Assessment of the physicochemical and microbiological evolution of agricultural and forest soils after underground oil piping

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INTRODUCTION

In the last two decades, among the bio-indicators used to determine soil quality a vast interest is devoted to soil biodiversity; in fact, the ability of a system to withstand stress and abiotic and biotic disturbances depends on its level of biodiversity, which is the basis of the functionality of ecosystems [1]. In this study, soil physical, chemical and microbiological properties in agricultural and forest areas were determined to assess their dynamics and evolution induced by environmental restoration processes due to the burial of an oil pipeline.

METHODS

Soil sampling: soil samples were collected from forest and agricultural areas in a Southern Italy farm. Soils were sampled ante-opera, to be used as control, and at the end of first and second years from oil pipeline burying.

Chemical, chemical-physical and biochemical analyses: the parameters, such as pH, total biomass-C and organic-C, were studied by different analytical methodologies.

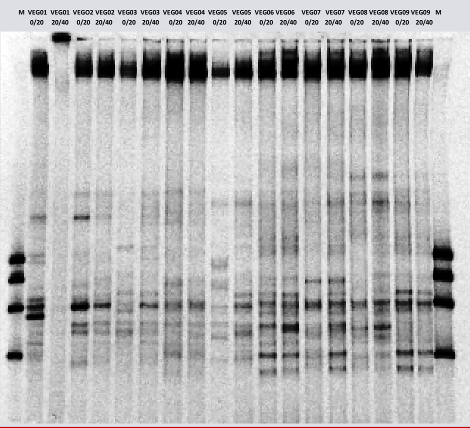
Biological indicators: respirometric tests were performed by Dumontet-Mathur method, while the edaphic fauna was valuated by the synthetic index of soil biological quality named QBS-ar according to Parisi [2].

Microbial community composition: DNA extracted directly from soil samples was amplified with primers 338f (5-'CGC CCG CCG CGC GCG GCG GGC GGG GCG GGG GCA CGG GGG G CCT ACG GGA GGC AGC AG-3') and 518r (5'–ATT ACC GCG GCT GCT GG-3') [3] targeting the V3 region of the bacterial 16S rRNA gene. PCR products were assessed by denaturing gradient gel electrophoresis (DGGE) and the bands were sequenced and then analyzed in the GenBank with the BLAST program.

