

RESEARCHES ON THE SOILS POLLUTED WITH PETROLEUM FROM THE NORTH-WESTERN ROMANIA

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Abstract

The researches performed followed to establish the influence of the pollution with different doses of petroleum residues in five versions of concentrations calculated for the ploughed layer (0 – 25cm) in order to establish the possibilities of amelioration of the luvic brown soil polluted with petroleum residues. The land from the experimental field was a natural lawn polluted with petroleum in different degrees, on which was installed a research field in the third decade of month May, when were executed the works of the soi land the fertilization in different doses, then was seeded millet, one of the most tolerant plants to pollution. In the following years the land was cultivated with millet and with spring wheat.

In the first year of effect 1993 the production of millet hay was much smaller in the version without aeration with the ripper and without organic or mineral fertilization compared to the version with ripping, with organic fertilization and maximum dose of mineral fertilizers. The factor of deep aeration by ripping, in the first year of effect, influences the average increase of 4,2 q/ha. We should mention that the degree of pollution of the ripped lots was maximum in two of three repetitions. The factor of organic fertilization accomplishes significant increases of 17,7 – 18,8 q/ha for the doses 50 and 100 t/ha and distinctively significant of 26,9 q/ha at the dose of 150 t/ha farmyard manure, on the ground without deep aeration.

Key words: petroleum residues, millet, wheat production, organic fertilizers, mineral fertilizers

INTRODUCTION

In Romania the pollution with petroleum affects approximately 50100 ha, between the affected counties (Teleorman, Brăila, Galați, Prahova, Dolj, Gorj, Vâlcea, Dâmbovița etc.) being also Bihor county due to the scaffold and refinery from Suplacu de Barcău and the scaffolds from Marghita and Oradea. I. Colibaș and collab. (1995) considers as causes of pollution with petroleum the eruptions of the petroleum drillings, the emissions around the extraction drillings, of the deposits, of the petrol tanks and of petrol products, and the infiltrations in the soil due to the discharges from the pipe buried or some technical defects; the pollution affects especially the superior part of the soil, but with degrees of pollution higher the polluter reached also at the depth of 80 cm, the depth of intrusion being influenced by the quantity and viscosity of the polluter, the time of action on the soil, microrelief, physical and chemical characteristics of the soil.

In the pollution caused by the drilling eruption can take place also processes of salinization of the soil, due to the drilling mud and the underground mineralized waters.

In Bihor county the potential polluters with petroleum are the scaffolds from Suplacu de Barcău, Marghita and Oradea. The greatest polluter is the scaffold from Suplacu de Barcău where it functioned approximately 1000 drillings placed in grid of 50/50, at each drilling being met polluted surfaces with petrol in different degrees.

In 1993, Maria Șandor had the initiative to perform researches regarding the rehabilitation of the soils polluted with petroleum in the laboratory of Pedology and Territorial improvements of the Station of agricultural research, development Oradea. Following the actions of the Institute of Researches for Pedology and Agrochemistry Bucharest, in the national program of research „Monitoring of the quality of soil” (responsible for the program Dumitru M.), theme „Researches for the ecologic rehabilitation of the degraded lands by petroleum residues” (responsible for the theme Dumitru M.), is received financing for the following experiments:

1. Researches regarding the amelioration of some albic pseudogleized luvisoil, degraded with petroleum residues from the Scaffold of Petroleum Products Suplacu de Barcău, Bihor county.

2. Researches on micro lots regarding the influence of the pollution with different doses of petroleum residues on the soil land plant, in the conditions of the luvic brown soil from Oradea.

3. Researches on micro lots regarding the amelioration of the luvic brown soil from Oradea polluted with petroleum residues.

The 3 stationary experiments exist also in the present. The results of the researches performed along the years were published by I.Colibaș and collab. (1995), Maria Șandor and N.C. Sabău (2007), Maria Șandor and collab. (2007), N.C. Sabău (2006, 2007, 2010), Sabău N.C. and collab. (2007, 2008 a, b, 2009 a, b, 2010 a, b, c, 2011 a, b, c).

