T.R.
ONDOKUZ MAYIS UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
DEPARTMENT OF SOIL SCIENCE AND PLANT NUTRITION

EVALUATION OF SOIL CONTAMINATION IN SOME OIL PRODUCTION SITES IN POLAND

Master's Thesis

Ulrich Gaetan Funga TCHOUNKWE

Supervisor
Prof. Dr. Tomasz ZALESKI
II. Supervisor
Prof. Dr. Orhan DENGİZ

SAMSUN
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SAMSUN
2023

ACCEPTANCE AND APPROVAL OF THE THESIS

The study entitled **"EVALUATION OF SOIL CONTAMINATION IN SOME OIL PRODUCTION SITES IN POLAND"** prepared by **Ulrich Gaetan Funga TCHOUNKE**, and supervised by **Prof. Dr. Tomasz ZALESKI and Prof. Dr. Orhan DENGİZ**, was found successful and unanimously accepted by committee members as Masterthesis, following the examination on the date 19.8.2023.

	Title Name SURNAME **University** **Department/Art**	**Final Decision**
Chairman	Prof. Dr. Orhan Dengiz Ondokuz Mayıs University Department of Soil Science and Plant Nutrition	☒Accept ☐Reject
Member	Prof. Dr. A.Albalasmeh Ondokuz Mayıs University Department of Soil Science and Plant Nutrition	☒Accept ☐Reject
Member	Assoc. Prof. Dr. Çoşkun Gülser Ondokuz Mayıs University Department of Soil Science and Plant Nutrition	☒Accept ☐Reject

This thesis has been approved by the committee members that already stated above and determined by the Institute Executive Board.

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Prof. Dr. Ahmet TABAK
Head of Institute of Graduate Studies

DECLARATION OF COMPLIANCE WITH SCIENTIFIC ETHIC

I hereby declare and undertake that I complied with scientific ethics and academic rules in all stages of myMaster's Thesis, that I have referred to each quotation that I use directly or indirectly in the study and that the works I have used consist of those shown in the sources, that it was written in accordance with the institute writing guide and that the situations stated in the article 3, section 9 of the Regulation for TÜBİTAK Research and Publication Ethics Board were not violated.

Is Ethics Committee Necessary?

Yes☐(If it necessary, please add appendices.)

No ☒

19 /09 / 2023
Ulrich Gaetan Funga TCHOUNKWE

DECLARATION OF THE THESIS STUDY ORIGINALITY REPORT

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As a result of the originality report taken by me from the plagiarism detection program on 25 /7 /2023 for the thesis titled above;

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ÖZET

POLONYA'DAKİ BAZI PETROL ÜRETİM TESİSLERİNDEKİ TOPRAK KİRLİLİĞİNİN DEĞERLENDİRİLMESİ

Ulrich Gaetan Funga TCHOUNKE
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Toprak Bilimi Ve Bitki Besleme Ana Bilim Dalı
Yüksek Lisans,Temmuz/2023
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Polonya'da, Jasiesko-Sanockie Havzası (Lehçe: Doły Jasielsko-Sanockie) bölgesinde (Karpat Dağları etrafında) bazı yerlerde petrol sızıntıları tespit edildi. Hala çevredeki bitkilere tehdit oluşturmayan küçük doğal petrol sızıntıları bulunmaktadır, çünkü bitkilerin nasıl geliştiği açıkça görülebilmektedir. Bu çalışmada, bazı seçilmiş petrol sızıntılarının fiziksel ve kimyasal özelliklerini analiz ettik; ROPA 1 ve 4 olarak adlandırılan iki toprak profilini tanımladık ve diğer bölgelerden 10-20 cm derinliğe kadar örnekler toplandı. Sonuçlar, petrol kirliliğinin sadece petrol sızıntısı ile sınırlı olduğunu ve çoğunlukla yüzey tabakalarında yoğunlaştığını göstermektedir: ROPA 1 için %29,18 (0-5 cm), ROPA 3 için %28,41 (0-10 cm), ROPA 4 için %8,08 (15-30 cm) ve ROPA 5 için %0,53 (0-20 cm). Petrol sızıntılarında C/N oranı >25 idi ve tüm örneklerin petrol içeriği, bazı ülkelerdeki temizleme seviyesinin olan 0,1 ve 1%'den daha yüksek bir değere sahipti. Toprak pH değeri, kalsiyum ve potasyum, petrol kirliliğinden daha çok ana materyaller tarafından etkilenmiş gibi görünmektedir. Ancak azot için durum böyle değildir, petrol içeriği azaldıkça azot artmış ve tam tersi de geçerli olmuştur, bu durum toprak profilinin ilk 30 cm'lik kısmı için geçerlidir.

Anahtar Sözcükler: petrol sızıntıları, gleysoller, toprakta petrol kirliliği

ABSTRACT

EVALUATION OF SOIL CONTAMINATION IN SOME OIL PRODUCTION SITES IN POLAND

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In Poland, oil seeps were identified in some place located in area of Jasiesko-Sanockie Basin (in Polish DołyJasielsko-Sanockie) region (part around Carpathian Mountains). There are still some small natural oil seeps that were not considered a threat to the surrounding vegetation since we could clearly see how plants were thriving. In this study, we analyzed some physical and chemical properties of some selected oil seeps; two soil profiles were described ROPA 1 and 4, and samples collected in other areas to a depth 10-20cm. The result shows that oil contamination limited to oil seep and mostly concentrated within the surface layers 29.18% for ROPA 1(0-5cm), 28.41% for ROPA 3(0-10 cm), 8.08% for ROPA 4 (15-30) and 0.53% for ROPA 5(0-20cm). C/N ratio in oil seeps was > 25, and oil content for all sample collected had a value superior to the cleanup level which is 0.1 and 1% in some countries. Soil pH, calcium and potassium seemed more to be affected by parent materials than oil contamination. However, this was not the case for nitrogen, oil content determined nitrogen level, as oil content decreased nitrogen increased and vice versa, this was true for the first 30cm of soil profiles.

Keywords: Oil seeps, Gleysols, oil contamination of soil

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I want to thank my whole family; my father Funga Moise, my mother Tchouembou Lisette, and to all my brothers and sisters who supported me morallyandfinancially. Once I landed on a foreignland, theyalwaysworriedabout me, hearing from them regularly gave me strength to focus on my studies and be free from stress.

