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CHEMICAL PROPERTIES AND BIOLOGICAL ACTIVITY OF ERODED SOILS UNDER FALLOW IN THE END-MORAINE ZONE OF WEST POMERANIA (THE WĘGORZYNO COMMUNE)

A. Koćmit, T. Tomaszewicz

Department of Soil Erosion and Soil Reclamation, Institute of Agricultural Engineering, University of Agriculture in Szczecin, Papieża Pawla VI 3, 71-442 Szczecin, Poland

A b s t r a c t. Since 1990 in Poland, a lot of soils have been changed to fallow. At first, degraded soils from eroded areas were changed. Some of them are fallow till today. Research work was carried out on the eroded soils that were under intense agricultural use in the 80-ties. Investigations on the superficial layer of these soils were carried out in 1995, after a four-year period of fallow conditions. The investigations concentrated on the changes in chemical properties of the humus horizon (0 - 20 cm) and changes of biological activity (0 - 40 cm) formed during the fallow period. The range of changes in the chemical properties was not big. However, biological activity of these soils changed more substantially. A decrease of C organic content was also characteristic. The present authors determined also a decrease of hydrolytic acidity in some soils, according to their location in the relief. In some soils, the content of Mg and K available forms was higher. Some of the soil functions related to habitation were changed too, e.g. visible forms of water erosion stopped.

K e y w o r d s: fallow, chemical properties, cellulolytic activity, water erosion of soils.

INTRODUCTION

Constitutional transformations in Poland that took place in 1989 and further period, caused changes in the agricultural economy. In consequence, part of the soils became fallow already in the following vegetative season. Some of these soils, especially in more eroded areas, are fallow up till now. In the former Szczecin voivodeship, state farms were predominant. They represented 60 % of arable land [8]. In 1995, 18.2 % of the arable land in this area was changed to fallow [7]. In the territory of Poland at that time, fallow constituted 7.2 % [5] of the area. Exclusion from agricultural production means no agrotechnical interventions that influenced various soil processes. In the period of intensive soil cultivation, high doses of mineral fertilizers, negative balance of organic matter, and influence of water erosion resulted in the process of soil degradation [1]. The soil of fallow compared to agriculturally utilised soils remains under the influences of other factors, such as segetal plants isolating soil from the immediate influence of rain drops. Under a permanent plant cover, the processes of infiltration and filtration of rain water are easier in the soil profile during the whole vegetative period. Plant cover restrains development of water erosion. There is an accumulation of organic matter from the plants savagely growing on the soil surface. This organic matter functions as mulch and activities development of soil micro-organisms. Lowered anthropogenic pressure on the soil (lack of mineral fertilizers, etc.) should have a definite influence on the chemical and biological processes taking place in the soil. In Polish literature, numerous articles concentrate on the changes in the phytocoenosis of fallow. Research work on the changes of fallow soil properties have not been so numerous.

The aim of the investigations carried out in 1995, was to define changes in the chemical and biological soil properties that took place under the influence of a four-year fallow period, after exclusion of the field from intensive cultivation, in the conditions of the permanent threat of water erosion.

METHODS

The research work was carried out in 1995, in Dlusko (the commune of Węgorzyno), on the western slope of the end-moraine hill, on a convex-concave slope. The investigations concentrated on the top, convex and concave sections of the slope, drainage foothill and foot of the slope with difficult outflow of surface water. In 1986-1990, the investigated area was subjected to deepened ploughing due to the development of water erosion. In this time, physical and chemical properties and biological activity of the eroded soils were investigated in the layer of 0-45 cm. The investigated area was divided into two belts: A and B. In 1986 and 1988, the belt A was ploughed by four - furrow plough without mouldboards to the depth of 42 cm. The belt B was ploughed traditionally to the depth of 25 cm. The same crop rotation was used in both belts [2]. In 1995, investigations on the chemical properties and biological activity were repeated in the divided sections of the convex-concave slope, in the superficial layer of soil profile. Cellulolytic activity was measured by the Kuźniar's method [3]. Stripes of blotting paper were placed in the soil in the period from June 7 to July 27, at the depths of 0-10, 10-20, 20-30, and 30-40 cm. Estimation of cellulolytic activity was made according to the scale by Kuźniar [3]. When the stripes of blotting paper were burned, soil samples were taken from the layer of 0-20 cm. The following properties were determined in these samples: pH – by a potentiometer in 1 N KCl, hydrolytic acidity and sum of cations with alkaline character – according to the Kappen's method, total nitrogen – acc. Kiejdahl, organic carbon – acc. Tiurin, available phosphorus and potassium forms - acc. Egner-Riehm and available magnesium – acc. Schachtschabel.

