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THE EFFECT OF PESTICIDE AND INSECTICIDE USE ON ORCHARD SOILS – A CASE STUDY OF ORCHARDS IN DAMBOVITA COUNTY

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Abstract

In the early 2000s, the European Commission laid the groundwork for soil protection with a report titled "Towards a Thematic Strategy for Soil Protection"[1]. This report outlined guidelines for preserving and enhancing soil quality. As a result, understanding the levels of heavy metals in soils and their sources became a key priority for the European Union. The main objective of this study is to investigate the effect of pesticide and insecticide use on the soils of the main orchards in Dambovita County. Using WDXRF spectrometry, the elemental concentrations of As, Cd, and Pb were determined in samples collected from 10 points located in the main orchards of Dambovita County. The distribution maps obtained, as well as the comparisons made with the maximum allowable limits of pollutant elements in soils, demonstrated the impact that pesticide and insecticide use can have on soil.

Keywords: heavy metal content, fertilizers, pesticides, orchard soil, analysis

1. INTRODUCTION

Dambovita County, located in southern Romania, is nationally recognized as a major fruit producer. The area is one of the country's most important fruit-growing regions, contributing significantly to Romania's fruit production.
The most widespread types of orchards in the region are apple and plum trees. In recent years, with the increase in fruit imports (especially apples), local producers have also shifted towards other types of fruit trees: cherries, sour cherries, peaches, nectarines, and pears. Thus, Dambovita County is an important area for Romanian horticulture, with a rich tradition and great potential for the future.
To combat pests and specific diseases, as well as to maximize production, fruit producers widely use various insecticides and pesticides.
The use of pesticides and insecticides in agriculture can have a significant environmental impact, especially on soil, water, and biodiversity. The effects of these substances on soil pollution include, among other things, soil contamination, degradation of its quality, negative impacts on beneficial soil microorganisms, harmful effects on human health, and an increase in pest resistance, which harms plant health.
Pesticides and insecticides applied to crops often end up in the soil, where they can inhibit natural soil processes, such as the activity of microorganisms essential for soil fertility and structure.
Long-term pesticide use can affect the soil's structure and composition, reducing its ability to retain water and support plant and organism life. Pesticides also affect soil pH, which can influence plant growth and reduce soil biodiversity.
Some pesticides, such as those in the organochlorine class, are resistant to degradation and tend to accumulate in soil, plants, and animals. These chemicals can move up the food chain, affecting not only agricultural crops but also wildlife and, ultimately, humans.
Soils contaminated with pesticides can impact human health through food grown on such land.
Pesticides can enter plants and reach the food chain, exposing the population to risks such as chronic diseases, hormonal disorders, or even cancers.
The study of heavy metals in orchard soils is a field of interest for researchers in agriculture, environment, and public health, due to the potential impact on human health and biodiversity.
On this subject, Wang, Q., et al. [2] conducted a review on the accumulation of heavy metals such as Pb, Hg, As, and Cd in orchard soils and emphasized the importance of regular monitoring and risk assessment regarding the health of the fruits and the consumers. Additionally, Shan, C, et al. [3] analyzed the effects of long-term fertilization and agricultural practices on the accumulation of heavy metals in orchard soils. Their research highlighted the role of organic and inorganic fertilizers in heavy metal pollution. Rashid, A., et al. [4] investigated the mobility and bioavailability of heavy metals such as cadmium and lead in irrigated orchard soils, as well as how different soil amendments (organic compounds, biochar) can reduce the risks associated with heavy metal pollution.
A similar study was conducted by Liang, Q., et al. [5], who explained in their article how long-term pesticide application can increase the concentrations of heavy metals, particularly arsenic and lead, in orchard soils. Masakazu Aoyama, Ryo Tanaka, [6] also investigated the mechanisms of metal absorption by plants and the effects on fruit quality.
In Dambovita County, a previous study on the effects of insecticide and pesticide use on apple and plum orchards was published by Gheboianu et al. [7], but the current study refers only to the accumulation of heavy metals in the soil.
These examples illustrate the various sources of heavy metal contamination, including agricultural practices, pesticides, and fertilizers, and their potential negative effects on the environment and food safety.

2. MATERIALS AND METHODS

Material

The soil samples were collected trimestral from the monitored orchards located in Dambovita County.
The samples was collected at different depths (from the soil surface - 0 cm, 10 cm, 20 cm, 30 cm). Below, we present the sample coding (Table 1) as well as the location map (Figure 1).

