ENZYMATIC ACTIVITY AS AN INDICATOR OF THE DEGRADATION AND ENVIRONMENTAL SUSTAINABILITY OF SOILS OF THE REPUBLIC OF MOLDOVA

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Abstract

Modifications of the enzymatic activity of soils of the Republic of Moldova as a result of their long-term arable use, the application of high doses of fertilizers, the use of saline waters for irrigation and the impacts of erosion processes have been established in present research. The database of enzymatic activities of different zonal soils in the long-term field experiments has been developed and constantly updated with a view to the operative evaluation of the degradation processes and ecological effectiveness of the land management. Sampling was carried out in profiles per soil horizons and from 0 - 30 cm layer separately. Database was evaluated statistically by the variance and correlation analysis. The current status of the enzymatic activity of arable soils of the Republic of Moldova is characterized by the significant reduction in comparison with soil's standards that are in conditions of natural ecosystems. Enzyme activities in soil profiles decreased with depth and depended of the soil type, fertilizers doses and the form of farming system. The negative effects on soil enzymatic activity were observed as a result of erosion processes and long-term land management practices without organic fertilizers. Losses of the urease constitute 68.6-94.3%, dehydrogenase – 19.1-55.6%, polyphenoloxidase – 6.5-32.8%, peroxidase – 10.9-28.7%, in the dependence of the erosion degree. The scales of enzymatic indicators that are proposed to use for the evaluation of the degree of chernozems degradation and its environmental certifications have been developed. The optimal doses of fertilizers and ameliorants for the recovery of the enzymatic potential of degraded soils and for the improvement of the soil quality and of the environment have been established.

Key words: enzymatic activity, enzyme, soil, degradation, scale

The enzymatic activity is one of the most important functional characteristics of soil ecosystem. Soil enzymes provide the connection between abiotic component and living organisms, carry out the basic soil function - the destruction of primary organic matter and the humus synthesis, contribute to the maintenance of homeostasis and soil resistance to external influences (Kiss Ş., Ştefanic Gh., et al., 1991; Zvyagintsev, D. G. 2003). The indicators of the enzymatic activity relate to the microbial indicators of soil quality (Kennedy A., Papendick R., 1995; Trasar-Cepeda C., et al., 1998). Their values are informative, highly sensitive to changes in the soil environment; objectively reflect the level of soil fertility (Ştefanic Gh., et al., 2001; Obrişcă M., et al., 2010).

Indicators of activity of enzymes satisfy such requirements of the environmental monitoring of soils, as efficiency, high reliability and reproducibility of results, methodological simplicity and the possibility of automation the process of obtaining the data (Dick, R. P., 1997). One of the main problems in predicting soil enzyme activities is that it is under influence of multitude interacting factors, including soil carbon quantity and quality, microbial community structure and size, physical and chemical soil properties, nutrient status and vegetation type. Therefore, reliable differences can be found in the experimental data of several years.

The current state of the soil cover in the Republic of Moldova is characterized by the intensification of the processes of degradation and desertification (Andries, S., et al., 2004). The total plowing of the land in 1950-1960 years and an intensive use of chemicals in the years that followed rendered the most powerful effect on the natural stability of soils. The decline of organic matter content and the compaction of the arable soils with the normal profile are the main manifestations of the degradation processes in agricultural lands. The intensification of erosion processes, salinization and alkalinization led in significant deterioration of the soil biota habitats (Senicovscaia I., et al., 2012). The decline of the

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natural stability of soils to various kinds of anthropogenic and natural impacts is mainly determined by the reduction in the level of their biochemical potential. There is a growing interest in developing valuable and sensitive enzymatic indicators of soil quality, which can reflect the effects of land management and ensure a long-term sustainability of soil fertility. In this context, enzymatic indices can be used for evaluation of the degradation process and comparison of different farming systems.

The purpose of the present research was to determine the effect of the long-term arable use, the application of high doses of fertilizers, the use of saline waters for irrigation and the impacts of erosion processes on the enzymatic activity of soils aiming to develop the scale parameters of their stability for the national soil quality standards.

