PhD THESIS

The Traceability of the Organic Agricultural Inputs with Pollutant Potential on Water, Soil, and Cultures in Satu Mare County

SUMMARY OF THE Ph.D THESIS

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1 . General considerations concerning the traceability of the agricultural inputs with pollutant potential

A general definition of traceability is "the ability to trace the history, application or location of an entity through recorded identifications" (BERTOLINI ET AL.,2006; CANAVARI ET AL.,2010; KARLSON ET AL., 2013; KELEPOURIS ET AL.,2007; OLSEN AND ASCHAN, 2010). Here it is necessary to mention that some researchers have tried to differentiate traceability as logistic traceability (following physical movement) and qualitative traceability (product following quality and consumer safety).

2. Agricultural inputs

The role of agriculture in the process of economic growth has played a central role in the problem of development for several decades. While arguments differ as to the specific mechanisms by which increased agricultural productivity might contribute to structural change in the economy, it has long been theorized that advances in agriculture can promote shifts in labor to higher productivity sectors that provide higher real incomes (COVACIU DIANA ET AL., 2020, NEAMȚU DIANA ET AL., 2021; COVACIU DIANA ET AL., 2022).

3. Research objectives

The objectives pursued in the doctoral thesis refer to: quantifying the impact of organic and mineral fertilization on soil quality; quantifying the impact of organic and mineral fertilization on groundwater quality; establishing the polluting potential of organic and inorganic fertilizers on water; quantifying the impact of organic and mineral fertilization on the potato crop and estimating the traceability of the nitrate pollutant potential of organic and mineral fertilizer inputs.

4. Environmental peculiarities of the experimental site

The experiments in the doctoral thesis were carried out in the village of Apa, Apa commune in Satu Mare county (47°45′48.6″ N 23°11′53.2″ E), Romania (Fig. 4.1.). Satu Mare county is located in the extreme northwest of Romania, bordering Hungary to the west and Ukraine to the north, and in the country it borders the counties of

Maramures, Sălaj and Bihor. The experimental fields were located in five private vegetable farms. Five plots were organized (one for each farm) and each on an area of 100 m2, corresponding to each farm (site 1 – 47° 47°45′57.16″ N 23°11′23.74″ E, site 2 – 47° 47°45′42.29″ N 23°11′23.74″ E, site 2 – 47° 45′36.11″ N 23°12′42.56″ E, site 4 – m 47°45′48.81″ N 23°12′13.4″ E, site 5 – 47°46′9.19″ N 23°12′13.21″ E).

5. Material and Method

In order to carry out the traceability of organic agricultural inputs with polluting potential on water, soil and crops in Satu Mare county, the soil resources in the experimental area, the underground water resources were qualitatively described and characterized from a productive and nutritional point of view the cultivated potato, in order to highlight the traceability of nitrates from organic agricultural inputs. The data resulting from the implementation of the experimental scheme were processed statistically. The biological material was made of potato, which belongs to the semi-early cultivar Roclas (Solanum tuberosum L.), obtained at the National Research and Development Institute for Potato and Sugar Beet Brașov. The chemical materials used consisted of the administered mineral fertilizer and the chemical reagents used for laboratory determinations. Physical materials were used for sampling. In order to carry out the laboratory analyses, the specific equipment necessary to carry out the analyzes was used. A bifactorial experiment was organized, in which the factors of experimental year with two graduations (the years 2021 and 2022) and fertilization with five graduations (unfertilized control, organic fertilization with manure in a dose of 39.52 t/ha, organic manure fertilization at a dose of 79.04 t/ha, organic manure fertilization at a dose of 118.56 t/ha, and mineral fertilization with NPK: 14:7:21. The laboratory analyzes and data processing was carried out in the Environmental Quality Monitoring Laboratory. In order to characterize the soil profiles in the experimental field, the following parameters were quantified: coarse sand, fine sand, dust I, dust II, clay, hygroscopicity, conductivity, pH, humus, Ntotal, Pmobil, Kmobil, $N\text{-}NO_3$, $N\text{-}NH_4$, $CaCO_3$, Fe, Cd, Cu, Ni, Zn, Cr, Pb, Hg. For a more accurate picture of the groundwater quality, in addition to the nutritional values, were analyzed and the pH and turbidity values, according to the standardized methodology The collected experimental data statistically processed and interpreted with the help of the programs STATISTICA v.8 for Windows and "XLSTAT".