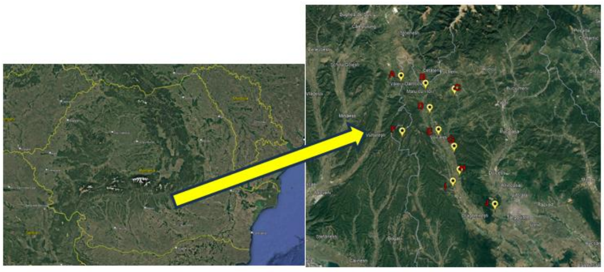

Figure 1. Location of the studied area

Table 1. Sample list details

No.	Location (Dambovita County)	GPS coordinates of the sample		Sample code		Sampling depth
		Latitude N	Longitude E			
1	Văleni	45° 9' 45.9354"	25° 10' 13.2888"	A	A0	0 cm
					A1	10 cm
					A2	20 cm
					A3	30 cm
2	Malu cu Flori	45° 8' 44.1276"	25° 11' 52.2738"	B	B0	0 cm
					B1	10 cm
					B2	20 cm
					B3	30 cm
3	Bărbulețu	45° 8' 18.6504"	25° 17' 26.5842"	C	C0	0 cm
					C1	10 cm
					C2	20 cm
					C3	30 cm
4	Gemenea - Brătulești	45° 6' 13.4274"	25° 13' 32.8146"	D	D0	0 cm
					D1	10 cm
					D2	20 cm
					D3	30 cm
5	Voinești	45° 3' 43.8258"	25° 14' 55.791"	E	E0	0 cm
					E1	10 cm
					E2	20 cm
					E3	30 cm
6	Valea Mare - Cândești	45° 3' 34.0302"	25° 9' 15.4686"	F	F0	0 cm
					F1	10 cm
					F2	20 cm
					F3	30 cm
7	Izvoare	45° 1' 50.7606"	25° 17' 22.8906"	G	G0	0 cm
					G1	10 cm
					G2	20 cm
					G3	30 cm
8	Gheboieni	44° 59' 12.9402"	25° 18' 14.31"	H	H0	0 cm
					H1	10 cm
					H2	20 cm
					H3	30 cm
9	Mănești	44° 57' 54.3456"	25° 17' 11.385"	I	I0	0 cm
					I1	10 cm
					I2	20 cm
					I3	30 cm
10	Priseaca	44° 55' 17.7198"	25° 23' 46.8348"	J	J0	0 cm
					J1	10 cm
					J2	20 cm
					J3	30 cm

Method description

For wavelength dispersive X-ray fluorescence (WDXRF) analysis, we used the WDXRF Supermini 200, Rigaku - Japan, available at ICSTM-UVT. The spectrometer is equipped with 12 places automatic sampler, and 3 position crystal changers. The detection limit is 1ppm - 10ppb and the precision is about 0.1-0.5%. X-ray fluorescence spectrometry (XRF) is a quick and efficient method for determining the concentrations of heavy metals in soil. This analytical technique can analyze a wide range of elements, oxides, and other compounds from oxygen (O) to uranium (U). XRF works by bombarding a sample with high-energy X-rays.
This causes the atoms in the sample to lose electrons from their inner shells. To fill these vacancies, electrons from the outer shells move inward, emitting characteristic X-ray radiation that is unique to each element. The intensity of this radiation is directly related to the concentration of the specific element within the sample.
All samples were transported to the laboratory, where they were dried in an oven for 24 hours at 45 °C. To measure the heavy metal content, representative samples of each soil were carefully ground into a fine powder using an agate mortar and pestle. The powdered samples were then stored in airtight containers.
For the analysis, approximately 2 g of powdered sample was used. This was mixed with 2 g of Boreoux binder (Fluxana) and homogenized, resulting in a 4 g pellet made using a Testchem pellet press with a pressure of 250 kN.
Soil pH measurements were conducted at room temperature for all samples. A 1:2.5 soil-to-water suspension was prepared, and pH was measured using an Inolab Multi 9430 meter (WTW) with automatic temperature compensation. The pH sensor model IDS SenTix 980 had an accuracy of 4.10-3 (Table 2).
Iso-concentration maps, which visually represent the spatial distribution of the elements analyzed in the soil samples, were generated using Surfer 9.0 software.