MATERIAL AND METHOD

Four experimental sites located in different zones of the Republic of Moldova have been tested. Various kinds of the soil degradation and land management practices in the condition of long-term field experiments have been analyzed.

The first site was in the north, on the long-term field experiments of the Research Institute of Field Crops “Selectia” (Beltsy). It had 2 plots: fallow land (60-year-old and 10-23-year-old) and the long-term arable land with crop rotation (management without fertilizers). The soil was the typical chernozem.

The second site was in the north, in the Tsaregrad village, Drokiya region on the field experiments without using waste management treatments and by applying sugar lime material annually, by dose with a reserve for three years and dose with a reserve for five years (24,9; 26,8 and 28,8 t ha $^{-1}$ accordingly). The dose of the ameliorant was calculated taking into account the full replacement of the exchangeable Na^+ and the content of this element in the irrigation water. Reclaimed plots received 60 t ha^{-1} of manure (Senikovskaya I., Filipchiuk V., 2011). For a period of 23-25 years, the irrigation was carried out using poor water quality from the Reut river. The irrigation effect was studied by comparing irrigated chernozem with un-irrigated and fallow (natural standard) chernozems. The site’s soil is a typical chernozem.

The third site was located in the center of the country, in the Ivancha village, Orhei region. The natural land under fallow (40-60-year-old), forests and the long-term arable land with crop rotation without fertilizers were tested. The level of soil enzymatic activities under a long-term application of different doses of inorganic fertilizers ($N_{60-300}P_{60}K_{60}$) was compared to the organic system with 60 t ha^{-1} of manure and incorporation of crop residues. Crop residues were plowed annually; farmyard manure was introduced in the dose of 60 t ha^{-1} in 1991, 1996 and 2005. Soils were presented by the leached chernozem and the gray forest soil.

The fourth site was located in the southern zone, in the Ursoaia village of the Lebedenco district, Cahul region. Arable chernozems with different degrees of degradation caused by erosion processes (slightly, moderately and severely eroded) have been compared to the chernozem with a normal profile and the eroded soil which was under 58-years-old fallow.The soil was the ordinary chernozem.

Soil samples were collected in profiles per soil horizons and from the 0-30 cm layer separately on the experimental plots.

The urease activity was measured by estimating the ammonium released on incubation of soil with buffered urea solution by colorimetrical procedure (Haziev, 2005). The catalase activity was measured by the volumetric method (Zvyagintsev, 1991). The dehydrogenase activity was determined by the colorimetric technique on the basis of triphenylformazan (TPF) presence from TTC (2, 3, 5-triphenyltetrazolium chloride) added to air-dry basis of soil (Haziev, 2005). The polyphenoloxidase and peroxidase activities were determined by the colorimetric technique on the basis of the oxidation of phenolic compounds to quinones with the use of hydroquinone as a substrate (Karyagina and Mikhailovskaya, 1986).

Organic C was analyzed by the dichromate oxidation method. The humus content was calculated using the coefficient of 1.724 (Arinushkina, 1970).

The database of the soil enzymatic indicators covers the period between 1988 and 2009. The enzymatic indices were evaluated statistically using the variation and correlation analysis.

REZULTS AND DICUSSIONS

The enzymatic activity of soils degraded as a result of a long arable land-use. The current state of the soil enzymatic activity in the Republic of Moldova is the result of a long-term influence of human activity, through agricultural land management. Conventional tillage practices are generally unfavorable to the activity of enzymes. The enzymatic activity in modern arable soils on the mean values, as well as confidence intervals, significantly lower than in fallow soils and soils of forest ecosystems *(tab. 1; fig. 1).* Indices of the urease activity have been decreased in arable soils by 2.7-6.0 in comparison with virgin and fallow soils that are in conditions of natural ecosystems *(tab. 1).* Less significant changes have been registered in the polyphenoloxidase and peroxidase activities. The humus content (confidence intervals, $P \leq 0.05$) in virgin and fallow soils constitutes: 4.9-5.1 % in the typical chernozem, 3.7-4.6 % in the leached chernozem and 4.0-5.7 % in the gray forest soil. The characteristic feature of arable soils is the low enzyme activity. More intensive land-use involving soil tillage stimulates the microbial decomposition of organic matter and tends to result in a decrease in the enzymatic pool and ultimately in the humus content. The humus content (confidence intervals, P ≤ 0.05) in arable soils constitutes: 4.4-4.7 % in the typical chernozem, 3.2-3.8 % in the leached chernozem and 2.1-2.4 % in the gray forest soil. The differences in the enzyme activity between arable and natural soils have been manifested in the whole soil profile *(fig. 2)*.

