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Due to Worm's Activities Physico-Chemical Parameters of Soil Get Change

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Abstract:
Earthworms are well known oligochaetes for improving fertility status of the soil. Physico-chemical parameters (PCPs) of worm's habitati.e. soil, contribute a major role not only in determining worm's density and species richness in a particular ecosystem but also affects their living pattern. Although, few workers have reported that worm-castings plays a significant role in decreasing pH, bulk density (BD), and % moisture content (MC) and by increasing the level of % water holding capacity (WHC), %nitrogen (N) and % organic matter (OM) of the habitat; while others reported that PCPs of worm-castings depend on the habitat and soil characteristics. In the present studies, an experiment was carried out during rainy season,2013 under laboratory conditions to assess alterations in PCPs of soil due to worm's activities by seven species of earthworms of western Uttar Pradesh state of India. These studies conclude that alterations in PCPs of the habitat (soil) depend upon the worm's species as they were found important creatures for alterations in PCPs of the soil in the study.

Keywords: *Physico-chemical parameters (PCPs), worm's species, Metaphire posthuma, Lampito mauritii, Perionyx excavates, Eutyphoeus waltoni, E. orientalis, E.gigas, and E.pharpingianus.*

1. Introduction

There have been many reports on the usefulness of earthworms. They are extremely used as fish feed, poultry feed and drugs for various common diseases (Dash *et al.,*1977; Reynolds and Reynolds,1972). Abundance of worm's species depends upon its feeding habits and PCPs of the habitat and the worm-castings (Tripathi and Bhardwaj,2004,). The PCPs of castings depend on the habitat and soil characteristics (Nijhawan and Kanwar, 1952). Singh *et al*. (2009a) have reported that worm-castings plays a significant role in lowering pH, bulk density, and % moisture content (MC) and by increasing the level of % water holding capacity (WHC), % nitrogen, % potassium and % organic matter of the habitat. Kale (1998) reported that worm-castings improves the physical, chemical and biological properties of the soil. There is a good evidence that worm-castings promotes growth of the plants (Lalitha *et al.,*2000; Reddy, 1988 and Rajkhowa *et al.,*2000). Our study was aimed to find out –i). Does PCPs of worm's habitat *i.e*. soil get changed after addition of worm-castings into the soil system? ii). Does earthworm species have any role in changing the PCPs of the soil? Keeping this in view, seven selected species of earthworms of western Uttar Pradesh state *viz.,M.posthuma, L.mauritii, P.excavatus, E.waltoni, E.orientalis, E.gigas* and *E.pharpingianus* were used for answers of above mentioned problems in the study.

2. Materials and Methods

The study was conducted under laboratory conditions (at 28-31^{o} C temperature), during rainy season, 2013.Earthworm's species were collected nearby areas of pilibhit district from orchard land and grasslands. The soil of orchard and grasslands of Pilibhit (study site) is fertile alluvial soil in general range from sandy to clay loamy. Four kg of soil of orchard lands having sufficient amount of organic matter with known parameters (%MC 35.84 ± 0.97, %WHC 40.42 ± 0.81, BD 1.19 ± 0.07, % OM 2.12 ± 0.10 and pH 8.87 ± 0.13) was taken in rectangular plastic tubs (size 43x32x17 cm) in replica of five and then 10 healthy worms of the genus, *M.posthuma, L.mauritii, P.excavatus,* belonging to family *Megascolecidae* and *E.waltoni, E.orientalis, E.gigas* and *E.pharpingianus*from family *Octochaetidae*were inoculated into each experimental tub, separately. Moisture of experimental tubs or soil was mentioned by sprinkling 250 ml of tap water alternatively. The experiment was continuously conducted for a period of 40 days of time to observe the alterations in PCPs of soil with crushed worm-castings, and growth and development (with respect to their number and weight) f all the seven worm's species.

2.1. Analysis of PCPs

2.1. 1. Moisture Content

Moisture content of samples of soil and worm-castings was measured by taking 10g of each sample separately, dried overnight at 105° C in an oven, cooled in desiccator and weighed using an electronic balance (Afcoset, ER-182-A). Loss in weight of the samples reflected the moisture content.
The % moisture content was calculated by following formula (Saxena,1994):

- Moisture content (%) = I – F / I x 100

Where,
I = Initial weight of sample (g) and
F = Final weight of dried sample (g).

