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Editorial

Earthworms - our beloved friends

It has been proved world widely by the research scientists that earthworms are creative creatures of the nature since their origin on our planet. They improve physical, chemical and biological state of the soil. The other group of the worms transforms various biodegradable "solid wastes" into compost and reducing the level of pollution and improving the quality of the air, although the composting ability of the worms is found different in different species. We, the researchers, must work hard in knowing their composting abilities so that the farmers will apply only those worms in the transformation of solid wastes which have high potential in converting the waste into vermicompost as it will give us a better impetus in replacing chemical fertilizers as regular use of earthworm transformed compost into the farming land improves the quality of the soil, crops, grains and vegetables and lowers the infestation of pests.

The main article of the bulletin entitled, "Composting ability and AchE enzyme activity of Eisenia fetida and Lampito mauritii exposed to fly ash amended lateritic soil" of Visva Bharati Central University, Santiniketan (West Bengal) will give the exhaustive information about the two composting earthworms to the readers about their capabilities in changing fly ash into bio-compost; while the other article of Prof. Radha Kale point out about the new frontiers of research on *Pontoscolex corethrurus* to the earthworm biologists.

Prof. S.M. Singh

Message from the President

In the present scenario, the human population is exponentially increasing and as a consequence the area of the farming land is decreasing. This state is developing a serious need of more production of food. How we will compete this alarming situation is a question which is not being solved by the biological scientists. Although, enormous usage of chemical fertilizers and pesticides has increased the food production but this much of food is not enough for the entire human population. We must search the new technologies for it. Earthworms may be one of such creative creatures of the nature since their origin on our planet. They have multifarious roles.

It is a peak time for our earthworm biologists, soil scientists and horticulturists to explore more unknown facets of earthworms so that these worms could be used not only in improving soil health but also to transform various solid wastes responsible for environmental degradation into bio manure and to save the environment.

The articles of the present issue of the bulletin might proof as a milestone for our researchers.

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Composting ability and neurotransmitter enzyme activity of *Eisenia fetida* and *Lampito mauritii* exposed to fly ash (FA) amended lateritic soil

"Solid Waste" is a problem of the modern civilized and developing society. Fly ash (FA) is one such waste from thermal power plants produced from coal combustion. It leads to several environmental hazards as it contains number of heavy metals. FA can be a choice of alternative fertilizer if used judicially. FA problem can be solved through its recycling in cultivation and rejuvenating low fertile soil. In order to evaluate the effects of heavy metal on organisms, the use of biomarkers is increasingly becoming a suitable tool.

Acetylcholinesterase (AChE) - a neuro synaptic enzyme is a predictable parameter for assessing the effects of heavy metal poisoning inside the living organisms.Amongst the several earthworm species *E. fetida* and *L. mauritii* have the highest potential in FA as well as bottom ash vermi conversion.

Adult earthworms of both species were collected from the stock population of vermiculture unit, rinsed in water and kept on moist water paper in the dark at 25 ± 2 °C for 12 h to allow gut evacuation. All the experiments were carried out under laboratory conditions. FA (FA) was collected from Bakreswar Thermal Power Plant and control soil from Santiniketan. General characteristics of FA and soil have been evaluated (Table 1). Six sets of experimental beds were prepared individually for both the earthworm's species in 500 mL culture/experimental pots containing 300 g of culture materials consisting of (I) control beds, i.e., soil + cow dung + earthworm and (II) FA treated beds, i.e., soil + cow dung + FA + earthworm (soil: cow dung were added in 1:1 ratio). For the treated beds, FA was added in each bed so as to make the percentage of the ash as 10%, 20%, 30%, 40% and 50% and mixed thoroughly to ensure a homogenous mixture. The moisture content was adjusted to 30% of the final weight in all experimental beds. The experimental pots (both treated and control) were left for 15 days undisturbed prior to experimentation for softening of wastes or thermo-stabilization. The moisture content and pH in the pots were adjusted to 30 ± 2% and 6.8 ± 0.05 respectively. Eighteen adult gut evacuated earthworms were inoculated in each treated and control bed. Culture pots were covered with nylon nets to prevent the escape of earthworms. For each assay, four worms from three different replicates of each experimental pot (specified for a particular day) were taken at the end of the exposure (2 day, 7 day, 14 day, 21 day and 30 day). Control specimens were also taken accordingly. Earthworm population was periodically counted during vermicomposting by sieving (3-5 mm) and biomass is reported as live weight, taken after rinsing the adhering materials and blotting them dry.