Table 1

Enzymatic activity and humus content in arable, fallow and virgin soils in the 0-30 cm layer (confidence intervals, P ≤ 0.05, n = 3-34)

Index	Typical chernozem		Leached chernozem		Gray forest soil	
	fallow	arable	fallow*	arable	virgin	arable
Urease, mg NH_3 10 g $^{-1}$ soil 24 h^{-1}	10.0-15.0	3.4-5.6	8.6	2.1-4.1	5.4-9.7	0.9-1.9
Catalaza, O_2, cm^3 g^{-1} soil min^{-1}	5.1-7.2	4.7-5.2	5.7	2.1-3.3	3.1-4.7	1.8-2.6
Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	2.22-3.62	1.59-2.29	2.31	1.23-1.71	2.13-2.67	0.59-0.89
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	4.1-10.7	4.7-8.9	5.5	3.4-4.4	1.1-7.1	1.9-2.7
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	26.5-32.7	31.8-36.8	36.0	26.8-30.6	23.4-32.2	23.4-28.0
Humus content, %	4.9-5.1	4.4-4.7	3.7-4.6	3,2 - 3,8	4,0 - 5,7	2,1 - 2,4

*mean values

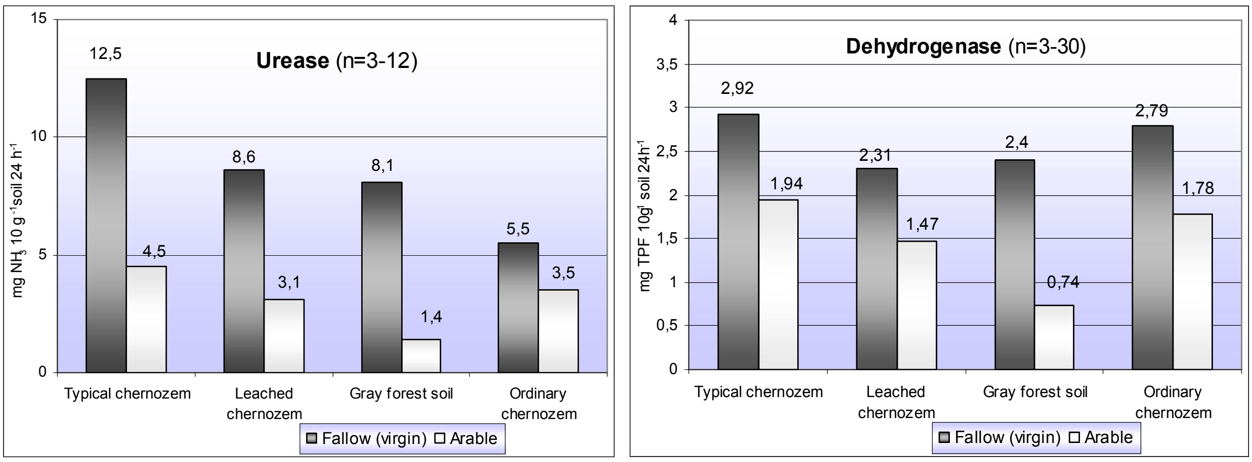

Figure 1. **Urease and dehydrogenase activity in arable, fallow and virgin soils (mean values, 0-30 cm)**

