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TOPOGRAPHICAL SURVEYS NEEDED FOR THE ASSESSMENT OF OIL AND SALT WATER POLLUTION OF A PASTURE

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INTRODUCTION

The soil salinity (in fact, anthropogenic salinisation) is a global problem (Schofield et al. 2001) and therefore increased attention has also been given to this subject. At global level, more than 800 million hectares of land are affected by salinity (FAO 2008). Romania is one of the European countries with the largest areas affected by salinity, with 484.835 hectares in 2009.

Many researchers around the globe have documented their findings on the negative impact of soil salinity on physiological and metabolic activities of most agricultural crops (Aredehey et al. 2018; Asfaw et al. 2018; Jouyban 2012; Mensah et al. 2006; Mosley et al. 2017; Nasri et al. 2015).

The problems associated with soil salinity, are most often associated with other abiotic stress factors such as drought and phosphorus deficiency. Consider also that all plants are sensitive to salts at a certain concentration. The critical threshold varies from species to species and from plant to plant, the sensitivity of plants being according to species, stage of development and duration of osmotic stress (Eynard et al. 2006). Soil salinity affects growth of plants by the osmotic pressure created within the plants, which delay the plant roots to take water smoothly (Corwin and Lesch 2003). The plant growth can be limited by salt in soil solution due to the toxicity or nutrient imbalance in the root zone (Thomas et al. 2007).

Oil production activities generate wastes, which contaminate the soil and groundwater (Metwaly et al. 2013). The physicochemical properties of groundwater are affected by the occurrence of oil spill in permeable sediments due to the creation of organic acids, the enrichment of groundwater with Fe^{2+} and Mn^{2+} cations, and outgassing of CO_2 (Atekwana et al. 2000). For example, the processed oil-contaminated soil is characterized by low resistivity due to chemical degradations and increase in the level of total dissolved solids created by bacterial action (Sauck 2000; Shevnin et al. 2005).

Oil contamination modifies the physical properties of forest soils after the chainsaw use. Oil between 100 g/m^2 and 200 g/m^2 causes a decrease of 4% up to 10% in air-filled porosity compared with unpolluted soil. The addition of oil to soil induces in the increased water resistance of different size aggregates (Iwan et al. 2015).

The association of laboratory analysis with spatial soil data using geographic information systems (GIS) allows a better assessment and monitoring for salt extension (Wulf et al. 2015; Triki Fourati et al. 2017; Yahiaoui et al. 2015). The spatial distribution of soil properties is influenced by topographical aspects, like surface shape and position in landscape (Brito et al. 2010; Epron et al. 2006).

The topographical surveys (planimetric and levelling) play a fundamental role in establishing the degraded lands, by means of a normal or excessive activity of oil exploitation. As an alternative to our proposed method would be the detection of soil by infrared spectroscopy (Wartini et al. 2017), but this method would be better suited to large areas, eventually unified cadastral parcels.

In this paper we studied a land (in cadastral documents it is a private property, with pasture use) in terms of oil and salt water pollution. This approach allowed us to easily indicate the real polluted surfaces and, along with the identified samples, to determine how pollution occurrs, its effect on soil, without neglecting the proposed solutions in order to fix this problem. The proposed method does not require new remote sensing technique, used by other authors (for example, Triki Fourati et al. 2017), the surface being small (5.6 hectares) and the owner physical person. But there are a lot of such surfaces, with individual owners. What we propose does not lead to high costs. Anyone can afford to pay measurements that are generally executed in order to obtain a cadastral number. Also, water and soil samples can be studied at the nearest research institutes, but also in the university's laboratories.

MATERIALS AND METHODS

The studied area is characteristic of a climate with cold and humid winters, with the coldest temperature below -3 °C and the temperature of the warmest month above 10 °C.

The amount of water in precipitation is greater than that lost in evapotranspiration, which is a factor that allows the penetration of polluted water into the depth of the soil. The average of the multiannual rainfall occurring during the vegetation period is 439.4 mm at the nearby Pitesti weather station. The fairly large differences in precipitation in different years, as well as the deviations from the average, indicate a climate that in some periods can lead to deficiencies or excess water in the soil.

