THE INFLUENCE ON SOIL AND GROUND WATER QUALITY BY ORGANIC COMPOUNDS USE IN ORCHARDS

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The environmental pollution problems resulted from organic compounds (e.g. pesticides, fertilizers) and their residues in food have become important research topics, since healthy food is urgently need, along with improved living standards. Thus, more attention is now being paid to ‘green’ food and organic food. Also, the environmental components soil and ground water are directly exposed to uses of organic compounds in orchards and not only. This paper presents a case study from Vaslui County, Romania where apples orchards are situated. Due to the mild climate and sufficient rainfall, substances are quickly transferred and transformed in this region. Thus, the quality of environmental components soil and groundwater could be highly influenced by the uses of organic compounds. The purpose of this paper was to analyze soil and ground water samples from orchards area and observe if the organic compounds can influence the environmental components, directly exposed to uses of chemicals. The results showed that there is a high impact on ground water and the quality of this environmental component could be influenced by organic compounds uses, while the impact induced on soil is classified being at a medium/low level. The impact induced on ground water could be an effect of synergic and cumulative pollution and has to be controlled by pollution prevention measures.

***Keywords**: environment, chemicals, orchards, pollution, impact and risk.*

The environmental pollution problems resulted from organic compounds (e.g. pesticides, fertilizers) and their residues in food have become important research topics, since healthy food is urgently need, along with improved living standards. Thus, more attention is now being paid to ‘green’ food and organic food. Also, the environmental components soil and ground water are directly exposed to uses of organic compounds in orchards and not only. Though the use of organic compounds (e.g. pesticides, fertilizers) has been banned worldwide for decades and a large amount is still used in developing countries because of the lowest price. The residues resulted are not only difficult to be degraded in the environment, but also can volatilize from the soil and diffuse on a long distance.

For these reasons, it is significant to research the movement of some compounds with dangerous potential in the soil–water–plant system, and their residues in the plant body, in order to find methods to control the environmental pollution and to decrease the residues in farm products. The Moldavia province is one of the most important apples production regions in Romania with a high yield, and where a high level of pesticide and fertilizer is traditionally used. Due to the mild climate and sufficient rainfall, substances transfer and transform quickly in this region. Therefore, this area is a representative in which to research the short-term movement characteristics of pesticides, distribution in the environment, and accumulation in farm products. Some reports have studied the pollution and residues of dangerous organic compounds in this region, but have rarely been concerned with the distribution between soil at various depths, ground water and the plant body at different growth stages.

The purpose of this paper was to analyze soil and ground water samples from orchards area and observe if the organic compounds can influence the environmental components, directly exposed to uses of chemicals. The usually chemicals that are used are based on compounds of heavy metals associated with organic compounds with a high degree of toxicity.

MATHERIAL AND METHOD

The new method to evaluate the environmental impact and risk used herein is a combination between tow methods: global pollution index and matrix of importance scale. An algorithm developed as software designed as ***SAB*** was applied to automatically quantify the environmental impacts and risks that arise from an evaluated activity, considering the measured concentration, levels of quality indicators [2, 4].

This new method for environmental impact and risk assessment (***EIRA***) was applied considering in the assessment process environmental components such as *soil* and *ground water.* The evaluation of environmental impacts was done using a matrix in order to calculate the “importance” of each environmental component, potentially affected by the evaluated activity (uses of organic compounds in orchards). The importance parameter can take values between 0 and 1; value 1 represents the most important environmental component, in this case the soil. These values are assigned by the evaluator (*table 1*). For the evaluated situation, it was considered *the most important* environmental component soil, while the ground water is considered in the evaluation process *important* (*table 2*).

Table 1

The calculation of *importance units* for environmental components

Environmental component	***Surface water (l)***	***Ground water (m)***	***Soil (n)***	***Air (o)***
Surface water (l)	l = 0.00	(1/m)	(l/n)	(l/o)
Ground water (m)	m = 0.7	(m/m)	(m/l)	(m/o)
Soil (n)	n = 1.0	(n/m)	(n/n)	(n/o)
Air (o)	o = 0.00	(o/m)	(o/n)	(o/o)

l – importance value for surface water, m – importance value for ground water,
n – importance value for soil, o – importance value for air

Table 2

Importance units obtained by solving the matrix from Table 1

Environmental component	***Normalized weights (NW)***	***Importance units (IU = NWx1000)***
Surface water	0	0
Ground water	0.41	411.28
Soil	0.59	587.54
Air	0	0

The impact on environmental component (*EI*) directly depends on measured concentration of pollutants, and it is expressed as the ratio between importance units (*IU*) and quality of environmental component (*EQ*), defined as follows (Eq. 1):

$$EI = \frac{IU}{EQ} \quad (1)$$

The parameter *quality of environmental component* (EQ) is defined as follows (Eq.2):

$$EQ = \frac{MAC}{MC} \quad (2)$$

where:

MAC – maximum allowed concentration of quality indicators;

MC – measured concentration of quality indicators.