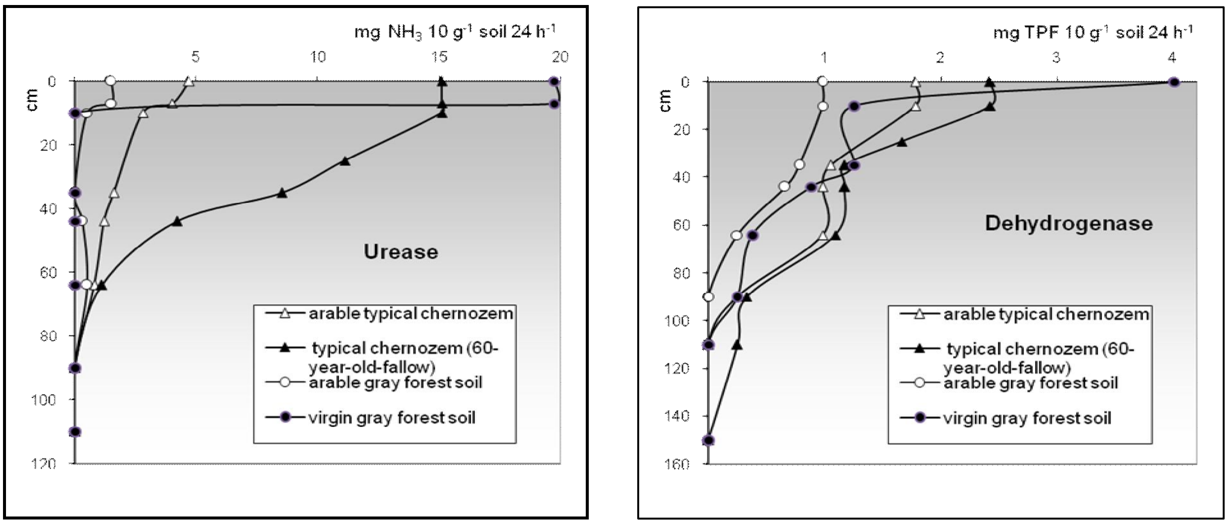

Figure 2. **The profile distribution of urease and dehydrogenase activities in the virgin, fallow and arable soils**

The highest levels of enzyme activities and organic carbon content have been determined in the A_1 horizons of the virgin and fallow soils and whereas the lowest – in the BC and C horizons of all profiles. The activity of urease reaches in the virgin gray forest soil to 19.7 mg NH_3 10 g^{-1} soil 24 h^{-1}, in the 60-year-old fallow typical chernozem – to 15.1 mg NH_3 10 g^{-1} soil 24 h^{-1}. The similar trend has been determined also for dehydrogenase (fig. 2). Arable soils are characterized by the gradual decrease in the enzymes activity with the depth as compared to soils of natural phytocenoses.

The enzymatic activity under clean-cultivated crops was lower than under close-growing crops and, especially, under bean cultures. The maximum value of enzymatic indices was determined under the lucerne.

The enzymatic activity of soils degraded as a result of the impact of mineral fertilizers application. There were no clear differences in enzyme activities between unfertilized and annually fertilized plots with $N_{60}P_{60}K_{60}$. However, the tendency towards catalase and polyfenoloxidase inhibition was observed. A long-term soil management practice with high doses of inorganic fertilizers application determines the appearance of negative changes in the complex of biota of leached chernozem and gray forest soils, reducing their stability and deteriorating their quality. As a result of the arable layer acidification (pH is reduced by 0.15-0.35) and increased hydrolytic acidity (at 0.55-1.95 me 100 g^{-1}) the total number of invertebrates in the leached chernozem reduced by 1.9 times, biomass - 2.1 times, mainly due to the reduction of saprophagous by 4-5 times (Senicovscaia I.A., et al., 2012).

