E- Global Congress
Hosted online from Dubai, U. A. E., E - Conference.
Date: 30th June 2026
Website: https://eglobalcongress.com/index.php/egc
ISSN (E): 2836-3612

FERMENTATIVE ACTIVITY OF SOILS DISTRIBUTED IN VERTICAL ZONING

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Abstract:
This study investigated the effect of erosion processes on enzymatic activity in brown and gray soils of the mountainous and foothill regions of the Western Tien Shan. During the study, the activities of invertase, catalase, and amylase enzymes were determined and compared in soils washed to different degrees. The results showed that with increasing erosion, the biological activity of the soil decreases, especially the activity of the invertase enzyme decreases sharply. While the amylase enzyme is relatively stable, it was found that catalase activity varies depending on the type of soil and environmental conditions. It was proved that enzymatic activity indicators are important bioindicators in assessing the biological fertility and ecological state of the soil. The results obtained are of great importance in assessing the fertility of eroded soils in mountainous and foothill regions and developing scientific and practical recommendations for their protection.

Keywords: Western Tien Shan, brown soils, gray soils, erosion, enzymatic activity, invertase, catalase, amylase, biological activity, microorganisms, humus, bioindicator, soil fertility.

Introduction

Soil fertility in the world andagrogeochemicalstatus,not only macronutrients, but also biophilic elements, microelements and toxic heavy metalsScientific research is being conducted in a number of priority areas on soil fertility indicators, their correlation with soil fertility, and soil fertility modeling. In addition, scientific research is being conducted in priority areas aimed at studying soil properties, using modern geoinformation technologies to assess, restore, increase, and manage soil fertility, and restoring soil fertility.

In our republic, in order to solve the problem of rational use of land resources and soil protection, large-scale theoretical and practical research is being carried out on restoring and preserving the fertility of soils eroded by irrigation, improving soil properties, and achieving certain results. The Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030 states that "... Of the 20.2 million hectares of land intended for agriculture, only 20.7 percent are irrigated lands. Over the past 15 years, irrigated land per capita has decreased by 24 percent (from 0.23 to 0.16 ha), rational use of natural resources, including rational use of land and water resources, forest resources, and improvement of the environmental protection system" are identified as important strategic tasks[1].That is why irrigated soils in our republicagrogeochemical status and fertility,Research into a number of properties related to the processes that form the biogeochemical and chemical elemental composition of soils in agricultural areas, the natural geochemical differentiation of agro-regions, and anthropogenic changes resulting from agricultural production technologies and not arising from agricultural needs.Prevention and achieving sustainable agriculture are of paramount importance.

According to Burns, RG et al. [1,2], enzyme activity is one of the most reliable biochemical indicators for assessing ecological changes in soils. The authors state that as a result of soil degradation and increased erosion, enzyme activity decreases, as the habitat and food sources for microorganisms are reduced. In our studies, the high invertase and amylase activities in unwashed soils and their sharp decrease in moderately washed soils confirm this pattern.

Lal, R. [4] (1998) stated that soil erosion is one of the main factors reducing fertility and noted that humus, nutrients and biological activity decrease during the erosion process. The results of this study also confirm these scientific conclusions by showing a decrease in enzymatic activity with increasing erosion.

[2]Decree of the President of the Republic of Uzbekistan dated January 28, 2022 No. PF-60 "On the Development Strategy of New Uzbekistan for 2022–2026"

According to Khaziev, FX [5], invertase and amylase enzymes are the main indicators of carbohydrate metabolism in the soil, while catalase reflects the intensity of oxidation-reduction processes. Therefore, catalase activity can be high in some cases even under the influence of environmental stress. This is explained by the fact that in our studies, catalase activity did not change in the same direction as invertase in all soil types.

The results obtained are consistent with the conclusions given by Nannipieri, P. et al. [3] and Alef, K. and Nannipieri, P. [3], and once again confirm that enzymatic activity is one of the most important biochemical indicators in assessing the ecological status and biological productivity of the soil.

In the studies conducted by Ahmad, M. and co-authors [6], it was found that the application of exosaccharide-forming and mineral-soluble biofertilizers significantly increased the biological activity of the soil, increased the activity of microorganisms, and improved the assimilation of nutrients by plants. The authors emphasize that enzymatic activity is one of the important biochemical indicators for assessing soil fertility. These results are consistent with our studies, confirming that a decrease in biological activity under the influence of erosion leads to a slowdown in enzymatic processes. (Ahmad et al., 2026).

