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Research Article

BIOCHEMICAL STATUS OF AGRICULTURAL SOILS IN THE SÃO VICENTE REGION OF CABINDA PROVINCE DERIVED BY HYDROCARBON CONTAMINATION

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A B S T R A C T

Soil contamination refers to the presence of toxic chemical substances such as volatile organic compounds, aliphatic and aromatic hydrocarbons such as benzene, toluene and xylene, heavy oils, cracking by-products of oil derivatives, radio-nucleotides, heavy metals, solvents and chlorinated compounds, polycyclic aromatic hydrocarbons, phenols, halogenated pesticides, nitrogenated amines, esters, alcohols and intermediate products, which can negatively affect soil quality, affecting vegetation and water wichch, constitutes a risk to human and wildlife health. Soil contamination with hydrocarbons can be treated through biological processes using organisms such as bacteria and fungi or plants to reduce or eliminate hazardous compounds. Of these, Enretech-1 stands out the bio-remediation process.

The objective of the work was to determine the Biochemical status of agricultural fields in the region of São Vicente in Cabinda Province which are affected by contamination of hydrocarbon to evaluate the percentage degree of presence of each hydrocarbon particle in the soils, and to recommend the soil correction method. Fifteen soil samples were collected from different points, at a distance of 50 meters from each other, in each field that were later analyzed in the laboratory. The results of the analyzes showed contamination efficiency, whose effects were quite decisive in the deterioration of these soils. For soil correction, the Bioremediation technique of the Enretech-1 method was used.

The laboratory results showed that the level of soil contamination exceeded the established limits, which resulted in soil degradation, losing its productive capacity. Laboratory tests were not performed to evaluate the soils after application of Enritech-1, therefore the studies should continue.

Numerous literatures report the effectiveness of cleaning with the Enritech-1 method, for an 82% reduction in total hydrocarbons (TPH) in 77 days.

INTRODUCTION

The agro-environmental study was carried out in the province of Cabinda in the agricultural region of São Vicente, municipality of Cabinda. It should be noted that the province of Cabinda is a region rich in oil, and this is produced both off-shore and on-shore. Oil, defined by Silva, Leidy (2011), is a naturally occurring complex mixture formed by several organic and inorganic components, and among the organic compounds are mainly paraffinic, naphthenic and aromatic hydrocarbons. The exploitation of this product can be at sea (Offshore) or on land (On-Shore). In the hydrocarbon exploration process, it often has implications for the environment, having by the way affected the sea or soils in terms of contamination. This contamination can cause harmful situations to the environment, with destruction to nature.

Soil is a layer of mineral particles resulting from the degradation of some type of rock added to a portion of organic matter. It contains a high content of microorganisms and has its own characteristics, being very dynamic in some cases. It is formed by a solid phase, and a certain amount of voids, which, in part are filled with water.

An area contaminated by hydrocarbons is defined as a place or land where there is proven pollution or contamination caused by the introduction of any substances or residues that have been deposited, accumulated, stored, buried or infiltrated in a planned, accidental or even natural way. For the minimization and repair of damages, the scientific community has been developing some technologies, to avoid the total degradation of the environment.

Based on studies carried out, they reveal that soil contamination with hydrocarbons can be treated by various

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biological, physical, chemical, physical-chemical or thermal processes. Biological processes refer to a treatment that uses organisms, such as bacteria and fungi, and/or plants to reduce or eliminate compounds that are harmful to the environment (Picado *et.al*., 2001). Among the treatments of soil contaminated by petroleum hydrocarbons, Enretech-1 is recommended, which is a bio-remediation process that can be defined as the use of microorganisms to remove environmental pollutants from contaminated soils, waters and sediments.

Currently, the application of biological processes in the treatment of soils contaminated by petroleum hydrocarbons has aroused great interest in the technical and scientific community. Such processes have been considered an important alternative to solve or mitigate the problems of contaminated areas (Seabra, Paulo, 2005). Among the main advantages of using biological processes is their low cost when compared to conventional processes. It is noteworthy that the process occurs with low energy consumption and that it causes few changes in the physical, chemical and biological characteristics in the place where they are applied (Ururahy, 1998).