Special thanks go toTurkish lecturers, Prof. Dr. Orhan Dengiz whosupervised me andalso Prof. Dr. Coşkun Gülser who coordinated this program successfully. Their class was inspiring; they also supported me with all administrative procedures.

Ulrich Gaetan Funga TCHOUNKWE

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1. INTRODUCTION

In Poland, there are few cities such as Krosno, Jasło, and Gorlicewhere oil wells are being exploited for commercial purpose, there traditional well dug by individuals for private use are also found. Also, oil seeps can be seen close to areas where those wells are located. Those seeps are characterized by a very dark color, a viscous dark liquid, which showed the presence of oil, water and bubbles, which was a sign of gas emission.

Oil seeps seems to have no negative effects on the surrounding vegetation; a rich vegetation was observed all over the area and farmers around seem to have no problem growing their crops such as potato in the first site we visited and rape seeds in the second site. Therefore, our assumption in this research is that oil seeps in the study areas are safe; seeping has not yet reached the critical point to pose a threat to the environment.

Our objective is to evaluate the soil physical and chemical properties of some soils from places natural oil seeps exist. The second objective was to assume that these places were sources of soil contamination by oil substances.

2. LITERATURE REVIEW

2.1. Oil history in Poland

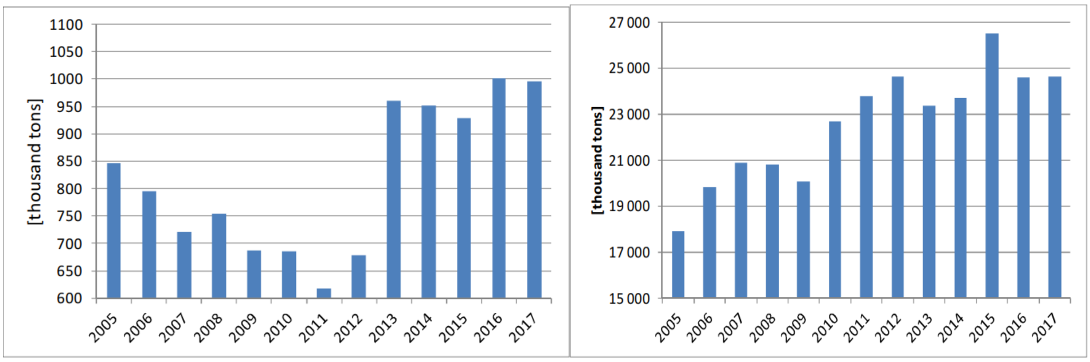
Poland has played a major contribution in the modernization of the oil industry through the establishment of distillation procedure of petroleum on an industrial scale and the invention of the world's first street oil lamp by Ignacy Łukasiewicz in the year 1853-1858 (Online 1, 2023). Łukasiewicz was a pharmacist by profession, the construction of the oil street lamp came after he and his colleague Jan Zeh discovered paraffin while working on a research to develop substances that could be used in pharmaceutical production; oil was heated to 200-250 degree Celsius and refined with concentrated sulfuric acid and a sodium solution, and a liquid (paraffin) that does not smoke when burned was obtained (Online 2, 2023). Just a year later on August 27 1859, the first drilled oil well in Pensylvania was completed by Edwin Drake, which marked the beginning of the new oil era (Online 3, 2023).

2.2. Oil production in Poland

Major discovery of hydrocarbon reservoirs started after 1950 and earlier in the years 2000-2015; reservoirs of kościan, bronsko, BMB (Barnówko-Mostno-Buszewo) and LMG were discovered. Still between 2000-2015 years, 104 conventional boreholes and 72 unconventional were completed for oil extraction. Unfortunately, 22 out 72 unconventional reservoirs were given up due to reasons such as low quality of the reservoir, unsatisfactory test results and surrender of license by the operator. Oil resources have been mapped in 5 major provinces (Figure 5); Gdanks, Pomerania, Wielkopolska, Lublin and Małopolska (Stanisław Rychlicki et Jerzy Stopa, 2016).

Figure 2.1Petroleum provinces in Poland (source: Stanisław Rychlicki et Jerzy Stopa, 2016)

Despite the low oil reserves of the country, there have been a decrease in potential of the existing oil fields; in 2017 for instance, a total of 86 oil fields were registered in the whole country and were distributed as such: 29 in the Carpathian, 12 in the Carpathian fordeep, 43 in the polish lowland and 2 in the polish economic zone of the Baltic sea. Those of the Carpathian and Carpathian fordeep are depleting, while the major reserves which account 73.5% of the polish reserves remain in the polish lowland. This shortage of oil resource led to an increase Importation (figure 6) from diverse origins. In 2015, Russia was the main supplier with 81% of crude oil imports. Later, there was a diversification of suppliers which included: Saudi Arabia, Iraq, Iran, Azerbaijan, Lithuania, Kazakhstan, Nigeria and Norway. Imports from Azerbaijan, Lithuania, Kazakhstan and Nigeria were canceled in 2017 and replaced with crude oil from Canada, America and Denmark (Olkuski et al., 2020)



(a) (b)

Figure 2.2(a) Oil production in Poland 2005-2017, (b) crude oil import in Poland 2005-2017 (Source:Olkuski et al., 2020)

Energy is so important for Poland that it has a large portion in the country's total imports. In 2018, the share of energy (crude oil and natural gas) accounted for 64.3% of national importations. The country is best known for its potential in coal production which represents 47% of its energy supply (figure 7), oil 28%,natural gas 15%, biofuels and waste 8%, geothermal, wind and solar energy 1% (OECD, 2020)

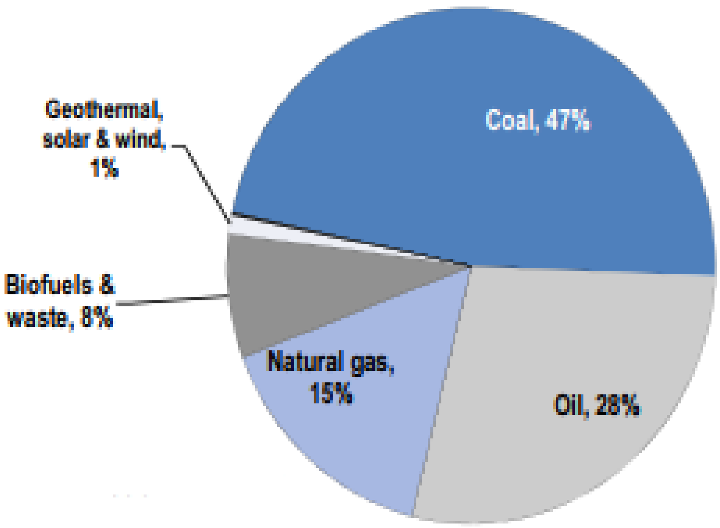


Figure 2.3Energy sources of Poland 2018 (source: OECD, 2020)