MATERIAL AND METHOD

Suplacu de Barcău is situated in an area in which the multianual average of precipitations is of 619 mm (following the meteorologic station Nusfalau situated at 10 km away) and an annual average temperature of 10°C. For the cold season (X -III) the multianual average of precipitations is of 205,6 mm, and for the warm season (IV - IX) of 413.4 mm. The soil on which is placed the experiment is an albic pseudogleized luvisoil, with phreatic water at the depth greater than 10 m.

The three factors experiment from Suplacu de Barcău was placed in 1993 by the method of randomized blocks with subdivided lots. The number of repetitions: 3. The surface of an experimental lot 40 m² (4x10).

The experimental device from Suplacu de Barcău is the following:

Factor A: working the soil.

a1 = normal ploughing

a2 = scarification at 0,5 m distance / 0,6 m depth

Factor B: doses of manure

b0 = 0,0 t/ha

b1 = 50,0 t/ha

b2 = 100,0 t/ha

b3 = 150,0 t/ha

Factor C: doses of NPK

c1 = N – 0 P – 0 K – 0 kg/ha s.a.

c2 = N – 100 P – 80 K – 70 kg/ha s.a.

c3 = N – 200 P – 160 K – 140 kg/ha s.a.

c4 = N – 300 P – 240 K – 210 kg/ha s.a.

The land on which was placed the experiment was a natural lawn polluted with petroleum in different degrees. The staff of the laboratory of Pedology and Territorial improvements created the research field in the third decade of month May, when were executed the works of the soil, the fertilization. The land was seeded with millet, one of the most tolerant plants to pollution. In the following years the field was cultivated with millet and with spring wheat.

In Oradea, the researches began in 1993 by placing two experiments with micro lots. The researches were developed on the preluvosoil from the Station of agricultural research, development Oradea. The multiannual average of the precipitations registered at the Meteorological station Oradea is of 635 mm; in the year of placing the experiments were registered 111,2 mm less precipitations. The average annual temperature in Oradea is of 10,3°C and in the year of placing the experiments this was over the multiannual average with 0,9°C.

The experiment with microlots for the establishing of the influence with different doses of petroleum residues included five versions of concentrations calculated for the ploughed layer (0 – 25cm):

V1 = 0%;

V2 = 1%;

V3 = 3%;

V4 = 5%;

V5 = 10%;

The surface of an experimental surface: 1m².

Number of repetitions 4.

After the digs between the micro lots were made was applied the petroleum brought from Suplacu de Barcau in the established doses.

The pollutant was applied from the beginning of month August and the time of absorption was of:

- 2 hours for the dose of 1% (3 l/m²)

- 6 hours for the dose of 3% (9 l/m²)
- 9 hours for the dose of 5% (15 l/m²)
- 24 hours for the dose of 10% (30 l/m²)

The land was processed manually with the spade and rake. The micro lots were seeded with millet using a machine for micro lots manually hauled. In this experiment were not applied fertilizers, being followed only the effect of the pollution.

For the determination of the physical and chemical properties of the soil from the experiment, were harvested soil samples from the layers 0 – 20 cm and 20 – 40 cm, the average sample on micro lot resulting from 5 individual tests.

The experiment with micro lots for the establishing of the possibilities of amelioration of the luvic brown soil polluted with petroleum residues is three factorial, the factors used being the following:

Factor A – degree of pollution;

a1 = without pollution;

a2 = pollution; 3%;

Factor B: dose of farm yard manure;

b1 = 0,0 t/ha

b2 = 50,0 t/ha

b3 = 100,0 t/ha

b4 = 150,0 t/ha.

Factor C: dose of NPK (kg/ha s.a.)

c1 = N₀P₀K₀

c2 = N₁₀₀P₈₀K₇₀

c3 = N₂₀₀P₁₆₀K₁₄₀

c4 = N₃₀₀P₂₄₀K₂₁₀.

The experiment was placed after the method of the latin retangle, with subdivided lots; the surface of a microlot: 1 m². The number of repetitions: 4. The harvest of the samples of soil for analysis was made as in the previous experiment.