Metal content in FA treated soil

The analysis of trace metals (Pb, Cd, and Ni) was done by Perkin Elmer ICP-OES Model: Optima 2100 DV. FA Soil mixture samples were analysed by standard methods. The AChE activity of *L. mauritii* and *E. fetida* was estimated spectrophotometrically. The composting ability of *E. fetida* and *L. mauritii* was determined on 0 day and 30th day through the available status of soil nitrogen, phosphorous, potassium and organic carbon in FA treated soil (Table 2 and 3 respectively).

In case of *E. fetida,* compared to control, the organic C maintained a steady state up to 20% FA treated soil, which gradually decreased significantly ($p<0.05$) (with time) and maximum decrease was observed in soil treated with 40% FA. Interestingly, the total N amount increased significantly ($p<0.05$) with time (time dependent) for all the FA combinations with maximum increase noticed in 10% FA treated vermicomposted soil after 30 days exposure. The amount of K also enhanced significantly ($p<0.05$) with time and maximum increase was observed in 10% FA treated vermicomposted soil after 30 days of exposure. P availability increased significantly ($p<0.05$) with time, with a maximum increase in 10% FA treated vermicomposted soil. However, compared to control, a significant dose dependent increase ($p<0.05$) in P availability was noted with increasing amount of FA in soil (Table 2).

Unlike *E. fetida*, in case of *L. mauritii* (Table 3) the organic C availability decreased with time (except in control and 50%) where significant decrease was observed in 20% FA treated soil. Total N increased significantly in control with time followed by a steady state up to 20% FA treated soil (i.e., no significant change in nitrogen concentration) which further proceeded with significant increment up to 50% FA treatment ($p<0.05$). In *L. mauritii* cultured soil, available potassium also significantly increased with time where maximum increase was noted in 20% FA treatment. Gradual increase of available P was observed with time with maximum increase in 30% FA treated soil.

Earthworm number and biomass count after FA treatment

The results showed favourable ambient environment, food palatability and feed stock density positively influence the earthworm growth up to a certain time. This might be a reason for increased earth worm populations at initial FA exposure. In present study, the variation of soil health quality due to addition of FA posed a significant effect on both the earthworm reproduction and their overall population as well. While studying the earthworm population, *E. fetida* has shown significant increment in number up to 30 days in control and 10, 20% FA treated soil mixture ($p<0.05$). However a significant decrease in number was counted in *E. fetida* treated with 30-50% FA after 30 days of exposure ($p<0.05$). However in case of *L. mauritii,* a significant reduction in number was observed with the increment of FA doses in 30 days exposure ($p<0.05$).

The changes in worm biomass over the period of 30 days with various combinations of substrate showed a gradual and significant decrease in biomass from 30% FA has been noticed after 30th day in *E. fetida.* However, a distinct significant reduction in biomass (g) has been observed in *L. mauritti* after 14 days of exposure with the increasing concentrations of FA which persists still 30 days up to the end of the exposure period ($p<0.05$).

Earthworms reside in contaminated soil allows field validation of chemical bioavailability. It was found that the maximum remediation of heavy metals has been occurred for Cd followed by Pb and Ni for both the species. % metal recovery has been observed effectively in the mid level substitution for both the species; whereas, at higher doses of FA *E. fetida* is found to be efficient.

In vivo AChEe activity in *Lampito mauritii* and *Eisenia fetida*

The AChE activity of *E. fetida* and *L. Mauritii* under the treatment of different FA doses (10%, 20%, 30%, 40% and 50%) are given in Table -4 and 5 respectively. The data suggested that the effects of FA doses on AChE activity were different in both the earthworm species. For studying the initial impact of FA exposure on AChE activity of both the earthworms, day 2 has been considered as a relatively moderate exposure period.