3. MATERIAL AND METHODS

3.1. StudyArea

The research was carried out in two locations; in the lesser Siary village in Gorlice (figure 8) town and sub-carpathian Łężany close to Krosno town (figure 9). Those regions are well known because they have been sources of oil production in the country, though some wells were closed or abandoned because of the decrease in production. Oil seeps seems to be quite common, some of those area were identified for our investigation. Soil class was different in each location; Gleysol was identified in the city of Gorlice meanwhile in Krosno we found Histosols. Petroleum seeps did not seem to have an effect on surrounding plant communities. The site in Tarnow was surrounded by farmland, trees and grasses. The most dominant tree was Silver fir (*Abies alba*) which is a coniferous plant and typically found in the Carpathian mountains,meanwhile the main grass found was nutsedge grass (*Cyperusrotundus*). There was sparse vegetation in the Krosno location; petroleum seep was located within a farmland.

3.2. Soil Sample Collection

Site selection was made based on analyzed relief map, information of geologist working in this region, Prof Michał Jankowski from polish geological institute - National Research Institute, Carpathian branch in Cracow. The coordinates obtained helped to identify precisely areas where soil samples could be collected. It took two days to get samples from each area. In each site where seeps were observed, soil profile was dug and soil samples from each horizon or specific soil depth were collected. Depth of soil profiles measured 60 cm, and just few meters away from seeps other soil samples were randomly collected at a depth ranging from 15 – 20 cm.

During the process, we use a spade to dig the build the profile and collect samples. Samples from horizons were placed on the ground, tested for pH and calcium carbonates. They were then put into plastic bag, labeled (date, location and soil depth/horizons) and taken to the laboratory for drying and analysis.

Table 3.1Geo-localization of sample sites

	S1	
	lat	long
ROPA 1	49º36’54.4’’N	21° 9'43.30"E
ROPA 1B	49°36'54.56"N	21° 9'43.25"E
ROPA 1C	49°36'56.29"N	21° 9'40.36"E
ROPA CF	49°36'56.11"N	21° 9'38.78"E
	S2	
ROPA 3	49°38'17.53"N	21°49'34.79"E
ROPA 4	49°39'1.71"N	21°47'21.44"E
ROPA 5	49°38'59.26"N	21°47'27.30"E