The dose of pollution calculated and applied was of 9 l/m². Between the microlots were accomplished digs for impeding the discharge of petroleum from a lot to another.

After the absorption of the petroleum was applied farm yard manure; this was included with the spade and then were applied the chemical fertilizers. The germinative bed for millet was prepared manually and the seeding was accomplished with a machine of lots manually hauled.

RESULTS AND DISCUSSION

The partial results obtained at Suplacu de Barcău

Climatic indices of the initial field before the placing of the experiment are presented as the following:

- the reaction of the soil on the ploughed layer had values between 4,9 and 5,2 units pH, being strongly acid; on the soil layer from 20 – 40 cm depth, the reaction of the soil is maintained in the same field (pH = 4,99 – 5,21).

- the mineral nitrogen accesible has values between 3,3 ppm și 10,1 ppm on the ploughed layer and on the layer between 20 – 40 cm the values are between 3,4 and 7,8 ppm. By the content in $N - NO_3 + N - NH_4$ the soil has a mediocre supply.

- the mobile Phosphorus has values between 41 and 50 ppm, the supply with this element being good.

- the mobile Potassium has values between 99 and 127 ppm on the ploughed layer and between 105 and 155 ppm. The supply of the soil with mobile Potassium is good.

In the first year of effect 1993 the production of hay millet has varied between 36,5 q/ha for the version without aeration with the ripper and without organic or mineral fertilization and 86,6 q/ha in the version with ripping, 50 t/ha farmyard manure and the maximum dose of mineral fertilizers ($N_{300}P_{240}K_{210}$).

The factor deep aeration by ripping, in the first year of effect, influences the average increase of 4,2 q/ha. We should mention that the degree of pollution of the ripped lots was maximum in two of three repetitions.

The factor of organic fertilization accomplishes significant increases of 17,7 – 18,8 q/ha at the doses of 50 and 100 t/ha and distinctly significant at 26,9 q/ha for the dose of 150 t/ha farmyard manure, on the ground without deep aeration.

The increases accomplished on the ground with ripping are all distinctly significant, between 20,5 – 22,7 q/ha.

The ground of mineral fertilization on the ground without deep aeration accomplishes a very significant increase of 22,2 q/ha at the maximum dose of $N_{300}P_{240}K_{210}$. On the ground of ripping were obtained significant increases of 11,8 q/ha (21%) at the dose of $N_{200}P_{160}K_{140}$ and very significant of 20,3 q/ha (37%) at the maximum dose.

The results of the researches regarding the influence of the pollution with different doses of petroleum residues on the soil plant in the conditions of the preluvosoil from Oradea.

In 1996 and 1997 the experiment was cultivated with autumn wheat (Table 1).

Table 1

Influence of the pollution of the soil with different doses of petroleum on the production of autumn wheat in the conditions from Oradea

Version	1996			1997		
	Production			Production		
	q/ha	%	Significance st	q/ha	%	Significance st
1. Without pollution	21,8	100	Mt.	20,9	100	Mt.
2. Pollution with petroleum 1%	16,5	75,6	00	16,2	77,5	-
3. Pollution with petroleum 3%	10,7	49,1	000	13,8	66,0	0
4. Pollution with petroleum 5%	8,7	39,9	000	10,8	51,7	00
5. Pollution with petroleum 10%	5,5	25,2	000	8,6	41,1	000
	DL 5%	3.62		5.47		
	DL 1%	5.08		7.68		
	DL 0.1%	7.17		10.84		

In all the cases of pollution with petroleum were registered losses of production. In the first year of effect these losses were greater than in the second year of effect. At the concentration of 1% petroleum compared to the non polluted witness in 1996 was registered a loss of wheat production (53 q/ha) distinctly significant statistically, and in 1997 was registered a loss of production (4,7 q/ha) non significant statistically. At the concentration of 3% the loss of production was significant statistically (11,1 q/ha) in 2006 and significant statistically (7,1 q/ha) in 2007. In the version with concentration of 5% petroleum, compared to the non polluted witness was registered a loss (13 q/ha) very significant statistically in 1996 and a loss (10,1 q/ha) distinctly significant statistically in 1997. At the concentration of 10% the losses of production were significant statistically in 1996 (16,3 q/ha) and in 1997 (12,3 q/ha).