Also noteworthy among the biological processes is the bio-remediation system by Land farming, which is a technology already developed on an industrial scale, where the contaminated excavated soil is placed in piles or cells and the contaminant content is reduced through the presence of carbon-consuming aerobic and heterotrophic bacteria, thus breaking down petroleum hydrocarbon compounds present in contaminated soil.

In the region of São Vicente there is a company called Pluspetrol, which explores oil in on-shore in the region, whose effects of this activity have brought consequences of contamination in the agricultural soils of the area. It should be noted that in the same region is located the agricultural scientific research station called "São Vicente Agricultural Experimental Station", of the Agronomic Research Institute of Angola-IIA, whose mission is to support agricultural research in the province and beyond. Despite not mentioning the size of oil spills and their effects, which this company represents is visible and through reports from farmers around that indicate that agricultural production has been affected by the effects of the presence of hydrocarbon particles in the region. The research was carried out by Universidade Independente Angola and Agronomic Research Institute of Angola-IIA in collaboration with the company Pluspetrol within the spirit of social responsibility, which the same company entails and. The main objective of the work was to analyze the bio-chemical state in which the soils of the region are, derived from contamination by hydrocarbons (petroleum), as well as recommend a form of correction through the Enretech-1 method, effective and of less cost according to many similar works carried out as an example: Coelho et, al.;, J. Andrade, F. Augusto & I. Jardim, and others. The work also intends to draw society's attention to the care that must be taken in the relationship between soils and hydrocarbons, for the protection and conservation of the environment.

MATERIAL AND METHODS

Field process

The study covers an area of 9 hectares divided into 3 plots of 3 hectares each, respectively plots A, B and C. As shown in the figure below 5 soil samples of up to 20 cm were collected randomly in each plot. Then, the simple samples were mixed in each plot, obtaining a composite sample in each of these plots, which were placed in well-identified glass flasks and later taken to the soil analysis laboratory. For soil extraction, the "placed draft auger" was used.

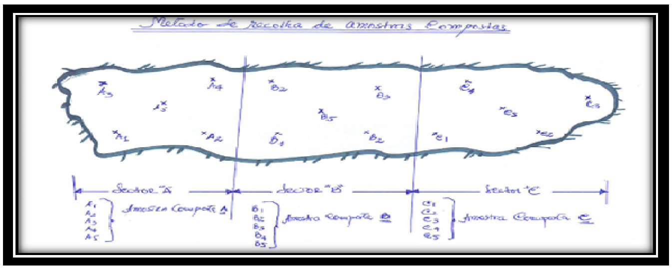


Figure 1 Soil sample collection field

Own source, 2019

After 60 days, the cell soil samples were taken to the analysis laboratory, in well-identified glass flasks with respective labels.

Fig 4 Soil sample in the glass bottle for laboratory analysis
Source: Own, 2019

Laboratory process

In the laboratory the percentage of hydrocarbon elements in each given plot of land was determined. The contaminating hydrocarbons formed by Metals, BTEX, VOC, TPH, HAP and Cl were determined, whose results were compared with the internationally required parameters, expressed in the USEPA standard. The analyzes were carried out in the reference laboratory of Empresa Pluspetrol Angola. The table below, nº 1, represents the parameters and reference methods of USEPA.

Table 1 Parameters and reference methods used for laboratory analysis of soils affected by hydrocarbons USEPA method soil analysis.

Nº	Parametros	Mmetodos De Referencia De Analises De Solos
1	BETEX/COV	USEPA 5035 E USEPA 8260C
2	TPH C10 – C28	USEPA 8015
3	HAP	USEPA 8270
4	Metais: As, Cd. Ba. Cr, Cu, Hg, Ni, V, e Zn	USEPA 200. 2007 E APHA 3120
5	Cloretos	APHA 4110B

Source: Oil and physical environment, master's dissertation, (R. Viviane, 2003)