After the calculation of importance units, the next step was to calculate the quality of environmental component defined above. If the quality parameter of environmental component is equal with 0, it results that the environmental quality is very poor (this means that the measured concentration of pollutant is very high); if *EQ* value is close to 1, or higher than 1, then the quality of environmental component is good or very good [1].

The impact induced on *soil* by organic compounds use in orchards is (Eq.3, 4):

$$EI_s = \frac{\sum_{i=1}^{n} EI_{(s)i}}{n} \quad (3)$$

$$EI_{s_i} = \frac{IU_s}{EQ_{s_i}} \quad (4)$$

$EQ_{(s)i}$ – quality of environmental component *soil*, considering the quality indicator *i*;
IU_s – importance units obtained by *soil*.

The impact on *ground water* (EI_{sw}) is given by the following equations (Eqs.5, 6):

$$EI_{gw} = \frac{\sum_{i=1}^{n} EI_{(gw)i}}{n} \quad (5)$$

$EI_{(sw)i}$ – environmental impact on ground water, considering quality indicator *i*;
i – quality indicators (e.g. COD-Cr, BOD etc.)

$$EI_{(gw)i} = \frac{IU_{gw}}{EQ_{(gw)i}} \quad (6)$$

$EQ_{(sw)i}$ – quality of *ground water*, considering the quality indicator *i*;
IU_{sw} – importance units obtained by *ground water*.

This way the impacts for environmental components considered the most representative for the evaluated situation were calculated. The next step was to quantify the risks that arise, in the view of the results for environmental impacts. The risks are calculated as follows (Eq.7):

$$ER_j = EI_j \cdot P_j \tag{7}$$

ER_j – environmental risk for environmental component *j*;
EI_j – environmental impact on environmental component *j*;
P_j – probability of impact occurrence on environmental component *j*.

The probability of impact occurrence was calculated using the same matrix as described above (*table 1*) to calculate the importance units. The normalized weights are presented in table 3. The evaluator has to give values between 0 and 1 for probability (*table 4*), which is detailed in table 5 [3].

Table 3

The calculation of *probability*

Environmental component	***Surface water***	***Ground water***	***Soil***	***Air***
Surface water	0.00	0.00	0.00	0.00
Ground water	0.70	1.00	0.88	700.00
Soil	0.80	1.14	1.00	800.00
Air	0.00	0.00	0.00	0.00

Table 4

Normalized weights obtained by solving the matrix from Table 3

Environmental component	***Normalized weights (NW)***	***Probability units (P)***
Surface water	0.00	0.00
Ground water	0.47	0.47
Soil	0.53	0.53
Air	0.00	0.00

Table 5

Description of probability

Probability	***Description***
0.91-1.0 (Almost certain)	Is expected to occur in most circumstances (99%)
0.61-0.9 (Likely)	Will probably occur in most circumstances (90%)
0.31-0.6 (Possible)	Might occur at some times (50%)
0.05-0.3 (Unlikely)	Could occur at some times (10%)
<0.05 (Rare)	May occur only in exceptional circumstances (1%)

Considering the fact that the measured concentrations of main pollutants analyzed in soil and ground water samples from orchards are close to or higher than the maximum allowed concentrations (MAC), likely probability was accorded or, in some situations it was considered that environmental impact might occur at some times. It should be mentioned here that the maximum allowed concentrations were considered in accordance with Romanian legislation, and due to the fact that soil from orchard is used in agriculture purposes, the maximum concentration of pollutant have to be under warning level (70% from maximum allowed concentration).

RESULTS AND DISCUSSIONS

The soft *SAB* designed for integrated impact and risk quantification, described above was applied for quantification of heavy metals presence soil and ground water samples from orchards from Vaslui County. The impact and associated risk induced in environmental components directly depend on concentration of pollutant analyzed.

It has to be emphasized that if the impact and risk have very high values, then the impact induced by the considered activities in the environment is great and the environmental risks are at an unacceptable level. High values for environmental impacts and risks underlay the presence of pollutants in environment in very high concentrations, because impact directly depends on the measured concentration of pollutants. Considering the impact classification from method of global pollution index, a classification of impacts and risks is proposed *(table 6*).

