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A study of population dynamic of soil biota with reference to earthworm relation to recycling of solid wastes

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Abstract
In this modern era of green revolution and biotechnology, the significant use of our natural resources and traditional practices of preparing organic manure and applying them to soil is a matter of great concern. Modern crop production technology has considerably raised output but have also jeopardized environment through nitrate pollution and exterminating the beneficial soil Microflora and Microfauna by adversely altering the physical and chemical properties of soil resulting in adverse effects on fragile ecosystem. The cycling of nutrients is a critical eco system function that is essential to life on earth and is followed by the production of organic matter. There is increasing evidence that soil macro invertebrates play a key role in soil organic matter (SOM) transformations and nutrient dynamic at different spatial and temporal scales through perturbation and the production of biogenic structures for the improvement of soil fertility and land productivity (Brussaard *et al*., 1997; Lavelle and Spain, 2001).
Organic matter has a unique role to play in soil fertility. The pH of soil of Godda district range from 4.7 to 8.1. The organic carbon content in the district ranges from 0.29 to 1.63 %. Available nitrogen content in the surface soils of Godda district ranges between 220 and 630 kg/hac. Available phosphorus content in these soils ranges between 1.0 and 12.8kg/hac. Soil biota community largely includes collembolan, Soil Mites, other soil Arthropods and earthworms. Earthworm abundance in upper 0.1 m of the soil profile is positively correlated with decomposition rate of plant leaf litter. The analysis of between – subject effects and within-subject was also found to be highly significant. Regression analysis for different soil fauna and abiotic factors in different ecosystem. Earthworm were positivity correlated with soil temperature, soil moisture, atmospheric temperature and rainfall, but showed a negative correlation with pH, organic matter and relative humidity.
Eisenia Foetida is the most efficient in waste processing, while Eudrilus Eugeniae is large fast growing, reasonably prolific and would be ideal for protein product. This is the only study highlight the cyclic fluctuation in the species structure at different time intervals. A composite study on microbial association with the predominant earthworm species at a given time may provide necessary information on its ecological role.

Keywords: Soil biota, soil organism, recycling, soil fauna, soil mesofauna, decomposition

Introduction
Soil is a dynamic system in which soil biota play an important role in its development, genesis and maintaining its nutrient dynamics. In modern times reckless use of synthetic chemicals in the form of fertilizers have degraded the soil quality, reducing its fertility and finally affected the crop production. In the era of sustainable agriculture use of biologically derived fertilizers and plant protection are the eco-friendly approaches which are ecologically sound and economically viable alternative to chemical fertilizers.
Thus, with advent modern era of green revolution and biotechnology the significant use of our natural resources and traditional practices of manufacturing organic manure and applying them to soil is a matter of great concern that form the basic concept of sustainable agriculture. Out of all soil organisms earthworm play a key role in improving soil fertility in terms of maintaining nutrient recycling which is known from time immemorial. Santhal Pargana is a hilly terrain dominated by tribal population where agricultural productivity is poor because of low water holding capacity of soil, deficient nutrient recycling and vast tract of wastelands.

Thus, agriculture alone cannot sustain the local population unless or until some modern techniques and tools for increasing soil productivity using eco-friendly approaches will not be adopted. Considering such objectives the present study on the **"Population Dynamics of Soil Biota with Reference to Earthworm in Relation to Recycling of Solid Wastes"** have been carried out in Godda District of Santhal Pargana of Jharkhand State. In its natural state the soil is not only a mixture of decayed organic substances and minerals but it has its own genesis and own history of development. It is also the home of many teeming animals and plant, hence considered as the living tissue and seat of biological activity. Muller (1879) was the first to recognize that soil animals play an important role in the development of soil. In fact soil fauna represents the most rewarding are of current biological exploration. It perhaps remained as one of the least known biological frontiers, particularly in terms of soil zoological systematic, taxonomy and ecology.