Table 2 Metal Parameter Limits in Soil, USEPA method

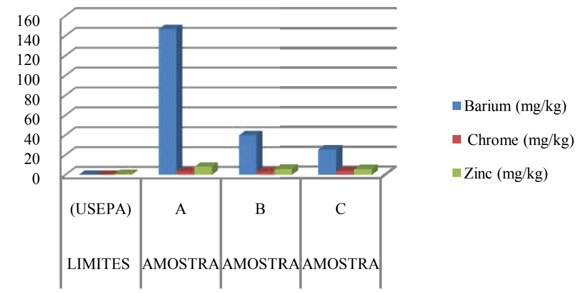
Metals		
Substance	**Units**	**Limit (USEPA)**
arsenic	mg/kg	1,0
Barium	mg/kg	0,2
Cadmium	mg/kg	0,1
Chrome	mg/kg	0,2
Copper	mg/kg	2,0
Mercury	mg/kg	0,1
Nickel	mg/kg	0,5
Vanadium	mg/kg	0,1
Zinc	mg/kg	1,0

Table 3 BTEX Parameter Limits on the ground, USEPA method

BTEX		
Benzene	µ/kg	1
Toluene	µ/kg	1
Ethylbenzene	µ/kg	0,75
m/p Xlene	µ/kg	6,8
oxylene	µ/kg	0,75
Xylene	µ/kg	80

The tables below represent the results obtained from the laboratory analysis of the concentration of hydrocarbon particles in the soils of the region under study.

Vanadium



Graph 1: Concentration of hydrocarbon particles in the soils of S. Vicente

Table 4 Limits of VOC Parameters in soil, USEPA or USEPA method

Parameter	UN	Limit usepa	Parameter	UN	Limit Usepa	Parameter	UNI	Limit (usepa)	Parameter	UN	Limit Usepa
Dichlorofluoromethane	µ/kg	0,8	2,2-Dichloropropane	µ/kg	0,95	cis-1,3-Dichloropropane	µ/kg	0,9	2-Chlorotoluene	µ/kg	0,85
Venilchloride Chloroethylene	µ/kg	0,8	Trichlorofluorom-ethane	µ/kg	0,5	1,1,2-Trichloroethane	µ/kg	0,75	4-Chlorotulene	µ/kg	0,7
Bromethane	µ/kg	0,6	1,1,1,Trichlorome-thane	µ/kg	0,95	1,3-Dichloropropane	µ/kg	0,95	1,3,5-Trimethybenzene	µ/kg	0,55
Chloroethane	µ/kg	0,9	1,2-Dichloroethane	µ/kg	0,65	Dibromochloro-methane	µ/kg	0,75	Tert-butybenzene	µ/kg	0,85
Triclofluoromethane	µ/kg	0.6	1,1-Chloropropane	µ/kg	0,75	1,2-Dibromethane	µ/kg	0.95	1,2,4-Trimethibenzene	µ/kg	0.75
1,1-Dichloroethane	µ/kg	0,85	Tetrachloroethane	µ/kg	1	Tetrachloroethane	µ/kg	0,8	1,3-Dichlorobenzene	µ/kg	1
Dichloromethane	µ/kg	1	Eter metil	µ/kg	1	Chlorobenzene	µ/kg	0,8	1,4-Dichlorobenzene		0,75

Table 5 Limits of VOC Parameters in Soil, USEPA or USEPA Method (Cont'd)

Parameter	Un	Limit Usepa	Parameter	Un	Limit Usepa	Parameter	UN	Limit Usepa	Parameter	UN	Limit Usepa
Trans-1,2-Dichloroethane	µ/kg	0,95	1.2, Dichloropropane	µ/kg	0,55	1,1,1,2-Tetrachloroethane	µ/kg	0,75	Sec-Butylbenzene	µ/kg	0.8
Metil-terc-Eter but (MTBE)	µ/kg	0,95	Trichloroethane	µ/kg	0,85	Tribromethane	µ/kg	0,9	P-Isopropylluene	µ/kg	0.85
1,1-Dichloroethane	µ/kg	0,9	Dibromethane	µ/kg	0,5	Estreno	µ/kg	0,85	1,2-Dichlorobenzene	µ/kg	0,85
Cs-1,2-Dichloroethane	µ/kg	0,65	Bromodi-chloromethane	µ/kg	0,8	1,1,2,2-Tetrachloroethane	µ/kg	0,9	n-butybenzene	µ/kg	0,6

Table 6 HPA Parameter Limits, USEPA method

Parameter	UN	Limit Usepa
Chrysenus	µ/kg	10
Benzene (b) Fluoranthene	µ/kg	10
Benzo(k) Fluoranthene	µ/kg	10
Benzo (a) Pyrene	µ/kg	10
Indene (1,2,3-CD) Pyrene	µ/kg	10
Dibenzo(a,h) Anthracine	µ/kg	10
Benzo (g.h.j) Pyrylene	µ/kg	10