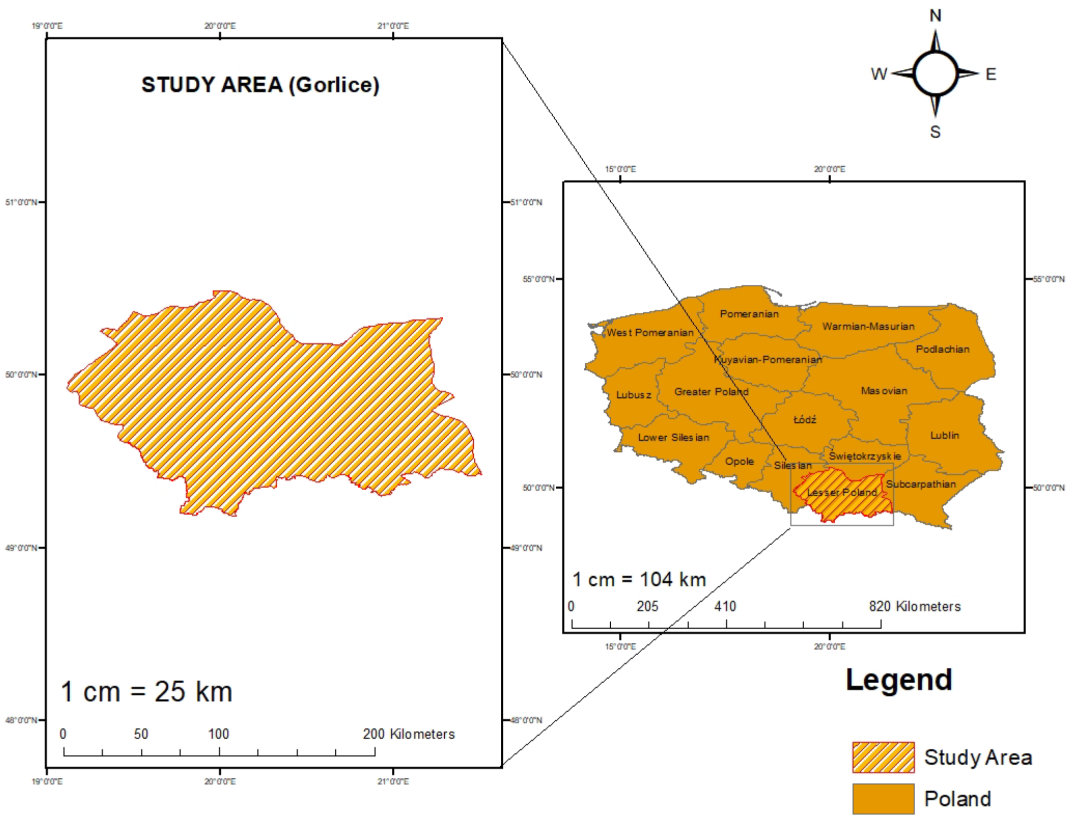


Figure 3.1Map location of Ropa1,B, C, and CF

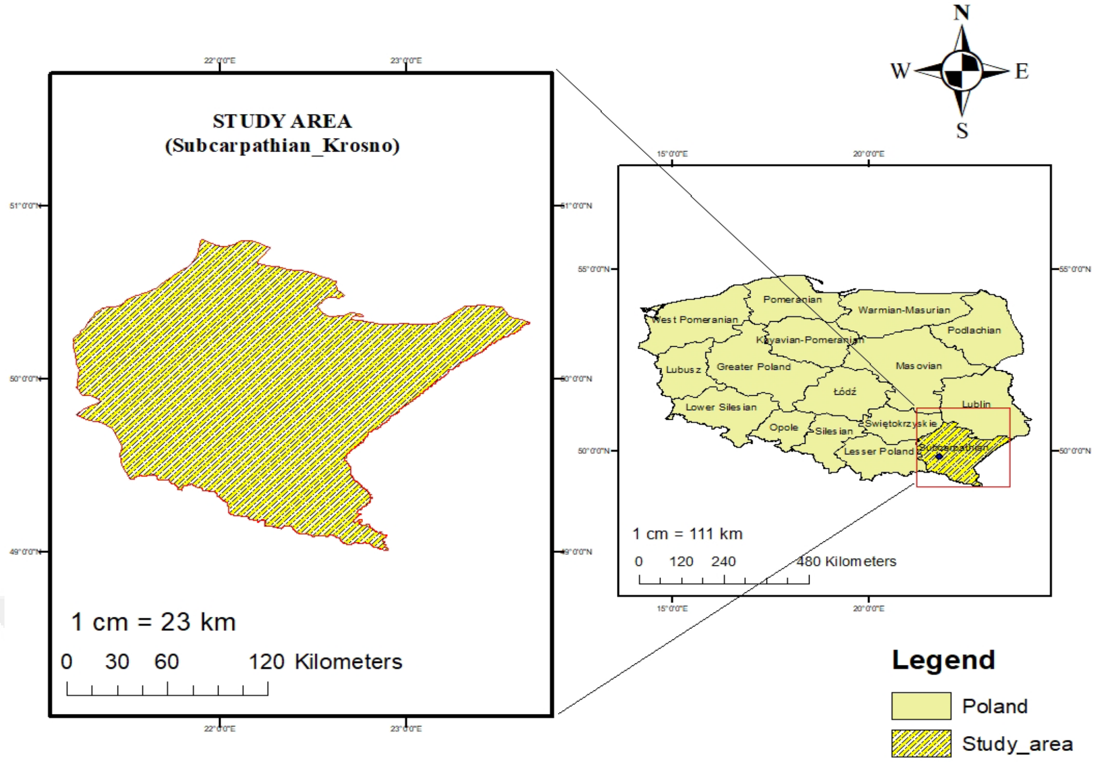


Figure 3.2Map location of ROPA 3,4 and 5


(a) (b)


(c) (d)

Figure 3.3Pictures of the sampling areas in Gorlice.

(a)ROPA 1B, (b) ROPA 1, (c) ROPA 1C,(d) ROPA CF

(a)

(b)

(c)

(d)

Figure 3.4Pictures of the sampling areas in Krosno.

(a) ROPA 4, (b) ROPA 3, (c) ROPA 5, (d) ROPA 5 blank

3.3. Soil pH

Potentiometric measurements of pH were taken using a standard combination electrode and a CPI-551 Elmetron pH meter in 1 mol·dm−3KCl solution and H2O.Soil was added to 50ml plastic tubes to 15 ml level. Two racks were prepared; one for distilled water and the other for potassium chloride, 50 ml of solution was added into various soil sample and measurements were taken the following day, about 20 hours later.

3.4. Soil Texture

The soil texture of studied soils was determined using the Bouyoucos aerometric method, which have been modified by Cassagrande and Prószyński, according to Polish Standard (PN-R-04032, 1998).

3.5. Soil Organic Carbon

The content of total organic carbon (TOC) was determined applying the Tiurin method modified byOleksynowa modification, using the potassium dichromate and Mohr's salt, without the calcium carbonate removing. 0.2g fine soil was put into an Erlenmeyer and mixed with a solution containing potassium dichromate ($K_2Cr_2O_7$) and sulfuric acid (H_2SO_4). Samples were repeated twice and were treated with different doses of the reagent, 10, 20 and 30 ml. They were heated at 105 degree Celsius for few minutes and later taken for titration. We used 10 drops indicator (barium diphenylamine sulphonate) for each sample and mohr salt chemically known as Ammonium iron sulfate Fe $(SO_4)(NH_4)_2(SO_4)$ for titration purpose. Each sample during titration was carefully swirled until the end point was reached; color change was as follow, brown-green and red. The green color indicated the near end point; drops speed was slowed and stopped once the solution turned to red.

$$\%C = \frac{(V1 - V2) * 0.06 * 1}{100}$$

V1= volume of ammonium sulfate for the blank solution

V2= volume of ammonium sulfate for the solution containing soil

3.6. Cation Exchange Capacity

Evaluation of the sum of exchangeable bases (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were extracted in 1 M NH_4Cl at pH 7.0 (Kociałkowski et al. 1984) and analyzed with ICP-OES Optima 7300 DV. 5g of air dry soil was measured and mixed with <50 ml ammonium acetate into 200 ml glass. The mixture was manually shaken and left overnight. The next day, using a paper filter and a funnel, the mixture was decanted into a volumetric flask, and thoroughly washed with ammonium acetate until 100 ml solution was obtained. The extract was then taken for analysis to estimate the amount of Na, K, Ca and Mg.

3.7 Nitrogen Determination

The content of total nitrogen (TN) was determined using the Kjeldahl method (Lityński, et al., 1976) on a FOSS Kjeltec TM 8100 apparatus. Total $CaCO_3$ content was determined using the Scheibler method with the hydrochloric acid (Lityński et al., 1976).

3.8 Oil Content Analysis

Soxhlet extraction method was used to determine oil content in contaminated soils. 5g of soil was for each sample was prepared in soxhlet apparatus. Petroleum ether (boiling point 40-60ºC) was uses as extraction solvent. To ensure complete oil extraction from soil, three extraction cycles were carried out; 4, 2 and 2 hours extraction respectively for the first, second and third, with each sample repeated twice.

$$\% \, crude \; oil = \frac{W2 - W1}{S} * 100$$

W1= Weight of empty flask (g) W2= Weight of flask and extracted fat (g) S= Weight of sample.