In this modern era of green revolution and biotechnology, the significant use of our natural resources and traditional practices of preparing organic manure and applying them to soil is a matter of great concern. Modern crop production technology has considerably raised output but have also jeopardized environment through nitrate pollution and exterminating the beneficial soil microflora and microfauna by adversely alerting the physical and chemical properties of soil resulting adverse effects on fragile ecosystem

Having become conscious of such over dependence on synthetic chemicals and the associated degradation in environmental quality, sustainable agriculture has assumed a great significance. Furthermore, sustainable agriculture not only improves the physical, chemical and biological properties of the soil also improves the quality of the produce enriched with phyto-nutrients with known beneficial (often antioxidants) effects of human health.

There is increasing evidence that soil macro invertebrates play a key role in soil organic matter (SOM) transformation and nutrients dynamics at different spatial and temporal scales through perturbation and the production of biogenic structures for the improvement of soil fertility and land productivity.

Organic matter has a unique role to play in soil fertility. it acts both as sink and source for nutrients. Organic matter prevent nutrient loss and environment pollution and above all helps to maintain resilience of soil nutrients balance, which is the basis attributes for sustainability.

In view of the other facts, it is imperative to undertake such a study under following lines, which in long term will generate information for agriculture scientist, socialist, farmers and corporate person in providing adequate base and guide line for an Agro-based country like India.

Materials and Methods

The study area Godda was a part of undivided santhalpargana district until 1981. Later the old Godda sub-division was separa ted and formed as a new district of Jharkhand. It is bounded by Bhagalpur district in north, Dumka in south, Sahibganj and Pakur in the east and Banka in the west.

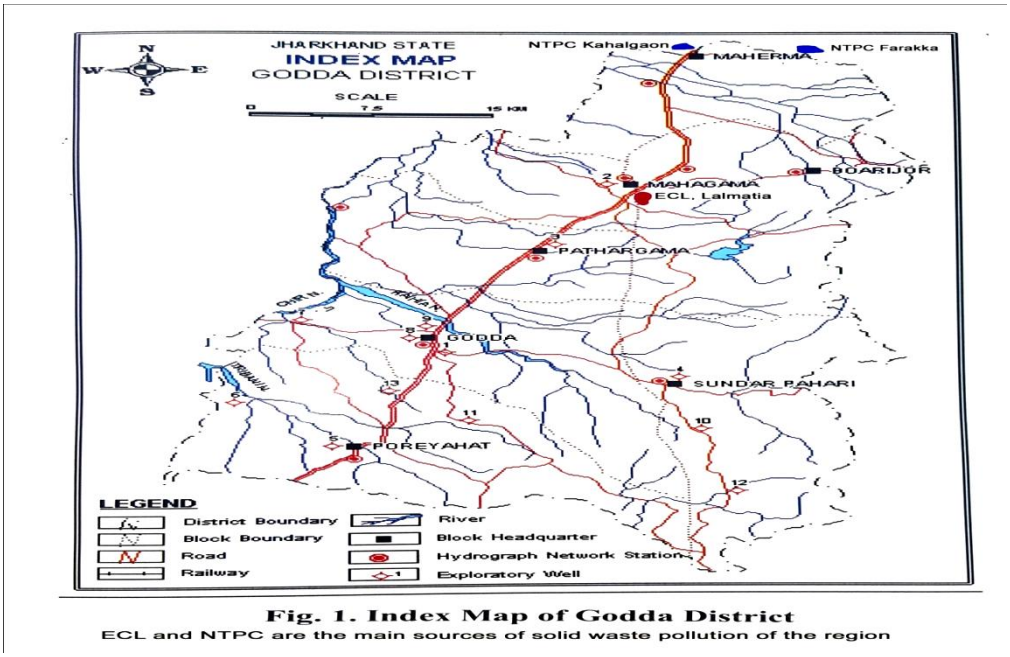
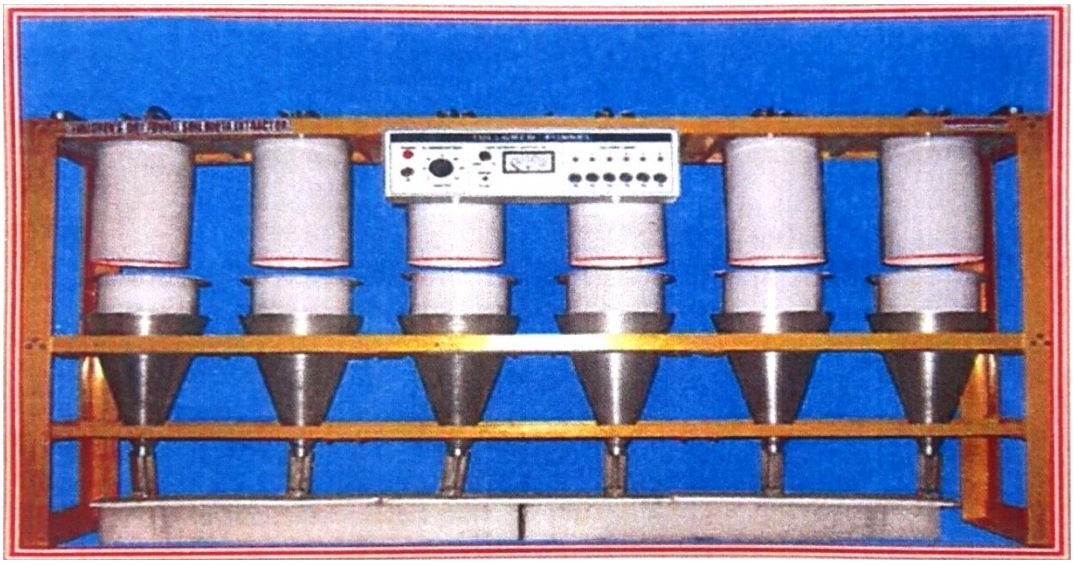