The average annual potential evapotranspiration is 662 mm in Pitesti, while the average real evapotranspiration records lower values of only 604 mm at the same weather station.

The water deficit in the soil versus the potential evaporation is 38 mm in Pitesti (with a maximum in August of 44 mm). The predominant wind direction is from the west (19.2%) and northwest (19.5%). The calm is set for 29.3% of the number of days in a year.

In the case of fragmented platform relief with narrow valleys that extend into erosion basins with forests present in the area, climatic conditions undergo a series of changes due to exposure, inclination, color and texture soil. So, in the case of the nordic slopes, around the forests on the valleys with cold currents, the air temperature is generally lower by 1.5-2 °C.

From the point of latitude, the whole area is at the southern boundary of the forest area in the immediate vicinity of the bioclimatic area of the silvosteppe.

The natural vegetation, mostly in some cases disappeared either by deforestation or by the cultivation of meadows, is preserved on small areas.

Recognizing the property as a field location, identifying the nodes of the major control network of this area and pegging out the traverse stations were required in order to write this paper.

The measurements were performed with a Total Station South NTS-350 having the following technical performances: precision angle measurements 5", 1 mgon, distance measurements 2500 m Reflector 3 mm + 2 ppm, measurement times 1 s. SOKKIA GPSes, Stratus model, 12-channel signal L1, C/A code, precision 1–5 m, 5 mm, cold start 2 min, 45 s warm start, resume 3 s, internal antenna were also used. After recognizing the land and surroundings, in order to identify points within the geodetic network of the known coordinates which allow the connection to the stereographic system 1970 and ensure the required accuracy, the creation of 4 points of support (by GPS technology) was considered to be necessary. Then a supported traverse of 5 stations was conducted. The planimetric and levelling survey of the topographical details was conducted, determining the actual position of the characteristic points.

The surface and distances between points on the outline were calculated from the coordinates. Measurement verification was done by comparing, in the field book, the coordinates of the points checked from the station and the distances obtained from coordinates, to the distances obtained through direct measurements.

It was noticed that the result of the measurements as well as the discrepancies in closing were within the admitted norms. The drawing up of the final plan and the determination of the areas were performed with a specialized software (ACAD), providing a high accuracy of calculations as well as accurate graphics. The property layout plan with indication of borders drawn at 1:500 is showed in Fig. 1.

Fig. 1. Property layout plan with indication of borders and its position on orthophotomap

Soil samples were collected by opening three profiles of which a number of disturbed samples were taken (in plastic bags) and several undisturbed samples (in metal cans). Stagnant water on the soil surface coming from rainfall was also taken. For determining the hydrocarbons in the water sample, the legislation according to which ground and surface water containing more than 0.1 mg/dm^3 hydrocarbon oil is considered to be polluted, was used. The element that was taken into consideration for the acidification procedure was the pH value and for the degree of salinity were the mineral and conductometric residue at 105 °C, chlorides, sulfates, calcium, magnesium and sodium.

In the laboratory phase, physical and chemical analyzes were conducted on the soil and water samples according to the methodology suggested by Florea et al. (1987).

All sampling points were located using the GPS, the coordinated being recorded in the Stereo 70 system, including the absolute altitude. The type of soil, hydrophysical properties such as: apparent density, penetration resistance, saturated hydraulic conductivity, total porosity were identified.

The obtained data were systematized and then the results were interpreted according to the methodology suggested by Florea et al. (1987), Order 161/16.02.2006 of Ministry of Environment and

Water Management for approving the normative regarding the classification of the quality of surface waters in order to establish the ecological status of water bodies and Order 756/1997 concerning the Reglementation regarding evaluation of environment contamination, modified and completed by Order 592/2002 and Order 1144/2002.

The methods of analysis and methodology of analytical data interpretation are in accordance with the international standards.

Regarding the pasture, as dominant land use within the studied area, the cormophyte species were identified according to the reference work of Sârbu et al. (2013).