Table 7 HPA Parameter Limits, USEPA method (Cont'd)

Parametr	Un	Limit Usepa
naphthalene	µ/kg	10
Acenafline	µ/kg	10
Acenaphthene	µ/kg	10
Flurene	µ/kg	10
Phenanthrene	µ/kg	10
Anthrecine	µ/kg	10
Fluoranthene	µ/kg	10
Poiren	µ/kg	10
Benzonol (a) Anthracine	µ/kg	10

Table 8 Laboratory results of the Metal Hydrocarbon Parameters, USEPA method

Metal	Parameter	UN	Limit Usepa	Sample A	Sample B	Sample C
1	arsenic	mg/kg	1,0	<1,0	<1,0	<1,0
2	Barium	mg/kg	0,2	147	40	25
3	Cadmium	mg/kg	0,1	0,2	0,1	0,1
4	Chrome	mg/kg	0,2	3,5	3,4	3,5
5	Copper	mg/kg	2,0	<2,0	<2,0	<2,0
6	Mercury	mg/kg	0,1	<0,1	<1,0	<1,0
7	Nickel	mg/kg	0,5	0,8	0,8	0,9
8	Vanadium	mg/kg	0,1	6,7	6	6,2
9	Zinc	mg/kg	1,0	8,4	5,7	5,2

Table 9 Laboratory results of BTEX Parameters, USEPA method

Btex	Parameter	UN	Limit Usepa	Sample A	Sample B	Sample C
1	Benzene	µ/kg	1	486	137	190
2	Toluene	µ/kg	1	1796	946	893
3	Ethylbenzene	µ/kg	0,75	323	166	158
4	m/p Xlene	µ/kg	6,8	3538	1893	1748
5	oxylene	µ/kg	0,75	1185	479	451
6	Xylene	µ/kg	80	4723	2372	2199

BTEX-Benzene, Toluene, Ethylbenzene and Xylenes

Graph 2 . Concentration of BTEX and S. Vicente particles in soils

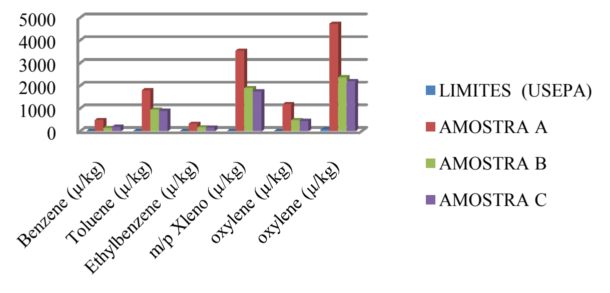


Table 10 Laboratory results of VOC Parameters, USEPA method

Voc	Parameter	UN	Limit Usepa	Sample A	Sample B	Sample C
1	Venilchloride	µ/kg	0,8	<0,8	<0,8	<0,8
2	Chloroethylene	µ/kg	0,85	<0,85	<0,85	<0,85
3	Bromethane Chloroethane	µ/kg	0,8	<0,8	<0,8	<,08
4	Triclofluoromethane	µ/kg	0,6	<0,6	<0,6	<0,6
5	Chloroethane	µ/kg	0,9	<0,9	<0,9	<0,9
6	Triclofluoromethane	µ/kg	0.6	<0,6	<0,6	<0,6
7	1,1-Dichloroethane	µ/kg	0,85	<0,85	<0,85	<0,85
8	Dichloromethane	µ/kg	1	<1	<1	<1,0
9	Trans-1,2-dichloroethane	µ/kg	0,95	<0,95	<0,95	<0,95
10	Metil-terc-Eter but (MTBE)	µ/kg	0,95	<0,95	<0,95	<0,95
11	1,1-Dichloroethane	µ/kg	0,9	<0,9	<0,9	<0,9
12	Cs-1,2-dichloroethane	µ/kg	0,65	<0,65	<0,65	<0,65
13	2,2-Dichloropropane	µ/kg	0,95	<0,95	<0,95	0<,95
14	Bromochloromethane	µ/kg	0,75	<0,75	<0,75	0<,75
15	Trichlorofluoromethane	µ/kg	0,5	<0,5	<0,5	0<,5
16	1,1,1-trichloromethane	µ/kg	0,95	<0,95	0<,95	0<,95
17	1,2-Dichloroethane	µ/kg	0,65	<0,75	<0,65	<0,65
18	1,1-Chloropropane	µ/kg	0,75	<0,75	<0,75	<0,75
19	Tetrachloroethane	µ/kg	1	<1	<1	<1
20	Methyl ether	µ/kg	0,55	<0,55	<0,55	<0,55