Fig. 1. Index Map of Godda District
ECL and NTPC are the main sources of solid waste pollution of the region

Sorting and Preservation

Method of Collection: Soil fauna were collected by a rectangular sampler from the different sites (size 7.5 x 22.5 x 1 cm) (1687.5 cubic cm in volume), which is best suited for fauna that are less abundant, larger in size and found in top 1 cm soil profile (Ruesink, 1972). Soil samples were packed in polythene bags, tagged with sampling sites, dates, vegetation etc. and brought to the laboratory for identification and further processing.

2. Extraction: In the present investigation Tullgren dry funnel extraction technique was employed to extract the soil mesofauna. It works on the moisture content of the sample, the rate at which the sample is heated and dried; and the reaction, particularly to temperature and moisture of many different species in the sample.



Sorting and Preservation of Soil Mesofauna

Under stereoscopic binocular microscope the mesofauna were picked up with the help of fine bamboo splinter and preserved in an aqueous solution of 70% alcohol and 5% glycerine until sorted into major taxon group. Soil mites were preserved in Quedemansfluids, Collembola and Pauropoda in Kevans fluid and other in 70% alcohol.

Microscopic Preparations

Larger mesofauna were dehydrated and mounted in DPX by routine method. Acari were cleared either in lactic acid or lactophenol and were mounted over Hoyersmedia. Collembola were mounted in Salmons new polyvinyl alcohol or Kevans fluid B.

Collect of Earthworm

Density

The numerical strength of organisms in a community represents their number per unit area. Sample are taken to enumerate the density per unit area. In frequency and dominance studies, the size of sampler is very important. Because of the constraints of time and money, the entire organisms cannot be enumerated; samples are to taken to estimate the numerical strength of a species population and of the total community. The data is then multiplied with an appropriate factors to express the total number of organisms per unit area. The relative density (RD) of a species was calculated as follows:

$$\text{RD} = \frac{Number\ of\ individuals\ of\ a\ species\ in\ all\ samples}{Number\ of\ individuals\ of\ all\ species\ in\ all\ samples} \text{X100}$$

Some ecologist use the term abundance is defined as

$$\text{Abundance} = \frac{Total\ no.Individual\ a\ species\ in\ all\ Sample}{Total\ Number\ of\ Sample\ in\ which\ a\ Species\ O}$$

$$\text{Abundance} = \frac{Abundance\ of\ a\ Species\ per\ Sample}{Total\ Abundance\ value\ Based\ on\ Number\ /Girts/Size/Basal\ Area} \text{X100}$$

Screening of Fauna Associated with Decomposition

In India, local species of earthworm that are generally used in vermicomposting are: lampitoterrestris, Perionyxexcavates, Lampitomauritii, Umbricusrubellus Lampitomauritii, in India, is the most widely distributed earthworm in different agro-ecosystems. Lampitomauritii preferred decomposing grass of paddy (Oryza sativa) and finger millet (Eleucinecoracana) to other leaf litter. The grasses when developed in reclamation sites can form an ideals base for establishment of Lampitomauritii to bring about improvement in soil structure and finally chemical and biological activities.