From a chemical point of view, the soil reaction, the soil organic matter, the carbon/nitrogen ratio, the content of mobile phosphorus and potassium, the sum of the bases, the hydrolytic acidity, the content of exchangeable sodium and the degree of pollutants and soluble salts were taken into consideration.

RESULTS AND DISCUSSIONS

A normal surface of oil exploitation resulted from the surveys that were carried out (846 m^2 the surface related to a drill without derrick), but also an exceedance of the limit of exploitation, which resulted from an excessive activity (the wells numbered I, II, VII, IX and roads in general). The location of ground surveys (S1, S2 and S3) and water (A) by GPS is showed in Figs. 2, 3, 4 and 5.

The stagnant water (Fig. 6) is loaded with hydrocarbons over the permissible limit (1.67 mg/l), with the risk of infiltration into the soil or its evaporation, resulting in the deposition of pollutants at the soil surface.

The salinity regime of the collected water classifies it, depending on the chemical elements and mineral residue, into quality classes from I (very good), II (good), III (moderate) to IV (poor), as shown in Fig. 7.

The identified soil type was Hypostagnic Luvisol, with a succession of the At-Ao-AE-horizons in the first 20 cm, Elw-EBw- between 20 and 40 cm, Bt1w-Bt2w- from 50 to 70 cm and C at 80–100 cm. Water from rainfall or technological accidents has infiltrated from the top layer of the soil, then it got accumulated in the Bt horizon producing strong moisture or it even led to the appearance of a layer of stagnant water which can be loaded with oil or soluble salts.

During periods of heavy rainfall, the infiltrated water was united with the layer of stagnant water leading to soil moisture uniformity, i.e. to a recontamination. During dry periods, cracks occur at the level of Bt horizon. Soil loaded with pollutants penetrates through these cracks. Thus, oil and soluble salts pollution reaches the soil depth.

The movements at the soil surface led to the formation of a mulch layer which brought pollutants from depth to surface.

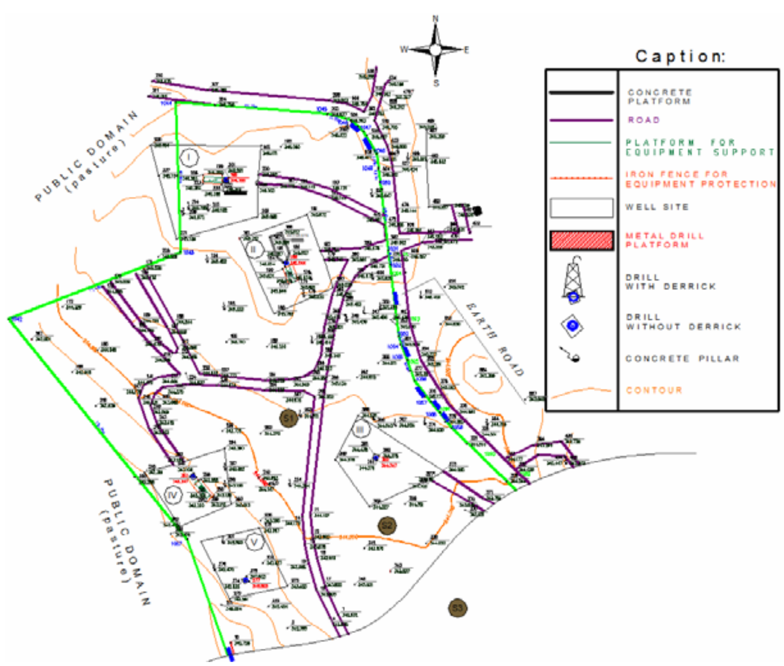

Fig. 2. The plan which includes planimetric and level related details, along with the location of soil and water surveys (S1, S2)