Table 6

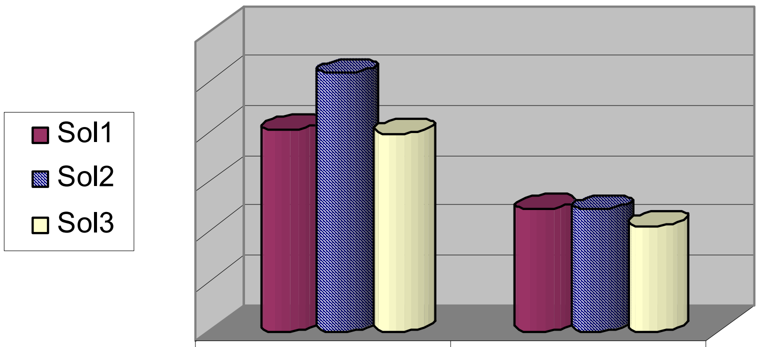
Classification of environmental impact and risk

Impact Scale	*Description*	*Risk Scale*	*Description*
<100	Natural environment, not affected by industrial/human activities	<100	Negligible/insignificant risks
100-350	Environment modified by industrial activities within admissible limits	100-200	Minor risks, monitoring actions are required
350-500	Environment modified by industrial activities causing discomfort conditions	200-350	Moderate risk at an acceptable level, monitoring and prevention actions are required
500-700	Environment modified by industrial activities causing distress to life forms	350-700	Moderate risks at an unaccep-table level, control and prevention measures are needed
700-1000	Environment modified by industrial activities, dangerous for life forms	700-1000	Major risks, remediation, control and prevention measures are needed
>1000	Degraded environment, not proper for life forms	>1000	Catastrophic risks, all activities should be stopped

From the evaluated site, 3 soil samples and 2 ground water samples from 20 meter deep were analyzed. Each soil samples were taken from different depth (5 and 30 cm), so that the transfer of pollutants from surface to the depth, and finally to the ground water is analyzed.

In *figure 1* the environmental impact and risk induced on soil is shown, and the main pollutants that influence the soil quality are shown in *figure 2*.

The impact induced on ground water, sampled from the evaluated site is causing an environment modified by human activities, dangerous for life forms, and the transfer of main pollutants from soil to ground water has a high degree in case of cadmium and copper (*fig. 3*), this means that the uses of organic compounds in this orchard could influence the quality of ground water and soil.



	IM	RM
Sol1	402.20	244.44
Sol2	515.67	242.43
Sol3	394.65	210.20

Figure 1. **Environmental impact and risk induced on soil**

It can be observed from figure 3 the fact that the main pollutants for ground water are heavy metals (such as copper and cadmium), which are transferred from polluted soil to the aquatic systems. So that, it is launched out the idea that the apple trees from this evaluated orchard could have assimilated a part from the heavy metals (zinc, copper and cadmium) found in high concentration in soil-ground water system, but this will be a further study.

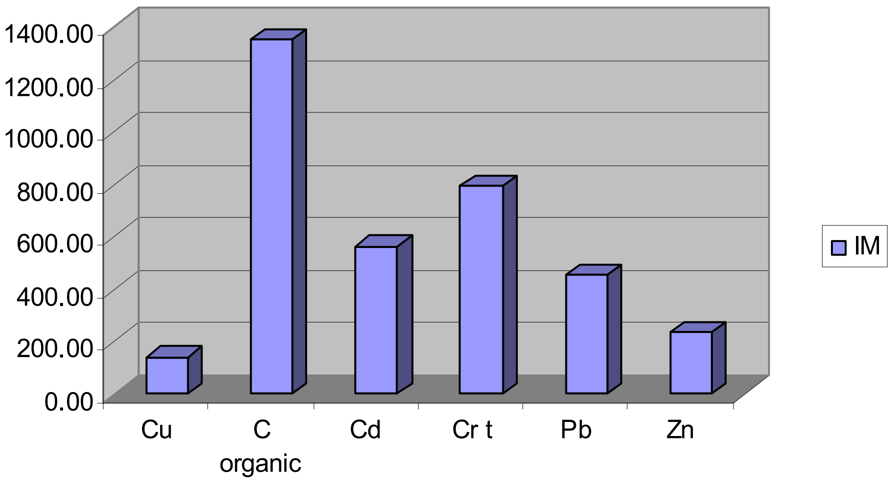
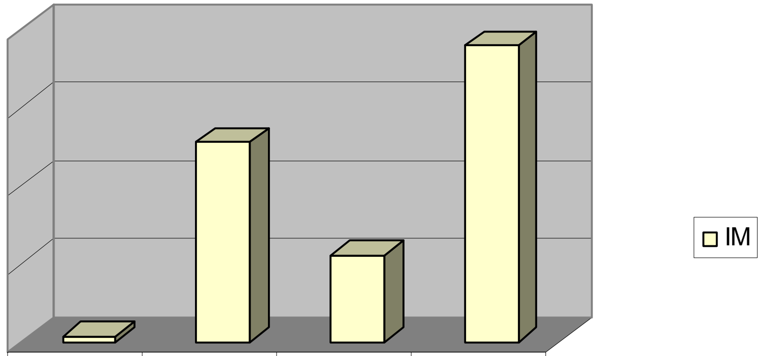