In case of *E. fetida*, the AChE activity significantly reduced ($p<0.05$) as compared to control with the increasing doses of FA (except in day 0), as well as, with time. Though a steady state was maintained up to 14th day, compared to day 2, interestingly, a significant increase ($p<0.05$) in AChE activity was observed in *E. fetida* even after 21 days exposure to 10% FA treated soil (Table 4).

On the other side, comparing day 2 exposure with rest of the exposure days, a significant reduction ($p<0.05$) in AChE activity was observed in *E. fetida* cultured in 20%, 30%, 40% FA treated soil after 14th, 7th, 14th days of exposure respectively. However, the activity increased after 21st days exposure in the 20%, 30%, 40% treatments. But, in 50% FA treated soil, compare to day 2, the AChE activity reduced significantly ($p<0.05$) after 14th days of exposure and never recovered. Finally at the end of the incubation period i.e. on 30th day, significantly lowest AChE activity ($p<0.05$) was found in *E. fetida* up to 30% treated soil compared to day 2. But the lowest activity for 40%

and 50% treatments was noted on the day 14th day exposure (Table 4). Similar to *E. fetida*, the change of AChE activity in *L. mauritii* was insignificant in control after different days of exposure. Compared to control, it significantly reduced ($p<0.05$) with the increasing doses of FA (except in day 0) and with time and maximum reduction observed on 7th day exposure in 20-50% FA treatment. In 10% FA treated soil, compared to 2 day exposure, the AChE activity of Lampito significantly increased ($p<0.05$) for the different exposure period, except for day 7 (Table 5). When comparing among 2nd day exposure with the rest of the exposure days, a significant reduction ($p<0.05$) up to 14th day was followed by a significant recovery up to 21th day and again a drastic, significant fall in AChE activity was prominent in Lampito exposed to 20% and 30% FA treated soil ($p<0.05$). However, the AchE activity, compare to 2nd day exposure, significantly reduced with increasing time in 40 and 50% FA treated soil ($p<0.05$).

The AChE activity in general is high in *L. mauritii* as is relevant from the tables. It is clear from Table 2 and 3 that the AChE activity was found to be significantly higher ($p<0.05$) in *L. mauritii* than *E. fetida* (when comparing among same exposure dose and period) in all experimental sets including the control except in 40% and 50% FA treated soil after 7th days exposure.

The present study reveals a positive potential of mid-level substitution of FA to lateritic soil and vermi conversion of it with Eisenia for effective soil health. Furthermore, it is surmised that FA contaminated soil inhibits AChE in earthworms *L. mauritii* and *E. fetida*. Thus, the AChE can be developed as the biomarker of FA exposure. On the other hand *L. mauritiii* can be termed as an effective stress responsive species in FA exposure. Thus considering both the AChE activity and composting ability, the FA dose of 10-30% to lateritic soil is recommended for lateritic soil amelioration. Although extensive research is required for exploring the probability of co-culture of *E. fetida* and *L. mauritii* in FA contaminated lateritic soil for improving soil quality.

Table 1: General characteristics of lateritic soil and fly ash.

	Soil	FA
pH	6.7	7.3
Cd (mg/kg)	2.07	2.02
Pb(mg/kg)	5.08	8.95
Ni(mg/kg)	20.56	65.23
Cr (mg/kg)	12	20.8
Fe(mg/kg)	1740.6	990

Table 2: Showing composting ability of *E. fetida* through available status of C, N, K, & P of % FA

Treatment	Organic Carbon (%)		Total Nitrogen (%)		Available K (%)		Available P (%)	
	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30
Control	3.22±0.030	3.20±0.09	0.012±0.002	0.05±0.001†	1.26±0.08	2.48±0.03†	0.57±0.02	0.80±0.05†
10% FA	3.45±0.08	3.39±0.01	0.023±0.003	0.08±0.001†	1.58±0.37	3.93±0.40†	0.68±0.01	1.94±0.05†
20% FA	3.40±0.06	3.30±0.06	0.023±0.005	0.07±0.002†	1.6±0.06	3.53±0.05†	0.68±0.03	1.75±0.07†
30% FA	1.20±0.030	1.05±0.04†	0.014±0.004	0.05±0.004†	1.73±0.02	2.80±0.05†	0.97±0.03	1.51±0.02†
40% FA	1.60±0.03	0.19±0.07†	0.016±0.003	0.04±0.003†	1.83±0.06	2.14±0.11†	0.98±0.03	1.11±0.08†
50% FA	1.63±0.02	1.59±0.03†	0.014±0.001	0.03±0.008†	1.86±0.05	2.15±0.21†	1.12±0.04	1.18±0.04†