Table 11 Laboratory Results of VOC Parameters, USEPA method (Cont'd)

21	**1,2-Dichloropropane**	**µ/kg**	**0,85**	**<0,85**	**<0,85**	**<0,85**
22	Trichloroethane	µ/kg	0,5	<0,5	<0,5	<0,5
23	Dibromethane	µ/kg	0,8	<0,8	0<,8	0<,8
24	Bromodichloromethane	µ/kg	0,9	<1	<1	<1
25	Cis-1,3-Dichloropropane	µ/kg	0,9	<0,8	0<,8	0<,8
26	Trans 1,2-Dichloropropane	µ/kg	0,65	<0,9	0<,9	<0,9
27	1,1,2-Trichloroethane	µ/kg	0,75	<0,9	<0,9	0<,9
28	Dibromochloromethane	µ/kg	0,95	0,65	0,65	0,65
29	Dibromochloromethane	µ/kg	0,75	<0,75	<0,75	<0,75
30	1,2-Dibromethane	µ/kg	0.95	<0,95	<0,95	<0,95
31	Tetrachloroethane	µ/kg	0,8	<0,8	<0,8	<0,8
32	Chlorobenzene	µ/kg	0,8	<0,8	<0,8	<0,8
33	1,1,1,2-Tetrachloroethane	µ/kg	0,75	<0,75	<0,75	<0,75
34	Tribromethane	µ/kg	0,9	0<,9	<0,9	<0,9
35	Estreno	µ/kg	0,85	<0,85	<0,85	<0,85
36	1,1,2,2-Tetrachloroethane	µ/kg	0,9	<0,9	<0,9	<0,9
37	1,2,3-Trichloroethane	µ/kg	0,9	<0,9	<0,9	<0,9
38	Isopropylbenzane	µ/kg	0,75	33	22	28
39	Bromobenzene	µ/kg	0,8	<0,8	<0,8	<0,8

Table 12 Laboratory Results of VOC Parameters, USEPA method (Cont.)

	2-Chlorotolulene	**µ/kg**	**0,85**	**<0,85**	**<0,85**	**<0,85**
	n-Propylbenzene	µ/kg	0,8	<0,85	38	39
42	4-Chlorotulene	µ/kg	0,7	<0,7	<0,7	<0,7
43	1,3,5-Trimethybenzene	µ/kg	0,55	1016	286	260
44	Tert-Butybenzene	µ/kg	0,85	<0,85	<0,85	<0,85
45	1,2,4-Trimethibenzene	µ/kg	0.75	100	100	100
46	1,3-Dichlorobenzene	µ/kg	1	<1	<1	<1
47	1,4-Dichlorobenzene	µ/kg	0,75	<0,75	<0,75	<0,75
48	Sec-butylbenzene	µ/kg	0.8	<0,8	<0,8	<0,8
49	P-Isopropylluene	µ/kg	0.85	111	65	50
50	1,2-Dichlorobenzene	µ/kg	0,85	<0,85	<0,85	<0,85
51	n-Butybenzene	µ/kg	0,6	91	46	37
52	1,2-Dibromo-3-Chloropropane	µ/kg	0,85	<0,85	<0,85	<0,85
53	1,2,4-Trichlorobenzene	µ/kg	0,8	<0,8	<0,8	<0,8
54	1,2,3-Trichlorobenzene	µ/kg	0,8	<0,8	<0,8	<0,8
55	Hexachlorobutadiene	µ/kg	0,5	<0,5	<0,5	<0,5

VOC - Volatile Organic Compounds

Graph 4. Concentration of COV particles of hydrocarbons in the soils of S. Vicente