6. Results concerning the soil quality

In order to highlight the influence of differentiated, organic and mineral fertilization, on the soil profile in the experimental field, its characteristics are presented, namely the results of the granulometric analysis (proportions of coarse and fine sand, dust and clay), the physico-chemical properties (pH, hygroscopicity, conductivity, the content in humus, nitric nitrogen, ammoniacal nitrogen and calcium carbonate), the content in macro- and microelements, as well as the interactions between the studied parameters, within each experimental variant, as exemplified in Table 6.4.

Table 6.4

The characterization of the soil profile from the experimental field, organic fertilization with 118,56 t manure/ha (V_4), in experimental years 2021 and 2022

Issue	N	X		s		CV(%)	
		2021	2022	2021	2022	2021	2022
Coarse sand, %	10	6.67	6.72	0.50	0.53	7.45	7.96
Fine sand, %	10	31.07	31.15	0.71	0.63	2.30	2.03
Dust I, %	10	5.91	5.97	0.73	0.68	12.37	11.33
Dust II, %	10	12.48	12.59	0.80	0.81	6.42	6.44
Clay, %	10	43.10	43.24	0.88	0.99	2.03	2.28
Hygroscopicity, %	10	7.90	8.03	0.78	0.68	9.82	8.43
Conductivity, mS	10	0.34	0.35	0.09	0.09	25.59	26.17
pH	10	7.56	7.60	0.13	0.13	1.67	1.75
Humus, %	10	8.28	8.33	0.67	0.72	8.05	8.60
N_{total}, %	10	0.35	0.35	0.02	0.02	4.57	5.08
P_{mobile}, ppm	10	38.31	38.41	1.41	1.42	3.69	3.71
K_{mobile}, ppm	10	300.00	301.20	15.45	15.48	5.15	5.14
$N\text{-}NO_3$, ppm	10	147.00	147.26	1.21	1.18	0.82	0.80
$N\text{-}NH_4$, ppm	10	169.00	169.35	1.22	1.39	0.72	0.82
$CaCO_3$, %	10	0.40	0.47	0.11	0.13	26.35	28.46
Fe, ppm	10	41.32	41.86	1.05	1.10	2.55	2.63
Cd, ppm	10	1.19	1.28	0.47	0.46	39.11	36.23
Cu, ppm	10	36.14	36.28	1.00	1.12	2.77	3.09
Ni, ppm	10	22.14	22.31	0.91	1.02	4.10	4.55
Zn, ppm	10	76.12	76.30	1.51	1.40	1.98	1.83
Cr,ppm	10	47.52	47.79	1.04	1.19	2.18	2.48
Pb, ppm	10	13.45	13.65	1.08	0.96	8.02	7.02
Hg, ppm	10	0.11	0.12	0.02	0.02	19.64	15.47

N –number of samples; X –mean; s –standard deviation; CV –coefficient of variation; the differences between any two variants are significant if their values are followed by different letters or gropup of letters.

7. Results concerning the groundwater quality

In order to carry out the study of the traceability of organic agricultural inputs with polluting potential on soil water and crops, the quality of underground water is studied at the level of the 5 experimental fields located in Apa commune, Satu Mare county. The physico-chemical characteristics of groundwater are presented, respectively, turbidity, conductivity, pH, permanganate index, ammonium, total hardness, total dissolved substances, alkalinity, salts (chlorines, fluorides, sulfites, sulfates, bicarbonates, phosphates, nitrites, nitrates) and macro- and microelements, such as (Table 7.11).

