Micropedological Approach to the Study of Dynamics of Paddy Soils

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The usual way to get certain kind of information about soil is to handle a more or less bulky soil sample as if it were a homogeneous mass. But if we reflect upon complex constitution of the soil sample, we must realize that any property of the soil thus obtained is put as an average of numerous widely different values of each minute part of the soil sample.

Therefore in case where we want to know the fine mechanisms of soil dynamics, we must analyze carefully every important material transformation occurring in the soil and elucidate substances, organisms and enzymes which are directly concerned with the elementary reaction going on at each micro-site of the soil. Such study will constitute a new branch of soil science and might be called "dynamic micropedology".

Heterogeneous distribution of Eh

The distribution pattern of Eh in the submerged Apg horizon was studied precisely by Nishigaki et al.,[1] using a micro platinum electrode. Eh of high-yielding paddy soils was found to be higher on the average and more unevenly distributed over fields than that of low-yielding ones (Fig. 1). Accordingly, this mosaic work of Eh was considered to be suitable for the healthy functioning of rice plant roots.

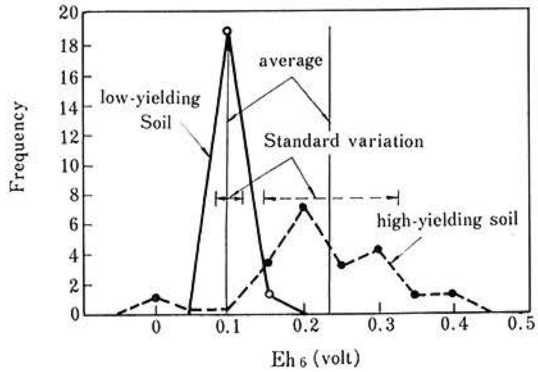
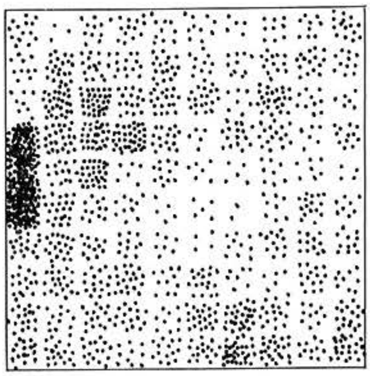


Fig. 1. Heterogeneous distribution of Eh in submerge dApg horizon of paddy soils (Nishigaki, et al., 1960)



(Wako & Furusaka, 1972)

Fig. 2. Distribution map of sulfate reducing bacteria in waterlogged paddy-field soil. One month after being flooded with water. Mean bacterial number is 157 per 2 mg dry soil. Each dot corresponds to 10 cells

Heterogeneous distribution of sulfate reducing bacteria

Furusaka et al. correlated this heterogeneous distribution of Eh with dotted micro-colonies of sulfate-reducing bacteria. A soil sample added with $Na_2{}^{35}SO_4$ was incubated under submerged condition and its radioautography revealed the dotted accumulation of ^{35}S, which was interpreted as iron sulfide precipitated on the micro colonies of the sulfate-reducing bacteria[2].

Wakao and Furusaka[3] confirmed the dotted distribution of the sulfate reducing bacteria by counting the number of the bacteria in minute soil samples taken numerously from a small section of the submerged Apg horizon (Fig. 2).

Furthermore the pattern of the heterogeneous distribution thus recognized suggested existence of the micro-site rich in substrate where the sulfate-reducing bacteria could grow vigorously.

Role of organic debrises and aggregates

Granulous nature of the large part of the organic matter of the paddy soil was clarified by Wada et al.,[4),5),6)] using a new method of quantitative separation of soil particles according to both its size and density, without almost any modification of native properties of individual particle: Sum of the amount of the organic matter in the form of plant debrises, which were contained in the fractions larger than 37 μ, was about 30 per cent of the total organic matter. In addition, enrichment of organic matter derived from microorganisms in a fine fraction ($<2\mu$) was suggested[7].