A long-term soil management practice with high doses of inorganic fertilizers application ($N_{90-300}P_{60}K_{60}$ in the leached chernozem and $N_{240}P_{60}K_{60}$ in the grey forest soil) led to decreases in dehydrogenase activity by 8-19 % and polyphenoloxidase activity by 1.5 times compared to unfertilized control plots *(tab. 2)*. Enzyme activities were lower than the optimum level, providing the soil system stability. Negative shifts in the state of enzymes were accompanied by increase of the soil acidity, disturbance in the humification–mineralization equilibrium and by soil degradation on the whole. Enzyme activities under mineral system with maximum doses were suppressed even in 10 years after the cessation of inorganic fertilizers use. The use of high doses of nitrogen fertilizers has a long aftereffect and persists for some indicators on the organic fertilizers backgrounds.

The organic farming system with a long-term application of 60 t ha^{-1} of manure (once a crop rotation) and incorporation of crop residues returns the organic matter to the soil and creates conditions for carbon sink.

Table 2

The state of soil enzymes in conditions of the long-term use of mineral and organic fertilizers (n = 4-34, P ≤ 0.05)

Variant	Dehydrogenase, mg TPF 10g^{-1} soil 24h^{-1}	Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}
Leached chernozem		
Control	1.47±0.24	3.9±0.5
$N_{90-300}P_{60}K_{60}$	1.19±0.27	2.6±0.5
Fond*	1.99±0.33	5.9±1.2
Fond + $N_{60}P_{60}K_{60}$	1.86±0.40	4.4±1.5
Gray forest soil		
Control	0.74±0.15	2.2±0.5
$N_{240}P_{60}K_{60}$	0.68±0.42	1.5±0.5
Fond*	1.40±0.76	5.0±0.5
Fond + $N_{60}P_{60}K_{60}$	1.45±0.08	2.8±0.5

*Fond: plant residues + farmyard manure 60 t ha^{-1}

This can be important in the light of the mitigation of carbon losses, the compensation of the CO_2 emissions by soils and in maintaining the soil microorganisms' nutrition. According to statistical parameters dehydrogenase activity raises from 0.74 to 1.40 mg TPF 10 g^{-1} soil 24 h^{-1} in the gray forest soil, from 1.47 to 1.99 mg TPF 10 g^{-1} soil 24 h^{-1} in the leached chernozem. A similar trend was evident in catalase, polyfenoloxidase and peroxidase activities. The humus content level was higher under application of organic fertilizers. Thus, the organic farming system greatly improves the enzymatic status and fertility of arable soils.

The influence of irrigation on the enzymatic activity. The long-term irrigated typical chernozem showed a significant decrease in the enzymological indices as compared to un-irrigated and fallow soils *(fig. 3)*. The highest level of enzymatic activities has been determined in the A_1 horizon of the fallow chernozem and the lowest – in the BC and C horizons of all profiles.

A negative impact on soil's enzymatic properties was observed as a result of the irrigation with poor water quality. Dehydrogenase and polyphenoloxidase activities in the soil profiles increased with its depth. The dehydrogenase activity in the 0-50 cm of the irrigated chernozem was 1,2 - 5,2 times lower than in un-irrigated and fallow soils. The profile distribution of the polyphenoloxidase activity was more complex. However, the inhibitory effect of irrigation on the activity of this enzyme is obvious.

Modifications of the enzymatic properties in the degraded chernozem occured because of changes in the chemical and physical properties of the soil. Negative shifts in the state of enzymes occurred because of the soil alkalization, changes in the composition of the organic matter and the deterioration of the soil structure. The number of exchangeable Na^+ in the irrigated chernozem has reached 12%, which corresponds to the moderate degree of alkalization. The soil became slightly alkaline, pH increased from 7,1 to 7,6. The data presented in research demonstrates that the long-term irrigation of typical chernozems with water from the Reut river has negatively affected the soil enzymes and the soil in general. The values of enzymatic indices were typical for degraded chernozems. These soils have a low ecological stability and need the amelioration of the soil's root layer.