Results

Analysis of soil profile of the study area:

pH:

The pH of soil of Godda district ranges from 4.7 to 8.1. The soil reaction classes with area are given. The data reveals that 84.4 percent area of the district have acidic soils of which moderately acid soil covers 34.8 percent, strongly acid covers 22.8 percent slightly acid covers 21.3 percent and 5.5 percent area covers very strongly acid soils. Soils of 9.3 and 4.5 percent area of the district are neutral and alkaline in reaction respectively

Organic Carbon: The organic carbon content in the district ranges from 0.29 to 1.63%. They are mapped into three classes i.e., low (below 0.5%), medium (0.5-0.75%) and high (above 0.75%) as depicted. It is seen that majority of soils (83.8% of TGA) have high organic carbon content. Medium and low organic carbon (OC) content constitutes 11.7 and 2.7 percent area respectively.

Table 2: Organic carbon

Organic carbon status (%)	Area ('00 ha)	% of the TGA
Low (below 0.50%)	57	2.7
Medium (0.50-0.75%)	246	11.7
High (above 0.75%)	1768	83.8
Miscellaneous	39	1.8
Total	2110	100.0

Nitrogen: Available nitrogen content in the surface soils of the Godda district ranges between 220 and 630 kg/ha and details are given. Majority area (88.7% of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha-1). Soils of high and low available nitrogen content constitute 7.7 and 1.8 percent area respectively.

Table 3: Available nitrogen status in the surface soils

Available Nitrogen (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 280)	38	1.8
Medium (280-560)	1872	88.7
High (above 560)	161	7.7
Miscellaneous	39	1.8
Total	2110	100.0

Phosphorus: Available phosphorus content in these soils ranges between 1.0 and 12.8 kg/ha and area and distribution is given. Data reveals that soils of the 92.2 percent area are low in available phosphorous content whereas 6.0 percent areas have medium available phosphorus content.

Structural analysis of soil boitic community

Soil biotic community analyzed were:

1 **Collembola**
2 **Earthworms**
3 **Other soil arthropods**
4 **Soil Mites**

Collembola: Springtails are small 1-5 mm, entognathus, wingless hexapods with antennae always present and most successful animal in the world. The tiniest and least pigmentation species tend to be those that live permanently between the particles of the sand and soil. Collembola may be recognized by a posteror ventral forked abdominal appendage, the furca. The ventral projection or the ventral tube or scollophore, plays and extremely important role in the fluid and electrolyte balance. The eversible vesicles of the ventral tube may also be used as a source of grooming fluid and for adhering to smooth surface (Hopkin, 1997). The body of Collembola basically comprises three tegmata, a head capsule, a thorax with three segments, and an abdomen with five segments and a terminal priproct.

Soil Mites: Mites are predominanty soil dwelling and there is no sample of humus that does not contain a mass of herbivorous beetle mites (Oribatida). They constitute more than 90% of the total microarthropod population.

Table 4: Common Mites found in different fields

Cunaxa sp.	**Order:** Prostigmata **Fam.:** Cunaxidae
Acarus sp.	**Order:** Sarcoptiformes **Fam.:** Acarinae
Tetranychusurticae	**Order:** Trombidiformes **Fam.:** Tetranychidae
Galumna sp.	**Order:** Cryptostigmata **Fam.:** Galumnidae

Soil Mites are the major soil mesofauna for fragmentation and humification of solid wastes and identified mites are shown in Plate-II

Other Soil Arthropods:

- The dominant other soil arthropods included myriapods (Centipedes and Millipedes), Beetles, Scorpions etc. They played a great role in fragmentation and humification of solid wastes.
- **Slugs and Snails:** They eat dead creatures and plants. They are a good source of food supply for birds.
- **Earthworms:** Earthworms burrow through the soil making it looser and allowing air in soil. They are food for the birds and beetles.
- **Ants:** They live in large colonies and burrow in the soil to build their nests. They are omnivores and scavengers.
- **Beetles and Earwigs:** There are lots of different types of beetles. Some eat wood and some eat plants. Some eat other creatures and some eat dung. Earwigs eat roots, leaves and dead creatures. Woodlice live in damp places. They eat decaying things. Their favourite food are dead wood and leaves.
- **Centipedes:** live under stones and in the soil. They eat other living creatures.