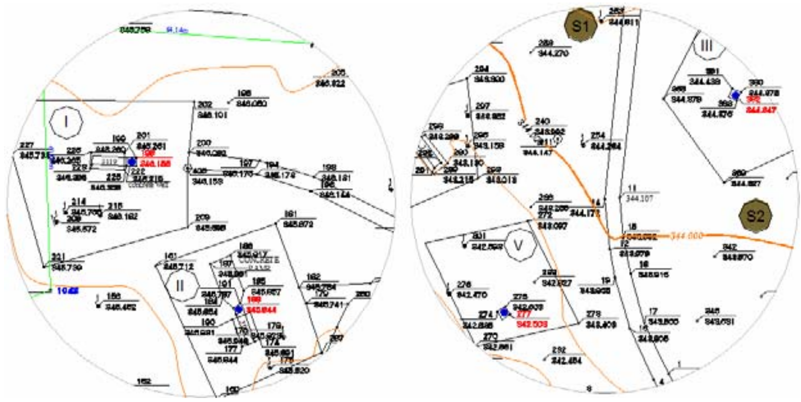

Fig. 3. Details of the property in northern side

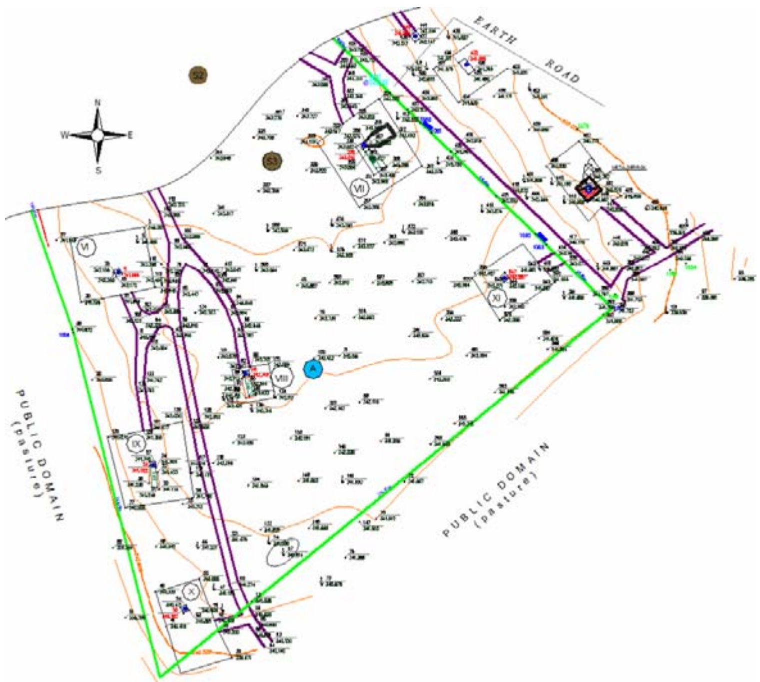

Fig. 4. The plan which includes planimetric and level related details, along with the location of soil and water surveys (S3, A)

