Quality Standards for City/Urban Compost

The Ministry of Agriculture, Govt. of India held series of meetings with the scientists, extension workers, composters, In-charges of quality control standards and others, and a gazette notification issued on Nov.3, 2009, which was later included in FCO (Table 2)

Table 2: Minimum quality standards for city/urban compost and vermicompost as per FCO (2013)

Parameters	City Compost	Vermicompost
Moisture, per cent by weight, maximum	15.0- 25.0	15.0-25.0
Colour	Dark brown to black	
Odour	Absence of foul odour	
Particle	Minimum 90% material should pass through 4.0 mm IS sieve	
Bulk density (g/cc)	<1.0	0.7-0.9
Total organic carbon per cent by weight, minimum	12.0	18.0
Total nitrogen (as N) per cent by weight, minimum	0.8	1.0
Total phosphates (as P_2O_5) per cent by weight, minimum	0.4	0.8
Total potash (as K_2O) per cent by weight, minimum	0.4	0.8
C:N ratio	<20	-
pH (compost : water :: 1:2)	6.5-7.5	-
Conductivity (as dS m^{-1}) not more than	4.0	-
Pathogens	Nil	-
Heavy metal content (as mg/kg), maximum	Arsenic (as As_2O_3) 10.0, Cadmium (as Cd) 5.0, Chromium (as Cr) 50.0, Copper (as Cu) 300.0, Mercury (as Hg) 0.15, Nickel (as Ni) 50.0, Lead (as Pb) 100.0, Zinc (as Zn) 1000.0	Cadmium (as Cd) 5.0, Chromium (as Cr) 50.0, Nickel (as Ni) 50.0, Lead (as Pb) 100.0

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Publication Year : 2015

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Rapid Composting Technique

Ways to Enhance Soil Organic Carbon, Productivity and Soil Health

ICAR- Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal - 462038 (M.P.)

Village and City Clean and Field Green

स्वच्छ भारत
एक कदम स्वच्छता की ओर

India achieved a remarkable growth in agriculture as scientists from ICAR and Agricultural Universities have played a pioneering role in ushering Green Revolution by increasing food grains by 4 times, horticulture by 6 times, fisheries by 9 times, milk by 6 times and eggs by 27 times since 1950-51. Thereby, making a visible impact on the national food and nutritional security. But now we are witnessing the second generation problems due to intensive cultivation and imbalanced use of fertilizers and hardly any application of organic manure. There is a sharp decline in soil organic carbon content, lowering of water table, climate change and lack of required genotype. A decline in yield and productivity of rice and wheat in Punjab, U.P, Bihar and other areas has shaken the planners and scientists. In fact, scientists have found out that less organic carbon in soil system is the main cause of decline in the response ratio of added chemical fertilizers, which follows the law of diminishing returns. The burgeoning population and scarcity of limited natural resources are heading our country to lesser and lesser food availability per capita and hence, there is an urgency to enhance food production and to make our country prosperous from food security point of view. The decline in yield and fatigue in productivity have been indicated through long-term experiments in various cropping systems of different agro-eco-regions of the country. Most of the Indian soils are deficient in nitrogen, phosphorus and zinc coupled with low organic matter is a constraint limiting the productivity of the soils. The amount of soil organic carbon in Indian soils is relatively low, less than 0.5%, influencing on soil fertility, microbial activity and physical condition. The data in Table 1 shows a decline in SOC concentration of cultivated soils by 30 to 60% compared with the antecedent level in undisturbed ecosystems. Organic carbon plays a multifunctional role in soil such as regulating nutrient supply to plant, buffering, filtering, restoring and maintaining soil health. Their efficient management is indispensable for the sustainability of production in different cropping systems. In view of ever escalating cost of chemical fertilizers the biodegradable organic sources is the only way to supplement the nutrients and save as the cost of fertilizers, sustain soil health and ecosystem functions.