2.1.2. % Water Holding Capacity (WHC)

The % WHC of soil and worm-castings was analyzed as per the techniques of Saxena (1994). Samples were put in an oven at 105 ° C for 24 hours. Place a filter paper (Whatman No.1) inside the perforated bottom of circular box, and fill it with oven-dried homogenized samples. Noted the weight of the box filled with dried samples, and then place the box into petridish (perforated with holes of 0.75 mm diameter) of 10 cm diameter, containing water for about 12 hours, so that water enters in the box and saturates the soil samples. The box was taken out of water and wiped and dried it in air. The final weight was recorded and % WHC was calculated by using the formula given below:

- $\%WHC = (W_2-W_1) - (W_1-W_0) / W_1-W_{0\,x}\ 100$

Where,
WHC=Water holding capacity,
W_0=Weight of empty box (g),
W_1= Weight of box with dried samples (g)
W_2= Weight of box with water saturated samples (g).

2.1.3. Bulk Density

Fresh homogenized samples of soil and castings were taken to determine their bulk densities. These were dried in an oven at 105 ° C for 24 hours. Then 3 g oven dried samples of each were transferred to measuring cylinders (10 ml Capacity) separately and noted their volumes. Finally, the bulk density was calculated as per the formula given below (Saxena, 1994):

- Bulk density (g/cm^3) = Weight of soil (g) / Volume of soil (cm^3)

2.1.4. % Organic Matter

Organic matter content of samples of soil and worm-castings were analysed by Walkley and Black (1947) method. Half g air dried sample was taken in a conical flask of 500 ml and 10 ml of $K_2Cr_2O_7$ solution was added in it followed by gradual addition of 20 ml of conc.H_2SO_4. After half an hour, 200 ml of distilled water, 10 ml of Ortho-phosphoric acid (O-H_3PO_4), 0.2 g of Sodium fluoride (Na F) and 1 ml (about 30 drops) of Diphenyl amine indicator were added in the mixture. Further, it was titrated against 0.5 N Ferrous ammonium sulphate solution. A brilliant green colour appeared at the end point and the reading was noted. Side by side a blank titration was also carried out against distilled water and per cent organic matter content of soil and castings was calculated as formula given below;

- $\%\ OM = 6.791 / W \times (1-T_1/T_2)$

Where,
%OM = Organic matter,
W=Weight of sample taken (g),
T_1=Volume of titrant used against sample (ml) and
T_2=Volume of titrant used against distilled water blank (ml).

2.1.5. pH

pH of soil and worm-castings is determined by using systronic digital pH meter (MKVI) by taking 1 g air dried sample with 10 ml of distilled water and mixed well. The mixture was filtered. After standardization of the pH meter, pH of soil and castings was recorded by dipping the electrode in the sample (APHA, 1985).

3. Results and Discussion

Decrement in the % MC and BD was noticed in the worm's castings (egested material *i.e*. soil) than that of the parent soil (worm's feed and their habitat). % MC decreased by 1.08,1.15, 1.19, 1.13, 1.11, 1.08, and 1.08, times, respectively; while BD decreased by 1.29, 1.38, 1.46, 1.21, 1.23, 1.36 and 1.27 times, respectively in the castings of *M. posthuma, L.mauritii, P.excavatus, E.waltoni, E.orientalis, E.gigas* and *E.pharpingianus* than that of the parent soil. It is known that different earthworm species have different strategies for coping with different soil conditions. Edwards and Bohlen (1996) have reported that worm's activity depends upon adequate availability of soil moisture. Zicsi (1958b) have reported that *A.caliginosa* goes into diapauses at a soil moisture content below 25-30 % and does not survive well below 20 % soil moisture. Buckerfield (1992) has noticed that populations of *Aporrectodea trapezoids* and *A.rosea* were still active at soil moisture as low as 10 % in cereal fields of semi-arid regions of southern Australia. Soil with moisture content of about 23.3 % appeared to be optimal for *H.africanus* worms to produce casts (Madge, 1969).*Allolobophora caliginosa* and *Metaphire californica* seemed to prefer soil moisture contents of 20-45 % and 35-50 %, respectively, in a clay soil (El-

Duweini and Ghabbour,1968). In addition, change in the BD due to the presence of worm-castings which always have lower BD than that of the parent soil (Gupta and Sakal,1967).