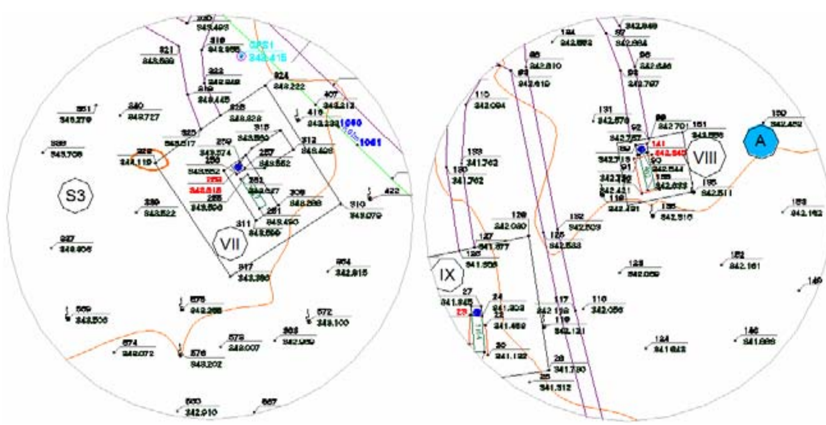

Fig. 5. Details of the property in southern side

Fig. 6. Stagnant water at the soil surface

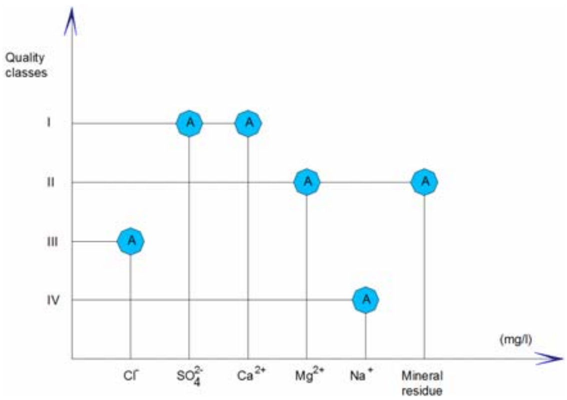

Fig. 7. Classification of water sample quality, according to Order 161/2006

The result of the hydrophysical analysis marked out how soil resists to the agricultural activities or improvements and how it favors or prevents infiltration of the surface water and their circulation.

The density was placed at the boundary between high and very high to the base of the layers. Starting with EB horizon, the water infiltration into the soil is more difficult.

The total porosity is very small, classifying the soil into strongly settled which makes water infiltration difficult.

Resistance to penetration is small in the eluvial horizon and then it grows in the transition horizon to the base layer. According to the hydraulic conductivity, water stagnation is estimated to a depth of 45–50 cm, making infiltration difficult.

The soil reaction is slightly acid with a pH of 6.8 at the surface and moderate to slightly acid in depth.

There are however horizons with a weak alkaline reaction due to the presence of the exchangeable sodium (survey S2).

The content of organic matter depended on the location of the sampling site which first took place on grassy field, then on the natural or anthropic peeled surfaces and finally within the soil crust made of petroleum fractions in various stages of degradation.

Table 1. The analytical results of soil samples from S1

The depth of sampling (cm)	**pH**		**Humus content %**		**Content of soluble salts %**		**Petroleum residue %**	
	value	**interpretation**	**value**	**interpretation**	**value**	**interpretation**	**value**	**interpretation**
0-20	6.25	weak acid	0.60	extremely small	0.156	medium	0.313	small
20-40	5.28	moderate acid	0.59	extremely small	0.156	medium	0.124	very small
40-60	3.98	very strong acid	0.61	extremely small	0.335	high	0.074	extremely small
60-80	3.72	very strong acid	0.97	extremely small	0.454	high	-	-
80-100	3.80	very strong acid	1.02	very small	0.469	high	-	-

Table 2. The analytical results of soil samples from S3

The depth of sampling (cm)	**pH**		**Humus content %**		**Content of soluble salts %**		**Petroleum residue %**	
	value	**interpretation**	**value**	**interpretation**	**value**	**interpretation**	**value**	**interpretation**
0-20	5.28	moderate acid	2.31	small	0.080	small	0.290	small
20-40	5.37	moderate acid	1.01	very small	0.056	small	0.135	very small
40-60	4.67	very strong acid	1.03	very small	0.061	small	0.065	extremely small
60-80	4.70	very strong acid	1.14	very small	0.053	small	-	-
80-100	4.87	very strong acid	0.91	extremely small	0.051	small	-	-

The soil is poor in nitrogen, except for the grassy surface. For the carbon/nitrogen ratio high values were obtained, unevenly distributed according to the amount of oil spilled. In the S2 sample, the high value takes place in the soil depth, where a higher oil residue is recorded.

The phosphorus content was very low, decreasing with depth. The content of mobile potassium is low in the first 39 cm and moderate in depth. The sum of the bases fell into middle value. The values for the hydrolytic acidity did not exceed the lower class. The content of exchangeable sodium decreases from the surface to the bottom of the eluvial horizon.

Regarding the degree of soluble salt load, the differentiation of the samples was noted. Thus, in the S1 survey, in the first 40 cm the salt content was middle, below this depth and to the base of the layer being high.

Basically, the entire Bt horizon was contaminated with soluble salts (Table 1). In the S2 survey, the first 20 cm resulted as being desalinized. From 20–40 cm the degree of salinization was low and from 50 to 100 cm in depth, the soil was moderately salinized. The S3 survey had in the entire depth a small amount of soluble salts, the water stagnation loaded with soluble salts being long-lasting (Table 2).