Table 5: Common other soil Arthropods found in different fields

Scutigerella sp.	**Order :** Geophilomorpha
Soil Beetle	**Order :** Coleoptera
Compsadithaindica	**Order :** Scorpionida
Lithobius sp.	**Order :** Scolopendromorpha

Functional role of soil fauna: Mites are most abundant among soil arthropods. Mites and Collembolans and earthworms are beneficial, because:

- They feed on micro-organisms and other soil arthropods.
- Assist in decomposition by browsing on preferred fungi thus. Prevent any one species from becoming dominant.
- Transport spores through the soil.

Earthworms: The earthworms surveyed and collected from the study area were: *Lumbricusterrestris, Dendrobaenaoctaedra, Lumbricusrubellus, Allolobophorachlorotica, Pontoscolexcorethrurus and Lampitomauritii*. However, Earthworms species collected for vermiculturewere:

1. *Eiseniafoetida*
2. *Eiseniaandrei*

Suitability of these species: These species were found more suitable for their small size, easy in culture and fast growing utilizing large amount of solid wastes for humification and worm cast production.

Recycling of solid wastes by earthworms:- Earthworms were observed mixing the soil layers containing solid wastes and incorporating organic matter into the soil. This mixing improves the fertility of the soil by allowing the organic matter to be dispersed through the soil and the nutrients released become available to micro organisms (bacteria and fungi) and finally to plants.

The solid wastes exposed to enzymes secreted from fungi and bacteria and their action played an important role in the mineralization. Thus, it was observed that decomposition of solid wastes were done through a chain of reactions in following three steps:

1. Fragmentation
2. Humification
3. Mineralization

Fragmentation and humification were done by mesofauna while mineralization is the final step completed by microbes colonising in the gut of earthworms.

Decomposition Potentiality of Solid Waste by Mesofauna and Earthworm (Vermicompost)

India scenario The familiar earthworm species, Eudriluseugeniae, Eiseniadoetida, Lumbricusrubellus and perionyx excavates are well know about other species of earthworms that may be as efficient or better in their performance over the above mentioned species in a country having rich diversity of fauna for in situ and ex situ vermiculture. There are more than a dozen of earthworm species that have been reported to be efficient in vermicomposting. Most of the species that are include under genus Perionyx show great potential to work on organic, matter.

Discussion

Increasing concern for the sustainability of our natural resources has led to the development of more complex concept of soil health /"soil quality".

1. Sustaining biological activity, diversity and productivity;
2. Providing support of socioeconomic structures and protection for archeological treasures associated with human habitation.
3. The term "soil quality" has been coined to describe the combination of chemical, physical and biological characteristics that enables soils to perform a wide range of functions.

Following Practices Boost Earthworm Populations

1. Till Management (no-till, strips till, ridge till)
2. Crop Rotation (with legumes) and cover crops
3. Manure & organic By-product application
4. Pasture & Hay land Management
5. Soil Reaction (pH) Management
6. Irrigation or Drainage

Decomposition and Soil Organic Matter:- Nutrient cycling, water regulation, and other soil functions are normal processes occurring in all ecosystems. From these functions came many benefits to human such, as food production, water quality and flood control, which have value economically or in improved quality of life. People can increase or decrease the value of soil benefits because land-management choices affect soil functions. Thus, it is important to understand what benefits we derive from soil and their value so we can appreciate the importance of managing land in a way that maintain soil functions. Earthworms play an important role in breaking down dead organic matter in a process known as decomposition. This is what the earthworm living in your compost bin are doing and earthworms living in soils also decompose organic matter. Decomposition releases nutrients locked up in dead plants and animals and makes them available for use by living plants. Earthworms do this by eating organic matter and breaking it down into smaller pieces allowing bacteria and fungi to feed on it and release the nutrients.