The application of wastes improves greatly the ameliorative status of irrigated soils and enzymatic properties of the irrigated chernozem. The modifications occurred were bigger in the 0-30 cm layer than in the 30-50 cm layer. However, there were significant differences in the enzymatic activities between the values of the control (un-irrigated) plot and the amended plots to a depth of 50 cm. According to the statistical parameters, the dehydrogenase activity in the 0-30 cm layer increases by 1,6-2,3 times and the polyphenoloxidase activity – by 1,8-2,3 times depending on the ameliorants doses. A similar trend has been noticed in enzymatic activities in the 30-50 cm layer.

The enzymatic soil parameters have been depended of the doses of sugar lime material and the content of Na^+ in the absorbing complex. A scale to estimate the irrigated chernozem reclamation had been elaborated *(tab. 3)*. The use of sugar industry waste (the reserve for five years) with manure 60 t ha^{-1} has been recommended for the immobilization of enzymes and improvement of soil quality.

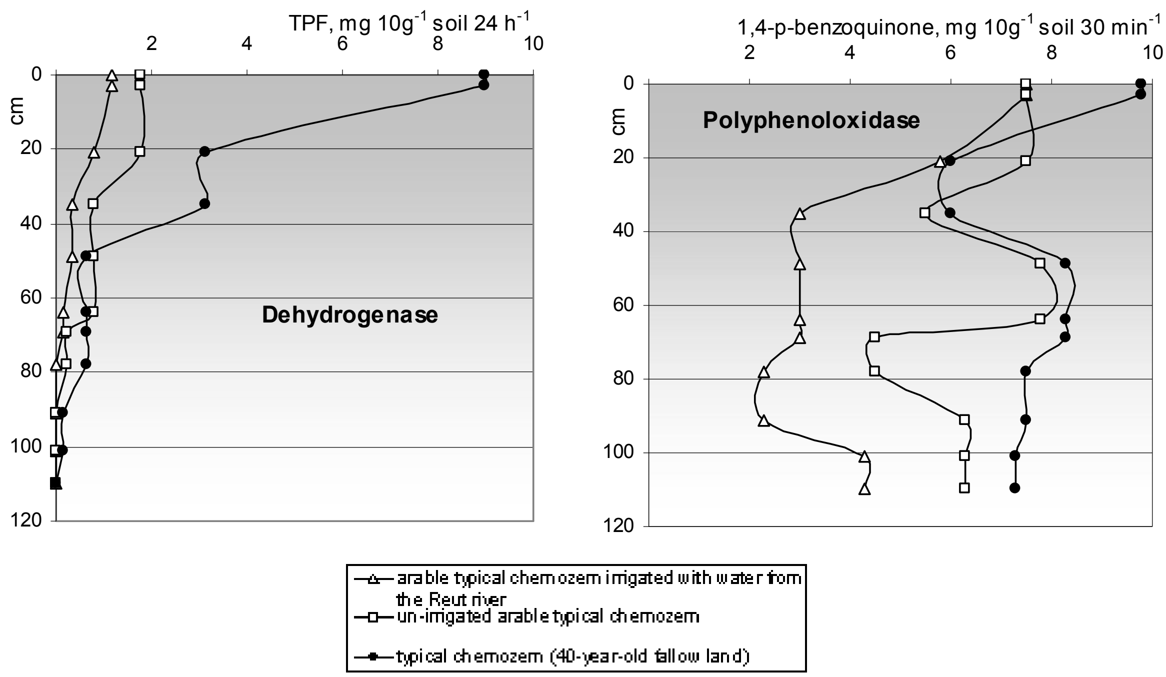

Figure 3. **Effects of the long-term irrigation on the profile distribution of enzyms in the typical chernozem**

Table 3

The estimation scale of enzyme's stability of the irrigated typical chernozem (0-30 cm)

Variant*	Degree of stability	Na^+, % of sum	Dehydro-genase, mg TPF 10 g^{-1} soil 24 h^{-1}	Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}
Control	Low	12	1.2-1.9	5.3-6.9
Sugar industry waste applied annually	Low	10	1.7-3.2	8.1-13.7
Sugar industry waste (the reserve for three years)	Moderate	8	1.9-4.0	9.8-14.0
Sugar industry waste (the reserve for five years)	Moderate	7	2.5-4.7	11.3-16.5