The natural vegetation is represented by degraded mesophilic pastures, which retains remnants of the past floristic composition represented by: *Lotus corniculatus*, *Taraxacum officinale*, *Veronica chamaedrys*, *Daucus carota*, *Achillea millefolium*, *Agrostis capillaris*, *Plantago lanceolata*, *Ranunculus acris*, *Cerastium fontanum* subsp. *vulgare*, *Rumex acetosa*, *Trifolium pratense*, *Trifolium repens*, *Schedonorus pratensis*, *Poa pratensis*.

The species having the largest coverage in these pastures is *Calamagrostis epigejos*, highly resistant to oil pollution, considered to be a bioindicator in case of pollution with heavy metals. Ranđelović et al. (2018) show that *Calamagrostis epigejos* has the capacity to accumulate heavy metals in the soil and stores it in the roots thereby can be used for phytoremediation.

The pasture habitats are invaded by scrubs with *Prunus spinosa*, *Crataegus monogyna*, *Rosa canina*, *Ulmus minor*, *Malus sylvestris*, *Populus alba*, *Populus tremula*. From place to place there are also micro-depressions with excessive humidity where the species *Juncus effusus*, *Phragmites australis*, *Typha latifolia* dominate.

Although the amount of fodder plants of the pastures is still low, grazing is practiced. We also noticed the existence of a temporary shelter for sheep within the studied area. The anthropozoic impact is highlighted by the presence of the ruderal species: *Dipsacus laciniatus*, *Carduus acanthoides*, *Rumex obtusifolius*.

The studied land is affected by a physical pollution highlighted by soil settlement and reduction of grazing areas. The problems are created by the equipment used in the settlement of well sites, drilling and maintenance equipment.

As a result of strippings, excavations, storage of various materials, the natural relief has changed, anthropical micro-depressions or artificial mounds of various materials being formed. There are areas which are unnecessarily occupied with gravel, areas occupied by some new undesigned roads, unused overground pipes. The removal of any remnants of human activity as well as the restoration of the upper soil layer and clear delimitation of well sites is necessary.

For the physical improvement, a stripping of 30 cm of the peeled surfaces resulting from salinization and oil residue near the II, III, VII drills is proposed.

Oil residues that have polluted are well established changing in time under the influence of natural factors and microorganisms in the soil, into organic matter.

Therefore, the main restrictive pollutant is represented by the salt water. The degree of soil load with oil was quite low given that pollution first occurred long time ago. The pollution comes from the well sites spills or the cracks of the pipelines transporting oil to the oil field.

The S1 and S3 surveys confirms pollution of the first 60 cm of soil with oil residues, the loading degree decreasing from surface to depth. The S3 survey is affected by pollution throughout the profile, but the pollution is weak.

From a pedo-ameliorative point of view, we recommend deep soil loosening to remove the excess of rainwater soaked with salt water and oil that stagnate at the level of Btwy horizon, making the soil surface to be permanently supplied with pollutant, creating an aerated environment in which the bacterial microflora develops and resists oil and salt water pollution.

We also recommend liming for the optimization of soil reaction, a determinant for the development and activity of soil microorganisms, by creating an optimal environment that leads to more intensive biodegradation processes, resulting in soil decontamination. Ameliorative fertilization is necessary in order to have an optimal level of the nitrogen content in soil. In order to eliminate the existing microdepressions and mounds, leveling is recommended.

A collector ditch can be built in the north-west part of the land. Thus, the collector ditch will absorb among drills I, II and will reach the north of the drill IV, where a collection tank will be built.

Seeding of the perennials specific to the site over a period of three years is recommended for revegetation. Afforestation is recommended after this period.

CONCLUSIONS

Without a rigorous identification from a topographical point of view, the polluted surfaces seem much larger, the results confirming the initial hypothesis according to which not the entire measured area is subjected to pollution.

There can be visible identified the affected areas by oil pollution and saltwater through those areas without vegetation, called peeled surfaces, areas with ballast and pipelines but, without rigorous topo-cadastral measurements, they can create a false prediction.