In years 3, 4 and 5 of effect the experiment was cultivated with spring wheat (Table 2).

Table 2

Influence of the pollution of the soil with different doses of petroleum on the production of spring wheat in the conditions from Oradea

Version	1997			1998			1999		
	Production			Production			Production		
	q/ha	%	Significance st.	q/ha	%	Significance st.	q/ha	%	Significance st.
1. Without pollution	8.7	100	Mt.	8.1	100	Mt.	5.8	100	Mt.
2. Pollution with petroleum 1%	7.7	88.5	-	7.6	93.8	-	4.6	79.3	-
3. Pollution with petroleum 3%	5.8	66.7	00	5.8	71.6	00	4.1	70.6	00
4. Pollution with petroleum 5%	5.2	59.7	00	5.6	69.1	000	3.8	65.5	00
5. Pollution with petroleum 10%	4.1	47.1	000	4.1	50.6	000	3.3	56.9	000
	DL 5%	1.02		1.13			0.92		
	DL 1%	2.55		1.78			1.34		
	DL 0.1%	3.90		2.54			2.06		

The concentration of 1% petroleum did not influence significantly statistically the production of spring wheat obtained in years 3, 4 and 5 of effect. At the concentrations of 3 and 5% of petroleum the differences compared to the witness were distinctly significant statistically. At the concentration of 10% of petroleum the productions of spring wheat were very significant statistically smaller than the productions registered in the non polluted witness with petroleum in years 3, 4 and 5 of effect.

The results of the researches on micro lots regarding the amelioration of the luvic brown soil from Oradea polluted with petroleum residues.

In the first year of effect, the pollution with residues of petroleum in concentration of 3% has determined an average loss on the versions studied of 6,4 q/ha (22,0%) millet hay. The increase of the doses of farmyard manure and chemical fertilizers used, determined the increase of the production of millet hay (Table 3).

Table 3

The influence of the pollution with different doses of petroleum and of the organic and mineral fertilization on the millet harvest (q/ha), in the conditions of the luvic brown soil from Oradea, in year 1993 (the first year of research)

B = Doses of organic fertilization – t/ha	C= Doses of mineral fertilization				The average of organic fertilization		
	c - 0	c - 1	c - 2	c - 3	q/ha	%	dif.
a – 1 Without pollution							
b - 0	17.7	24.8	27,1	27,7	24,3	100	-
b - 1	22.0	26.8	27,3	30,1	26,5	109	2,2
b - 2	25.8	28.1	31,0	32,7	29,4	121	5,1 ^x
b - 3	29.0	37.2	40,0	42,1	37,1	153	12,8 ^{xxx}
The average of mineral fertiliz. q/ha %	23.6	29.2	31,3	33,1	29,3		
Difference q/ha	100	124	133	140			
	-	5,6 ^{xxx}	7,7 ^{xxx}	9,5 ^{xxx}			
a – 2 Pollution with petroleum residues of 3%							
b - 0	13.5	20.9	21,6	24,7	20,2	100	-
b - 1	18.9	22.1	23,3	25,2	22,4	111	2,2
b - 2	20.5	23.0	24,6	26,0	23,5	116	3,3
b - 3	22.4	24.0	26,2	29,1	25,4	126	5,2 ^{xx}
The average of mineral fertiliz. q/ha %	18.8	22.5	23,9	26,3	22,9 ^x		
Difference q/ha	100	120	127	140			
	-	3,7 ^{xxx}	5,1 ^{xxx}	7,5 ^{xxx}			

DL	5%	1%	0.1%
A to A	6.26	11.50	25.49
B to B	3.61	4.95	6.74
C to C	1.91	2.54	3.29
B to A	5.12	7.03	9.56
A to B	7.51	12.31	23.50
C to A	2.71	3.60	4.66
C to B	3.82	5.09	6.59
B to C	4.90	6.62	7.50
A to C	6.60	11.52	24.03
C to A and B	5.38	7.18	9.29
B to A and C	6.95	9.39	10.64
A to B and C	8.80	13.50	23.35

b0 = 0 t/ha manure
 b1 = 50 t/ha gunoi de grajd
 b2 = 100 t/ha gunoi de grajd
 b3 = 150 t/ha. gunoi de grajd
 c0 = N₀P₀K₀
 c1 = N₁₀₀P₈₀K₇₀
 c2 = N₂₀₀P₁₆₀K₁₄₀
 c3 = N₃₀₀P₂₄₀K₂₁₀.

