ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SOIL ENZYMES AND CHARACTERISTICS

İnci Sevinç Kravkaz Kuşcu*, M. Ömer Karaöz
*Kastamonu University Faculty of Forestry, Forest Engineering Department
Istanbul University Faculty of Forestry, Forest Engineering Department

ABSTRACT

For understanding the structure and the functions of soil ecosystem, the analysis of soil microorganisms' population and the factors affecting their activities are important. For this purpose, the soil enzymes: are used as indicators of soil fertility and microbial activity.

The distribution of soil enzymes and activities on the agricultural lands under the monoculture or sowing is accepted as a wide research subject however the researches which investigate the ecological relation in natural ecosystem by using the enzymes on biotope characterization are rare or not too much.

With this study it was attempted to establish a base for future studies by evaluating the done researches on soil properties and their effects on soil fertility.

KEYWORDS: Soil Enzymes, enzyme properties, catalase enzyme, urease.

INTRODUCTION

Enzymes are protein structured molecules which catalyse the biochemical reactions. Enzymes have many important metabolic functions on cells and have stepped into daily and economical life for their wide range uses on many different purposes. (Wiseman, 1987).

It is a common truth accepted by all of the scientists that enzymatic reactions and the fertility of soil have a close relation. In recent years the questions on: the roots of the soil enzymes, spreading, functions and kinetic properties were not only tried to being answered by biogeochemistry; also agriculture, ecology, industry, medicine, space science and even law. (Durand, 1965, Howard, 1972).

ENZYMES AND CHARACTERISTICS

The natural reactions could be classified like: chemical, biological and physical (Tabatabai and Dick, 2002). One of the most astonishing properties of a living cell is: it achieves the most complex and different chemical reactions rapidly. Even though with today's technology it is impossible or very hard to do the same, a living cell can easily manage this reactions. (Haktanır and Arcak, 1996).

The biological and chemical processes in the soil are the basis of terrestrial ecosystem (Dick and Kandeler, 2004). Eventually, all nutrients in the ecosystem are related with soil, fragmentation and complex organic cycle for being a nutrition and energy source. The soil enzymes are the main centre of these processes which were created by many catalysts which have no importance in terms of global biochemistry. Enzymes are proteins which speed up the reactions by catalysing them without any permanent transformation (Dick and Kandeler, 2004).

Most of the biochemical reactions are catalysed by enzymes (Tabatabai and Dick, 2002). Enzymes are protein based biocatalysts which accelerate the biochemical reactions. Enzymes regulate the biological systems (Karlson, 1992).Enzymes are in all kind of substance transformation reactions and there is no life without enzymes (Dick and Kandeler, 2004).

Briefly it is possible to say that: enzymes are high molecular catalysts which were gotten from organisms but do not need that organism to be active. The main function of the enzymes are transforming the high molecular organism into simple ones which can easily pass into cells and finally the organism will be able to use them. As it was told in the beginning enzymes are only speeding up the reactions by catalysing them with their existence.

SOIL ENZYMES

The soil enzymes do some biogeochemical transformations. These are functioning on dead or

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

alive microorganisms as intracellular catalysts or out of the cell far away from the creation point. The extracellular enzymes can be; free, rapidly decaying and short term effective or bonded to soil colloids and staying longer. ((Burns,1978).

In soil ecosystems the enzymes play vital role on carbon, nitrogen, sulfur and other nutrients cycles (Tabatabai and Dick, 2002; Caldwell, 2005). The soil has a wide ranged microbial flora which decomposes many different organic materials in various characteristics. For decomposing the substrates of organic material, many different microorganisms involve sequentially and for this decomposition process they excrete different extracellular enzymes according to the type of substrates. Hence they play vital role on nutrient cycle (Arcak et al., 1994).

In the soil, almost 100 enzymes activities have been defined (Tabatabai, Dick, 2002). Mostly these enzymes can be grouped as: oxidoreductases, hydrolases and transferases. Certainly the amount of enzymes in the soil are much more but for defining the existence and activities of other enzymes; today's technic is not enough (Dick and Kandeler, 2004). The commonly used enzymes at the done studies in the literature are; acid phosphatase, alkaline phosphatase, β-glucosidase, phenol oxidase, Protease, urease, peroxidase, Xlylase, invertase, dehydrogenose, catalase, carboxymethycellulase, α-β amylase, arylsulfatase, glucose oxidase, glyoxal oxidase, Deaminase. For determining the source of these enzymes some researchers showed the relations between enzymes and the total micro flora, some others have discovered that some special bacteria and funguses groups are more reliable indicator. On the other hand, the best correlation has been gotten on: organic carbon, pH, plant roots, soil fauna and also with the lichen and algae from the soil surface ((Burns,1978). In soil, oxidoreductase and dehydrogenase have been studied a little bit more because of their important role on the oxidation of organic materials by transferring the hydrogen. Catalase activity bases the amount of released oxygen from the added oxygen to hydrogen peroxide (H_2O_2) or detected (H_2O_2). Some hydrolases and transferases have been extensively investigated because they have important role on decomposition of some organic compounds and hence they are important on nutrient cycle and soil organic material formation. These contain the contents of the enzymes: carbon cycle, such as: cellulase, xylanase, glucosidase, and invertase: The nitrogen cycle, for instance, protease, amidase, urease and deaminase; phosphorus cycle, for example, phosphatase; and Sulfur cycle, such as: arylsulfatase (Dick and Kandeler, 2004).