There are still real solutions to reduce the polluted area to a normal one in the case of such exploitations, applying certain rules and measures.

To apply a methodology of improvement to remove soluble salts and petroleum residues, it is necessary first of all a physical de-pollution, leaving it a free land and to stop accidental pollution.

The topographical technique could be considered a powerful tool for tracing the surface pollution in an acceptable manner.

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ABSTRACT

The paper proposes an assessment of polluted land with oil and salt water mixed, having as primarily aim the analysis of a real identification and more precise of the pollution magnitude.

The necessity of this study came from the antithesis of a real situation where the oil pollution of an agricultural land used as a pasture seems, at first sight, to have a much larger dimension compared to the results obtained with the use of precision instruments. The rigorous identification of surfaces of wells quadrate, current access roads, underground and above-ground pipelines, surface erosion or deep erosion has made a clear difference between surface degradation through normal operation of crude oil and an excessive, inappropriate activity.

Using an equipment and technique with high accuracy of the measurement, the field phase consisted in planimetric and levelling measurements and the collection of soil sampling and stagnant water sampling on the soil surface, from precipitations. The chemical and physical measurements were done in laboratory. In the office work the surveys were processed, the obtained data were systematized and the results were interpreted.

The analysis showed that the salinity was the main and the most severely limitative factor in lowering of fertility by slowing the development or even the extinction of microorganims. Although the fodder value of the lawn has been found to be low, however, the grazing in the studied area is practiced. The initial hypothesis concerning the size of the affected surface emphasized an exceeding of the limit of exploitation.

REFERENCES

1. AREDEHEY G., LIBSEKA H., BRHANE M., WELDE K., GIDAY A., 2018 - Top-soil salinity mapping using geostatistical approach in the agricultural landscape of Timuga irrigation scheme, South Tigray, Ethiopia, Cogent Food & Agriculture, 4, 1514959.
2. ASFAW E., SURYABHAGAVAN K., ARGAW M., 2018 - Soil salinity modeling and mapping using remote sensing and GIS: the case of Wonji sugar cane irrigation farm, Ethiopia, Journal of the Saudi Society of Agricultural Sciences, 17, pp. 250-258.
3. ATEKWANA E. A., SAUCK W. A., WERKEMA D. D. JR., 2000 - Investigations of geoelectrical signatures at a hydrocarbon contaminated site, Journal of Applied Geophysics, 44, pp. 167-180.
4. BRITO L. F., MARQUES JÚNIOR J., PEREIRA G. T., LASCALA JUNIOR N., 2010 - Spatial variability of soil CO_2 emission in different topographic positions. Bragantia, 69 (Suppl.), pp. 19-27.
5. CORWIN D., LESCH S., 2003 - Application of soil electrical conductivity to precision agriculture. Agronomy Journal, 95(3), pp. 455–471.
6. EPRON D., BOSC A., BONALD D., FREYCON V., 2006 - Spatial variation of soil respiration across a topographic gradient in a tropical rain forest in French Guiana, Journal of Tropical Ecology, 22, pp. 565-574.
7. EYNARD A., LAL R., WIEBE K. D., 2006 - Salt-affected soils, In Lal R (Ed.), Encyclopedia of soil science, 2nd edn, Abingdon, UK: Taylor and Francis, pp. 1538-1541.
8. FLOREA N., BĂLĂCEANU V., RĂUȚĂ C., CANARACHE A., 1987 - Metodologia elaborării studiilor pedologice, Partea I. Colectarea şi sistematizarea datelor pedologice, ICPA, Bucureşti: Redacția de propagandă tehnică agricolă.
9. IWAN A. K., BLOŃKSA E., LASOTA J., KALANDYK A., WALIGÓRSKI P., 2015 - Influence of oil contamination on physical and biological properties of forest soil after chainsaw use, Water, Air & Soil Pollution, 226, 389.
10. JOUYBAN Z., 2012 - The effects of salt stress on plant growth, Technical Journal of Engineering and Applied Sciences, 2(1), pp. 7–10.
11. LĂCĂTUŞU R., 2016 - Agrochimie, ediția a III-a, Ed. Terra Nostra, Iaşi.