It was also observed that % WHC and % OM,both were increased. WHC increased by 1.06, 1.06, 1.09, 1.10, 1.04,1.13 and 1.06 times, respectively; while such increment in % OM was 1.27, 1.31,1.33,1.25,1.21,1.39 and 1.11 times, respectively, in the worm-castings of all the seven species of earthworms. Several workers have also pointed out that earthworms increase the % WHC of the soil (Stockdill and Cossen,1966;Gupta and Sakal,1967;Vyas,1976; Lee,1983; Singh *et al.*,2009a; Chaudhury*et al*.,2009, Prakash,2011); while in case of % OM our findings are similar with that of Gupta and Sakal (1967), Chaudhuri*et al*. (2009) and Singh *et al.*(2009a). Although, increment as well as decrement both were recorded in case of ph. It was 1.00 times increased in the castings of both worms *i.e.L.mauritii* and *E.pharpingianus* and decreased by 1.01, 1.01, 1.03,1.02 and 1.05 times, respectively, in the castings of *M.posthuma, P.excavatus,E.waltoni,E.orientalis* and *E.gigas* than that of the parent soil (see Table-1).Several workers have found that the pH of worm-castings was higher than that of the soil (Lunt and Jacobson,1944;Shrikhande and Pathak,1948;Gupta and Sakal,1967;Vyas,1976 and Reddy,1983);while others have reported it in the reversed order (Salisbury,1925;Dotterweich,1933;Puh,1941;Stokdill,1949;Fink,1952;Nijhawan and Kanwar,1952; Nye,1955; Chaudhuri *et al.,*2009). Varma and Chauhan (1979) have reported that castings-pH depends upon the worm's species. They have mentioned that worm casts of acid intolerant species have a pH lower than that of the pH of soils.

It may be seen in Table-2, that % WHC and % OM are higher in crushed castings of all the seven worm's species than the soil. However, % MC, BD and pH were lower than that of the parent soil *i.e.* worm's habitat. when these crushed worm-castings were added to the same soil then PCPs of this soil get changed. It was further noticed that the limited feeding medium of the worms i.e. soil having sufficient amount of % OM affects the growth and development of earthworms. It may be seen in the Table-3, that after a period of 10 days, worm's weight was increased due to sufficient amount of food whereas after 20 days, 30 days and 40 days of time, it was continuously decreased due to reduction in the food material *i.e.* soil because earthworms consumed it and excrete it in the form of castings (worm-casts).After 40 days of time *i.e.* completion of the experiment, reduction in worm's weight was noticed 1.27, 1.16, 1.29, 1.32, 1.35,1.25 and 1.38 times, respectively, in the experimental set ups of *M.posthuma, L.mauritii, P.excavatus, E.waltoni, E.orientalis, E.gigas* and *E.pharpingianus,* respectively.

In conclusion, it is clear that worm's species increased the level of %WHC, %OM on the one hand and decreased the BD on the other. Although, increment as well as decrement, both were observed in the worm-castings. The pH of worm-castings of*L.mauritii,* and *E.pharpingianus* was higher than the soil, therefore, these two species of earthworms are responsible for increasing the level of pH in the soil. This increment was 1.00 times higher than that of the parent soil medium. *M.posthuma, P.excavatus, E.waltoni, E.orientalis, and E.gigas*, worm's species were found as a pH reducer species because the pH of the castings of these species was observed lower than that of parent soil. Hence, these lowers the pH of the soil. This decrement was 1.01, 1.01, 1.03, 1.02, and 1.05 times, respectively, in the worm-castings.Chaudhuri *et al.* (2009) have reported that the pH of worm-castings of *P.corethrurus, Kanchuria* sp., *M.houlleti, Eutyphoeus caliginosa, E.comillahnus,E.gammiei, E.gigas* and another unidentified species of *Eutyphoeus was* higher than that of the surrounding soils. However, Varma and Chauhan (1979) determined the pH of soils and castings of *E.waltoni,M.posthuma,M.houlleti,M.anomala,Perionyx millardi,P.crassiseptatus,Diploccardia sinularis* species of earthworms and reported that the pH of casts of acid-intolerant species were lower than soils as in our findings; while it was higher in case of *Diplocardia singularis*, because this species found in acidic soil *i.e.* acid-tolerant sps. Finally, it may be concluded that acid-intolerant worm's species decreases pH of the soil and acid-tolerant species of worms increases the pH of their living habitat *i.e.* soil. Thus, this study advocated that earthworms are also responsible for alterations in PCPs of the soil.