Earthworm are also responsible for mixing soil layers and incorporating organic matter into the soil. Charles Darwin referred to earthworms as 'nature's ploughs' because of this mixing of soil and organic matter. This mixing improves the fertility of the by allowing the organic matter to be dispersed through the soil and the nutrient held in it to became available to bacteria, fungi and plant.

Significance of Earthworm Digestion:- Earth worms can consume their weight in soil, water and mineral over a 24-hour period. It takes around 16 hours for this material to pass through the worm. During this time, the contents are subjected to a series of digestion processes as follows:

1. The material is broken down into small pieces and sucked into the pharynx
2. It is acted upon by acid mucus and starch enzymes and sucked further into the oesophagus
3. The calciferous glands secrete calcium carbonate and it passes through to the crops
4. Crop condition are made alkaline by the calcium secretions and a variety enzymes and microorganism actions takes place. It is then forced through to the gizzard.
5. Gizzard condition are highly alkaline, helping break up of complex molecules and relasing some elements bound to other elements fox example phosphorus to aluminum, there is a grinding action with small stones and mineral particles, as well as further enzymes and microorganism activity.
6. It is exposed to more enzyme and microorganism action while passing through the intestine.
7. After it is excreted as castings, bacteria continue to decompose some of the material.

Worm Power Benefits Include

- E excellent in starting new plants from seed or transplants.
- Improves germination and reduces transplant shock.
- Improved root growth and plant rooting structure.
- Timely release of plant available nutrients (no risk of fertilizer burn).
- Improved soil structure and porosity for a better root environment.
- Improved moisture infiltration rates (reduces erosion).
- Beneficial supply of microorganisms to surround soil and growing media.
- Odorless.
- Safe around kids and pets.
- Great supply of water soluble nutrient to plants.
- Earthworms speed up the decomposition of dead leaves and roots, and roots, and manure so that nutrients contained are available sooner to growing plants. Worms combat root matting, a common limitation in grass growth.
- Worn casts are rich in colloidal humus with good water retention, soil structure properties and cation exchange capacity (ability to hold the trail of available cation-exchange-sites Nitrogen, Calcium, Magnesium etc. until utilized).
- Plant roots will often follow worm burrows taking advantage of minerals and the free space that facilitates roots penetration. Conversely, dead roots of deep penetrating plants are fodder for worms, leaving channels, which increase soil drainage.
- Earthworms aid the spread of beneficial microorganisms by ingesting them or their spores and depositing them in casts. Microorganisms also multiply fast on the earthworm casts.

Summary and Conclusion

In this modern era of green revolution and biotechnology, the significant use of our natural resource and traditional practices of preparing organic manure and applying them to soil is a matter of great concern. Modern crop production technology has considerably raised output but have also jeopardized environment through nitrate pollution and exterminating the beneficial soil microflora and microfauna by adversely altering the physical and chemical properties of soil resulting in adverse effects on fragile ecosystem.

1. Meteorological parameters of the SanthalPargana particularly Godda district have been recorded showing deficiency in rainfall with high temperature and humidity. Rainfall is generally monsoonic and cyclonic.
2. pH of the soil was both acidic and alkaline. Acidic soil is not suitable for crop production.
3. Organic carbon values ranges from 0.29 to 1.63% indicating meagre organic matter in the soil.
4. Nitrogen content ranges between 220 to 630 kg/ha

showing medium availability of nitrogen to crops.
5. Available phosphorus ranges between 1.0 to 12.8 kg/ha. The study conducted found that soil of the area (about 92.2%) were low in available phosphorus whereas 6.0% area have medium available phosphorus content.
6. Thus, in the soil pH, organic carbon, N & P were not available for crop production.
7. Soil biotic communities populations were moderately available but use of *Eiesenia* sp. of earthworm will be beneficial for the solid waste management which are plentifully available in the region specially released from ECL, Lalmatia, NTPC, Kahalgaon and Farakka.
8. This study is eco-friendly and will have some contribution in pollution abatement strategies.
9. Further elaborative experimental studies will be needed for knowing the more species of earthworms involved for humification and mineralization of solid wastes which in turn helpful in the upliftment of the socio-economic conditions of local tribal population of the region.

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