Table 1: Depletion of soil organic carbon concentration of cultivated compared with that in undisturbed soils

Region	SOC content		Percent (%) reduction
	Cultivated (%)	Undisturbed (%)	
1. Northwest India			
• Indo-Gangetic Plains	0.42 ± 0.09	1.04 ± 0.36	59.6
• Northwest Himalaya	2.43 ± 0.87	3.45 ± 1.16	29.6
2. Northeast India	2.32 ± 1.04	3.83 ± 2.33	39.4
3. Southeast India	2.96 ± 3.01	4.37 ± 2.34	32.3
4. West coast	1.32 ± 0.81	1.86 ± 0.21	29.1
5. Deccan Plateau	0.77 ± 0.41	1.79 ±0.76	57.0

Source: Swarup et al. (2000) modified from Jenny and Raychaudhary (1960)

Benefits of Stable Soil Organic Matter

Physical Benefits

- Enhances aggregate stability and improves soil aeration
- Better seed germination
- Improves water infiltration by reducing runoff and thus increase water holding capacity
- Reduces the stickiness of clayey soils and thus making them easier to till
- Reduces surface crusting

Chemical Benefits

- Increases the cation exchange capacity (CEC) of soil or its ability to hold and supply essential nutrients such as calcium, magnesium and potassium
- Enhances fertilizer and water use efficiency
- Improves the buffering capacity i.e. ability of a soil to resist pH change
- Accelerates decomposition of soil minerals and making the nutrients available for plant uptake

Biological Benefits

- Provides food for the living organisms in the soil and efficiency of nitrogen fixing microbes is enhanced
- Enhances soil microbial biodiversity and activity which can help in the suppression of diseases and pests
- Enhances pore space through the actions of soil microorganisms and thus increases infiltration and reduced runoff

Availability of Biodegradable Waste in India

Biodegradable organic wastes such as crop residues, agro industrial organic wastes, city garbage and forest litter have wide C/N ratios ranging from 80 to 110, and low concentration of available plant nutrients particularly N, P and K. On the basis of crop production levels, it is estimated that ten major crops (rice, wheat, sorghum, pearl millet, barley, finger millet, sugarcane, potato, tubers and pulses) of India generate about 679 Million tonnes (Mt) of crop residues, in which 226 Mt is actually available that has nutrient potential of about 5.6 Mt of NPK. The potential availability of all animal excreta is about 369 Mt of which 119 Mt is actually available that potentially supply about 1.7 Mt of plant nutrients. In recent survey, it is estimated that about 64.8 Mt of city wastes is generated every year from different cities of India that have nutrient potential of about 0.285 Mt of N, P and K. In addition to field crops, the estimated annual generation of byproducts/wastes from the horticultural and plantation sectors is estimated at 263.4 Mt, out of which, 134 Mt is considered to be available for recycling. It is also estimated that every million tonne increase in food grain production will produce 1.2-1.5 Mt of crop residue and every million increases in cattle population will provide additional 1.2 Mt of dry dung per annum. Every million increase in human population will discharge 16,500 tonne faeces (dry basis). Thus, the estimated NPK supply from all the wastes including crop residues is 5.0, 6.25 and 10.25 Mt, respectively during the year 1991, 2011 and 2030.

Organic solid wastes generated by agriculture, domestic, commercial and industrial activities are often indiscriminately disposed on the soils. The disposal pattern of wastes also varies from season to season. However, under ordinary conditions of storage, there are significant losses of plant nutrients either by burning, uses as fuel cake, leaching or volatilization when manures remain exposed to sun and rain. It is estimated that if these wastes are managed properly in a scientific manner, it can be source of 10 Mt plant nutrients and would also improve soil health and crop productivity. **Thus, a sound technology is required to improve the quality of manures in the shortest possible time, where farmers can prepare the compost easily and improve its nutritional quality by the addition of cheap amendments such as rock phosphate and pyrites, micas etc.** Therefore, proper management is essential for recycling or organic wastes available from different sources, which is economically viable, eco-friendly and socially acceptable.

Composting and its Importance

Composting is a microbiological and non-polluting safe method for disposal and recycling of wastes by converting them into organic fertilizer. During composting, mixed microbial populations convert organic wastes into humus, which has significant value in agriculture. Anaerobic composting enhance denitrification processes and emits several green house gases to atmosphere.