Table 7.11

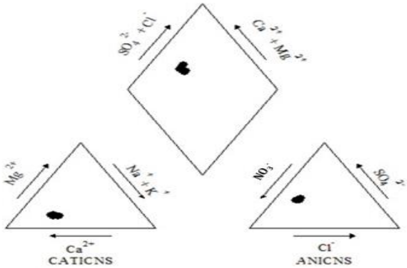
The means of the parameters, which characterize the groundwater from the experimental field, by experimental period 2021 – 2022

Issue	1	2	3	4	5
Turbidity, NTU	0.21a	0.22a	0.20a	0.23a	0.23a
Conductivity, µS/cm	414.68	415.29a	421.04a	437.60b	429.30a
pH	7.63a	7.64a	7.01a	6.27b	7.51a
Permanganat index, mg O_2/L	0.2a1	0.24a	0.26a	0.32b	0.24a
Ammonium, mg/L	0.008a	0.009a	0.010a	0.012a	0.012a
Total hardness, °G	10.13a	10.43a	10.26a	10.48a	10.77a
TDS, mg/L	267.01a	266.76a	264.36a	263.86a	262.45a
Alkalinity, ml HCl 0,1N	1.81a	1.88a	1.68a	1.33b	1.65a
Chlorides, mg/L	29.68a	30.32a	30.96a	31.76a	31.32a
Florides$^-$, mg/L	0.15a	0.15a	0.15a	0.18a	0.17a
Sulfides, µg/L	3.02a	3.22a	3.26a	3.39a	3.27a
Sulfates, mg/L	60.80a	61.40a	62.50a	67.89b	63.25a
Bicarbonates, mg/L	91.18a	92.21a	89.64a	85.06b	89.14a
Phosphates$^-$, mg/L	0.040a	0.041a	0.041a	0.042a	0.045a
Nitrites, mg/L	0.004a	0.004a	0.005a	0.008b	0.007a
/Nitrates, mg/L	39.13a	44.30a	43.43a	62.89b	44.63a
Ca, mg/L	50.50a	51.08a	52.01a	52.60a	52.73a
Mg, mg/L	12.34a	13.33a	13.71a	13.66a	14.10aa
Na, mg/L	16.23a	16.20a	15.93a	15.71a	15.58a
K, mg/L	5.08a	5.06a	4.98a	5.00a	4.71a
Fe, µg/L	33.75a	34.45a	34.55a	34.94a	34.70a

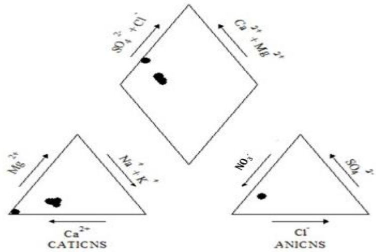
1 –unfertilized control; 2 organic fertilization with 39.5 t manure/ha; 3 –organic fertilization with 79,4 t manure/ha; 4 – organic fertilization with 118,56 t manure/ha; 5 – fertilizare minerală cu N_{14}:P_7:K_{21}; the differences between any two variants are significant if their values are followed by different letters or gropup of letters.

Piper diagrams highlight the ionic composition of groundwater resources at the level of the experimental field corresponding to the five fertilization options (Fig. 7.1). In all cases it is found that calcium cations and nitrates predominate. Particularities are noted, however, in the case of the groundwater corresponding to the experimental variants organically fertilized with different doses of organic fertilizer, respectively manure (V2, V3 and V4). These are represented on the one hand by the greater abundance of calcium ions ($Ca^{2+)}$ in the case of experimental variants V2 and V3 (Fig. 1b and Fig. 1c), and on the other hand by the abundance of nitrates, in the case of variant

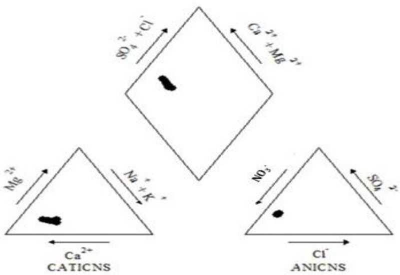
V4 (Fig. 1d) and in addition to the abundance of calcium ions (Ca^{2+}) and the presence, in quantities worthy of consideration, of sodium and potassium ions (Na+ and K+).