4. RESULT AND DISCUSSION

4.1. Soil Profiles Description

Name: (ropa 1): EutricHisticStagnicGleysol (Clayic, Uterquic)

Location: Gorlice, GPS: N 49º36’54.4’’ and 21º.09’43.3’,’ Elevation: 358m

Figure 4.1 Profile 1

O: 0-5 cm, organic matter horizon, olive black (5Y 3/1), sandy loam, moist

Ag: 5-10 cm, humus horizon, dark olive (5Y 4/1) and grayish olive (5Y 5/2), silty clay loam, moist, mottled, very fine roots

ABg1: 10-30 cm, transition horizon, gray (5Y 5/1), silty clay, mottled

ABg2: 30-45 cm, mineral horizon, dull reddish brown (2.5 YR 4/4), silty clay, dry

Name: (ROPA 4):EutricFibricHistosol

Location: Krosno

Figure 4.2 Profile 2

O1p: 0-15 cm, plough humus horizon, brownish black (10 YR 2/2), loam, wet, few fine roots, channels, presence of oil

O2pg: 15-30 cm, plough humus horizon, brownish black, loam, channels, common roots, very fine

ABg: 30-50 cm, brownish black, loam, common roots, very fine

4.2. Results

Soil pH in ROPA1 decreases with soil depth; surface layers are acidic, meanwhile sub-surface layers are alkaline. Soil pH was acidic 6.3, 6.6 at 0-5 and 5-

10 cm within surface layers;alkaline 7.45 and 7.86 within sub-surface layers 10-30 and 30 – 45 cm. There was a sudden change of soil pH from alkaline to acidic as soil depth increases to 45 cm. There was moderate amount of calcium and high amount of magnesium within the soil profile; the range for calcium was 6.9-9.6me/100g while that of magnesium was 3.7-6.4 me/100g. There was moderate amount of potassium between 0-5, 5-10 and 10-30 cm of the soil profile. The level of sodium varies from moderate to very high; sodium concentration increased with soil depth, it is moderate (0.38 me/100g) between 0-5 cm, high, 0.8 and 1.3 me/100g at 5-10 and 10-30 cm respectively, a very high level which is 2.1 was observed within 30-45cm.

Soil sample collected at ROPA B (0-10cm) was acidic with a pH of 5.68; the amount of cationswas high for calcium and magnesium 13.46 me/100g and 4.48 me/100g, moderate for potassium 0.5882 me/100g, and low for sodium 0.2 me/g.

Like ROPA B, ROPA C was also collected close to an oil seep, soil Ph was acidic 6.32. There was high amount of calcium and magnesium on the top soil; about 19.11 me/100g for calcium 3.7210 me/100g for magnesium.

ROPA CF which represented the tilled crop field was acidic. Macro nutrients level for calcium, Potassium, magnesium and sodium were respectively estimated at 12.06 (high), 0.6266 (moderate), 1.6061 (moderate) and 0.2111 me/100mg (low).

Sample obtained from ROPA 3 was acidic within both layers. Mineral analysis revealed a high level of calcium 18.53 and 17.53me/100g at 0-10 and 10-30 cm. The first layer of soil had a moderate level of potassium 0.3980 me/100g and low in the second layer 0.2988 me/100g. The level of magnesium was moderate; ranged between 1-3me/100g, with low level of sodium ranging between 0.1-0.3.

ROPA represented the second soil profile of this study; soil pH was generally alkaline except for the second layer (15-30cm) which was acidic (6.9). The surface layer 0-15 cm was richer in most macro-nutrients compared to the subsurface layer. Calcium level was high throughout the profile 10-20 me/100g. Potassium level changes from moderate (0.3-0.7me/100g) to low (0.2-0.3me/100g) from 0-30 and 30-70 cm. and the lowest 11.40, 0.51me/100g and 0.23 for potassium, and 4.3 and 3.1 me/100g for magnesium. The amount of magnesium was also high and ranged between 3.9-4.3me/100g. Meanwhile sodium content was very high within the profile 2.95-3.96 me/100g.

ROPA 5 appeared to be very alkaline, soil pH was 8.53. The value for Ca, K, Mg and Na was as follow 12.24 (high), 0.2197 (low), 2.4803 (moderate) and 0.2042 me/100g (low).

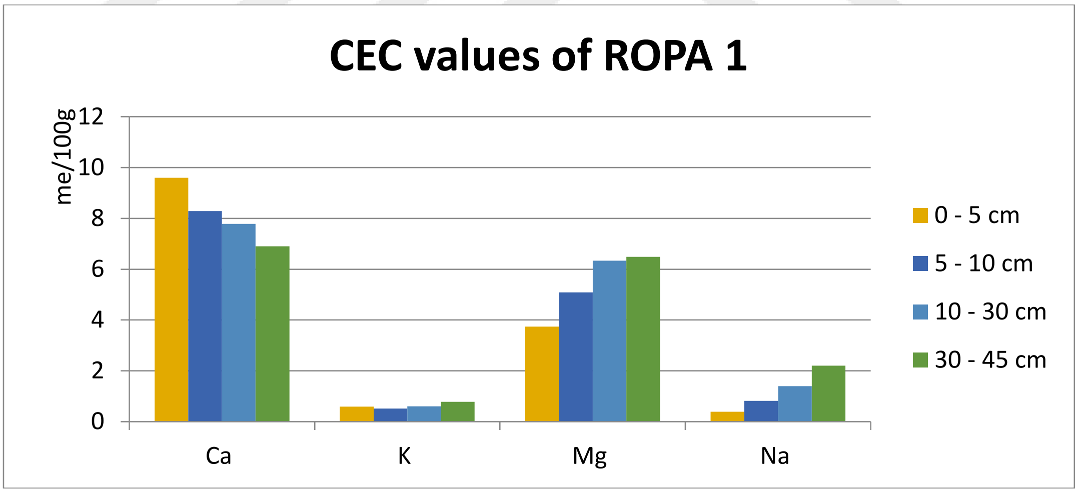
ROPA 5 blank represented the sample collected 5m away from ROPA 5; soil pH was quite acidic 5.5. The value obtained from soil analysis indicates 10.29(high), 0.2490 (low), 1.9803 (moderate) and 8.6568 me/100mg (very high) for calcium, potassium, magnesium and sodium.