The valid reasons for composting decomposable wastes of diverse origin and composition are:

- It improves the physical characteristics of agricultural wastes making them easy to handle and use.
- Composting lowers the C:N ratio of materials with wide C:N ratio such as cereal straw, thus avoiding nutrient competition between plants and microorganisms
- It reduces the final volume of waste by about half of its original volume
- It facilitates the recycling of humus and nutrients into the soil
- It protects and improves the microbiological diversity and quality of cultivated soils
- The high temperatures produced during composting sterilize weed seeds, kills pathogens and pests in the wastes, thus reducing the cost of production, health hazards and control pests and diseases
- It minimizes and even eliminates the problems arising from poor aeration such as emission of H_2S, phenolic compounds, methane etc.
- During composting, various microorganisms promote biodegradation of toxic compounds and pollutants (bioremediation)

Problems Using Immature Compost

- Less degree of stability and immaturity leads to the presence of phytotoxic material and also the pathogen growth Nitrogen immobilization at a high C:N ratio and thereby reduction in the supply of available N
- Stocking and bagging of wet and immature compost can induce anaerobic decomposition resulting in the production of toxic substances such as alcohol, methane and acetic acid
- Thus an appropriate decomposition technique must be adopted

1. Composting Technology for Solid Wastes from Rural and Urban Areas

Rural Areas: In India 2/3rd part of cattle dung is used for fuels whereas only 1/3rd part is being used as farm yard manure for agriculture. Similarly the crop residue like wheat straw is being used for cattle feed or burnt directly in field. It is vital that we search for making best use of rural wastes as compost/organic manure and return back as much as to the soil. At the same time our endeavour should be that the composting technology should be easily adopted by the farmers and the quality should not be sacrificed. This would certainly keep the rural areas clean and would be savior from insect borne diseases.

Urban Areas: In urban areas lots of garbage is produced. A rough estimate reveals that around 0.4 kg/day garbage is produced by one individual. It is estimated that in Delhi, Bombay, Chennai, Bangalore, Hyderabad and other metropolitan cities about 6000-9000 tonnes of garbage is produced daily (approximately). The composition of unsegregated Municipal Solid Waste (MSW) from average of 6 cities is plastic 4.1%, glassware 4.5%, rag 2.8%, metal 1.7%, stone/soil 30.7%, biodegradable materials 39.8%, tyre/tube 3.3%, others (ceramic, earthenpot, etc). This analysis reveals that a concept of **Zero Garbage** can easily be adopted by Local Self Governments (LSG). Around 40% biodegradable segment can be easily separated for composting channel; rag and horticultural waste can be used for Residual Derived Fuel (RDF) purpose; stone/soil can readily be used for filling dug hole, roads, flyovers and metals, plastic and glassware may be readily sold back to industry for recycling. Thus, the LSG can make some money from this garbage, if the concept of zero garbage is properly and systematically adopted by them. Naturally there would not be any garbage mountains as normally encountered in the cities which pollutes the air, underground water, attract flies and a great nuisance for residents residing around the area.

Composting Mechanism

Segregation: A thorough segregation is most vital part for achieving pollutant free, well decomposed quality compost. If the quantity is larger than 50 ton/day the use of sieving machine is a must. It is a paradox that we have not been able to impress each household to separate the biodegradable material, recyclable material, civil works material, etc. for which we should use the electronic media, social workers, NGO and others, at the generating and collecting stage.

The Seven Stages of Composting Process as depicted in the flow chart are:

