

B. Factors interaction (A/B)

<table>
<thead>
<tr>
<th>Macrobiological parameter</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing sulphito – Clostridia (no.)</td>
<td>9.35</td>
<td>8.47</td>
<td>8.67</td>
<td>13.07</td>
<td>14.96</td>
</tr>
<tr>
<td>Enterococi (no.)</td>
<td>21.7</td>
<td>19.0</td>
<td>30.7</td>
<td>36</td>
<td>29.7</td>
</tr>
<tr>
<td>Reducing sulphito – Clostridia (no.)</td>
<td>46</td>
<td>32.0</td>
<td>32.7</td>
<td>39.3</td>
<td>14.1</td>
</tr>
<tr>
<td>Leavens and moulds (No)</td>
<td>7.9</td>
<td>8.1</td>
<td>8.7</td>
<td>8.2</td>
<td>NS</td>
</tr>
</tbody>
</table>

5%LSD, 1 = between two graduations of B factor at A constant, 2 = between two graduations of factor A at B constant; NS = non significant

The significance of experimental factors graduations is shown in the text at chapter „Material and methods”

3.2 Influence of urban sludge application on some chemical components in the leaves of Idared cv.

3.2.1. Influence of sludge on the leaf macroelements

The five chemical components analyzed (table 5) had no different values in the six fertilization treatments for both application depths: 0-60 cm and 0-30 cm.

So, the application of 340 g/l manure and 170-680 g/l sludge did not modify the total N content as well as the K, Ca and Mg contents in leaves versus the unfertilized control. Under the same conditions the amount of 680 g/l sludge increased the P content in leaves by 104%. This increase was found when this rate of sludge was applied at 0-60 cm depth (table 5).

Table 5. Influence of urban sludge application on the macroelements in the leaves of the Idared apple cv., Maracineni, 2007

A. Average values of the experimental factors A,B)

<table>
<thead>
<tr>
<th>Chemical component</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>2.18</td>
<td>2.20</td>
<td>NS</td>
<td>2.20</td>
<td>2.16</td>
<td>2.22</td>
<td>2.19</td>
<td>2.19</td>
<td>2.18</td>
<td>NS</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.133</td>
<td>0.135</td>
<td>NS</td>
<td>0.142</td>
<td>0.137</td>
<td>0.123</td>
<td>0.127</td>
<td>0.130</td>
<td>1.47</td>
<td>0.024</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.84</td>
<td>1.79</td>
<td>NS</td>
<td>1.83</td>
<td>1.82</td>
<td>1.78</td>
<td>1.82</td>
<td>1.82</td>
<td>1.68</td>
<td>1.94</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.762</td>
<td>0.780</td>
<td>NS</td>
<td>0.77</td>
<td>0.72</td>
<td>0.76</td>
<td>0.81</td>
<td>0.77</td>
<td>0.80</td>
<td>NS</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.231</td>
<td>0.233</td>
<td>NS</td>
<td>0.213</td>
<td>0.235</td>
<td>0.253</td>
<td>0.238</td>
<td>0.235</td>
<td>0.235</td>
<td>0.218</td>
</tr>
</tbody>
</table>

192
B. Factors interaction (A/B)

<table>
<thead>
<tr>
<th></th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>a1</td>
<td>2.28</td>
<td>2.15</td>
<td>2.28</td>
<td>2.21</td>
<td>2.11</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>2.12</td>
<td>2.17</td>
<td>2.17</td>
<td>2.16</td>
<td>2.27</td>
<td>2.28</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>a1</td>
<td>0.153</td>
<td>0.133</td>
<td>0.130</td>
<td>0.117</td>
<td>0.130</td>
<td>0.137</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>0.130</td>
<td>0.140</td>
<td>0.117</td>
<td>0.137</td>
<td>0.130</td>
<td>0.157</td>
</tr>
<tr>
<td>Potassium</td>
<td>a1</td>
<td>1.97</td>
<td>1.85</td>
<td>1.83</td>
<td>1.68</td>
<td>1.77</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>1.69</td>
<td>1.80</td>
<td>1.73</td>
<td>1.97</td>
<td>1.58</td>
<td>1.95</td>
</tr>
<tr>
<td>Calcium</td>
<td>a1</td>
<td>0.73</td>
<td>0.72</td>
<td>0.74</td>
<td>0.82</td>
<td>0.77</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>0.81</td>
<td>0.72</td>
<td>0.78</td>
<td>0.80</td>
<td>0.77</td>
<td>0.80</td>
</tr>
<tr>
<td>Magnesium</td>
<td>a1</td>
<td>0.208</td>
<td>0.233</td>
<td>0.250</td>
<td>0.253</td>
<td>0.240</td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td>a2</td>
<td>0.227</td>
<td>0.237</td>
<td>0.257</td>
<td>0.223</td>
<td>0.230</td>
<td>0.227</td>
</tr>
</tbody>
</table>