Table 4.1pH of soil samples taken at various depths

		pH	
Soil names	Depth (cm)	H_2O	KCl
ROPA 1	0 -5	6.33	5.31
	5 -10	6.60	5.44
	10 -30	7.45	6.3
	30 - 45	7.86	6.32
ROPA 1B	0 - 10	6.24	5.59
ROPA 1C	0 – 10	6.59	5.68
ROPA CF	0 - 10	6.32	5.78
ROPA 3	0 – 10	6.10	5.66
	10 – 30	6.60	6.10
ROPA 4	0 – 15	7,00	6.28
	15 – 30	6.9	5.8
	30 – 50	7.78	5.91
	50 – 70	7.04	6.15
ROPA 5	0 – 20	8.53	7.10
ROPA 5 (Blank)	0 - 20	5.50	4.35

Table 4.2Cations exchange capacity(CEC)of soil samples

		CEC			
Soil locations	Depth (cm)	Ca (me/100g)	K (me/100g)	Mg (me/100g)	Na (me/100g)
ROPA 1	0 -5	9.60	0.5826	3.7368	0.3857
	5 -10	8.29	0.5069	5.0872	0.8090
	10 -30	7.78	0.5980	6.3289	1.3980
	30 - 45	6.90	0.7806	6.4918	2.1957
ROPA 1B	0 - 10	13.46	0.5882	4.4523	0.2334
ROPA 1C	0 – 10	19.11	0.6107	3.7270	0.5862
ROPA CF	0 - 10	12.06	0.6266	1.6061	0.2111
ROPA 3	0 – 10	18.53	0.3980	2.1184	0.1683
	10 – 30	17.53	0.2988	2.9539	0.2043
ROPA 4	0 – 15	19.82	0.5113	4.3109	3.3014
	15 – 30	14.50	0.4860	3.8306	4.5167
	30 – 50	11.40	0.2476	3.1283	2.9561
	50 – 70	16.75	0.2349	3.9046	3.9617
ROPA 5	0 – 20	12.24	0.2197	2.4803	0.2042
ROPA 5 (Blank)	0 - 20	10.29	0.2490	1.9803	8.6568



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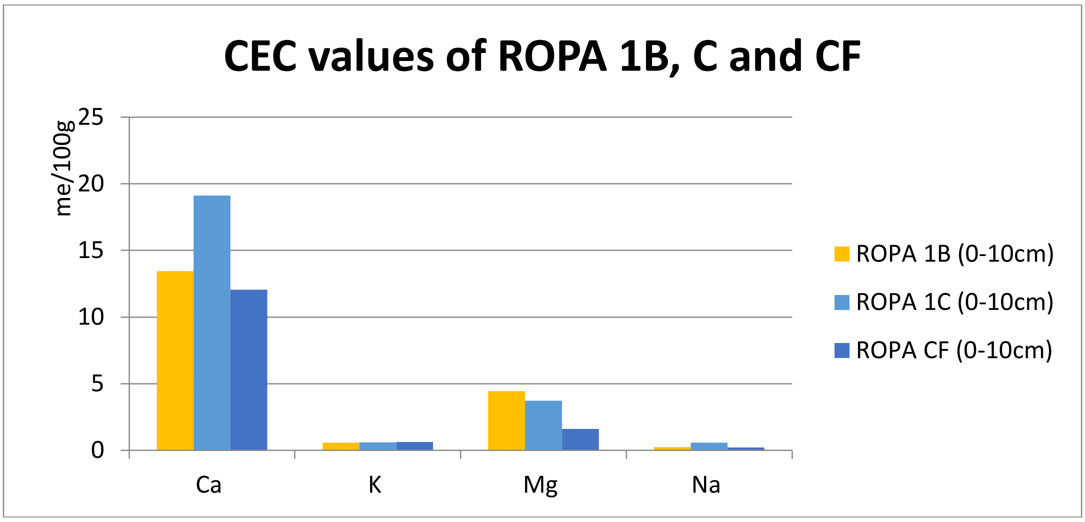
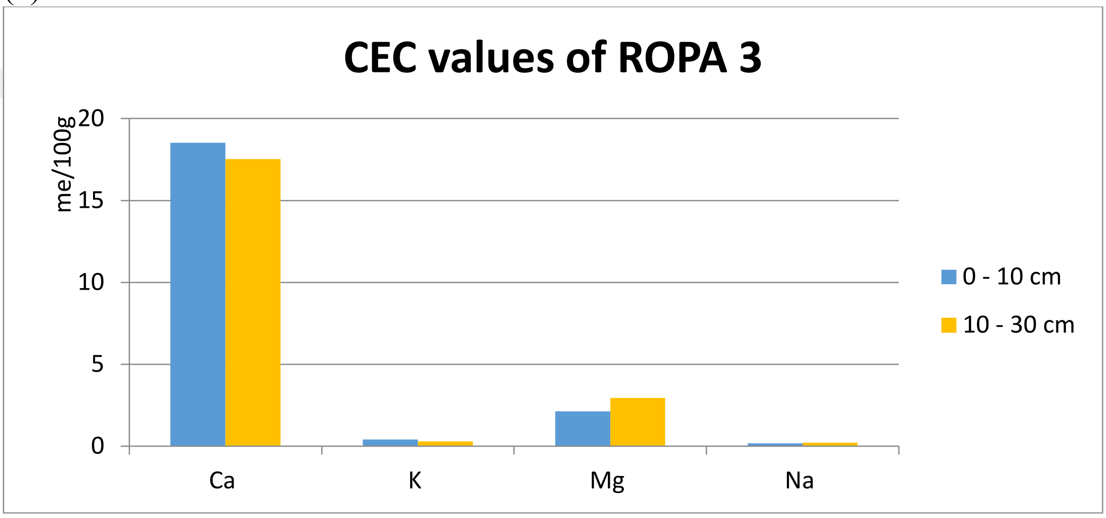
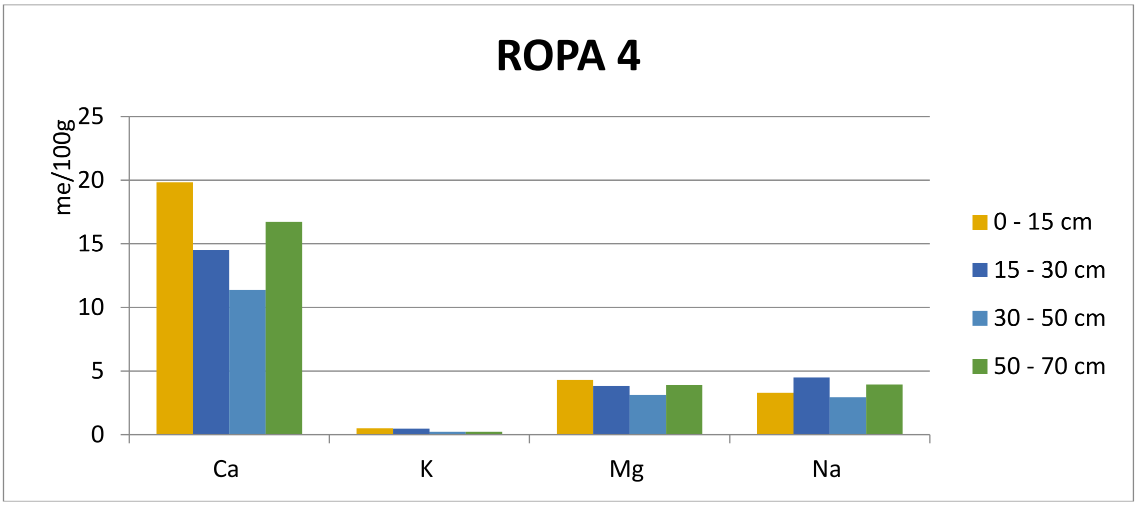
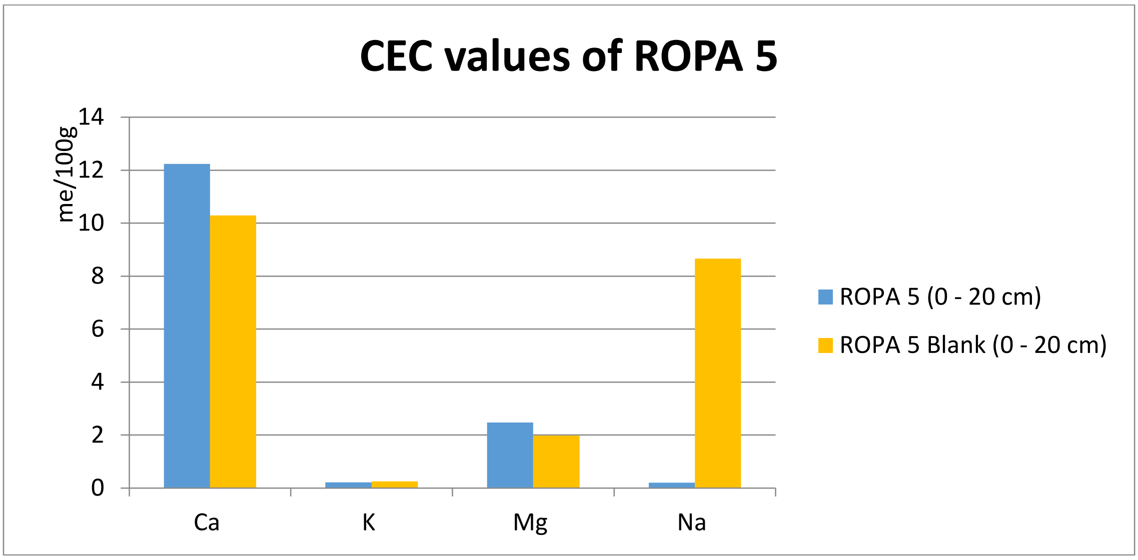