1. ***Mesophilic Phase:*** For regular observation and monitoring such as proper aeration, turning the mass, watering, addition of bio-inoculum etc. Desired length x width x height varies, but should not be more than 2 m height and 2.5 m width. Temperature is in the range of 15-45°C, moisture 50-60% by volume, different microbial communities depending upon the substrate are sprayed under aerobic condition. Total period is not more than 10 days and then turning is performed and if required the inoculum is added again.
2. ***Thermophilic Phase:*** During this phase temperature reaches from 45°C to 70°C, lasting around two weeks. Turning must be done as it is aerobic process.
3. ***Second Mesophilic Phase:*** Ensure that during last stage the decomposition process is apparent and some steam is released while turning. In this stage too, add some inoculum if required and maintain moisture at 50%. The mesophilic organisms, often dissimilar to those of first mesophilic phase, recolonize the substrate. This phase last for one week or so.
4. ***Cooling Phase:*** The bacterial/micro-organisms activity may have decreased by 50% but their taxonomic and metabolic diversity increase. Detailed analysis revealed that organic oxidizers have degraded natural complex polymers such as cellulose, hemicellulose, lignin, wax, fat and others.
5. ***Maturation Phase:*** During this phase the main activity which takes place is degradation of the more resistant compounds and getting them partly transformed into humus. These compounds are lignin, lignocellulose and other recalcitrant components of tree bark, yard wastes, agricultural wastes, etc. Paper may contain up to 20% of lignin. Most of the fungi, predominant cellulose and lignin degraders, are responsible for their decomposition and enzymatic activity.
6. ***Screening:*** The well decomposed material is passed through 4mm sieve and air classification machine. It has to be ensured that no pollutant is passed through those sieves and also glass pieces are removed through air classification system.
7. ***Humification Stage:*** Synthesis of humus during composting in which organic compounds of natural origin are transformed into relatively stable compounds. Humus is the end product of composting, which is black brown, high molecular weight, high CEC and is a store house of plant nutrients. During humification aliphatic compounds of waste materials changes into aromatic compounds upon microbial action. Humus is composed of fulvic acid and humin, matured humified compost is characterized by high content of humic acid and is largely responsible for clay-humus complex, which inturn responsible for nutrient supply, water holding capacity and soil aggregate formation.

CLEANLINESS IS GODLINESS

Depiction of Different Stages of Composting

Collection of MSW

↓

SEGREGATION
(100 mm sieve) Above 100 mm as RDF & below 100 mm for compostable

↓

WINDROW FORMATION
(2.5 M Height Max., 3.5 m wide bottom Max)

↓

CULTURE TREATMENT
(At every 50 cm layer & 50-60% Moisture maintenance)

↓

FIRST MESOPHILLIC STAGE
(Temp. below 45°C, 55 % moisture & time 1 week) Turning for aeration

↓

THERMOPHILLIC STAGE
Inoculation (Temp. 65-75°C, Moisture at 50 % & time – 2 Week) Turning after a week

↓

SECOND MESOPHILLIC STAGE
(Cooling) (Temp. 45-50°C, moisture at 45 % & time 1 week) Turning

↓

MATURATION STAGE (CURING)
(Degradation of lignin, lignocellulose and other recalcitrant compounds, Time 1-2 weeks)

↓

SCREENING
(4mm seive)

↓

HUMIFICATION (SYNTHESIS OF HUMUS)
Change of aliphatic compounds into aromatic compounds (high humic acid content & low fulvic acid content) high content of nutrient but no pollutants, Time 1 week, & Moisture around 20-25%)

↓

QUALITY COMPOST (AS PER FCO STANDARDS)
To achieve this essentials are inoculants and aeration. We have Indigenous culture & EM culture as inoculants and turning for aeration is must.

National Policy and Action Plan for Improving Compost Quality

In recent past, Inter-ministerial task force was set up by the Hon'ble Supreme Court of India, mainly for preparation of Policy Strategy and Action Plan for promoting integrated plant nutrient management (IPNM) using city compost along with synthetic fertilizers in every sector of agriculture, horticulture, plantation crops, forestry and rehabilitation of mining areas. Further, the subgroup-1 of **Inter-ministerial task force** was appointed to study problems faced by compost plants, quality issues, marketability, sustainability, sale price and operation and maintenance issues. The subgroup-2 of **Inter-ministerial task force** was further appointed to finalize the compost plant designs, drawings, specifications of plant machineries, land area requirement and operation and maintenance costs etc. The combined report of Task Force and Sub Groups (1 & 2) based on the availability of biodegradable component of the garbage and total class 1 city waste of about 50 million MT was submitted to the Urban Development Ministry for onward submission to the Hon'ble Supreme Court. The major thrust of the recommended policy are waste reduction through concerted Information, Education and Communication (IEC), segregation of different types of waste at source at home, in the hospitals and in the industry, resources recovery and recycling so that waste is turned into useful material for use in daily life and appropriate technology for safe collection, transportation and disposal of solid waste.

Major Components of the National Action Plan of Urban Solid Waste Management

- Awareness generation at all levels-community, industry and hospitals and bear 1/3rd of the cost of compost plant.
- Legal enactment to supplement and support the efforts generated through IEC.
- Human resource development for better management of Urban Solid waste.
- Research and development for evolving and evaluating
- Pilot projects preferably in the joint section for utilization of proven technological options for urban solid waste management.
- Strengthening the existing services for urban solid waste management by buy back arrangement and providing subsidy for organic manure and follow the Integrated Nutrient Management (Basket Approach).
- Establishment of rag pickers cooperatives in association with NGOs.

