Soil fauna-as indicator of soil quality

Authors: Sunanda Biswas[1] and Bharat H. Gawade[2]

[1]Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi-110012

[2]Quarantine Division, ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012

*Corresponding author, email: sunandabiswas13@gmail.com

The word "Fauna" comes from the Latin word of Faunus, the Roman goddess of earth and fertility and the related forest spirits called Fauns. The term was first used by Linnaeus in the title of his 1745 work *Fauna Suecica*. Soil is the natural habitat of various organisms, including soil fauna invertebrates. These organisms vary in size and metabolism and they play numerous functional roles in the environment. The quality of the soil environment is related to its capacity to sustain biological production and to maintain or improve the environmental quality within the limits of a natural or managed system (Doran & Parkin, 1994). Biological indicators are species or groups of species that reflect the impact of habitat changes due to their sensitivity to the environmental conditions. The soil fauna sensitivity to environmental variations, soil management practices and can therefore be a potential indicator of soil quality.

Types of soil fauna: There are three types of fauna present in soil viz. microfauna, mesofauna and macrofauna.

1. Microfauna: Organisms whose body size is between 20 µm and 200 µm. eg. nematode and protozoa.

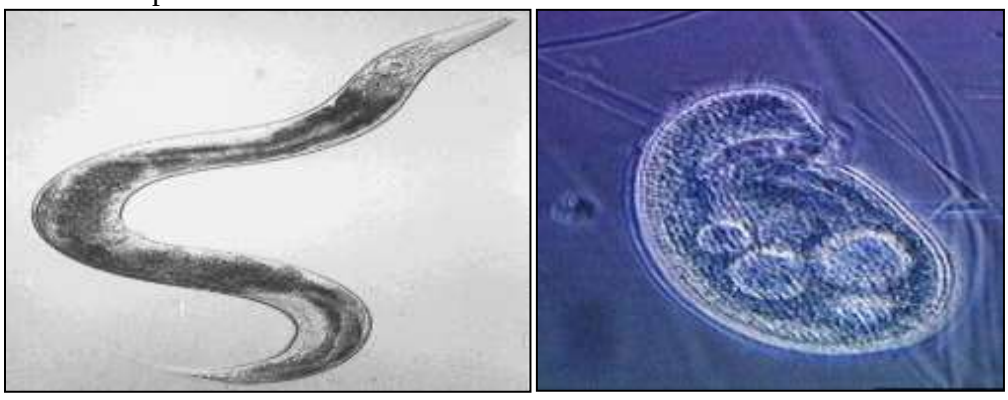

Fig.1 Nematode and Protozoa

2. Mesofauna: Mesofauna are 0.1 to 2mm in size. They include arthropods, such as mites, collembola and enchytraeids.

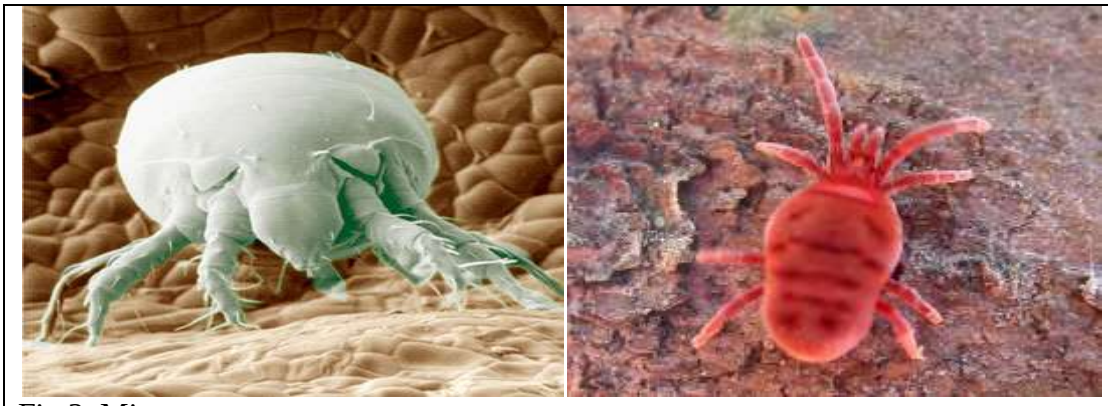

Fig.2. Mites

3. Macrofauna: Macrofauna are defined as being larger than 2mm in size as well as moles, snails, slugs, earthworms, ants, termites, millipedes, woodlice, which all spend most of their life in the soil.