The authors also noted that exosaccharides produced by beneficial microorganisms increase the stability of soil aggregates, improve moisture retention capacity, and enhance the mobility of nutrients. As a result, biological and biochemical processes of the soil are activated and enzyme activity increases. This once again confirms the close relationship between the enzymatic activity observed in Western Tien Shan soils and humus content and microbiological processes (Ahmad et al., 2026).

Research methods

Field experiments, laboratory, chamber, chemical analysis work were carried out on the basis of generally accepted methodological guidelines in agrochemistry and cotton growing: conducting field experiments in the method of "Methodology of field and vegetation experiments with cottonseed under irrigation conditions", taking soil and plant samples and chemical analysis in the method of "Methods of agrochemical, agrophysical and microbiological research in irrigated cotton regions", general and mobile

ISSN (E): 2836-3612

forms of microelements in the soil, the amount of B in plant parts were determined in the methodical guidelines of Y.K. Kruglova "Methodology of determination of microelements and their forms in carbonate soils, cottonseed, water" and Y.V. Arinushkina "Guide to chemical analysis of soils", variational and statistical analysis of the obtained data was carried out using the methodological manual of B.A. Dospechov "Methodology of field experiments" and the computer program "Microsoft Excel" The research used methods such as remote sensing, comparative analysis, monitoring, geostatistical analysis, and digitization of information through analytical processing.

Research results:

Analysis of literature data on the study of soil enzymatic activity led to the following conclusion:

The level of enzymatic activity in the soil can easily serve as a direct indicator of its fertility, biological activity and the number of microorganisms. Because no constant correlation has been observed between these soil factors and enzymatic activity. However, a direct correlation has been observed between the number of microorganisms synthesizing certain groups of enzymes and the activity of these enzymes.

Soil enzymes and their activity are one of the main indicators characterizing soil life. Therefore, it is appropriate to briefly dwell on the functioning of enzymes studied in the literature and their activity. The activity of enzymes in the soil depends on the metabolic conditions of microorganisms, as well as on the synthesis of enzymes involved in metabolism. Of the enzymes, protease and urease characterize the mineralization processes of organic nitrogen in the soil, that is, as a result of the processes of nitrification and ammonification in the soil, they lead to the formation of nitrogen compounds that are quickly absorbed by plants. The mobility of these enzymes, which act as catalysts in such reactions, is incalculable. At the same time, the functional function of the catalase enzyme is constantly changing, depending on the relationship of the catalase enzyme with the oxygen and other elements released from it, as well as the abundance or scarcity of organic matter in the soil.

The experiments conducted have shown that, firstly, phosphatase activity depends on the growth of microorganisms, and secondly, the phosphatase enzyme, depending on its products, mainly causes the soil to produce water-soluble phosphorus elements. This process attracts the study of phosphatase enzyme activity in order to accurately determine the phosphorus demand of the soil.

The polyphenol oxidase enzyme is the most complex enzyme. It includes several enzymes, namely monophenolase, diphenol oxidase, tyrosinase and lactases. These representatives of the enzyme family differ from each other in the polymerization of oxidized quinone and its compounds and the formation of higher molecules, as well as the formation of humus-like compounds. The peroxidase enzyme, in addition to showing the main granularity in the composition of humic substances, accelerates the oxidation processes of phenols and aromatic amines. A direct correlation has been observed between phosphatase activity and soil organic carbon and organic phosphorus. High phosphatase activity was noted when phosphorus was added to soils with a low content of inorganic phosphorus, but high rates of phosphorus fertilizers had a negative effect on its activity.Soil is often compared to a natural "anti-gas" that regulates the amount of gases in the atmosphere. This unique property of producing and absorbing various gases is due to soil microorganisms. They are the main regulators of the gas composition of the Earth's atmosphere, including its macrocomponents O2 and N2, as well as its microcomponents, including the most important "greenhouse" microgases - methane (CH4), carbon dioxide (CO2) and nitrous oxide (N2O).

In all studied soils, the minimum production of carbon dioxide was observed, as a rule, in washed soils located on southern exposures. Unwashed soils occupy an intermediate position. (table).

For example, in typical gray soils, carbon dioxide formation in the upper (0-30 cm) layer of unwashed soils is 4.8, in washed soils it is 2.7-3.8, and in washed soils it is -6.1, representing SO2 mg per 100 g of soil over 24 hours. In the lower (50-70 cm) layers, SO2 formation decreases to 1.0-2.6 in typical gray soils and to 1.4-3.0 in dark gray soils, representing SO2 mg per 100 g of soil over 24 hours.