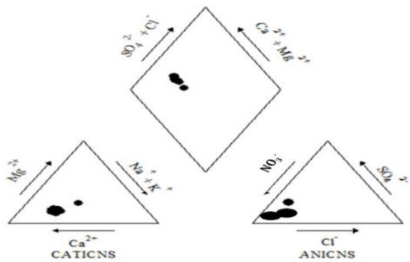
a – V_1, control unfertilized



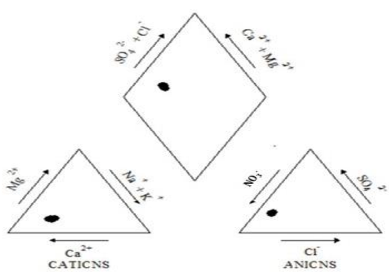
b – V_2, fertilization with 39.5 t manure/ha



c – V_3, fertilization with 79,4 t manure/ha



d – V_4, fertilization with 118.56 t manure/ha



e – V_5, mineral fertilization with N_{14}:P_7:K_{21}

Figure 7.1. The Piper diagram of groundwater correspondig to experimental variants V_1 – V_5

The level of groundwater pollution found in the experimental field, corresponding to the four fertilized options, is highlighted by calculating the nitrate pollution index, NPI. Over the entire experimental period 2021 – 2022, the analyzed groundwater corresponding to mineral fertilization and organic fertilization with manure fall into the category of moderate pollution, while the groundwater collected from the experimental field, where the potato crop was fertilized with manure in the dose of 118.56 t/Ha, falls into the category of significant pollution.

Table 7.14

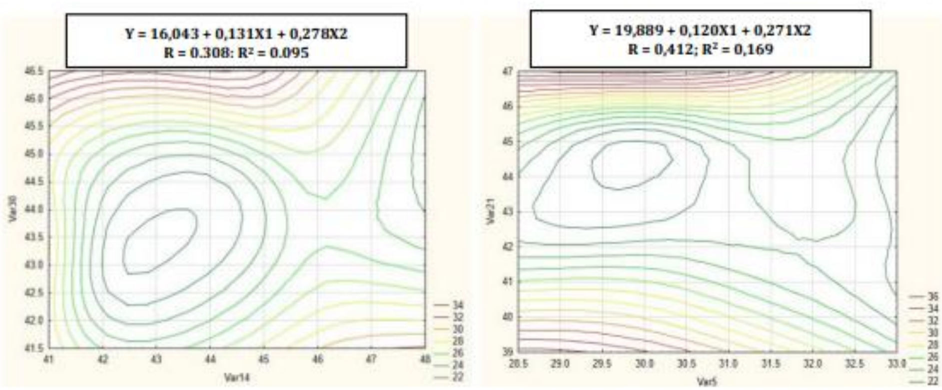
The means and dispersion parameters for NPI corresponding to the groundwater from the experimental field, 2021 – 2022

Experimental variant	N	Mean (X)	Standard deviation (s)	Coefficient of variation (CV, %)
2	20	1.24	0.07	5,64
3	20	1.20	0.05	4,16
4	20	2.23	0.11	4,93
5	20	1.24	0.06	4,83

1 –unfertilized control; 2 organic fertilization with 39.5 t manure/ha; 3 –organic fertilization with 79,4 t manure/ha; 4 – organic fertilization with 118,56 t manure/ha; 5 – fertilizare minerală cu N_{14}:P_7:K_{21}; the differences between any two variants are significant if their values are followed by different letters or gropup of letters.

8. Results concerning the traceability of the organic agricultural inputs (fertilizers) with pollutant potential on soil water and potato culture, Roclas variety

The quantification of the production and qualitative characteristics of the Roclas potato cultivar was carried out in order to estimate the traceability of organic agricultural inputs with polluting potential on the soil, water and crops (Fig. 8.1).