Fig.3. Termite and Earthworm

Properties of soil fauna for use as indicators of soil quality:

As soil fauna involves in numerous biological processes in soil, they are an important indicator of soil quality. They help in bioaccumulation of heavy metals and organic pollutants. Soil fauna decompose organic matter by fragmentation, so they are called ecological engineer. They help in mineralization of C and other nutrients in soil. Earthworm improves the soil fertility by mixing nutrient rich earthworm cast with soil, stabilization of soil aggregate and water holding capacity of soil. Termites influence soil properties and processes by the formation of mounds and galleries. They help in changing drainage and moisture regime, nature and distribution of organic matter and soil texture. Protozoa mainly influence on organic cycle of nutrients. Due to their predatory nature on bacteria contributes turnover of available nutrients in soil by preventing immobilization of nutrients by bacteria. Nematodes play an important role in nutrient cycling specially mineralization of nitrtogen.

Soil Quality: Capacity of a soil to sustain plant and animal productivity, to maintain or enhance water and air quality, and to support human health and habitat.

$$SQ=S\times P$$

Where, SQ = Soil quality

S = Number of faunal species in the soil community

P is apparent performance of soil fauna in soil functioning

SQ values to between 0 and 1

Indices: There are different indices of soil fauna for assessing soil quality.

1. **EMI (Eco- morphological index):** EMI based on the types of soil microarthropods present and which does not require species level identification.

   EMI calculated through this formula:-

$$F_{\mathrm{EMI}} = \frac{s_o}{S} \times \frac{\sum_{i=1}^{s_o} \left(\frac{d_{io}}{d_{i\max}} \times \mathrm{EMI}_i \right)}{\sum_{i=1}^{S} (\mathrm{EMI}_i)}$$

EMI score ranges from 1 to 20. For eu-edaphic organisms EMI score is 20, hemi-edaphic organisms 1-20 and epi-edaphic organisms 1.

2. **QBS index (Biological quality soil index):** QBS index was given by Parisi et al. (2005). This index based on the concept, higher the soil quality; higher will be the number of microarthropods groups well adapted to soil habitats. It is sum of EMI score (ranges from 1 to 20).
3. **Soil faunal quality index:** FAI is based on the functional traits of each species of soil fauna to reflect the strength of each species that performs a special function in soil. It's value ranges from 0 to 1.

   FAI calculated by following mathematical equation

$$FAI = SQ_o / SQ_h$$

   where, FAI is a faunal index that indicates soil quality,

   SQ_o is the SQ of the studied site

   SQ_h is the SQ of the site with the highest soil quality.

4. **Shannon's diversity index:** Shannon's diversity index is a function of the community group richness and relative distribution of abundance of individual between the groups. It indicates by H. It is calculated by using this formula

$$H = -\Sigma pi.\log pi$$

   Where, pi = ni / N;

   ni = value of importance of each species or group;

N = total of values of importance

5. **Pielou uniformity index:** Pielou Uniformity Index (e) it is a equability or uniformity index, where the uniformity refers to the distribution pattern of the between species,

$$e = H / \log S\ d$$

Where, H is Shannon 's diversity index

S is number of species or group

6. **Change index (V):** The change index (V) was determined for the evaluation of the changes in the soil fauna under the different soil management systems. The change index (V) is a good indicator of management conditions, as it can indicate disturbance or stability of the soil fauna.

The following equation is used to calculate the change index:

$$V = \frac{2dM}{dM + dNM} - 1$$

Where, V = change index;
dM = density of individuals in managed systems
dNM = density of individuals in non-managed systems

There is a clear relationship between soil fauna and soil fertility. The index is thus reliable on predicting tendencies in soil quality either it is aggrading or degrading. One of the challenges in evaluating soil quality lies in selecting a feasible soil faunal community as an indicator. When function traits were selected to classify the organism, the extent to which the index will assess soil functioning will depend on the accuracy of such classification measuring the capacity of those organisms of performing a certain soil function. The accuracy of assessment will depend on the capability of the taxaon as an indicator. What taxa should be included, i.e. soil invertebrates, soil arthropods or the other assemblage, determines which classification level should be adopted, i.e. class, order, family, depending on demand of soil quality assessment. In conclusion, this approach provides a new tool for exploring the relationships between soil fauna and soil quality, and useful for soil management.

References (if any)

References:

1. Doran, J.W. and Parkin, T.B. 1994. Defining and assessing soil quality. In: J. W. Doran, D. C. Coleman, D. F. Bezdicek, and B. A. Stewart (eds). Defining Soil Quality for a Sustainable Enviroment. SSSA Spec. Publ. No. 35, Madison, Wisconsin, USA, pp. 3-21.

2. Parisi, V., Menta, C., Gardi, C., Jacomini, C., Mozzanica, E., 2005. Microarthropodcommunities as a tool to assess soil quality and biodiversity: a new approach in Italy. Agriculture, Ecosystems & Environment 105, 323-333.
3. Yan, S., Singh, A. N., Fu, S., Liao, C., Wang, S., Li, Y., Cui, Y., Hu, L. A soil fauna index for assessing soil quality. Soil Biology & Biochemistry 47 (2012) 158-165.