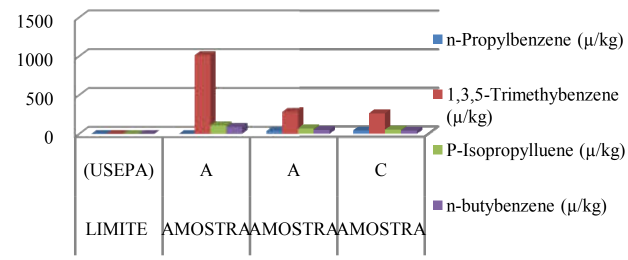


Table 13 Laboratory Results of HPA Parameters, USEPA method

HPA	Parâmetros	Unidade	Limite (USEPA)	Amostra A	Amostra B	Amostra C
1.	Naphthalene	µ/kg	10	<10	445,7	450.85
2	Acenafline	µ/kg	10	<10	<10	<10
3	Acenaphthene	µ/kg	10	<10	<10	<10
4	Flurene	µ/kg	10	<10	<10	200,39
5	Phenanthrene	µ/kg	10	356,11	366,91	426,18
6	Anthrecine	µ/kg	10	307,28	3814	<10
7	Fluoranthene	µ/kg	10	<10	<10	160,64
8	Poiren	µ/kg	10	303,47	178,35	<10
9	Benzonol (a) Anthracine	µ/kg	10	<10	<10	265,92
10	Chrysenus	µ/kg	10	<10	403,84	<10
11	Benzene (b) Fluoranthene	µ/kg	10	<10	<10	<10
12	Benzo(k) Fluoranthene	µ/kg	10	<10	<10	<10
13	Benzo (a) Pyrene	µ/kg	10	<10	<10	<10
14	Indene (1,2,3-CD) Pyrene	µ/kg	10	<10	<10	<10
15	Dibenzo(a,h) Anthracine	µ/kg	10	<10	<10	<10
16	Benzo (g.h.j) Pyrylene	µ/kg	10	<10	<10	<10

HPA – Hydrocarbons, Polycyclics, Aromatics

Graph 4. Concentration of HPA particles of hydrocarbons in the soils of S. Vicente

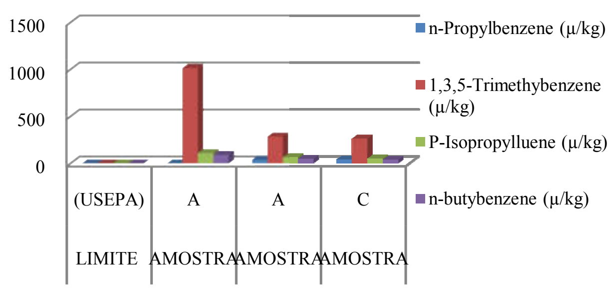


Table 14 Laboratory results of TPH Parameters, USEPA method

TPH	Parameter	UN	Limit Usepa	Sample A	Sample B	Sample C
1	TPH (C10-C28)	mg/kg	280	-	-	-
2	TPH (C7-C9)	mg/kg	-	-	-	-
3	TPH (C10-C14)	mg/kg	-	-	-	-
4	TPH (C15-C36)	mg/kg	-	-	-	-
5	Chloride	mg/kg	5	25800	19600	18600

TPH - Total Oil Hydrocarbons

Correction of contaminated soils

An experiment was carried out for soil correction using the Enretech-1 method, which is a capsulator of Australian origin, which has a dual purpose: as an absorbent agent and bio-remediation of contaminated soil. This product contains natural bacteria that are commonly found in common plants and soils. When these bacteria have HC contaminated soils as a food source, this soil must be kept moist to encapsulate the HC particles, in order for these bacteria to propagate, biodegrading the soil contaminants. According to the researched literature Enretech-1 has been successfully used to clean many areas contaminated with petroleum derivatives such as gasoline, diesel and oil. However, they show an 82% reduction in total hydrocarbons (TPH) in 77 days.

Figure 2 Enretech-1 product bag show

Treatment process with Enretech-1

For the practical experience of the remediation process three (3) cells named respectively C1, C2 and C3 were built, covered with 1.00 mm thick waterproof plastic material, added to the bio-degrader named Enretech-1, the main product for the treatments, using the following procedures whose the cell C1 was treated with Enretech-1 and water, cell C2 with Enretech-1, water and sawdust straw, while cell C3 was treated with Enretech-1, water, sawdust straw and original soil uncontaminated, with the aim of verifying which one would be the most effective in terms of decreasing or increasing the concentration of hydrocarbons in the soil (Figures below).