2. Rapo-Compost Technique for Recycling of Vegetable Waste from City

Rapid composting is the need of the hour for reducing the time required for obtaining good quality compost. This technology is especially suitable for recycling of kitchen waste and vegetable wastes. ICAR-IISS developed this technique in collaboration with ICAR-CIAE, Bhopal and ICAR-NBAIM, Mau. Lignocellulolytic thermophilic organisms were isolated, screened and identified by ICAR-IISS.

Ingredients Required

For the preparation of 100 kg compost, 150 kg fresh biomass (waste material), 50 kg fresh cowdung, 1.1 kg urea, 50 g fungal inoculum (10^5 viable cell), 1 litre bacterial (10^8 viable cell), and 1 litre actinomycetes (10^8 viable cell) inocula are required.

Salient Features

- A new technology has been developed to speed up the composting using consortium of Ligno-cellulolytic thermophilic organisms
- For this purpose, rapo-compost technology has been designed with a capacity of 100 kg (Fig. 1)
- Biowaste materials like domestic wastes and vegetable wastes are collected and partially dried
- Fresh cowdung mixed with the waste materials in the ratio of 1:0.2 (on dry weight basis)
- Microbial consortia are inoculated to accelerate the decomposition processes at 7 and 14 days of decomposition
- Moisture content is maintained throughout the composting period at 60% of water holding capacity
- Temperature is maintained at 55°C during first 21 days of composting
- Periodic turning is done using hand peddle to homogenize the inside materials

Fig. 1: Steps followed for Rapo-composting

Impact and Benefits of Rapo-compost

- ✓ Rapo-compost would prepare compost within 1-1.5 months from domestic and vegetable waste
- ✓ The manurial value improved such as total nitrogen 0.89 to 1.75 %
- ✓ At 30 days of decomposition the colour of the compost was dark brown and with no foul odour
- ✓ C:N ratio of matured compost is 14:1, CEC reached to 94 cmol(p+)/kg, lignin/cellulose ratio increased to 2.4%, CEC/TOC ratio was 0.27 (initial) reached to 4.56 at 30 days of decomposition, water soluble carbon reached to 0.5% whereas the content of NH_4-N and NO_3-N varied from 1.3-0.28 and 0.14-0.84 g/kg, respectively
- ✓ Large quantities of wastes materials may be recycled back to the field after converting them to quality manure
- ✓ The production of a valuable soil amendment from many organic materials which normally might be wasted
- ✓ Pathogens and weed seeds do not survive at high temperature during the composting process

Steps for Rapo-composting

Collection of biowaste materials

↓

Segregation of non-biodegradable materials

↓

waste materials mixed with fresh cowdung

↓

Inoculation with consortium of organisms

↓

All materials mixed together and fed to rapo-compost bioreactor

↓

After one month the humified organic manure was allowed for curing

↓

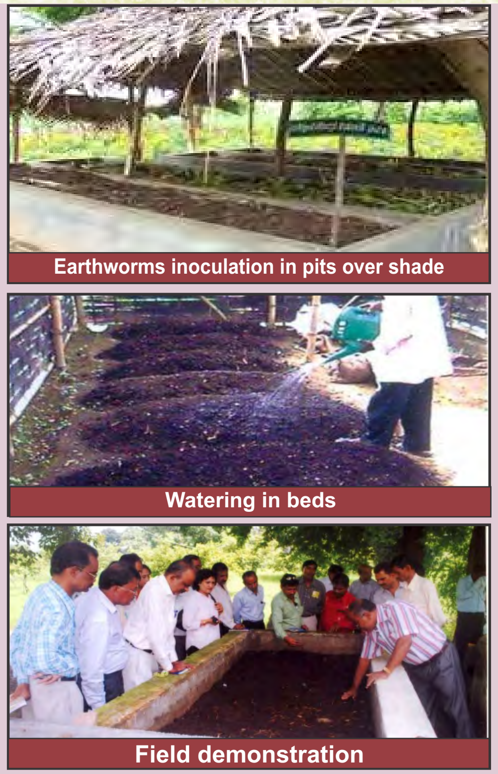
Sieved (4 mm sieves) and stored at 25% moisture condition

3. Vermicomposting for Recycling of Rural and Urban Waste

Vermicomposting is a very effective method of converting wastes into useful manure with the help of earthworms to recycle decomposable organic wastes such as animal excreta, kitchen waste, farm residues, forest litters, etc..