Figure 2. **Main pollutants that influence the soil quality**



	total Cr, mg/l	Cu, mg/l	Ca, mg/l	Cd, mg/l
IM	37.84	1274.97	555.78	1891.89

Figure 3. T**he impact induced on ground water by organic compounds use (containing heavy mettals)**

The comparison of impact/risk induced on soil and ground water are presented in *figure 4*. It can be observed that the impact induced on ground water is higher than the impact induced on soil; this could be due to the migration of main pollutants from soil to the aquatic system.

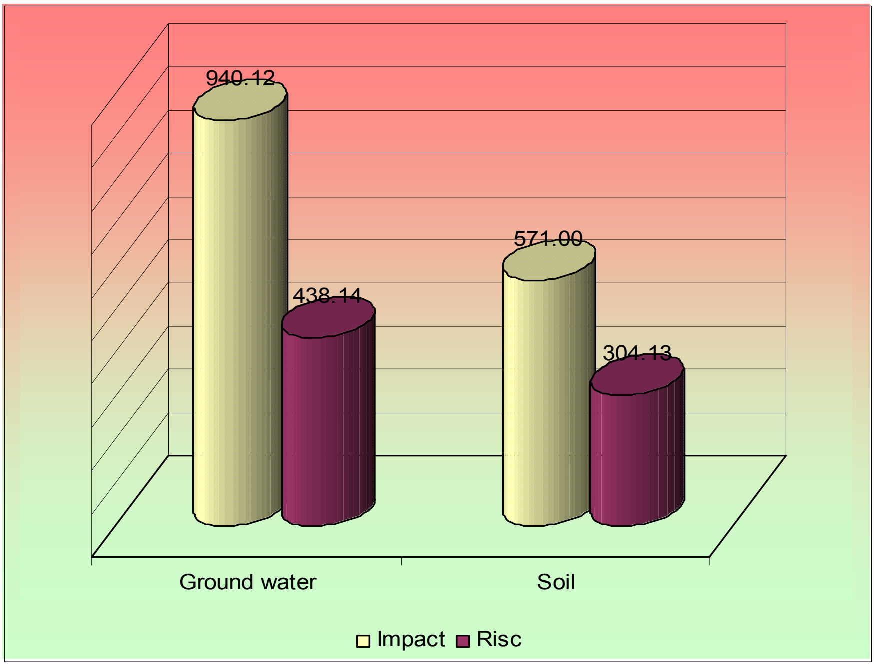


Figure 4. **The impact/risk induced on soil and ground water**

CONCLUSIONS

The purpose of this paper was to analyze soil and ground water samples from orchards area and observe if the organic compounds and heavy metals can influence the environmental components, directly exposed to uses of chemicals. The usually chemicals that are used are based on compounds of heavy metals associated with organic compounds with a high degree of toxicity. Thus, from the evaluated site, 3 soil samples and 2 ground water samples from 20 meter deep were analyzed. Each soil samples were taken from different depth (5 and 30 cm), so that the transfer of pollutants from surface to the depth, and finally to the ground water is analyzed.

The impact induced on ground water, sampled from the evaluated site is causing an environment modified by human activities, dangerous for life forms, and the transfer of main pollutants from soil to ground water has a high degree in case of cadmium and copper, this means that the uses of organic compounds in this orchard could influence the quality of ground water and soil.

The value of impact induced on soil, which is directly exposed to the action of chemical compounds and heavy metals underlay the fact that the environment is modified by the uses of organic compounds, causing discomfort conditions. Mainly, the impact on soil is induced by the presence of organic compounds and heavy metals such as total chromium, cadmium and lead.

The impact induced on ground water is mainly caused by the presence of cooper and cadmium in high concentration, over maximum allowed concentration concordant to Romanian legislation.

Considering these facts, it is recommended to remove the use of organic compounds with high degrees of toxicity or with heavy metals that can influence the quality of soil, with others that are more environmental friendly.

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