CONCLUSIONS

The land from the experimental field was a natural lawn polluted with petroleum in different degrees, on which was installed a research field in the third decade of month May, when were executed the works of the soi land the fertilization in different doses, then was seeded millet, one of the most tolerant plants to pollution. In the following years the land was cultivated with millet and with spring wheat.

In the first year of effect 1993 the production of millet hay was much smaller in the version without aeration with the ripper and without organic or mineral fertilization compared to the version with ripping, with organic fertilization and maximum dose of mineral fertilizers. The factor of deep aeration by ripping, in the first year of effect, influences the average increase of 4,2 q/ha. We should mention that the degree of pollution of the ripped lots was maximum in two of three repetitions. The factor of organic fertilization accomplishes significant increases of 17,7 – 18,8 q/ha for the doses 50 and 100 t/ha and distinctively significant of 26,9 q/ha at the dose of 150 t/ha farmyard manure, on the ground without deep aeration.

REFERENCES

1. Brejea R., 2010, Știința solului – îndrumător de lucrări practice. Editura Universității din Oradea.
2. Brejea R., Domuța C., 2011, Practicum de pedologie. Editura Universității din Oradea.
3. Brejea R., 2011, Practicum de tehnologii de protecție a solurilor. Editura Universității din Oradea.
4. Brejea R., 2014, Tehnologii de protecție a solurilor. Editura Universității din Oradea.
5. Domuța C., 2006, Agrotehnica diferențiată, Editura Universității din Oradea.
6. Domuța C. coord., 2008, Asolamentele în sistemele de agricultură. Ed. Universității din Oradea.
7. Domuța C. coord., 2012, Cercetări agricole în Oradea. Ed. Universității din Oradea.
8. Domuța C., 2012, Agrotehnica. Editura Universității din Oradea.
9. Sabău N. C., Șandor M., Domuța C., Jurcuț T., Brejea R., Domuța Cr., 2006, Aspects regarding the soil pollution by petroleum in the Bihor County - Programul celei de a XVIII-a Conferințe Naționale de Știința Solului cu Participare Internațională „100 de ani de Știința Solului în România” “Management and Soil Resources Use, Agrienvironment Protection and Rural Development from Central and North-Western Romania” – Cluj-Napoca 20-26 august.
10. Sabău N. C., Șandor M., 2006, The influence of the soil pollution with petroleum on the millet productions – The annals of the University of Oradea, Fascicle Environment Protection, Vol. XI, Year XI, ISSN 1224-6255, pp.227-236,
11. Sabău N. C., 2007, The link between agricultural crops and the oil concentration of polluted soil - Bulletin of University of Agricultural Sciences and Veterinary