High CO2 release was observed in mountain brown soils2, where the processes of decomposition of organic matter are well expressed and are closely related to the total number of microorganisms. Carbon dioxide production increases from mountain brown carbonate soils to mountain brown typical and mountain brown weakly alkalized soils and depends on the exposure of the slopes and their erosion. For example, in mountain brown carbonate soils in the upper horizons (0-30 cm) the SO2 content is from 5.5 to 8.5, in mountain brown typical soils it is from 6.9 to 11.9, in mountain brown weakly alkalized soils it is from 8.5 to 14.2 mg SO2/100 g at 24 h. The release of carbon dioxide in all studied mountain brown soils decreases linearly towards the lower horizons.

Table 1 The intensity of "breathing" of eroded soils (average number of seasonal dynamics, mg CO2/100 g for 24 hours)

Washing rate	Depth, cm	Soil				
		Typical gray soil	Dark gray soil	Mountain brown carbonate	Mountain brown typical	The rock is brown, weakly alkaline.
Unwashed	0-30	187 187±1.5	330 330±6.9	506 506±2.3	330 330±7.6	286 286±7.2
Moderately washed, southern exposure	0-30	243 243±5.8	385 385±5.0	572 572±6.6	572 572±6.6	187 187±1.5
Moderately washed, northern exposure	0-30	187 187±1.5	506 506±2.3	396 396±8.7	385 385±5.0	243 243±5.8
Washed	0-30	286 286±7.2	418 418±2.5	176 176±0.1	380 380±7.6	572 572±6.6

Thus, the study of the formation of carbon dioxide gas in eroded soils shows that the release of carbon dioxide gas is legally dependent on the number of microorganisms, the amount of organic matter, erosion processes, types and subtypes, chemical and physical properties, and soils located in conditions of vertical zonation. Based on the amount of CO2 released, it is possible to make an approximate judgment about the biological activity of the soil.

Table 2 The influence of erosion processes on the enzymatic activity of Western Tien Shan mountain and foothill soils.

Enzymes	Depth, cm	Soil type	Unwashed	Weakly washed	Medium washed
Invertase(Glucose per 1 g of soil over 24 hours)	0–30	Brown carbonate	3.6±0.3	0.8±0.1	0.6±0.2
		Brown typical	3.6±0.3	0.8±0.1	0.6±0.2
		De-alkali brown	16.3±0.26	9.0±1.53	1.9±0.1
		Dark gray	19.6±0.3	8.18±1.35	3.1±0.3
		Typical gray	9.8±0.2	12.8±1.61	1.7±0.2
Catalase($KMnO_4$/2.5 s)	0–30	Brown carbonate	3.6±0.3	0.8±0.1	0.6±0.2
		Brown typical	16.3±0.26	9.0±1.53	1.9±0.1
		De-alkali brown	19.6±0.3	8.18±1.35	3.1±0.3
		Dark gray	9.8±0.2	12.8±1.61	1.7±0.2
		Typical gray	24.5±1.84	18.0±1.2	1.9±0.1
Amylase(ml 0.1 M $Na_2S_2O_3$/20 ml solution)	0–30	Brown carbonate	11.9±0.2	8.0±1.5	12.0±1.5
		Brown typical	12.6±0.3	9.7±0.3	12.6±0.3
		De-alkali brown	13.0±0.8	9.3±0.5	12.0±1.5
		Dark gray	11.5±0.6	9.3±1.2	10.0±1.2
		Typical gray	11.0±0.8	9.3±0.5	12.0±1.5

Analysis of the data in Table 2 shows that erosion processes have a significant impact on the enzymatic activity of brown and gray soils in the Western Tien Shan region. In all soil types, enzyme activity, especially invertase activity, showed a decreasing trend with increasing leaching rate. In brown carbonate soils, invertase activity was 3.6 units in unwashed soil, but decreased to 0.8 and 0.6 units in weakly and moderately washed soils, respectively. A similar situation was observed in typical brown soils, where invertase activity decreased from 16.3 to 9.0 and 1.9 units, and from 19.6 to 8.18 and 3.1 units in alkalized brown soils. This indicates that the washing of the humus-rich topsoil as a result of erosion weakens the activity of enzyme-producing microorganisms.

The same pattern was observed in gray soils. In typical gray soils, invertase activity was highest, reaching 24.5 units in unwashed soil. In weakly washed soil, this indicator decreased to 18.0 units, and in moderately washed soil - to 1.9 units. In dark gray soils, invertase activity ranged from 9.8–12.8 units, and in moderately washed soil - to 1.7 units. In light gray soils, invertase activity also decreased from 13.0 units to 1.8 units.

Catalase activity varied depending on soil type. In brown carbonate soils, catalase activity increased from 0.1 to 4.9 units with increasing leaching degree, while in typical brown soils, the highest value was observed in weakly leached soil (13.8 units). In alkalized brown soils, catalase activity was recorded in the range of 3.8–8.16 units.