THE IMPORTANCE OF SOIL ENZYMATIC REACTIONS AND IMPACT ON FERTILITY

The soil hosts plants and animal organisms and also it contains many dead organic materials. The soil microorganisms have to obtain the needed nutrient from the organic materials around them. One of the most important activities of microorganisms is mineralisation of the organic materials, namely; decomposing the complex organic materials into simple inorganic compounds or nutrient ions (Haktanır and Arcak, 1996).

The main function of the enzymes is: transforming the high molecular organic materials into simple ones which can pass through cell and can be used by organism (Arcak, 1987). Many direct or indirect processes which affect soil fertility are related with enzymatic biodegradation and biosynthesis (Çengel, 2004). While the nutrients from the falling plant and animal residues on the ground are high polymer compounds, the high plants and microorganisms cannot directly benefit from them. Most of the organic materials in the soil such as: lignin, proteins, non-protein nitrogenous compounds, pectin substances, cellulose and other polysaccharides are macromolecular compounds which are not able to be absorbed directly by microorganisms. For using the macromolecular compounds in the soil, microorganisms must excrete enzymes and decompose them to simple compounds. For this purpose, soil contains most of the known enzymes (Haktanır and Arcak, 1996). In terms of soil reactions, the most important enzymes are: hydrolases, aldolases, dehydrogenase, oxidase, reductase, enolase, carboxylase, decarboxylase and catalase. Determining the amount of soil organisms, helps to understand their real activities. Therefore in addition to their amount their real activities should be revealed. Generally biochemical methods are used to defining the soil organism's activities. The activity methods are divided into 2: specific and nonspecific methods. The nonspecific method contains: catalase enzyme activity and dehydrogenase enzym activity, the specific method contains: urease activity, protease activity, saccarase activity (Çengel, 2004).

The enzyme urease is an extracellular enzyme held by the organic and inorganic soil colloids. It is an enzyme that catalyses the hydrolysis of urea to carbon dioxide and ammonia (Çengel, 2004). The done studies prove that: the urease enzyme activity of soil has important relations with soil properties such

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

as: organic materials, texture, pH, cation exchange capacity (CEC) and also the done researches state that, adding organic residues to soil increases the urease activity (Özdemir et al., 2000).

Many aerobic and facultative anaerobes organisms contain catalase enzyme. Catalase enzyme decomposes hydrogen peroxide (H_2O_2) which was created by living organism's metabolic activities and respiration and also has poisonous effect to water and oxygen (Çengel, 2004).

The soil respiration (CO_2 production) and dehydrogenase (DHG) enzyme activity values are widely used to determine the biological activity in soil. Dehydrogenase enzyme activity is a respiratory enzyme activity which carries the hydrogen and electron from substrate to appropriate acceptors during the oxidation of the organic compounds. (Chander et al., 1991).

The eco-enzymes released by living soil microorganisms to decompose nutrients and the microorganisms after the death; will be mixed into soil partially or completely free by autolysis. These are being absorbed by inorganic and organic soil colloids such as: clays and humic substances. The absorbed enzymes are more resistant to external factors than the others. They can maintain their activities more (Haktanır and Arcak, 1996). Hence with the help of these enzymes, sequential enzymatic reactions decompose organic residues; mostly from plants, into macromolecular simple compounds. For example, the carbohydrase enzymes decompose cellulose, starch, and similar polysaccharides to disaccharides and finally to monosaccharides. Proteases hydrolyse proteinaceous substances to polypeptides, dipeptides, oligopeptides, and finally to amino acids. Pectin decomposing enzymes hydrolyse pectin substances to simple substances.

The esterases group enzymes such as: phosphatases, lipases, sulfatases and tannase hydrolyse their nucleic acids and other phosphate esters to phosphate anions. As a result of these reactions, some part of the substances will be decomposed to small molecules and ions are used by microorganisms. Most of them are used by plants as nutrients and some part of them join to some reactions with the help of enzymes and transformed into high molecular and more resistant humic substances. (Arcak, 1987).

THE DONE STUDIES ABOUT ENZYMES

The enzyme activities are accepted as an important subject and have been studied for many years. But in the beginning of 1950s, it has been accepted as the main topic of soil microbiology and biochemistry field hence it has expanded a lot as a research subject (Arcak, 1989).