Figure 5 Soil treatment with Enretech-1 and water

Figure 6 Soil treatment straw

Figure 7 Treatment with Ernretech-1, water, straw and uncontaminated soil

Source, Own, UnIA and Empresa Pluspetrol Angola, 2019

RESULTS AND DISCUSSION

The results presented in tables 2,3,4,5 and 6 below represent the degree of soil contamination by the respective contaminating substances that each cell had compared to those recommended by USEPA.

According to the indicators presented, these show that the soils present great contamination by hydrocarbon components in relation to the recommended and this has enormous chances of losing its production capacity due to degradation. Metal particles were observed in soils with the highest incidence of Barium in plot A=147; B=40 and C=25. Then Chromium with A=3.5; B=3.4 and C=3.5. Vanadium presented A=6.7; B=6.2, while Zinc showed A=8.4; B=5.7 and C=5.2. It was found that the result was the highest Barium, especially in plot A .

Table 3 reveals that for the BTEX results, the contamination index was higher in all plots, with Xylene with the highest value at A=4723; B=2372 and C=2199. E followed by Benzene with A= 486; B=137 and C=190. Xylene m/p values indicated A=3538; B=1898 and C=1748. Thus, xylene was the one with the highest contamination value, especially in plot A.

The VOC indicators were 80% regular within the USEPA limits, although high levels of A=33 were observed for isopropylbenzane; B=22 and C=28 and 1,3,5-trimethibenzane respectively with A=1016; B=286 and C=260. High values were still observed for 1,2,4,-trimethibenzane of A,B and C >100. For P-isopropylene the results indicate for A=11; B=65 and C=50. A value above the recommended value of A=91 was also noted for n-butybenzene; B=46 and C=37. Therefore, 1,3,5-trimethibenzane is the one that showed the highest levels of contamination in the 3 plots.

As for PAH indicators, they show to be high in all plots, with a maximum for Naphthalene at A=445.7 and C=450.85 respectively. It then presents Phenanthrene with A=356.11; B=366.91 and C=426.18. Anthrecine comes next with A=307.28; B=381.4. Further down, Chrysene was recorded with A=403.84, Poiren with A=303.47 and B=178.35, followed by Flurantene with A=160.64 and Bronzonol (a)-anthracine which presented B =265.92. Thus, it is concluded that the plots are affected above 80% of PAH.

The TPH values represent a greater scale of contamination in the respective soils, with the following values being observed: For A=7283.24; B=2909 and C=3065.21, considering the elements extremely severe in contamination. Finally, Chloride also presented itself as an infectant with values of A=25800; B=19600 and C=18600.

The results presented in this work demonstrate how much the soils of São Vicente are extremely contaminated by hydrocarbons.

The results after treatment were not presented due to the fact that laboratory analyzes were not performed.

CONCLUSIONS

As we can understand, soils contaminated by hydrocarbons lose their quality were the plants and other terrestrial and aquatic habitats can be harmful. There are several ways to remediate soils contaminated by compounds of hydrocarbons type of contaminants. The choice of a particular method for remediation of a contaminated site is made only after determining the characteristics of the porous medium, of the soil type of contaminant, the climatic conditions of the place, the size of the contaminated area, the disposal of resources, among others. Therefore, when faced with a situation in which the soil is contaminated and has been diagnosed, it is necessary to intervene in the environment to promote its recovery. All options for remediation methods appropriate to the situation should be listed, so that the intervention is technologically and economically coherent, yet still aiming for the best possible outcome on the spot.

From the research carried out, it is concluded that the oil spills in the soils influenced the biological alteration of the soils. The contaminated soils showed some concentrations of hydrocarbon components in considerable proportion that alter the physical and chemical structure of the soil, which generally deserved a treatment for reuse. It was concluded that the studied soils after treatment indicated a significant decrease in hydrocarbon concentration and can be recommended for use for agricultural activity. It is also concluded that the method used (Enretech-1) is recomended to be more efficient for the biological treatment of soils contaminated by hydrocarbons in this region.

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