5% LSD, 1 = between two graduations of B factor at A constant, 2 = between two graduations of factor A at B constant; NS = non significant

The significance of experimental factors graduations is shown in the text at chapter „Material and methods”

3.2.2. Influence of sludge application on the heavy metals content in leaves

The manure and sludge fertilization in the six treatments did not significantly influence the heavy metals content in neither of the two depths: 0-60 cm vs. 0-30 cm (table 6).

The manure application (340 g/l) did not change the content of the five heavy metals but at the same time, application of 170 g/l sludge increased the Zn content in leaves by 108% vs. the unfertilized control. A rate of 340 g/l sludge decreased by 1.82 times the lead content vs. the control. This decrease was more obviously when sludge was applied at 0-60 cm vs. 0-30 cm depth (table 6).

4. Discussion

Data in table 1A showed that the soil used for the pot plants where organic fertilizers were not applied – manure or urban sludge (b1) had a low content in humus, total N, P and K, being poor in organic matter and macroelements according to ICPA norms (Florea et al., 1987)

The application of manure and sludge at the rates above mentioned led to a general increase in chemical compounds, P content getting a higher value. Other authors reported such results following manure and sludge fertilization in the plant pots and field (Dumitru, 1983; Dumitru et al., 1983-1993; Mihalache et al., 2006; Vajiala et al., 1988-1992) However, the mixtures of soil and organic matter in the b2 - b6 treatments showed rather low values of humus, N, P and K contents, classifying these mixtures as poor and very poor soils in organic matter and macroelements according to ICPA interpretation norms (Florea et al. 1987).

P and K contents in the plant mixtures are much lower compared to 21-26 ppm in the case of P or to 210 ppm in case of K given by Pasc (1980) as thresholds below which the K and P application can positively influence the tree growth and fruiting.

Table 6. Influence of urban sludge application on the heavy metals contained in the leaves of the Idared apple cv.

<table>
<thead>
<tr>
<th>Analized metal (mg/kg)</th>
<th>a1</th>
<th>a2</th>
<th>LSD 5%</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>LSD 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>6.95</td>
<td>7.13</td>
<td>NS</td>
<td>6.77</td>
<td>6.68</td>
<td>7.30</td>
<td>7.03</td>
<td>7.25</td>
<td>7.20</td>
<td>0.529</td>
</tr>
<tr>
<td>Zinc</td>
<td>39.5</td>
<td>38.1</td>
<td>NS</td>
<td>32.8</td>
<td>35.2</td>
<td>41.5</td>
<td>49.3</td>
<td>39.3</td>
<td>34.7</td>
<td>NS</td>
</tr>
<tr>
<td>Lead</td>
<td>2.28</td>
<td>2.28</td>
<td>NS</td>
<td>3.15</td>
<td>2.68</td>
<td>2.10</td>
<td>1.73</td>
<td>2.14</td>
<td>1.89</td>
<td>1.11</td>
</tr>
<tr>
<td>Manganese</td>
<td>51.2</td>
<td>55.5</td>
<td>NS</td>
<td>52.8</td>
<td>52.5</td>
<td>51.0</td>
<td>55.0</td>
<td>53.8</td>
<td>54.0</td>
<td>NS</td>
</tr>
<tr>
<td>Nickel</td>
<td>3.44</td>
<td>2.91</td>
<td>NS</td>
<td>4.34</td>
<td>3.73</td>
<td>2.82</td>
<td>2.88</td>
<td>3.0</td>
<td>2.27</td>
<td>NS</td>
</tr>
</tbody>
</table>
The significance of experimental factors graduations is shown in the text at chapter „Material and methods”

The percentage of soluble salts was higher when the rates of 340 g/l manure and 170-680 g/l sludge were applied. The results were better when these fertilizers were applied at 0-60 cm vs. 0-30 cm depth. So, when in b₁, 49.3 mg/100 g soluble salts in soil were found, after application of 680 g/l substrate at 0-60 cm depth, the value of soluble salts grew up to 159.3 mg/100 g soil. The soil classification system of ICPA Bucharest (1979) shows that for separation of salted soils from unsalted ones, the limit of the salts content should be between 90-115 mg/100 g soil (for chloruric salinization) and 140 -170 mg/100 g soil (for sulphatic salinization) determined in water extract (1:5). In our case, the highest values of the soluble salts were below the values of sulphatic salinization. This aspect should be taken into account because the presence of soluble salts in greater concentration than those admitted can affect the tree behavior in certain ways.

