Elaboration of The Doctrine of Soil Microorganism Coenoses

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The diagnostic difficulties and inadequate development of taxonomy of microorganism account for the poor developement of the doctrine of soil microflora coenoses. This problem was given more consideration by Russian scientists.

The general theoretical principles of classification of soil microorganism were stated by Winogradsky (1950), an out standing scientist. He distinguished two essentially different groups of soil micropopulation, the zymogenic and autochthonous ones. The first is responsible for decomposing the organic substances of plant and animal origin getting into the soil. The second group mineralizes the humus soil compounds. Winogradsky did not give any details of the taxonomic position of the microorganisms belonging to the above groups.

Winogradsky's concepts were extended in the studies of a number of Soviet microbiologists. The above mentioned problem has been developed at the Institute of Microbiology, Acad. Sci. USSR, under the guidance of the author of this paper, in which the established concepts are setforth.

The accumulated experimental meterial allows the conclusion that the whole diversity of soil microorganisms can be conventionally divided into four large groups. Using Winogradsky's terminology we suggest the following denomination :

1. The *zymogenic group* decomposes the organic substances of plants and animal origin.
2. *The autochthonous group* mineralizes not only the monomers, but also the polymers, including humus compounds.
3. *The oligotrophic organisms* complete the mineralization of organic substances and prefer media with low content of organic substances for their development.
4. *The autotrophic* (lithoautotrophic) *organisms*, oxidizing mineral compounds.

The problems that may come into question are, whether the number of microorganisms is the same in different soil types and whether the representatives of the above groups are identical. The problems were cansidered by us and

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the results are setforth below. They could be revealed most distinctly in analysis of virgin soils since the cultivavation practices are rather diverse and each of them affects specifically the micropopulation of the soil.

We shall dwell, first of all, on the micropopulation density of different soil types. The solution of this problem is hindered by the dynamics of micropopulation density depending on the processes occurring in the soil itself, as well as on the climatic conditions. Thus, rather significant changes in microbe population occurring in the soil within short periods of time have been reported by a number of researchers. The reliability of this phenomenon has not been specified, however, it may be an artefact (Harmsen, 1939; Aristovskaya, 1965; Parinkina, 1972; Zvyagintsev *et al.*, 1976; Zvyagintsev and Zaitseva, 1979). It is obvious, however, that the state of soil microflora is highly affected by the weather.

In spite of the difficulties mentioned above, accumulated materials allow the conclusion of a higher microbe population in soils of southern region of U. S. S. R. The conclusion is based on culture technique and direct microscopy using the optical and electron microscopes. The more favourable conditions of southern soils promote development of microorganism and rapid transformation of organic and mineral substances.

From the general analysis, another quite obvious regularity becomes clear, i. e. that the soils become enriched with the spore-forming bacteria and actinomyces from north to south. It results also from the more energetic processing of organic residues of plant origin, dominating in the soil, is followed by the successions of microorganism. The process is initiated by the nonspore-forming bacteria and microscopic fungi, that are joined later by bacilli and actinomyces. For the reasons mentioned above, these microbe groups get into more favourable conditions in the southern soils.

The above regularities were mentioned by the author in number of papers (Mishustin, 1975; Mishustin and Jemsev, 1975)

A few notes should be made about the weight of the microbes. Number of techniques were used to solve the problem and it can be assumed that the weight of the microbes does not exceed 2% of the total soil organic matter. But owing to the small dimensions the active surface, the microbial mass is extremely large which reaches dozens of kilometers (Zvyagintsev, 1973, 1974; Jenkinson and Oades, 1979)

The studies on the composition of soil microflora resulted in certain data set forth below. This problem is still inadequately studied and can be investigated in detail only by joint efforts of a number of specialists. Nevertheless, it is already obvious that the microorganisms, in spite of their cosmopolitism, have their own zones of optimum reproduction. It confirms the statement made earlier by Kluyve (1954), a Dutch microbiologist.

Zymogenic microorganisms

This group is widely represented by nonspore - forming bacteria and bacilli, actinomyces and microscopic fungi.

It has been already mentioned that the northern soils are richer in nonspore-forming bacteria than in bacilli. The generic and specific diagnostics of bac teria are extremely difficult because of the poorly developed taxonomy (Heden, 1973). It can be noted, however, that in the primary stage of soil formation, the mycobacteria are predominating among the non - sporogenous bacteria (Sushkina and Tsyurupa, 1973)

The fluorescent bacteria of the genus *Fseudomonas* (*Ps. fluorescens)* are largely presented in the first stages of plant - organic matter decomposition. The podzols and soddy - podzolic soils are rich in *Pseudomonas*. In chernozems, chestnut soils and sierozems they are replaced by the species of the genus *Arthrobacter* (Sorokina and Mishustin, 1978).

The distinct relationship between the soil type and bacilli composition was described by us earlier. We would remind that the group *B. aglomeratus-B. cereus* is predominating in northern podzols, whereas in podzols and soddy-podzolic soils it is added by *B. mycoides* and partially *B. megaterium*. The latter becomes a dominant species in in the chernozems The chestnut soils and sierozems are extremely rich in *B. megaterium*, *B. subtilis* and *B. mesentericus*.