Initial PCPs of soil	**Parameters**	**PCPs of castings of different worm's species (after 40 days)**						
		M.posthuma	***L.mauritii***	***P.excavatus***	***E.waltoni***	***E.orientalis***	***E.gigas***	***E.paharpingianus***
35.84 ± 0.97	**% MC**	32.90 ± 1.01	31.12 ± 0.86	30.09 ± 0.59	31.53 ± 0.91	32.01 ± 1.12	32.97 ± 0.47	33.13 ± 0.98
40.42 ± 0.81	**% WHC**	42.98 ± 0.47	43.01 ± 0.29	44.19 ± 0.78	44.83 ± 1.02	42.13 ± 0.83	45.94 ± 0.59	43.17 ± 0.62
1.19 ± 0.07	**BD (g/cm^3)**	0.92 ± 0.03	0.86 ± 0.08	0.81 ± 0.05	0.98 ± 0.04	0.96 ± 0.05	0.87 ± 0.01	0.93 ± 0.06
2.12 ± 0.10	**% OM**	2.71 ± 0.18	2.78 ± 0.13	2.82 ± 0.34	2.67 ± 0.14	2.58 ± 0.17	2.95 ± 0.31	2.37 ± 0.09
8.37 ± 0.13	**pH**	8.26 ± 0.30	8.41 ± 0.10	8.27 ± 0.27	8.12 ± 0.14	8.19 ± 0.12	7.93 ± 0.31	8.39 ± 0.12

Table 1: Showing initial and final PCPs of soil and worm-castings

PCPs	**Initial PCPs of the soil**	**PCPs of crushed castings of different species of worms**	**Final PCPs of the soil with crushed castings of worm's species**
% MC	35.84 ± 0.97	31.59 ± 1.04	32.07 ± 1.07
% WHC	40.42 ± 0.81	43.18 ± 1.12	42.07 ± 0.98
BD (g/cm^3)	1.19 ± 0.07	0.87 ± 0.02	0.91 ± 0.05
% OM	2.12 ± 0.10	2.76 ± 0.13	2.49 ± 0.17
pH	8.37 ± 0.13	8.09 ± 0.20	8.26 ± 0.17

Table 2: Showing initial PCPs of soil and crushed castings and final PCPs of soil with crushed castings of worm's species

Worm's species	Initial No. & Wt. of worms		Number and weight of earthworms							
			After 10 days		After 20 days		After 30 days		After 40 days	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
M.posthuma	10	35.81 ± 0.15	NC	40.43 ± 0.12	NC	36.95 ± 0.09	NC	31.35 ± 0.16	NC	28.07 ± 0.11
L.mauritii	10	27.98 ± 0.20	"	35.87 ± 0.18	"	32.71 ± 0.10	"	28.43 ± 0.08	"	24.08 ± 0.11
P.excavatus	10	26.24 ± 0.11	"	28.29 ± 0.09	"	26.02 ± 0.13	"	24.32 ± 0.21	"	20.31 ± 0.09
E.waltoni	10	37.38 ± 0.12	"	41.46 ± 0.19	"	38.97 ± 0.11	"	33.87 ± 0.10	"	28.12 ± 0.24
E.orientalis	10	36.92 ± 0.13	"	38.91 ± 0.15	"	36.09 ± 0.11	"	32.41 ± 0.23	"	27.30 ± 0.09
E.gigas	10	52.79 ± 0.10	"	62.65 ± 0.17	"	55.98 ± 0.09	"	51.91 ± 0.22	"	41.95 ± 0.12
E.pahrpingianus	10	27.97 ± 0.17	"	29.34 ± 0.08	"	26.76 ± 0.14	"	23.84 ± 0.09	"	20.14 ± 0.20

Table 3: Showing growth and development of different species of earthworms in their living habitat i.e. soil
Abbreviations: NC=Not change, NO= Number, Wt.=Weight, g=gram.

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