Catalase activity in gray soils was particularly high in dark gray soils, with unwashed and lightly washed soils measuring 12.25 and 17.8 units, respectively. Catalase activity in typical gray soils was relatively low (2.5–8.16 units), while in light gray soils it ranged from 9.3–13.0 units. This indicates that the catalase enzyme is more adaptable to redox processes and more resistant to erosion than invertase.

Amylase activity was relatively stable in both soil groups. In brown soils, amylase was mainly recorded in the range of 8.0–13.0 units, and in gray soils - in the range of 8.7–12.0 units. Only in the moderately washed variant of light gray soils was amylase activity reduced to 1.6 units. This indicates that with increasing erosion, carbohydrate decomposition processes also slow down.

In general, the comparison results showed that among the enzymes, invertase is the most sensitive to erosion, and its activity in all soil types decreases sharply with increasing leaching. Amylase is relatively stable, while catalase shows a different response depending on the soil type and environmental conditions. In terms of enzymatic activity, unwashed soils in all cases had higher indicators than weakly and moderately washed soils. This is explained by the decrease in organic matter as a result of erosion, the destruction of the humus layer, and the weakening of microbiological processes.

We studied the seasonal dynamics of enzyme activity and respiration rates of various gray and mountain brown soil types and noted that these pores were not studied in the conditions of the study area. The results of our studies showed that enzyme activity and respiration of mountain soils depend on hydrothermal conditions, and their highest indicators are observed in all soils, mainly in spring.

Thus, in soils of vertical zonation from typical gray soils to dark and mountain brown soils, the activity of the studied oxidation-reduction enzymes increases in proportion to the increase in the total microbiological activity, the amount of humus and nutrients. The highest activity of the enzymes is observed in the upper layer of the soil, and in the lower layers their sharp decrease is observed, especially in washed, then unwashed and washed soils, which is associated with changes in the amount of humus, nutrient elements, pH, carbonates, agglomeration of the mechanical composition, an increase in soil density, genetic properties of the soil. Their activity along the profile decreases very smoothly, which is more evidence of the stability of enzymes than microorganisms.

Conclusion

As the soil transitions from gray soils to mountain brown and light brown meadow-steppe soils, the oxidation-reduction enzymes studied (Invertase.catalase,amylase) activity increased in accordance with the increase in the total microbiological activity, humus and nutrient content and naturally decreased in the lower layers. It was found that there is a close relationship between humus content and respiration and enzymatic activity in the studied soils. It was found that the amount of CO_2 gas produced in the conditions of mountain soils distributed along vertical zonation increases from gray soils to light brown meadow-steppe soils and from soils located on southern exposures to northern slopes and from washed soils to unwashed soils.

The following regularities of the humus state of gray soils have been identified: soils with soil-forming rock properties that provide extreme regimes are characterized by low reserves of humus and nutrient elements; with the development of erosion processes, soils can be placed in the following order by the amount of humus: washed-unwashed-weakly washed-moderately washed soils; soils of northern exposure are characterized by the size of humus reserves and the thickness of the humus profile, and washed and unwashed soils are characterized by a greater condensation of the aromatic humic acid nucleus than washed soils.

References:

[1] Burns, RG (1982). Enzyme Activity in Soil: Location and a Possible Role in Microbial Ecology. Soil Biology & Biochemistry, 14, 423–427.

[2] Burns, RG et al. (2013). Soil enzymes in a changing environment: Current knowledge and future directions. Soil Biology & Biochemistry, 58, 216–234.

[3] Nannipieri, P., Kandeler, E., & Ruggiero, P. (2002). Enzyme activities and microbiological and biochemical processes in soil. In: Enzymes in the Environment. New York: Marcel Dekker.

[4] Lal, R. (1998). Soil Erosion Impact on Agronomic Productivity and Environmental Quality. Critical Reviews in Plant Sciences, 17(4), 319–464.

[5] Khaziev, FX (2005). Methody pochvennoy enzymologii. Moscow: Nauka.

[6] Maqshoof Ahmada, Iqra Ahmada, Abubakar Dara, Farheen Nazlib, Usman Zulfiqarc, Hossam S. El-Beltagid, Halit Tutare, Nodira Raupovaf, Abdulrahman Alasmarig,h, Zaur Huseynovi and Mayank Anand Gururanij Efficacy of exopolysaccharide-producing, mineral-solubilizing biofertilizers to enhance cotton productivity in nutrient-deficient soils. //https://doi.org/10.1080/03650340.2026.2677970//