12. MENSAH J. K., AKOMEAH P. A., IKHAJIAGBE B., EKPEKUREDE E. O., 2006 - Effects of salinity on germination, growth and yield of five groundnut genotypes, African Journal of Biotechnology, 5 (20), pp. 1973-1979.
13. METWALY M., KHALIL M. A., AL-SAYED E., EL-KENAWY A., 2013 - Tracing subsurface oil pollution leakage using 2D electrical resistivity tomography, Arabian Journal of Geosciences, 6 (9), pp. 3527-3533.
14. MOSLEY L. M., COOK F., FITZPATRICK R., 2017 - Field trial and modelling of different strategies for remediation of soil salinity and sodicity in the Lower Murray irrigation areas, Soil Research, 55 (7), pp. 670–681.
15. NASRI N., SAIDI I., KADDOUR R., LACHAÂL M., 2015 - Effect of salinity on germination, seedling growth and acid phosphatase activity in lettuce, American Journal of Plant Sciences, 6 (1), pp. 57–63.
16. RANĐELOVIĆ D., JAKOVLJEVIĆ K., MIHAILOVIĆ N., JOVANOVIĆ S., 2018 - Metal accumulation in populations of *Calamagrostis epigejos* (L.) Roth from diverse anthropogenically degraded sites (SE Europe, Serbia), Environmental Monitoring Assessment, 190, 183.
17. SAUCK W. A., 2000 - A model for the resistivity structure of LNAPL plumes and their environs in sandy sediments, Journal of Applied Geophysics, 44, pp. 151–165.
18. SÂRBU I., ŞTEFAN N., OPREA A., 2013 - Vascular plants of Romania. An illustrated field guide, Ed. Victor B. Victor, Bucure□ti.
19. SCHOFIELD R., THOMAS D. S. G., KIRKBY M. J., 2001 - Causal processes of soil salinization in Tunisia, Spain and Hungary, Land Degradation and Development, 12, pp. 163–181.
20. SHEVNIN V., DELGADO-RODRIGUEZ O., FERNANDEZ-LINARES L., MARTINEZ H. Z., MOUSATOV A., RYJOV A., ZEGARRA MARTINEZ H., 2005 - Geoelectrical characterization of an oil-contaminated site in Tabasco, Mexico, Geofisica Internacional, 44 (3), pp. 251–263.
21. TRIKI FOURATI H., BOUAZIZ M., BENZINA M., BOUAZIZ S., 2017 - Detection of terrain indices related to soil salinity and mapping salt-affected soils using remote sensing and geostatistical techniques, Environmental Monitoring and Assessment, 189, 177.
22. THOMAS G., DALAL R., STANDLEY J., 2007 - No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics, Soil and Tillage Research, 94 (2), pp. 295–304.
23. WARTINI N., BRENDAN P. M., BUDIMAN M., 2017 - Rapid assessment of petroleum-contaminated soils with infrared spectroscopy, Geoderma, 289, pp. 150-160.
24. WULF H., MULDER T., SCHAEPMAN M. E., KELLER A., JÖRG P. C., 2015 - Remote sensing of soils, Zürich Open Repository and Archive, University of Zürich.
25. YAHIAOUI I., DOUAOUI A., QIANG Z., ZIANE A., 2015 - Salinity prediction in the Lower Cheliff plain (Algeria) based on remote sensing and topographic feature analysis, Journal of Arid Land, 7 (6), pp. 794–805.
26. Order 161/16.02.2006 of Ministry of Environment and Water Management for approving the normative regarding the classification of the quality of surface waters in order to establish the ecological status of water bodies. http://www.rowater.ro/dacrisuri/Documente%20 Repository/Legislatie.
27. Order 756/1997 concerning the Reglementation regarding evaluation of environment contamination, modified and completed by Order 592/2002 and Order 1144/2002. http://www.legex.ro/Ordin-756-1997-13758.aspx.
28. FAO Land and Plant Nutrition Management Service. http://www.fao.org/ag/agl/agll/spush.

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