3. RESULTS AND DISCUSSIONS

Multivariate data analysis was employed to identify a potential common source for heavy metal contamination. Table 2 summarizes the pH measurements and the concentrations of arsenic, cadmium, and lead at all sampling locations. Figures 2-5 present the iso-concentration maps created for each depth level of soil sample collection.

Table 2. The contents of heavy metals (mg kg^{-1} DW) in soil samples, pH, EC

Sample code	pH	As	Cd	Pb
A0	6.69	28.81±1.32	63.42±0.62	19.35 ± 0.75
A1	6.83	29.34±0.84	67.88±1.28	19.82±0.85
A2	6.98	29.55±1.12	70.24±1.80	20.25±0.80
A3	7.09	30.41±1.26	71.08±2.04	20.55±0.75
B0	7.43	23.72±0.82	809.50± 3.86	54.15 ± 0.75
B1	7.49	24.88±1.04	824.34±4.66	55.10±0.85
B2	7.56	25.63±1.26	840.60±9.20	57.05±0.65
B3	7.69	27.03±1.28	861.28±9.84	57.85±0.85
C0	7.32	22.56±1.30	685.34±4.76	73.80±0.40
C1	7.40	23.42±1.62	690.88±6.76	75.05±0.50
C2	7.51	25.08±1.88	694.46±7.10	75.95±0.60
C3	7.68	27.12±1.64	702.32±7.40	76.25±0.55
D0	6.98	19.88±1.26	149.71±4.90	97.85±0.80
D1	7.07	21.04±1.14	153.63±3.24	98.45±1.00
D2	7.12	23.16±1.50	159.18±3.82	99.05±0.85
D3	7.25	24.95±1.45	162.44±4.10	99.55±0.75
E0	7.17	17.36±0.88	409.64±7.24	123.75±1.45
E1	7.23	18.90±0.76	412.35±5.20	124.55±2.50
E2	7.35	19.64±0.60	418.68±6.14	125.40±2.00
E3	7.37	21.72±0.94	423.80±5.8	126.80±1.55
F0	7.31	12.66±0.68	123.75±1.60	105.95±0.65
F1	7.46	13.84±0.90	131.46±2.32	106.25±0.55
F2	7.53	14.35±1.15	139.80±4.24	106.95±0.85
F3	7.71	15.08±1.22	144.65±3.60	107.35±1.05
G0	7.16	9.55±0.65	60.72±0.88	84.40±0.45
G1	7.29	10.73±0.82	62.41±1.30	84.90±0.55
G2	7.38	12.08±1.14	64.82±1.44	85.40±0.65
G3	7.47	13.36±0.94	66.94±1.30	85.95±0.50
H0	7.21	8.92±0.46	17.80±1.98	40.80±3.75
H1	7.35	9.85±0.60	19.12±1.76	41.35±1.05
H2	7.43	10.70±0.80	21.63±2.08	41.95±1.25
H3	7.51	12.06±1.08	22.84±2.32	43.05±1.05
I0	6.78	6.82±0.86	11.47±1.14	24.15±0.25
I1	6.86	7.65±0.66	12.80±1.40	24.85±0.55
I2	6.97	8.48±0.88	14.92±1.36	25.35±0.65
I3	7.15	9.22±1.06	16.84±1.10	26.05±0.55
J0	5.73	4.76±0.38	46.96±0.72	17.65±1.80
J1	5.92	5.32±0.50	48.22±1.10	18.55±0.90
J2	6.02	6.08±0.84	49.64±1.44	19.05±1.05
J3	6.24	7.16±0.86	51.86±1.38	19.45±1.35

The data are reported as the average value plus or minus the standard deviation (SD) calculated from three separate measurements.

*DW = dry weight.

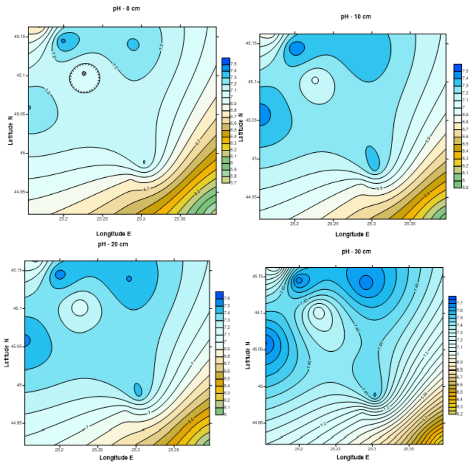

Figure 2. Iso-concentration maps showing the spatial variation of pH at different sampling depths