The fact that soil primary particles were apt to aggregate around plant debrises, resulting in large aggregate with less decomposed large plant debrises and small aggregate with more decomposed small plant debrises, was found by Wada et al.[8]. Incubation of the aggregates showed more vigorous NH_3 production and Fe(11) formation for the large aggregates than for the small aggregates[9] (Fig. 3, 4).

Accordingly, it might be said fairly safely that both heterogeneous distribution of the microorganisms and heterogeneity in the material transformation in the submerged Apg horizon of paddy soils are brought about mainly by the organic debrises and aggregates scattered through the soil, both of which are rich in substrates for microorganisms.

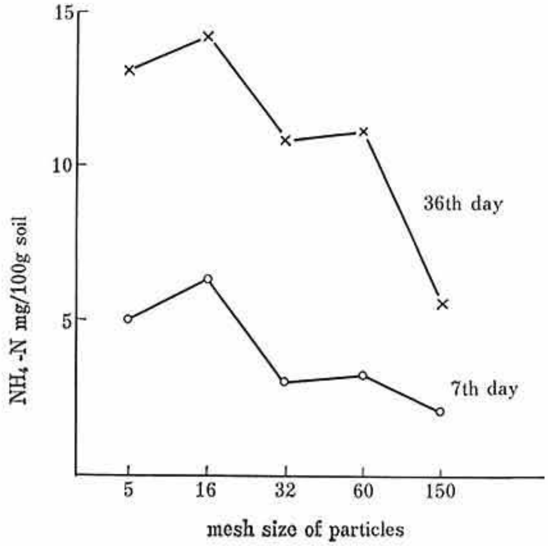


Fig. 3. NH_4-N production by incubating aggregates under submerged condition (Wada et al., 1974)

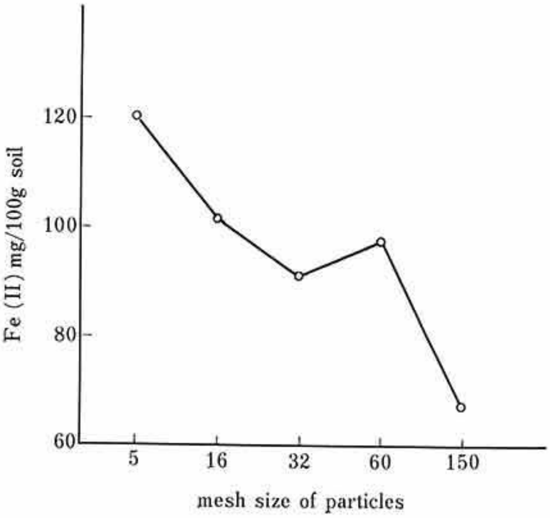


Fig. 4. Fe(II) formation by incubating aggregates under submerged condition (Wada et al., 1974)

Direct microscopic observation of soil

Recently detailed observation of the material transformation and its accompanying microorganisms at micro-sites of the submerged soil was made possible by a novel technique.

Some of the results of the soil observation were as follows:

1) Certain plant debrises and soil aggregates were found to be the preferred sites for the gas evolution, which seemed to be the result of denitrification[10] (Plate 1).

