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Review Article

Dehydrogenase Activity as a Biological Indicator of Soil Health

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Abstract
Soil health is a critical factor for sustainable crop production and it has to be assessed for managing agricultural practices and other human interventions. Various microorganisms and microbe-mediated processes can be used to track changes in soil quality. For the measurement of soil health, soil enzymes are a functional factor directly related to microorganisms. Among soil enzymes, soil dehydrogenase is a direct measure of soil microbial activity, indicating the microbial mechanisms going on in the soil. Dehydrogenase enzyme activity indicate the viable number of microorganisms, any abruptions in the biogeochemical cycles, anthropogenic activities, and climatic or ecosystem perturbations. This review focuses on the role of dehydrogenase activity as an assessment tool for soil health.

Keywords: Enzymes, soil biological activities, soil microbial population, soil quality.

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Introduction

The diverse range of soil microorganisms and their activities are crucial in maintaining the sustainability of the soil and the biogeochemical cycles. The wide range of microorganisms in soil acts as microbial indices to measure and improve soil health [1]. From the nutrient pool in the soil, the plants take up only selective forms. The required forms of nutrients might be present in inaccessible forms [2]. Soil organic matter is an extensive reservoir of nutrients, most of which are present in unavailable forms. Soil microflora act as significant agents in bio-transformations of these unavailable nutrient forms to available forms [3, 4]. Microbial enzymes aid in the transformation as well as mineralization of these nutrients. Soil or microbial enzymes are also responsible for management of soil toxicity as well as other biotransformation reactions of pollutants [5, 6]. These enzymes might be present intracellularly or extracellularly of the microbial cells.

The biogeochemical cycles of the nutrients are initiated and maintained by the soil enzymes, providing direct support for the fertility and healthy growth and development of the plant [7]. Among the soil enzymes, dehydrogenases are the most critical and significant representative of microbial activity. This enzyme is present intracellularly in all the viable cells as a part of their respiratory system and function in the measurement of the metabolic state of soil microbes [8]. The enzyme activity of dehydrogenase is among the most appropriate, crucial and responsive soil fertility indicators [9]. Its activity depends on the same factors that affect the abundance and activity of microorganisms. Dehydrogenase enzyme primarily obligates anaerobic microbes in the soil, most abundantly in the genus *Pseudomonas*, particularly in *Pseudomonas entomophila* [10]. It participates in oxidation-reduction reactions in the soil by transferring electrons from substrates to acceptors.

Role of dehydrogenase as bioindicator
Disturbances in the ecosystem

It was reported by [11] that changes in land use and different management practices alter the organic matter content in the soil, thereby affecting soil enzyme activities. The dehydrogenase activity was lower in devegetated soil than undisturbed soils, where devegetation was done by *Pinus halepenis* and other naturally occurring shrubs [12]. The elimination of vegetation has caused long term negative impact on the soil microbial communities and hence soil dehydrogenase activity among other soil enzymes. The conversion of forest area into agricultural land results in loss of C stocks, but its conversion back to native forest is difficult [13]. This causes loss of microbial diversity and hence soil enzymes associated with them. The soil enzymes are sensitive to seasonal variations, as the dehydrogenase activity decreased with the fall in temperature because the microbial activity was decreased.

Changes in agricultural practices

Fertilization practices

The application of different fertilizers like mineral fertilizers, manure (green manure, farmyard manure), compost, and vermicompost has different effects on soil dehydrogenase activity. The application of compost in the soil up to 540 Kg N ha^{-1} yr^{-1} increased the dehydrogenase activity and soil microbial communities compared to control [14]. It was also higher in cattle manure treated soils and vermicompost-treated soil than the control [15]. The application of FYM also increases dehydrogenase activity. With high organic matter present in the soil, the amount of carbon in the soil increases, increasing the microbial flora of the soil.

Tillage

Different tillage practices also affect the soil structure, where dehydrogenase activities were higher in shallow ploughing and scarification than in deep ploughing in the upper layers of the soil. After harvesting the rice, the dehydrogenase activity in the non-puddles soil was found significantly in the long-term rice-wheat system. It showed an increase of 5% compared to the puddled soil [16]. The use of minimum tillage practices causes minorsoil disturbance and keeps a better environment for microbial growth. The use of minimum tillage practices [17] and no-tillage practices [18, 19] have less impact on soil health. The increased culturable microbial population would aid in better organic matter decomposition and better nutrient availability to plants [20, 21]. The greater the number of viable soil microflora, the more the dehydrogenase activity, as the soil enzymes are of microbial origin [22]. It has been observed that dehydrogenase activity is often higher in soil layer of 0-15 cm with no-tillage [23].

Irrigation

Irrigation is one of the methods wherein moisture is made available to the soil and plants. The adequate amount of moisture sustains better microbial growth and hence better soil enzyme activity. Different methods of drainage also affect soil dehydrogenase activity. [16] found that drainage of irrigation water also improved the dehydrogenase activity with the highest found in W3 (irrigation after three days of drainage), followed by W2 (irrigation after one day of drainage) and then W1(continuous submergence).

Xenobiotic pollution

Pesticides

Sue to intensive agricultural practices, the amount of pesticide application in the form of herbicides, fungicides, insecticides, etc., has increased. These pesticides leach in the subsoil layers and may harm non-target organisms, including a wide range of microorganisms. The detrimental effect of pesticides on soil enzymes has been reported broadly [24]. The difference has been found in the effect of pesticides on the microbial populations depending on the ability of the microorganism to degrade or flourish in its presence. For example, the stability of alachlor for 337 days caused a decrease in the bioactivity of the dehydrogenase enzyme. A similar effect on dehydrogenase activity was found with 2,4-D [25].

Heavy metal contamination

The presence of heavy metals and other recalcitrant compounds results in the loss/decrease in microbial activity. Notable changes are observed under heavy metal contamination, which leads to a decrease in microbial carbon usage [26]. It was observed by [27] that heavy metals at sublethal concentration caused a significant decrease in dehydrogenase activity. [28] reported that during the summer season, low moisture content and high concentration of heavy metal reduced the intracellular water potential of the microorganisms, thereby reducing the hydration level and activity of the enzyme dehydrogenase.

Conclusion

Soil dehydrogenase activity is a significant component of soil enzymatic activities and a sensitive indicator of various biotic and abiotic factors. It serves as a direct indicator of soil microflora, ecosystem perturbations, or toxic components present in the soil. Dehydrogenase activity by assessing soil health can help manage agricultural practices. A better insight into the role of this enzyme can play a part as a diagnostic tool to address soil health.

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