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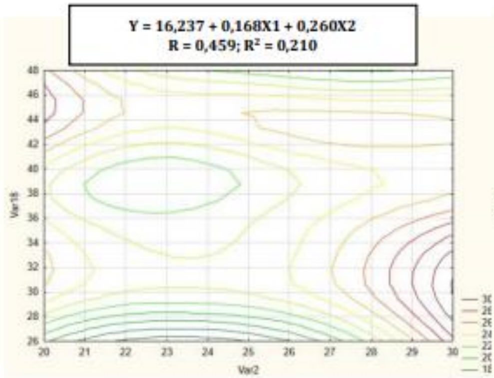
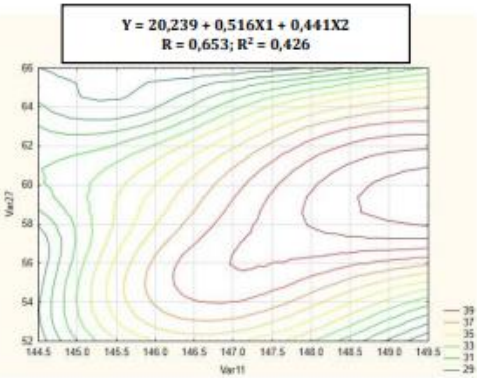
a – V₁ **b – V₂**



c – V3



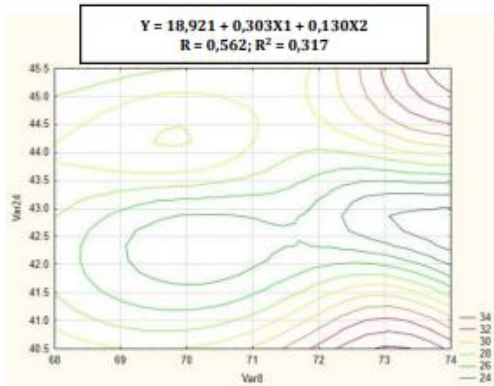
d – V4

Var 2, Var 5, Var 8, Var 11, Var 14 – azotul total din sol/total nitrogen from soil (%);

Var 18, Var 21, Var 24, Var 27, Var 30 – azotul nitric din apa subterană/nitric nitrogen from groundwater (%);

R – coeficientul de corelație multiplă/the coefficient of multiple correlation;

R^2 – coeficientul de determinație/the coefficient of determination.



e – V5

Figure 8.1. The graphical representation of the interrelations between the nitrogen from potato tubers (Y), soil (X1) and groundwater (X2) by using response area graphics

8. Conclusions and recommendations

The type of fertilization (organic and/or mineral), but also the doses of nitrogen administered have different influences on the quality parameters of the soil profile in the experimental field, with the specification that in terms of humus content, it is found that this is the more strongly influenced by the administered organic nitrogen input (F1). The type of fertilization (organic versus mineral) has different influences on groundwater quality parameters. The content of phosphates increased only under the conditions of application of mineral fertilization, while the content in fluorides, magnesium, calcium, ammonium nitrates and sulphides increased only when organic fertilization was used, regardless of the administered dose. Administration of higher doses of organic fertilizer (V4) leads to exceeding the permissible limits for nitrates (63.25 mg/L) and to acidification of groundwater. Organic fertilization with increased doses of nitrogen has a significant impact on the interactions between the content of nitrogen in the soil and water, on the one hand, and the absorption of this element in the plant tissue of potato tubers, on the other. This influence is much stronger compared to situations where no fertilization was applied, lower doses of nitrogen or even mineral fertilization were used.

Following the conduct of research within the doctoral thesis, we consider it appropriate to formulate the following recommendations: ▶ periodic analysis of soil fertility; ▶ implementing water management strategies to minimize high nitrate concentrations; ▶adjusting fertilization practices in accordance with the results of soil and groundwater analyzes in the production field and customizing fertilization practices; ▶ paying more attention to the appropriate dosing of nitrogen fertilizer inputs; ▶ promoting an informed approach in the management of agricultural resources.

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