* sugar industry waste was incorporated with manure 60 t ha^{-1}

The impact of erosion on enzymes' state. The humus loss as a result of erosion causes a sharp decline in the enzymatic activities of soil. Eroded soils have a low enzymatic activity *(tab. 4)*. The urease activity decreases by 17.5, dehydrogenase activity – by 2.3, polyphenoloxidase and peroxidase activities – from 1.4 to 1.5 in the severely eroded soil compared to the chernozem with normal profile. The losses of the urease activity constitute 68.6-94.3%, dehydrogenase – 19.1-55.6%, polyphenoloxidase – 6.5-32.8% and peroxidase - 10.9 to 28.7% depending on the degree of erosion.

Table 4

Enzymatic activity as a result of erosion processes in the ordinary chernozem in the 0-30 cm layer

Index	Mean values	S^2	V, %	Sx	Confidence intervals, $P \leq 0.05$	n
Chernozem with the normal profile						
Urease, mg NH_3 10 g $^{-1}$ soil 24 h^{-1}	3.5	0.68	24	0.24	3.0-4.0	12
Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	1.78	0.54	41	0.20	1.33-2.23	13
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	18.6	1.97	8	0.57	17.1-20.1	6
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	34.8	0.08	1	0.11	34.5-35.1	6
Slightly eroded chernozem						
Urease, mg NH_3 10 g $^{-1}$ soil 24 h^{-1}	1.1	0.58	70	0.25	0.5-1.7	9
Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	1.44	0.87	65	0.27	0.85-2.03	12
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	17.4	4.16	12	0.83	15.3-19.5	6
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	34.8	0.08	1	0.11	34.5-35.1	6
Moderately eroded chernozem						
Urease, mg NH_3 10 g $^{-1}$ soil 24 h^{-1}	0.5	0.13	65	0.12	0.2-0.8	9
Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	1.26	0.80	71	0.26	0.69-1.83	12
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	17.3	0.98	6	0.40	16.3-18.3	6
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	31.0	0.50	2	0.29	30.3-31.7	6
Severely eroded chernozem						
Urease, mg NH_3 10 g $^{-1}$ soil 24 h^{-1}	0.2	0.05	102	0.06	0.1-0.3	14
Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	0.79	0.22	59	0.10	0.59-0.99	23
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	12.5	3.06	14	0.41	11.6-13.4	18
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	24.8	11.0	13	0.78	23.1-26.5	18

The declines in the enzymatic activity caused by erosion represents a complicated process conditioned by the deterioration of physical, chemical and physico-chemical properties of eroded soils, destruction of organic compounds, abrupt reduction in the microorganisms' biomass.

When a mass of soil layers are washed away, eroded soils are losing not only the enzymes but also the conditions for their synthesis, and immobilization and stabilization in remaining horizons deteriorate. Urease and dehydrogenase indices are characterized by medium and significant variability. The variation coefficients of the enzymatic activity in eroded chernozems are higher than in chernozems with a normal profile. The variation coefficient for urease constitutes 24% in chernozems with normal profile, 70% – in slightly eroded, 65% – in moderately eroded and 102% – in severely eroded chernozems.

An analogical regularity has been observed in the dehydrogenase activity. The variability in peroxidase and polyphenoloxidase activities of eroded soils is either medium or insignificant. The increase of the coefficients of variation indicates a low natural resistance of the eroded chernozems.

The correlation analysis of the interdependence between the enzymatic indices and the humus content demonstrated their close connection. The correlation coefficients constitute 0.85-0.90. Two indicators have been selected and included to the general scale of biological parameters (Senicovscaia I., et al., 2012). They were more closely linked to the humus content and reflected the degrees of the ordinary chernozem erosion more thoroughly. The enzymatic parameters of soils have been grouped according to the humus content. A scale has been developed to estimate the soil stability as a result of the erosion processes impact on the ordinary chernozem and its ecological certification *(tab. 5)*. The scale can also be used to assess the quality of eroded soil.