Salient Features

- Open permanent pit in the size of 10 x 3 x 1.5 feet are made in shady site where there is a source of water near the pit. Brick walls are constructed above the floor of the pits leaving 5-6 gaps in the pit of wall of 10 cm diameter to facilitate aeration. These holes blocked with nylon screen to prevent escape of earth worms from the pits (Fig. 2).
- 3-4 cm thick layer of partially decomposed dung about (2 months old) is spread on the bottom of the pits. A layer of dung and decomposable organic wastes, chopped, dried and mixed in the ratio of 1:1 (w/w) is then added. A second layer of dung is then applied followed by another layer of litter/crop residue in the same ratio up to the height of 1.5 feet. The material is allowed to decompose for 20-21 days to stabilize the temperature after the initial thermophilic stage.
- After partial decomposition of materials, the earthworm species *Eisenia foetida, Eudrilus eugeniae and Perionyx excavatus* (identified by the institute) are directly inoculated in each pit by hand on the surface materials on the basis of 1kg/ 100 kg materials (Fig.3).
- Water should be sprinkled with can, immediately after the release of worms. Moisture content is maintained at 60-70% throughout composting period. Jute bags (gunny bags) should spread uniformly on the surface of the materials to facilitate maintenance of suitable moisture regime and temperature conditions.



Earthworms inoculation in pits over shade

Watering in beds

Field demonstration

Fig. 2: View of Vermicomposting Technology

Advantages of Vermicomposting

- ✓ It provides efficient conversion of organic wastes/crop/animal residues for production of vermicompost within 1.5 months to 2.5 months.
- ✓ Vermicompost is storehouse of plant nutrients.
- ✓ It improves physical, chemical and biological properties of soils and therefore better crop productivity.
- ✓ It is economically viable and environmentally safe nutrient supplement for organic food production.
- ✓ It is an easily adoptable low cost technology.
- ✓ About 3 tonnes of vermicompost can be produced from 10 beds of 10 x 3 x 1.5 feet size bed. The cost of earthworms is Rs 400 per kg. A 50 kg bags of vermicompost can be sold for Rs 150 (Rs 3000/tonne).
- ✓ This technology is better in terms of faster decomposition of the waste over conventional method.
- ✓ Secondly the nutrient composition of the vermicompost is higher than conventional compost.
- ✓ Application of vermicompost @ 5 tonne/ha in cropping system and 1-10 kg/tree in plantations, depending on the size of trees is recommended.

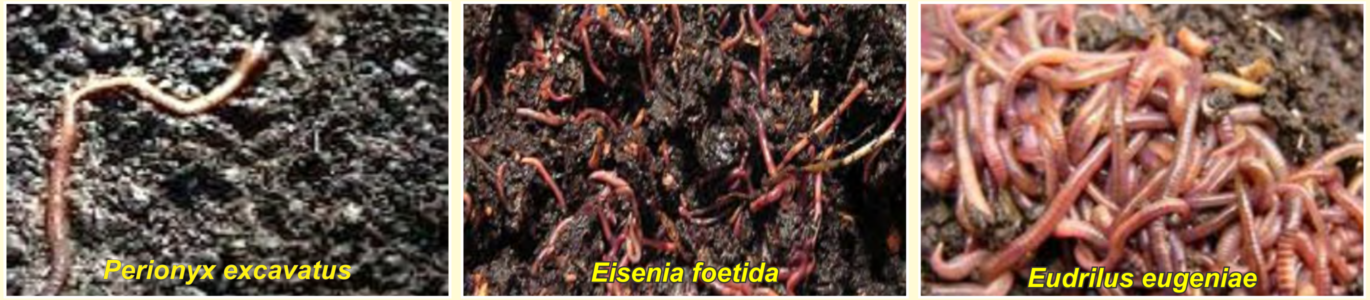


Fig. 3: View of different epigeic earthworms