The heavy metals content determined in soil from the plant pots (mixtures of soil and organic matter) and in water drained out from the plant pots did not exceed the maximum limits (86/278/EEC Directive and 344/2004 Order). Also the organic fertilization did not affect the macroelements and heavy metals content in leaves versus the unfertilized control. The average values of N content (2.19%) of P (134%) of K (1.82%) contents in the tree leaves in the fertilized treatments are pretty close to the optimum values reported by other authors, for instance in apple: Trzcinski (1964) – 1.9 -2% N, 0.20% P, 1.8% K; Levy (1967) – 2.3-2.7% N, 0.18-0.24% P, 1.40-1.70% K; Gautier (1968) – 2.2 -2.3 % N, 0.15-0.18% P, 1.60-1.70% K; Pasc (1980) – 2.3 -2.5% N, 0.17-0.18% P, 1.3-1.4% K; Stiles (1994) – 2.0-2.2% N, 0.15-0.35% P, 1.35-1.8% K.

Conclusions

1. Application of organic matter used as fertilizers at 0-60 cm depth versus 0-30 cm of the planting substrate had the following effects:

1.1. On average, in the six fertilization treatments at two sampling depths, a significant decrease in the P content by 133%, in soluble salts by 126%, in cadmium by 154% was found. There were not significantly changed for the humus, pH, total N, K Cu, Zn, Pb, Mn, Co, Ni contents.

1.2. On average, for the 6 fertilization treatments,

1.2.1. The water drained out from the plant pots showed a significant increase in Zn by 198%, in microorganisms and /or anaerobic bacteria from Enterococcus genus by 140%, but did not much influence the Cu, Pb, Mn, Ni contents and the number of reducing sulphits-clostridia, leavens and moulds.

1.2.2. The content of total N, P, K, Ca, Mg, Cu, Zn, Pb and Mn in the tree leaves was not much influenced.

2. The application of 340 g/l manure had the following effects vs. the unfertilized control:

2.1. On average, for the two applications and sampling depths, the P content was increased by 215%, soluble salts by 126%, but the K content decreased by 1.2. times; the humus content, total N, pH and heavy metals did not show any visible difference.

2.2. On average, on the two application depths of fertilizers:

2.2.1. In the water drained out from the plant pots, it was observed a greater Ni content by 226%, a decreased Cu content by 1.2 times, but the Zn, Ph, Mn contents and microbiological indicators did not significantly change.

2.2.2. The tree leaves did not have a different content in macroelements and heavy metals.
3. The application of 170-680 g/l sludge as fertilizer had the following effects vs. the unfertilized control:

3.1. On average, for the two applications and sampling depths a significant increase in the following compounds was found: P by 163%, soluble salts by 188% and also in Cu, Zn and cadmium when greater rates were used: pH significantly decreased by 1.03 times but the humus, total N, K, Ph, Mn, Ca and Ni contents were slightly changed.

3.2. On average, for the two fertilization depths:

3.2.1. In the water drained out from the plant pots, a significant lower Cu content and only in some treatments lower Zn, Mn, and Ni contents were found. Pb content and microbiological indicators were not significantly changed.

3.2.2. The rate of 680 g/l urban sludge influenced significantly the leaves components: P was higher by 104%, whereas the rate of 170 g/l increased Zn content by 108%. The rate of 340 g/l substrate decreased Pb content by 1.82% times.

The rates of 170 – 680 g/l substrate did not significantly modify the total N, K, Ca, Mg, Cu, Mn, Ni contents.

References

Dumitru M., 1983, Cercetări privind influența asupra solului a compostului obținut din nămolul rezultat de la stația de epurare a Municipiului Brașov, Știința Solului nr.3, I.C.P.A. Brașov;
Florea N., Balaceanu V., Rauta C., Canarache A. 1987 Metodologia elaborarii studiilor pedologice, București.
Levi J.F., 1967, Ou en est Ṽa propagation du diagnostic foliaire à la determination des besoins en elements fertilisants des cultures fruitières L’arboriculture fruitière, 158.
Pasc I., 1980, Aplicarea îngrășămintelor în plantătiile pomicole, Cap. VI în Ghidul pentru alcătuirea planurilor de fertilizare, Editura Ceres București;
Trzcinski T., 1964, Controle de la nutrition des arbres fruitières par diagnostic foliaire. Le Fruit Belge n. 270, 1964;