Table 3: Showing composting ability of *L. mauritii* through available status of C, N, K, & P of % FA

Treatment	Organic Carbon		Total Nitrogen		Available K		Available P	
	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30
Control	3.22±0.30	3.22±0.09	0.012±0.002	0.027±0.004†	1.26±0.02	2.45±0.08†	0.57±0.02	0.78±0.04
10% FA	3.45±0.28	2.79±0.14	0.023±0.003	0.03±0.008	1.58±0.07	2.55±0.08†	0.68±0.01	0.88±0.015
20% FA	3.40±0.36	1.45±0.10†	0.02±0.005	0.023±0.003	1.6±0.02	2.78±0.01†	0.68±0.03	0.90±0.05
30% FA	2.20±0.30	2.08±0.02	0.015±0.004	0.04±0.002†	1.73±0.02	2.65±0.05†	0.97±0.03	1.20±0.18
40% FA	1.60±0.31	1.56±0.03	0.016±0.003	0.03±0.003†	1.83±0.03	2.54±0.03†	0.98±0.03	1.10±0.09
50% FA	0.563±0.12	1.62±0.21	0.016±0.001	0.03±0.006†	1.86±0.15	2.50±0.02†	1.12±0.04	1.17±0.04

Table 4: Showing AchE activity of *E. fetida* under different FA doses

Treatment	Day 0	Day 2	Day 7	Day 14	Day 21	Day 30
Control	275.4± 2.0	274.28±0.5	273.1±0.6	273.51±0.4	275.31±1.7	275.2±0.5
10% FA	275.2± 3.0	246.32±0.2*†	249.5±1.7*†	262.90±0.6*†?	256.9±1.6*†?	256.6±1.0*†?
20% FA	276± 1.0	260.2±1.4*†	199.6±1.4*†?	221.78±3.7*†?	266.36±1.7*†?	185.4±1.9*†?
30% FA	275.8± 2.5	235.37±0.8*†	97.2±0.2*†?	177.36±2.3*†?	243.75±1.7*†?	222.0±2.1*†?
40% FA	275± 2.0	238.41±0.3*†	44.3±0.6*†?	165.09±1.4*†?	140.72±1.5*†	164.5±0.5*†?
50% FA	275.6± 2.2	188.85±2.2*†	28.6±0.5*†?	102.74±1.2*†?	119.24±1.1*†?	101.7±1.9*†?

Table 5: Showing AchE activity of *L. mauritii* under different FA doses

Treatment	Day 0	Day 2	Day 7	Day 14	Day 21	Day 30
Control (unexposed)	140±3.20	140.47±0.9	141.8±0.2	141.3±0.5	141.7±0.3	142.6±0.28
10% FA	140± 2.1	124.61±1.9*†	124.0±0.4*†	120.9±3.1*†	132.7±2.5*†?	101.7± 4.7*†?
20% FA	140.6±3.0	125.51±2.7*†	125.8±1.2*†	108.3±2.4*†?	127.3±0.4*†	80.6±0.5*†?
30% FA	140.8±2.2	123.33±3.1*†	92.3±0.82*†?	84.3±1.0*†?	122.8±1.3*†	80.3± 0.09*†?
40% FA	139±3.3	123.67±0.07*†	124.7±2.1*†	73.7±2.5*†?	120.6±1.1*†	86.0±0.71*†?
50% FA	139.5±2.0	121.41±3.9*†	121.4±0.4*†	61.2±5.7*†?	86.3±0.65*†?	87.2±0.3*†?

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Pontoscolex corethrurus really a soil compacting earthworm!

Pontoscolex corethrurus is an exotic earthworm which is found very widely distributed in India for centuries. Only geographical region where it is not reported is Indo-gangetic plains. In Karnataka, it is found in all the physiographic regions like Coastal region, heavy rainfall zone of Western Ghats and in medium or low rainfall region of Plains. These earthworms prefer places where there is sufficient shade and thus are found in orchards, plantations and in forest lands. They are scantily distributed or absent in much disturbed agricultural lands.