RESULTS

Sample		pH	Electric conductivity (mS/cm)	Organic carbon (g/Kg)	Organic matter (g/Kg)	$CaCO_3$ (g/Kg)	Total carbon (g/kg)	Total nitrogen (g/kg)	Total sulfur (g/kg)	CSC ($cmol^+/kg$)	Exchangeable K mg/Kg	Phosphorus Olsen mg/Kg	Heavy Hydrocarbons C > 12 mg/Kg	Exchangeable Ca (g/Kg)
VEG-01 forest	A1 0-20	7.63 ± 0.18	52.9 ± 1.10	22.42 ± 0.35	38.6 ± 0.01	8.93 ± 0.17	23.54 ± 0.18	1.80 ± 0.18	<0.1	40.6 ±4.1	320 ± 32	102 ± 10	21.6 ±3.9	18.5 ± 0.60
	B1 20-40	7.94 ± 0.07	37.9 ± 1.11	19.50 ± 0.37	33.6± 0.06	37.96 ± 0.29	23.73 ± 0.10	1.00 ±0.10	<0.1	37.0 ±3.7	151 ± 15	31.5 ± 3.2	24.9 ± 4.5	18.3 ± 0.55
VEG-02 forest	A1 0-20	8.58 ± 0.14	49.7 ± 1.21	12.87 ± 0.22	22.2 ± 0.05	53.59 ± 0.42	18.97 ± 0.16	1.30 ±0.13	<0.1	26.9 ±2.7	223 ± 22	45.2 ± 4.5	24.3 ± 4.4	17.5 ± 0.40
	B1 20-40	8.48 ± 0.22	79.2 ± 1.16	17.16 ± 0.24	29.9 ± 0.04	60.28 ± 0.52	23.76 ± 0.10	1.00 ±0.10	<0.1	28.3 ±2.8	256 ± 26	23.1 ± 2.3	28.7 ± 5.1	17.5 ± 0.42
VEG-03 forest	A1 0-20	8.66 ± 0.05	54.2 ± 1.19	16.38 ± 0.21	28.2 ± 0.04	20.09 ± 0.30	18.99 ± 0.10	2.30 ±0.23	<0.1	22.1 ±2.2	200 ± 20	31.4 ± 3.1	23.9 ± 4.3	17.2 ± 0.36
	B1 20-40	8.71 ± 0.12	54.4 ± 1.13	10.72 ± 0.13	18.5 ± 0.02	22.33 ± 0.31	13.93 ± 0.10	1.00 ±0.10	<0.1	25.2 ±2.5	171 ± 17	37.1 ± 3.7	26.2 ± 4.7	15.7 ± 0.33
VEG-04 forest	A1 0-20	8.48 ± 0.12	64.8 ± 0.98	36.07 ± 0.18	62.2 ±0.08	116.2 ± 1.30	50.15 ±0.24	1.20 ±0.12	<0.1	31.1 ±3.1	340 ± 34	131 ± 13	24.8 ± 4.4	15.9 ± 0.36
	B1 20-40	8.34 ± 0.19	92.7 ± 1.15	30.42 ± 0.46	52.4 ± 0.09	98.24 ± 1.17	42.22 ± 0.22	1.00 ±0.10	<0.1	29.3 ±2.9	370 ± 37	67.6 ± 6.8	26.7 ± 4.8	15.6 ± 0.37
VEG-05 agri	A5 0-20	8.81 ± 0.17	56.3 ± 1.23	18.52 ± 0.33	31.9 ± 0.03	40.19 ± 0.23	22.53 ± 0.14	1.30 ±0.13	1.60 ±0.32	51.0 ±5.1	0.28 ± 0.02	22.4 ± 2.2	17.6 ± 3.3	17.5 ± 0.45
	B5 20-40	8.9 ± 0.21	29.8 ± 1.16	10.14 ± 0.14	17.5 ± 0.02	44.65 ± 0.29	15.15 ± 0.10	0.70 ±0.07	<0.1	38.6 ±3.9	0.19 ± 0.01	17.2 ±1.7	16.1 ± 3.0	17.4 ± 0.40
VEG-06 agri	A6 0-20	8.52 ± 0.09	20.8 ± 1.12	18.33 ± 0.24	31.6 ± 0.02	40.39 ± 0.26	23.34 ± 0.15	1.50 ±0.15	<0.1	35.0 ±3.5	0.22 ± 0.02	31.9 ± 3.2	23.2 ± 4.2	17.6 ± 0.44
	B6 20-40	8.67 ± 0.11	23.4 ± 1.15	15.21 ± 0.29	26.2 ± 0.03	29.02 ± 0.14	19.22 ± 0.11	1.00 ±0.10	<0.1	37.7 ±3.8	0.23 ± 0.02	35.6 ± 3.6	16.5 ± 3.1	17.3 ± 0.40
VEG-07 agri	A7 0-20	8.51 ± 0.15	36.3 ± 1.20	15.4 ± 0.24	26.5 ± 0.04	15.63 ± 0.11	17.41 ± 0.10	1.00 ±0.10	<0.1	35.2 ±3.5	0.2 ± 0.02	23.5 ± 2.4	20.2 ± 3.7	18.9 ± 0.46
	B7 20-40	8.48 ± 0.18	44.8 ± 1.11	12.67 ± 0.28	21.8 ± 0.03	13.40 ± 0.10	14.68 ± 0.10	1.10 ±0.11	<0.1	33.3 ±3.3	0.19 ± 0.01	22.1 ± 2.2	26.4 ± 4.7	18.7 ± 0.45
VEG-08 agri	A8 0-20	8.16 ± 0.17	54.6 ± 1.13	23.98 ± 0.12	41.3 ± 0.08	15.93 ± 0.11	26.99 ± 0.26	1.40 ±0.14	<0.1	48.8 ±4.9	0.26 ± 0.02	40.6 ± 4.1	26.4 ± 4.8	18.5 ± 0.46
	B8 20-40	8.68 ± 0.12	28.3 ± 1.20	19.69 ± 0.32	33.9 ± 0.08	13.90 ± 0.11	22.70 ± 0.16	1.30 ±0.13	<0.1	39.8 ±4.00	0.2 ± 0.02	33.3 ± 3.3	30.9 ± 5.4	18.2 ± 0.40
VEG-09 agri	A9 0-20	8.26 ± 0.14	37.8 ± 1.11	17.35 ± 0.36	29.9 ± 0.10	20.09 ± 0.13	19.76 ± 0.11	1.00 ±0.10	<0.1	30.8 ±3.1	0.25 ± 0.02	26.8 ± 2.7	17.1 ± 3.2	18.4 ± 0.43
	B9 20-40	8.38 ± 0.20	69.2 ± 1.17	13.45 ± 0.39	23.2 ± 0.15	21.09 ± 0.14	16.46 ± 0.10	1.10 ±0.11	<0.1	30.9 ±3.1	0.21 ± 0.01	24.6 ± 2.5	32.0 ± 5.6	18.6 ± 0.42

Soils of both areas showed a considerable evolution of all physicochemical features compared with ante-opera status; a situation of great transformation, still very far from the normal stability condition, was observed. Forest area samples showed an even soil texture in all sites, compared to the relevant variation observed in the first and second years of post-opera, and an increase of pH and cumulative respiration, elevated values of germination indexes and a strong enrichment of edaphic fauna. The agricultural area proved an interesting diversification of the specific parameters for each sampling site, with significant changes of textural fractions, high values of pH and a remarkable bio-stimulation of germination.



The microbial community composition showed the presence of bacterial species commonly found in soil that mediate the complex metabolic processes and play a fundamental role for the functioning and stability of the system, but also of bacterial species belonging to the natural population of microorganisms present in soils with particular conditions, such as soils contaminated with hydrocarbons or subjected to extreme salt conditions and drying up, or methanotrophic bacteria and iron-reducing bacteria present in oilfields. The alteration state of the soil was detected by the presence of particular microbial species that attend in the natural process of bioremediation / biodegradation to restore the optimal conditions.

In conclusion, after two years from pipeline burying both the forest and agricultural areas were being under slow evolution. Physical, chemical and microbiological parameters were far from a steady state. Moreover, an elevated intra-specific and functional biodiversity was detected, underlining the soil capacity to tolerate and withstand the disturbances with the presence and the adaptation of bacterial species able to perform their functions in altered conditions

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