2) Red colored formazan, which was the

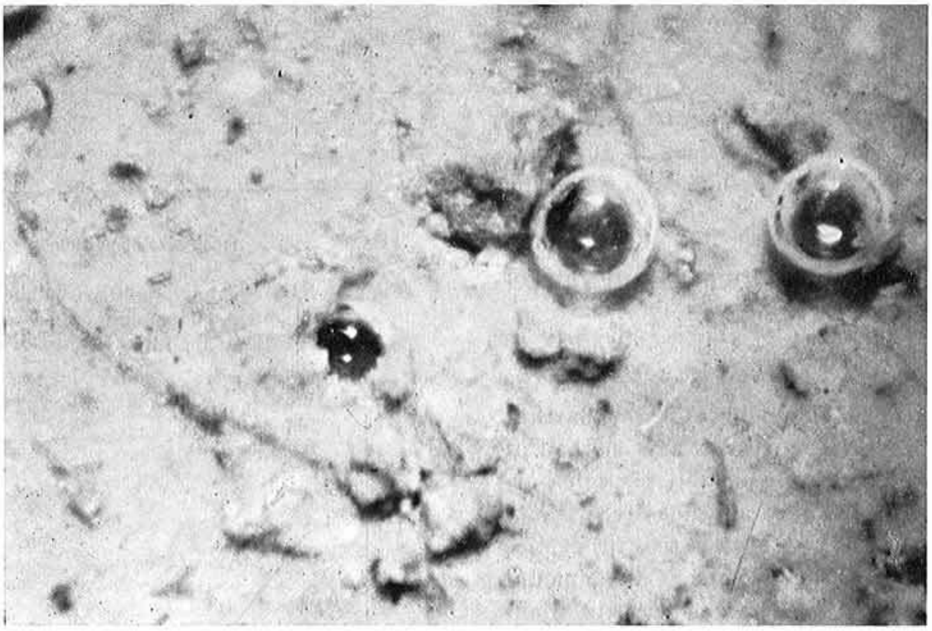


Plate 1. Appearnce of bubbles at micro-site of the submerged soil (Wada, in print) ×16

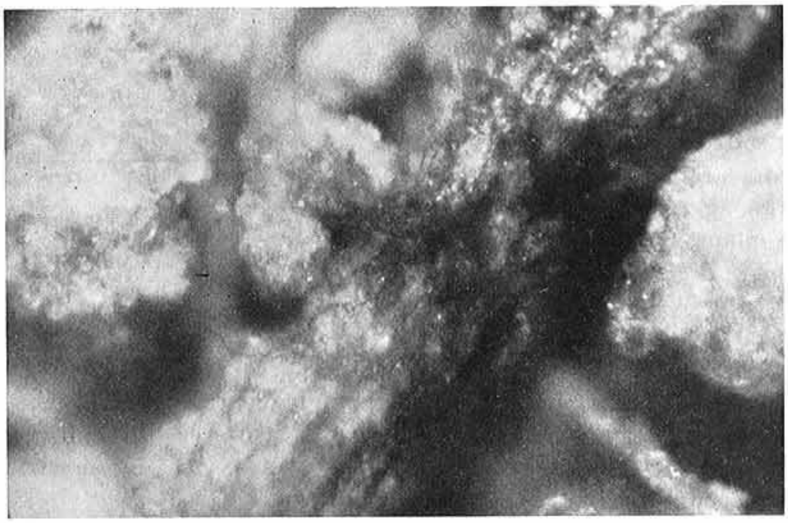


Plate 2. Filamentous microorganisms (Actinomycetes) growing on plant debris (Wada, in print) ×40

reduction product of TTC (triphenyl tetrazolium chloride) by dehydrogenase activity of active microorganisms, was deposited quite heterogeneously in the soil. Many organic debrises were preferentially turned red. Sometimes red-stained actinomycetes were found to grow on plant debrises (Plate 2). Protozoa were swimming actively around the red-stained remnants of organisms.

3) Sulfate reduction proceeded actively at the organic debrises and the water-soluble sulfides thus formed react mostly with the insoluble active iron distributed in and around the organic debrises.

Consequently, "Sphere of Organic Debrises", a new micropedological concept, was introduced to stress the important role of the organic debrises in material transformation and microbial activities in the submerged soil.

Conclusion

As seen from the explanations offered above, dynamic micropedology of paddy soil is still in its infancy but in course of time, being nourished with fresh ideas and special skill, it would become indispensable to science of paddy soil just as molecular biology is to general biology.

References

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