RESULTS

On the basis of our results from the period 1989-1995, no considerable differences between the character of changes in the soil chemical properties in the humus horizon (0-20 cm) were observed (Tables 1 and 2). Some of more clearly visible phenomena are: decrease of potential acidity represented by the values of hydrolytic acidity (Hh) and decrease of C organic content (Corg.). The authors proved also that there is an increase of the available forms of magnesium (Mg) and potassium (K_2O). Changes in other properties are related to the location of the soil in the terrain relief; soils from convex sections of the slope changed in a different way which could be observed in the sum of cations with alkaline character (S), sorption complex capacity (T) and degree of sorption complex saturation (V) in relation to soils from concave sections of slope. Changes of these properties resulted to a high degree from water erosion processes, which in the fallow conditions were hardly visible. In our opinion, the buffering process in the soil solution played a more important part in the changes of soil properties. In the previous period of soil cultivation, at considerable domination of H^+ ions in the sorption complex formed by high doses of NPK fertilization and in the conditions of water erosion, aluminium hydroxides were buffer substance [5]. These hydroxides would stabilize pH in the range from pH 4.8 to pH 3 for a longer period of time. The 1995 investigations showed little changes in the soil reaction. They were relatively more pronounced on the convex sections of the slope and considerably less visible on the concave sections, on which soil acidity was higher in the last years. This higher acidity caused also an increase in the aluminium activity.

Even though there was no Mg fertilization, an increase in the content of available Mg was meaningful, especially in the case of soils that were degraded early [6]. In the investigated soils (excluding top), an increase in the content of available Mg, similar to the increase of the available K content in the soils of the whole slope. With no fertilization, higher content of these elements could result from decomposition of organic matter from plants savagely growing in the following vegetative seasons and deposited on the soil surface. The authors noticed a decrease

Table 1. Chemical properties of soils: pH in KCl, hydrolytic acidity – Hh, sum of alkaline cations – S, sorption capacity - T and degree of sorption complex saturation – V, symbol of grain composition group, in 1989 and 1995

Relief segment	Year	pH in KCl	Hh	S	T	V	Symbol of grain composition group*
			(me/100 g soil)				
			Belt A				
Mount	1989	4.9	3.5	3.9	7.4	41.7	pgmp
	1995	4.5	3.1	2.8	5.9	47.5	pgmp
Convex slope	1989	4.4	3.5	4.7	8.2	57.3	pgmp/glp
	1995	4.7	3.4	4.0	7.4	54.1	pgmp
Concave slope	1989	4.2	4.1	1.1	5.2	21.2	pgmp/pglp
	1995	4.2	3.6	2.0	5.6	35.7	pglp
Foot of slope with good outflow	1989	4.3	4.3	2.4	6.7	35.8	pgmp/pglp
	1995	4.3	4.0	2.4	6.4	37.5	pglp
			Belt B				
Mount	1989	4.3	3.5	3.9	7.4	52.7	glp
	1995	4.2	4.4	2.8	7.2	38.9	pgm/pglp
Convex slope	1989	3.9	4.3	1.7	6.0	28.3	pgmp
	1995	4.9	2.4	5.0	7.4	67.6	pgm
Concave slope	1989	4.7	2.6	2.8	5.4	51.8	pglp
	1995	4.2	2.5	1.6	4.1	39.0	pgmp
Foot of slope with good outflow	1989	4.3	3.8	1.4	5.2	26.9	pgmp
	1995	4.3	3.1	1.5	4.6	32.6	pgmp/pglp
Foot of slope with difficult outflow	1989	4.0	4.6	1.6	6.2	25.8	pgmp
	1995	4.2	4.5	2.2	6.7	32.8	pgmp/pglp

*Explanations: pglp - light loamy silty sand; pgm - strong loamy sand; pgmp - strong loamy silty sand; glp - light silty loam.

of available Mg content in the soil of the dome-shaped top - in the driest place that resulted in the lower formation and deposition of organic matter.

Introduction and decomposition of organic substances by soil micro-organisms caused an increase of soil biological processes. These reactions were noticed during investigations of biological activity according to the Kuźniar's method [3] (Tables 3 and 4). In earlier experiments, the investigated soils situated in the belt B showed a visible increase of the degree of cellulose decomposition, in a few cases from "very weak" to "medium". An increase in the micro-organisms activity that decomposed cellulose was at the same the reason for a decrease of C organic content in the humus horizon. A decrease of this component was noticed also in the soils

T a b l e 2. Chemical properties of the soil: organic matter content, content nitrogen total – N og., ratio C:N, content available magnesium, phosphorus, potassium, eroded soils from Dlusko in 1989 and 1995

Relief segment	Year	Organic matter (%)	N total (%)	C:N	Mg (mg/100 g soil)	P_2O_5 (mg/100 g soil)	K_2O (mg/100 g soil)
		Belt A					
Top	1989	1.05	0.090	7.00	7.70	35.60	7.40
	1995	0.97	0.069	8.11	4.36	14.72	14.80
Convex slope	1989	1.09	0.090	6.90	4.40	15.90	9.00
	1995	0.79	0.073	9.40	5.66	18.50	11.74
Concave slope	1989	1.41	0.120	7.00	1.40	17.40	6.80
	1995	1.13	0.076	8.68	3.79	12.64	18.10
Foot of slope with good outflow	1989	1.41	0.110	7.70	2.90	15.40	17.50
	1995	1.31	0.098	7.76	3.19	14.30	13.02
		Belt B					
Top	1989	1.21	0.090	7.80	4.70	14.10	14.70
	1995	0.92	0.090	5.89	2.34	19.76	15.62
Convex slope	1989	1.21	0.090	7.70	1.20	20.00	11.60
	1995	0.77	0.090	4.78	1.64	16.06	16.52
Concave slope	1989	1.31	0.090	8.10	5.30	19.40	9.90
	1995	0.93	0.095	5.68	6.02	18.82	13.46
Foot of slope with good outflow	1989	1.53	0.110	8.20	3.20	15.00	19.31
	1995	1.39	0.101	8.02	3.84	12.74	24.92
Foot of slope with difficult outflow	1989	1.79	0.130	8.00	2.30	13.80	17.50
	1995	3.46	0.250	8.04	6.21	12.52	23.18