CEC values of ROPA 1B, C and CF
me/100g
25
20
15
10
5
0
Ca
K
Mg
Na
ROPA 1B (0-10cm)
ROPA 1C (0-10cm)
ROPA CF (0-10cm)
(b)


CEC values of ROPA 3
me/100g
20
15
10
5
0
Ca
K
Mg
Na
0 - 10 cm
10 - 30 cm
(c)


ROPA 4
me/100g
25
20
15
10
5
0
Ca
K
Mg
Na
0 - 15 cm
15 - 30 cm
30 - 50 cm
50 - 70 cm
(d)



(e)

Figure 4.3 Cation exchangeable of soil samples (a, b, c, d and e)

The soil profile studied at ROPA 1 location was rich sand and silt particles. Textural analysis showed that between 0-5cm we had sandy loam, silty clay loam at 5-10cm and 30-45cm, and silty clay between 10-15cm and 15-30 cm soil depth. Soil organic carbon was generally very high; the highest percentage (30.66%) was observed at 0 - 5cm, and the lowest value, which was classified as high, was found at 30-45 cm soil layer. Oil content results revealed high oil concentration within the upper layer (0-5cm), oil content was estimated at 29.18%, and the lowest value was 1.51% and was found at 10-30 cm of the soil profile. Medium nitrogen level 0.203% and 0.189% was obtained at surface layers 0-5 cm and sub-surface 10-30 cm, but very high nitrogen level was observed between 5-10 cm and 30-45cm, respectively 0.742% and 1.246%.

Soil of ROPA B, ROPA C and ROPA CF was generally silty; ROPA B was silt clay loam, ROPA C and CF silt loam. Soil organic matter was high in all three locations, and the highest percentage was recorded in ROPA C18.3%, for ROPA B6.705%, and ROPA CF 5.52%. Soil samples collected in those points had very low amount of oil ranging from 0 – 1%. However, there was very high level of nitrogen in those three locations; value range was 0.812, 0.798 and 0.644% for ROPA B, ROPA C and ROPA CF. There was good amount of organic matter in ROPA blank 8.145%.

Two soil types were identified in ROPA 3 within layers; soil collected between 0-10 cm was loamy sand and the other at 10-30 cm was sandy loam. There was very high content of organic matter; 33.72 and 20.31% within the layers. The upper layer 0-10 cm had an oil content of 28.41%, and 7.36% at the lower layer. High and very high level 0.749% of nitrogen was respectively obtained at 0-10 and 10-30 cm depth.

Soil texture allowed the identification of loamy soil in ROPA 4. Loam type was observed between 0-50 cm soil depths and changed to clay loam at 50-70 cm of the soil profile. Soil organic carbon was quite high and varied between layers of soil; the minimum percentage 4.695% was found at the lower layer 50-70 cm and the maximum 26.235% at 0-15cm of the soil profile. Oil content was less than 10% and decreased with soil depth; the maximum value was 8.08% and the minimum was 2.09% at 15-30 cm and 50-70 cm respectively. Nitrogen level varied within the soil profile; high level 0.329% and 0.378% were respectively observed at 0-15 cm and 30-50 cm, meanwhile very high values 0.868% and 0.637% were found at 15-30 and 50-70 cm of the profile.

Loamy soil was identified in ROPA 5 locations. The amount of oil content 0.53% in the seep point (ROPA 5) was close to the blank sample 0.33%. Also, nitrogen analysis showed a very high amount of N content in ROPA 5 (0.665%) compared to ROPA 5 blank (0.112%). Soil sample from these locations both had very high amount of soil organic carbon. In ROPA 5, SOC was 7.29% meanwhile the blank had 8.125%.