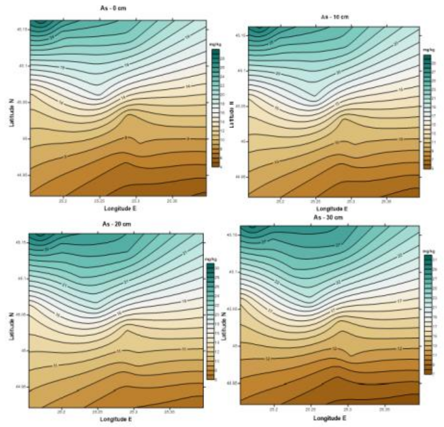

Figure 3. Iso-concentration maps illustrate the spatial distribution of As concentrations at different sampling depths

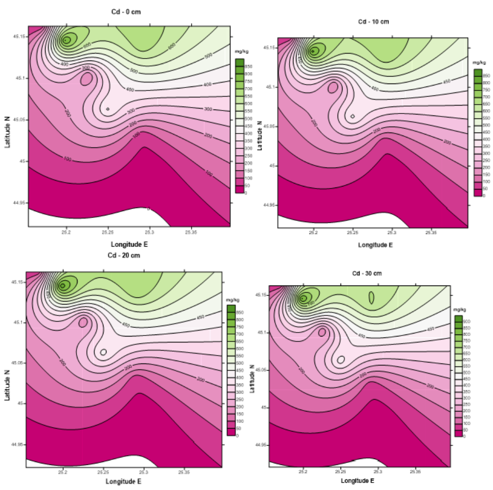

Figure 4. Iso-concentration maps illustrate the spatial distribution of Cd concentrations at different sampling depths

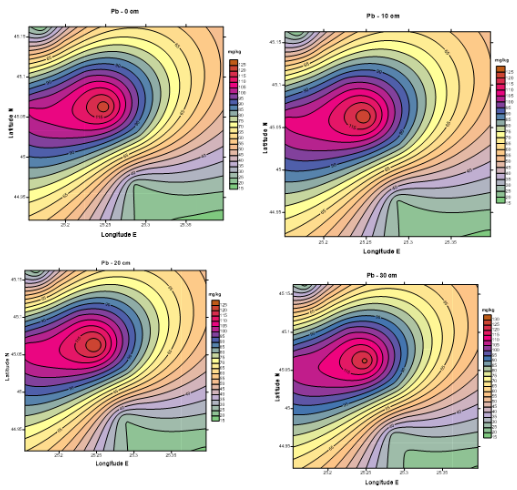

Figure 5. Iso-concentration maps illustrate the spatial distribution of Pb concentrations at different sampling depths

In general, pesticides approved in Romania by the National Phytosanitary Authority and the Ministry of Agriculture and Rural Development consist of the following main components: active substances (chemical compounds that have the desired effect on harmful organisms such as organophosphates, carbamates, pyrethroids, neonicotinoids, herbicides, fungicides), solvents and additives (organic solvents such as xylene, ethyl acetate, and stabilizers and wetting agents), and inactive ingredients – which assist in the application of pesticides (dispersing agents and surfactants).
Correlations were observed between the levels of heavy metals in the soil samples and the types and quantities of pesticides and fertilizers used in the corresponding regions.
From the data obtained, the accumulation of elemental concentrations can be observed as the depth of soil sample collection increases. Additionally, the decrease in latitude from North to South also highlights a decrease in the elemental concentrations of the heavy metals studied, as well as in the pH value.

4. CONCLUSIONS

Solutions for reducing negative impact:
• Organic farming: Using natural pest control techniques and avoiding chemical pesticides helps maintain soil health.
• Crop rotation: Alternating crops in different seasons can reduce the need for pesticides and help restore soil nutrients.
• Biopesticides: The use of biological pesticides (which break down more easily in the environment) is a safer alternative for protecting the environment.
Reducing the negative environmental impact of agriculture [8] is essential for maintaining natural balance and protecting resources in the long term. Practices such as organic farming, crop rotation, and the use of biopesticides represent effective and sustainable solutions. These measures not only improve soil and plant health but also contribute to protecting biodiversity and the quality of water and air. Implementing these strategies is an important step toward more responsible and environmentally friendly agriculture.

5. REFERENCES

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