Table 5

The estimation scale of enzyme's stability of the ordinary chernozem following the impact of erosion processes (0-30 cm)

Degree of stability	Humus content, %	Dehydro-genase, mg TPF 10 g^{-1} soil 24 h^{-1}	Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}
Very high	>3,2	>2.2	>4.0
High	2,9-3,2	1.3-2.2	3.0-4.0
Moderate	2,4-2,8	0.9-2.0	0.5-1.7
Low	1,8-2,3	0.7-1.8	0.2-0.8
Very low	<1,5	<0.7	<0.2

The degree of the soil stability decreases with the raising of the level of its degradation. The size of homeostasis zones and natural resistance of the ordinary chernozem decreases consecutively: chernozem under fallow → chernozem with the normal profile → slightly eroded chernozem → moderately eroded chernozem → severely eroded chernozem.

The level of enzymatic activity and therefore the soil stability reached the maximum levels in the fallow soil. Severely eroded chernozems have the lowest resistance.

CONCLUSIONS

The current status of the biota of arable soils of the Republic of Moldova is characterized by the significant reduction in the enzymatic activity in comparison with soil's standards that are in conditions of natural ecosystems. The long use of soils in agricultural production led to the imbalance between the processes of decomposition and humus formation and promoted the decrease of soil enzymatic stability and degradation. The biological degradation of arable soils is interconnected with the dehumification processes, compaction and destruction of the soil structure. A major reason for the deterioration of soil enzymatic properties and for the decline of humus content under arable agriculture is annual tillage, which aerates the soil and breaks up aggregates where microbes are living. The values of most soil enzymatic indices decrease in the following sequence: virgin and fallow soil → arable soil under organic system with farming manure and incorporation of crop residues → arable unfertilized soil → arable soil with mineral fertilization of N_{90-300}. The reduction of the biochemical potential results in the attenuation of natural soil stability.

Enzyme activities in soil profiles decreased with depth and depended of the soil type, fertilizers doses and the form of farming system. The highest level of enzymatic activities has been determined in the A_1 horizon of the virgin and fallow chernozems.

The restoration of enzymes' status is based on the change in the existing balance of carbon in degraded arable soils of agricultural ecosystems. Application of organic fertilizers in the form of farmyard manure and the annual addition into degraded soils of crop esidues with $N_{60}P_{60}K_{60}$ helps to prevent ecological violations in the state of soil biota, stabilize and improve the enzymatic activity.

A soil management with the involvement of areas with natural vegetation in a crop rotation system created conditions for the improvement of the enzymatic activity in the soil which degraded as a result of a long-term arable use.

The negative effects on soil enzymatic activity were observed with use of saline waters for irrigation. The enzymatic parameters depended on the doses of sugar lime material and the content of

Na^+ in the absorbing complex. The optimal doses of ameliorants (sugar industry wastes in the reserve for five years with manure 60 t ha^{-1}) for the recovery of the enzymatic potential of irrigated chernozems and for the improvement of the soil quality and of the environment have been established. The scale of enzymatic parameters is proposed for the evaluation of the stability of chernozem degraded as a result of the long-term irrigation with poor water quality.

The considerable loss of enzymes and their inactivation is one of the typical manifestations of the erosion process. The enzymatic indicators of chernozems depend on the degree of erosion. The growth of variation coefficients once the erosion degree increases indicates the reduction of the soil stability. Losses of the urease constitute 68.6-94.3%, dehydrogenase – 19.1-55.6%, polyphenoloxidase – 6.5-32.8%, peroxidase – 10.9-28.7%, in the dependence of the erosion degree.

The scale of enzymatic indicators is proposed for eroded chernozems to assess their stability and to establish the national soil quality standards.

The database of the soil enzyme state has a practical importance as a relative standard for an operative evaluation of the degradation processes and ecological effectiveness of land management in the Republic of Moldova. Future research in the domain of soil enzymology will be directed to a more fully understanding of the interaction between soil enzymes and the organic matter accumulation/loss. The important aspect of researches will be the elaboration of enzymatic standards for high quality soils.

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