Table 4.3SOC, oil content and nitrogen values of soil samples

Soil name	Depth (cm)	Oil content (%)	SOC (%)	Nitrogen (%)	C/N ratio
ROPA 1	0 -5	29.18	30.66	0.203	151.034
	5 -10	2.35	9.48	0.742	12.776
	10 -30	1.51	3.195	0.189	16.905
	30 - 45	2.19	2.76	1.246	2.215
ROPA 1B	0 - 10	0.72	6.705	0.812	8.257
ROPA 1C	0 – 10	1.22	18.3	0.798	22.932
ROPA CF	0 - 10	0.14	5.52	0.644	8.571
ROPA 3	0 – 10	28.41	33.72	0.364	92.637

	10 – 30	7.36	20.31	0.749	27.116
ROPA 4	0 – 15	7.79	26.235	0.329	79.742
	15 – 30	8.08	21.06	0.868	24.263
	30 – 50	2.38	7.665	0.378	20.278
	50 – 70	2.09	4.695	0.637	7.370
ROPA 5	0 – 20	0.53	7.29	0.665	10.962
ROPA 5 (Blank)	0 - 20	0.33	8.175	0.112	72.991

Table 4.4Soil texture taken at various depths of sampling areas

		Particle fractions (%)			
Soil name	Depth (cm)	Sand	Silt	Clay	Texture
ROPA 1	0 -5	67	29	4	sandy loam
	5-10	12	54	34	silty clay loam
	10-30	2	53	45	silty clay
	30 - 45	0	57	43	silty clay
ROPA 1B	0 - 10	13	55	32	silty clay loam
ROPA 1C	0 – 10	27	52	21	silt loam
ROPA CF	0 - 10	32	55	13	silt loam
ROPA 3	0 – 10	81	17	2	loamy sand
	10 – 30	61	34	5	sandy loam
ROPA 4	0 – 15	49	33	18	loam
	15 – 30	48	33	19	loam
	30 – 50	31	43	26	loam
	50 – 70	31	38	31	clay loam
ROPA 5	0 – 20	47	41	12	loam
ROPA 5 (Blank)	0 - 20	43	39	18	loam

4.3 Discussion

Soil profile analysis in Gorlice and Krosno region showed different variations of soil pH; in Gorlice, soil pH decreased with soil depth. This decrease could not be related to the high level of calcium but instead to the amount of magnesium or sodium in the soil. Sodium and magnesium behavior in the first profile are similar to pH, sodium and magnesium content in the surface layers were lower compared to the amount found in the sub-surface, soil pH decreased with the increase of sodium and magnesium. However, this behavior was not observed in the ROPA 4 profile. Soil pH seemed to be influenced neither by magnesium nor sodium. Both profiles were dominated by different soil texture; in ROPA 1 we mostly had silt clay soil while in ROPA 4 we had loamy soil. Therefore we can assume that pH in oil contaminated soil is not related to ion content but instead to parent materials which are responsible of the soil texture.

Oil contamination did not have similar effect on exchangeable cations. Calcium status for instance did not change throughout the soil profiles, in ROPA 1 it remained moderate (5-10me/100g) despite the 29.18% oil content identified within the first layer. In ROPA 3, it remained high (10-20me/100g) despite the wide difference in oil percentage (28.41% and 7.36%) between the first and the second layer. However, ROPA 4 which had a low oil content compared to 1 and 3 remained high.

Oil contamination influencedK variation from moderate (03-0.7me/100g) to high (0.7-2me/100g) in ROPA 1 within 30-45 cm depth, from moderate to low (0-0.2me/100g) in ROPA 3 and ROPA 4.

Magnesium remained high (3-8me/100g) in ROPA 1 and 4, and moderate (1-3me/100g) in ROPA 3.

Sodium content in ROPA 1 changed from moderate (0.3-0.7me/100g) to high (0.7-2me/100g), remained low (0-0.1me/100g) in ROPA 3 and very high (>2 me/100g) in ROPA 4.

These results reflect the information obtained from the literature; increase in the amount of oil content usually results in the decrease of potassium and nitrogen, and an increase in sodium content(Devatha et al., 2019 : Y. Wang et al., 2013). Because calcium and magnesium remained stable in soil layers, it should be assumed that the level of contamination did not have any considerable influence on their concentration.

C/N ratio plays an important role in the rate of decomposition of organic matter and the release of mineral into soil solution. C/N value was extremely high especially in contaminated soil layers rich in soil organic carbon. Soil layers with high oil content usually exhibited low nitrogen value; up to30 cm depth a general conclusion could be drawn; oil contamination decreased nitrogen level, as oil content decreased nitrogen level increased and vice versa. A C/N value <25 is recommended in order to ensure a fast decomposition of organic. In our case, the C/N ratio of contaminated layer ranges from 10-151. The lowest value obtained in ROPA 5 can be explain if we try to compare it with ROPA 5 blank, its nitrogen level is higher.

Altogether, soil samples collected have their oil contentment value ranging from 0.14 to 29.18%. The lowest value was attributed to the ROPA CF (crop field) and the highest to ROPA 1. In countries where there are regulations regarding oil contamination, 0.1% is sometimes considered as a critical level. For instance, in the united state, cleanup level for gasoline contamination was set at 1%. These levels were set because of the adverse effect on human health, plants and micro-organisms through ground water contamination or inhalation of volatile compound.

In this research, oil contamination was limited to oil seeps and did not have a negative effect on the surrounding vegetation, rape seed seemed to grow well on the land close to ROPA 4

5. CONCLUSION

1. All investigated soils were classified as Gleysols or Histosols.

2. The reaction of soil was in wide range, between medium acid to weakly alkaline.

3. The soils in the near vicinity of the oil seep were characterized by high organic carbon content.

4. The oil content varied widely. In most soils, the surface horizons contained the most of it.

5. Due to the high organic carbon content, the C/N was in high values, unusual for natural forest or meadow soils.

6. Calcium and magnesium cations dominated the soil sorption complex.

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CURRICULUM VITEA

My passion for agriculture came from the fact that during holydays, my sibling sand I would sometimes go to the village and spent time with our grand mother. Because farming was not that attractive and productive, I taught I could make things better if only I received a proper education in this field. Today, I have a deep interest in various areas such as seed production, plant biotechnology, soil nutrition and mapping.

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1. Funga, U., Pinar, H., and Uzun, A. (2022). Assessment of the response of some melon genotypes (*Cucumis Melo. L*) to different doses of sodium chloride (NaCl). Current Trends in Natural Science

2. Pinar, H., Funga, U., Kaplan, M. (2021). Effect of different drying methods on seed germination of two pepper varieties. Current Trends in Natural Science.

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1. Türkiye Bursları (2019)
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