- Medicine Cluj-Napoca Vol. 63, pp. 106 – 111, Print ISSN: 1843-5246, Electronic ISSN: 1843-5386.
12. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2008, The Influence of the Climate Conditions from Oradea, Romania on the Biodegradation of oil on a polluted soil - Journal of Agricultural Sciences, Debrecen, HU – ISSN 1588-8363, pp 258-265, pg. 354.
 13. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2008, The optimum of the climate conditions from Oradeam implicated on the biodegradation of oil on a polluted soil – Buletinul Științific al Universității “Politehnica” Timișoara, Romania, Seria Hidrotehnică, Volum aniversar cuprinzând lucrările simpozionului “60 de ani de Învățământ Hidrotehnic la Timișoara” Tomul 53(67), Fascicula 1, pp. 87 – 82, pg. 224.
 14. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2009, The estimation of degraded oill with the maximum of spring wheat yields on a prluvosoil from Oradea, Romania,- International Symposia “Risk Factors for Environment and Food Safety” & “Natural Resources and Sustainable Development” Oradea, Analele Universității din Oradea, Fascicula Protecția Mediului, Environmental Engineering, Vol XIV, Anul 14, Ed. Univ. din Oradea, I.S.S.N. 1224 – 6255, pp. 1131-1138, pg. 1150, November 6 – 7.
 15. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2009, The influence of the climate conditions on wheat yields, cultivated on a luvosoil from Oradea, controlated polluted with oil, Symposium “Trends in European Agriculture Development”, University of Agricultural Sciences and Veterinar Medicine of the Banat, Timișoara and University of Novi Sad, Research Journal of Agriculture Science, vol 41(1), Section 1 Field Crops Agroprint Editorial Timișoara ISSN 2066-1843, pp.108-117,pg. 522, 14-15 may.
 16. Sabău N. C., 2010, The link yield losses, climate conditions on a preluvosoil, polluted under control with oil, International Symposium “Trend In The European Agriculture Development”, Banat’s University of Agricultural Sciences and Veterinary Medicine Timișoara, Faculty of Agriculture and University of Novi Sad, Faculty of Agriculture, Timișoara, may 20-21.
 17. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2010, The influence of the fertilizer system on the petroleum residues biodegradation on a preluvosolil under control polluted,”Naturale Resources And Sustainable Development” International Scientific Symposium on Adaptation to climate change, Debreceni Egyetem, Journal of Agricultural Sciences, Acta Agraria Debreceniensis Suppliment, pg. 252-255.
 18. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2010, The effect of fertilizers concerning the millet yields on a soil under control polluted by petroleum residues - International Symposia “Risk Factors for Environment and Food Safety” University of Oradea, Faculty of Environmental Protection, Fascicula Protecția Mediului, Environment Engineering, Vol XIV, Anul 15, Ed. Univ. din Oradea, I.S.S.N. 1583 – 4301, I.S.S.N. (Ed. română): 2065 – 3476, I.S.S.N. (Ed. maghiară): 2065 – 3484, pp. 952-959, pg. 1565, November, 5 – 6, Oradea.
 19. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2010, Some aspects of the phytoremediation upon a Haplic Luvosoil under control polluted with crude oil from Oradea, Romania - Bulletin of University of Agriculture and Veterinary Medicine Cluj, Napoca – Agriculture, Volume 67 (2) pp. 111-118, Print ISSN 1843-5246, Electronic ISSN 1843-5386.

20. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2011, The link between agricultural crop and fertilizer system on a haplic luvisols under control polluted with crude oil, from Oradea, Bihor county - International Symposium "Trends in the European agriculture development", May 19 – 20, Timișoara, Romania.
21. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2011, The role of organic matter in the biodegradation process of crude oil from the soil – International Symposia "Risk Factors for Environment and Food Safety" & "Natural Resources and Sustainable Development" & "50 Years of Agriculture Research in Oradea", Faculty of Environmental Protection, pp 914 – 921, November 4 -5, Oradea.
22. Sabău N. C., Șandor M., Domuța C., Brejea R., Domuța Cr., 2011, The influence of the fertilizers in phytoremediation process upon a haplic luvisol polluted with crude oil from Oradea, Romania – Conference Program, International University of Alba Iulia (U.A.B. – B.En.A.) Balkan Environmental Association "Environmental Engineering and Sustainable Development" Alba Iulia, România, May 26-27th.
23. Șandor M., 1999-2003, Reports ICPA București, unpublished data
24. Șandor M., Sabău N. C., 2007, The influence of soil pollution by petroleum on millet yields - Analele Universității din Oradea, Fascicula Silvicultură, Vol XII, Anul XII, pp. 319 – 326.
25. Șandor M., Sabău N. C., Domuța C., Domuța Cr., Brejea R., 2007, The influence of soil oil pollution on agricultural crops, Joint International Conference on Long-term Experiments, "Agricultural Research and Natural Resources Debrecen-Nyírlugos", HU- ISBN.978-963-473-054-5, pp.304-311, 31st May – 1st June.