of the belt A, ploughed deeply to a depth of 42 cm in the experiments of 1986 and 1988. In these soils, in the fallow conditions, an increase of biological activity was lower than in the soils from the belt B. Some of the soils showed even a decrease of the degree of cellulose decomposition, especially in the soil layers of 20-30 cm and 30-40 cm.

The present results after a four-year period of fallow, did not show clearly any changes in the soil properties.

Changes in acidity or changes in the content of nutrient components and sometimes also an increase in the degree of saturation of the sorption complex, showed inhibition of degradation processes started in the period of intensive cultivation. Changes of C organic content showed a decrease of the soil humus. Perhaps, after some years, this negative process taking place in the fallow conditions (permanent

T a b l e 3. Cellulose losses in the soils of the belt A in 1989 and 1995 (acc. Kuźniar's method [3])

Year	Soil layer (cm)	Relief segment							
		Top		Convex slope		Concave slope		Foot of slope with good outflow	
		loss (%)	category acc. Kuźniar	loss (%)	category acc. Kuźniar	loss (%)	category acc. Kuźniar	loss (%)	category acc. Kuźniar
1989	0-10	42.7	strong	9.0	weal	13.6	weak	8.9	weak
	10-20	45.2	strong	7.3	weak	10.1	weak	5.9	weak
	20-30	25.6	medium	6.5	weak	7.2	weak	4.2	very weak
	30-40	8.0	weak	4.5	very weak	12.6	weak	2.4	very weak
1995	0-10	20.5	medium	9.5	weak	15.6	medium	10.9	weak
	10-20	16.6	medium	6.4	weak	9.6	weak	9.5	weak
	20-30	6.3	weak	4.8	very weak	6.3	weak	5.5	very weak
	30-40	4.2	very weak	3.8	very weak	3.4	very weak	4.4	very weak

T a b l e 4. Losses of cellulose in soils of belty B in 1989 and 1995 years (acc. Kuźniar's method [3])

Year	Soil layer (cm)	Relief segment: Top		Convex slope		Concave slope		Foot of slope with good outflow		Foot of slope with difficult	
		loss in %	category acc. Kuźniar	loss in %	category acc. Kuźniar	loss in %	category acc. Kuźniar	loss in %	category acc. Kuźniar	loss in %	category acc. Kuźniar
1989	0-10	5.2	very weak	10.4	weak	5.9	weak	3.7	very weak	5.8	weak
	10-20	2.0	very weak	4.6	very weak	5.6	weal	3.4	very weak	4.6	very weak
	20-30	0.6	unnoticed	8.7	weak	1.8	very weak	0.9	unnoticed	5.2	very weak
	30-40	0.0	unnoticed	0.01	unnoticed	1.3	very weak	0.0	unnoticed	6.1	weak
1995	0-10	17.2	medium	10.6	weak	22.4	medium	22.0	medium	10.9	weak
	10-20	11.4	weak	8.1	weak	15.8	medium	16.4	medium	7.0	weak
	20-30	5.6	very weak	5.3	very weak	10.6	weak	8.1	weak	5.7	weak
	30-40	4.3	very weak	3.3	very weak	6.6	weak	5.5	weak	4.4	very weak

deposition of organic substances on the soil surface) can be changed. An increase in the biological activity of the soil was very important, because this process is able to restore many soil functions necessary for habitation. It was also found that a visible soil runoff was stopped. However, the same process in the form of chemical washing was not stopped.

CONCLUSIONS

1. Investigations on the chemical properties and cellulolytic activity of a four-year fallow showed a change of trend in some soil processes, for instance: acidity, content of nutrients, development of micro-organisms.

2. Changes of soil processes caused a decrease of potential acidity and increase of available Mg and K content.

3. Changes of other properties such as: the sum of cations with alkaline character (S), sorption complex capacity (T) and degree of sorption complex saturation (V) were related to the location in the terrain relief; i.e. the soils from the convex section of the slope showed different reactions than the soils situated on the concave section of the slope.

4. The state of fallow increased biological activity of the soil determined by the investigations on cellulolytic activity of soil micro-organisms.

5. An increase in the biological activity probably caused a decrease in organic C content.

6. The processes of buffering soil solution during the years of soil degradation (period of intensive cultivation) was probably the reason for little changes in the soil reaction.

7. Changing an arable soil to fallow caused reduction of soil degradation processes and limitation of the visible forms of water erosion.

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