The done studies on enzymes such as: In France, the agroecosystem of apple orchard (Floch et al., 2008) and in forest ecosystems in Central America (Boerner et al.,) phenol oxidase, In Czech Republic Quercus petraea forests ligninolytic enzymes laccase, Mn-peroxidase, endoglucanase, endoxylanase, cellobiohydrolase, 1,4-b-glucosidase, 1,4-b-xylosidase, 1,4-b-Nacetylglucosaminidase and phosphorus-mineralizing acid phosphatase (Snajdr et al., 2007),

Agricultural and forest soils in Spain Acid phosphomonoesterase, b-glucosidase, phosphodiesterase and arylsulphatase (Sa´nchez-Peinado et al.,2008), On the territory of mount Etna volcano, b-glucosidase, acid phosphatase ve arylsulfatase (Shillam et al., 2008), In America at applications of agroforestry b-Glucosidase Glucosaminidase Dehydrogenase (Garcı´a-Ruiz et al., 2008), In Rhinelander *Populus tremuloides, Betula papyrifera and Acer saccharum* areas phosphatase, leucine aminopeptidase, -glucosidase, N-acetylglucosaminidase, cellobiohydrolase, phenol oxidase, and peroxidase (Larson, 2002), In Canada at forest lands; glucosidase, chitinase, phenol oxidase, and acid phosphatase (Decker, 1999), In China at high tempered areas; alkaline phosphatase and urease (Hu and Cao, 2007), In China at *Picea balfouriana* forest lands invertase, acid phosphatase, proteinase, catalase, peroxidase and polyphenoloxidase (Yong-Mei et al., 2005), in Czech Republic at *Quercus petraea* soils Mn-peroxidase, chitinase and acidic phosphatase (Snajdr et al., 2007) may be given as examples.

RESULTS

All the nutrients in the ecosystem are related to the soil as an energy and nutrient source and also to decomposition and complex organic cycle. While the nutrients from the falling plant and animal residues on the ground are high polymer compounds, the high plants and microorganisms cannot benefit from them directly. Most of the organic materials in the soil such as: lignin, proteins, non-protein nitrogenous compounds, pectin substances, cellulose and other polysaccharides are macromolecular compounds which are not able to be absorbed directly by microorganisms and high-organism plants' roots. For using these macromolecular compounds in the soil, enzymatic reactions must decompose them. Enzymes only speed up the reactions just being catalysts with their existence. They are macromolecular catalysts which were created from organism but do not need

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

the organism to be active. The main function of the enzymes is: transforming the macromolecular substances into simple ones which can be used by the organism and cells. Enzymes are involved with all of the substance transformation reactions and there is no life without the enzymes. Enzymes are protein based biocatalysts which accelerate the biochemical reactions. In soil ecosystems the enzymes play vital role on carbon, nitrogen, sulfur and other nutrients cycles. In the soil, almost 100 enzymes activities has been defined. Mostly these enzymes can be grouped as: oxidoreductases, hydrolases and transferases. In terms of soil reactions the most important enzymes are: hydrolases, aldolases, dehydrogenase, oxidase, reductase, enolase, carboxylase, decarboxylase and catalase. Almost all reactions in living systems occur under the control of enzymes. Enzymes are the regulators and specific activators in biological systems. Soil enzymes are used as an indicator of soil fertility and soil microbial activity. The distribution of soil enzymes and activities on the agricultural lands under the monoculture or sowing is accepted as a wide research subject however the researches which investigate the ecological relation in natural ecosystem by using the enzymes on biotope characterization are rare or not too much. The studies in this field should be more and the deficiencies must be corrected.