Pontoscolex corethrurus

In soil strata, they are found at a depth of 6 - 10 cm. They make very simple straight burrows in the soil which are of temporary nature. Normally the casting pattern of earthworms depends on the composition of the soil and the availability of organic matter. For those to say that the earthworm castings will compact the soil, it is essential for them to look at the composition of the local soil type (ratio of sand to clay and particle size) and how this ratio is important to assess the stability of castings. Earthworms in general may be selective in consuming the different sized particles and usually will not grind the soil particles. It is essential to look for the stability of the castings with aging, water holding capacity and percolation rate both in the castings and the soil. It is very much needed to carry out the studies on the physical characters of soil and the castings before concluding that they are contributing to soil compaction. Moreover, P. corethrurus does not move to deeper layers of soil and prefer tree canopy and thus the deep rooted trees are not affected by them. One has to look for the chemical properties of the castings of these earthworms with well developed calciferous glands. We, in our studies had observed increased soluble Calcium and Carbonates thus contributing to exchangeable carbonates. This will certainly help in raising the pH of the acidic soil which is an important factor for the productive soils.

I wish some interested students may take up elaborate studies on the distribution pattern in soil strata, feeding habits, reproduction pattern, population growth form and casting pattern of exotic earthworms. They should also concentrate on composition of casts, their stability in different soils under different moisture conditions and availability of organic matter. These studies may be taken up on all the exotic earthworms found in India to assess their contribution to soil properties and to decide whether to have them or wipe them out from the Indian soil.

Radha D. Kale- Former Professor & Head, Department of Zoology at the University of Agricultural Sciences, GKVK, Hebbel, Bengaluru

Indian Earthworm Biologist-9

Prof. Priyasankar Chaudhuri (b.1956)

Dr. Chaudhuri - a Professor of Zoology at the Tripura Central University, Tripura did his PG and Doctorate from Calcutta University, Calcutta. Earlier he served as the Head of the Department of Zoology from 2012 to 2014. He has more than 35 years of glorious journey of teaching of UG and PG students. He did remarkable research on biology, ecology and neuro endocrinology of earthworms and worked a lot on vermicomposting technology and published more than 76 earth-shattering research papers in International and National Journals of repute.

Prof. Chaudhuri has participated in three dozens of Seminars and conferences in the country and visited France in 1990; Spain in 1998; United Kingdom in 2002 and China in 2016 and presented his research findings at the International forums. He organised 3rd National Symposium on Earthworm Ecology and Environment from November 9-11, 2012 at Tripura University, Tripura in association with the academic forum, the Society for Earthworm Ecology and Environmental Research , India. He was awarded fellowship of ZSI, Kolkata; Society of Applied Sciences, India; "Certificate of Appreciation" as an Earthworm Biologist from the Society for Earthworm Ecology and Environmental Research, India in 2012.

He was awarded the crown of fellowship of ZSI, Kolkata; Society of Applied Sciences, India; "Certificate of Appreciation" as an Earthworm Biologist from The Society for Earthworm Ecology and Environmental Research, India in 2012 and Science Excellence Award by Foundation for Science and Environment, Kolkata in 2015.

Prof. Chaudhuri has completed four major Research Projects on earthworms one each from DST, UGC, ICAR and Tripura State Council of Science & Technology and supervised five students for their PhDs.

He is Life Member of Zoological Survey of India, Kolkata; Indian Society of Soil Biology & Ecology, Bangalore; National Environmentalists Association; Society of Applied Sciences, India and the Society for Earthworm Ecology and Environmental Research (SEEER), India. He is an Executive member of Tripura Biotechnology Council, Tripura; Member of International Society for Tropical Ecology, BHU, Varanasi and Tripura Biodiversity Board, Tripura.

Dr. Chaudhuri has written a book entitled, "Kenchor Jeevan Baichitra: Kencho Prajukti" (1996) in Bengali and edited a book "Biology and Ecology of Tropical Earthworms" (2014).

Presently he is teaching endocrinology, evolution, animal physiology and functional anatomy of chordates and working on untouched areas of earthworm biology.

READER'S OPINION IS SOLICITED

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