There is a certain relationship between the distribution of anaerobic fixers of molecular nitrogen and the soil type (Mishustin and Jemtsev, 1975).

Ths concentration of a number of micro-scopic fungi in certain soil-climatic zones was described by us in a paper published earlier (Mishustin and Pushkinskaya, 1960). These concepts were deepened considerably in the study by Mirchinck (1976). It can be noted that the northern soils are extremely rich in fungi of the genus *Penicillium*, that are replaced in the south by the representatives of the genus *Aspergillus*. The genus *Fusarium* is also prevalent in the southern soils.

As it was shown in the studies by Babyeva and Golovlyova (1963), the specific yeast genera are characteristic of certain soils. Thus, the representatives of the genus *Cryptococcus* predominate in thundra gley soils, *Candida* in podzols and *Lypomyces* in chernozems.

It has been already mentioned that the southern soils are characterized by a richer population of actinomyces and a wider range of their species (Mishustin, 1975; Andreyuk, 1972).

The composition of cellulose decomposing microorganisms undergoes rather specific changes in different soils. The fungi predominate in the northern soils with latent mineralization process. Bacteria *Cellvibrio, Cytophaga* and *Myxobacteria),* which need a higher level of nitrogen nutrition, predominate in the south.

Thus, the soil formation type is specifically represented by the saprophytic microflora.

Autochthonous microorganisms: They are characterized by the ability to decompose the humus soil compounds. This group was given particular consideration by us. It was found by Tepper (1976) that the red pigmented species

of *Nocardia* (*N. rubra*, *N.corallina*) played the principal role in this process. These microorganisms have not attracted the attention of microbiologists until recently since they can not be detected on the ordinary nutrient media. Media of specific composition have been suggested for their diagnosis. The southern soils are richer in the species *Nocardia* responsible for humus decomposition.

The colourless and yellow coloured species of *Nocardia* are typical saprophytes and do not decompose the cyclic compounds, including the humus.

The humus substances can be decomposed by other microorganisms. According to our data, the humus is actively mineralized by bacteria of the genus *Pseudomonas* (Mishustin and Mrysha, 1967). The species *Ps: putida* which decompose the cyclic compounds seems to be the most active ones (Skryabin *et al.*, 1978; Subba Rao and Alexander, 1977). Other microorganisms also play certain roles in this process.

The oligotrophic soil microorganisms have been poorly studied until recently. Zavarzin (1970) called this group as the "dispersion microflora". It is largely presented in all soils.

Most of these microorganisms undergo slow development and are practically not recorded on the ordinary nutrient media used in laboratories. They can be detected on poor media where they are not inhibited by common saprophytes. Besides, most oligotrophs are inhibited by the concentrations of organic substances that are present in the standard culture media.

The mineralization of organic compounds is completed by the oligotrophic microorganisms acting as receptors of the process initiated by the zymogenic microflora. The studies conducted at our laboratory (Nikitin *et al.*, 1966; Vasilyeva, 1972) as well as by other researchers (Aristovskaya, 1965; Belyayev, 1970; Maltseva 1973; Hirsch, 1974 Schmidt and Swaffard, 1979); Stanley *et al.*, 1979 make it possible to form a general idea of the rather interesting morphological and characteristics of these microorganisms (*Hyphomicrobium*, *Ancalomicrobium*, *Prosthecomicrobium*, *Stella*, *Seliberia*, *Caulobacter*, *Renobactor*).

The *autotrophic* (lithoautotrophic) soil microorganisms, except nitrifiers, are still inadequately studied. Many of them play an important role in developing the gas composition of the medium (Zavarzin, 1979; Schlegel, 1973).

It can be ascertained that nitrification intensifiers from north to south. It results from the intensified mobilization processes in the southern zone.

The soil processes play a fundamental role in regulating the gas composition in the terrestrial atmospheric layer. The problem has not been actually studied yet. Thus, molecular hydrogen accumulates even in the soil with normal moisture content. Its formation is caused not only by the microorganisms during fermentation but also by the nitrogen-fixing agents (Daday *et al.*, 1977; Ruiz-Argueso *et al.*, 1979). H_2 oxidation in the soil has been poorly studied.

During denitrification the nitrogen oxides are formed. Their further transformation is related to the activity of

microorganisms (Bollay and Tung 1972, Vedenina and Zavarzin, 1979). The cycle of these transformations needs clarification. A similar conclusion should be drawn concerning transformation of a number of other mineral and simple organic compounds (CO, H_2S, CH_4, C_2H_2 etc.).

It should be admitted from the above-stated information that the composition of soil micro population represents well the trends of the soil formation process. The cultivation techniques changing essentially the composition of microbial soil coenosis, are also rather specific. It allows application of micro biological diagnostics to solve a number of agronomy problems related to chemicalization and field management. It is of no less importance in developing measures on maintaining the sanitary state of the soil.

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