REFERENCES

1. Arcak, S., 1987, Toprak Organizmaları ve Enzimlerinin Toprak Verimliliğine Etkiler. *Türkiye Tabiabalçıkı Koruma Derneği Toprak Semineri Sempozyumu*, 132-194, İstanbul.
2. Arcak, S., 1989, *Toprak Pirofosfataz Aktivitesi Tayininde Etkili Olan Bazı Toprak Fizikokimyasal Özellikleri İle Metodolojik Uygulamaların Etkileri*. Doktora Tezi, A.Ü.Fen Bilimleri Enstitüsü Toprak Anabilim Dalı, 5-7,Ankara
3. Arcak, S., Haktanır, K., Karaca, A., 1994, Soğuksu Milli Parkı Topraklarında Bazı Ekolojik ve Kimyasal Özellikler ile Enzim Aktiviteleri Arasında İlişkiler. *Tr. J. Of Agriculture And Forestry*, 21 (1997) 35–40, Tübitak, Ankara
4. Boerner, R. E. J.,Giai, C., Huang, J., Miesel, J, R., 2008, Initial effects of fire and mechanical thinning on soil enzyme activity and nitrogen transformations in eight North American forest ecosystems. *Soil Biology & Biochemistry*, 40: 3076–3085, 1-10, USA
5. Burns, R. G. 1978. *Soil Enzymes*. Academic Press. 149-190.
6. Caldwell, B.A., 2005, *Enzime Activities as a Component of Soil Biodiversity*. A reviev. Pedobiologia 49, 637-644.
7. Chander K., Brookes P.C., 1991, Is the dehydrogenase assay invalid as amethod to estimate microbial activity in copper contaminated soils,*Soil Biol. Biochem*. 23, 909-915
8. Çengel, M., 2004, Toprak Mikrobiyolojisi. *Ege Üniversitesi Ziraat Fakültesi Yayınları*, 558:19-25, İzmir.
9. Decker, K.L., Boerner, R.E.J., Morris, S.J., 1999,Scale-dependent patterns of soil enzyme activity in a forested landscape. *Canadian Journal of Forest Research,*29(2): 232–241, Canada.
10. Dick, R. P., Kandeler, E., 2004, *Encyclopedia of Soils In The Environment*. Editors; Hatfield, J. L., Scow, K. M., Powlson, D. S., Singer J. M., Rosenzweig, C., Sparks, D. L., ISBN-13: 978-0123485304, 448-449, USA Durand, G., 1965. Ecol. Biol. Sol. 2,141.
11. Floch, C., Capowiez, Y., Criquet, S., 2008, Enzyme activities in apple orchard agroecosystems: How are they affected by management strategy and soil properties. *Soil Biology & Biochemistry* xxx: 1–8, 2-8, USA
12. Garcı´a-Ruiz R., Ochoa, V., Hinojosa, M.V., Carreira, J.A., 2008, Suitability of enzyme activities for the monitoring of soil quality improvement in organic agricultural systems. *Soil Biology & Biochemistry* 40: 2137–2145, 2137-2144, USA
13. Haktanır, K. Arcak S., 1996, Enzimler, Özellikleri ve Topraktaki İşlevleri. *A.Ü. Ziraat Fakültesi Yayınları: 79-94*, Ankara Howard, P.J.A., 1972. Oikos 2, 235.
14. Hu, C., Cao, Z., 2007, Size and Activity of the Soil Microbial Biomass and Soil Enzyme Activity in Long-Term Field Experiments. *World Journal of Agricultural Sciences* 3 (1): 63-70
15. Karlson P., 1992. *Tıp ve Fenciler İçin Biyokimya*. Ed: Telefoncu A., Sermet Matbaası, Kırklareli.
16. Larson, J.L., Zak, D.R., Sinsabaugh, R.L., 2002, Extracellular enzyme activity beneath temperate trees growing under elevated carbon dioxide and ozone.*Soil Biology & Biochemıstry,*66:1848-1856, USA

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

17. Özdemir, N., Kızılkaya, R., Sürücü, A., 2000, Farklı organik atıkların toprakların üreaz enzim aktivitesi üzerine etkisi. *Ekoloji Çevre Dergisi* 10(37), 23-26.
18. Sa´nchez-Peinado, M.M., Rodelas B., Martı´nez-Toledo, M.V., Gonza´ lez-Lo´ pez, J., Pozo, C., 2008, Response of soil enzymes to Linear Alkylbenzene Sulfonates (LASs) addition in soil microcosms. *Soil Biology & Biochemistry* xxx: 1–8, USA
19. Shillam, L., Hopkins, D.W., Badalucco, L., Laudicina, V.A., 2008, Structural diversity and enzyme activity of volcanic soils at different stages of development and response to experimental disturbance. *Soil Biology & Biochemistry* 40: 2182–2185, USA
20. Snajdr, J., Valaskova, V., Merhautova V., Herinkova, J., Cajthaml, T., Baldrian, P., 2007,Spatial variability of enzyme activities and microbial biomass in the upper layers of Quercus petraea forest soil. *Soil Biology & Biochemistry* 40: 2068–2075, USA
21. Tabatabai, M,A., Dick, W., 2002. *Enzymes in Soil: Research and Developments in Measuring Activities*. Enzymes in the environment, Editors; Burns, R, G, Dick, R, P.,ISBN: 0-8247-0614-5, 567-570, USA
22. Wiseman, A., 1987, *Handbook of Enzymes Biotechnology*. Second Edition.Chapter 3. The Application of Enzymes in Industry p. 274-373.
23. Yong-Mei, Z., Ning, V., Guo-Yi, Z., Wei-Kai, B., 2005, *Changes in enzyme activities of spruce (Picea balfouriana) forest soil as related to burning in the eastern Qinghai-Tibetan Plateau*. Agriculture, Ecosystems & Environment. Applied soil ecology ISSN 0929–1393, 215–225.