Effect of Different Land use Practices on Earthworm Abundance and Soil Properties

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Abstract: ***The aim of our study was to evaluate the density and species richness of earthworm and physicochemical properties of soil in different land use systems. The study was carried out in Sambalpur district of western Odisha. Soil sampling was carried out in between the months of June 2019 to December 2019 from natural forest site, agriculture systems, pasture land and 15 year fallow lands. Earthworm collection and soil characteristics were done as per TSBF Protocol (Anderson and Ingram, 1994). A total 7 species have been found from the selected land use study sites including seven family namely Megascolecidae, Acanthodrilidae, Canthodrilidae, Almidae, Moniligastridae with two new species identified after Julka and Senapati (1989) from Sambalpur districts namely Drawida japonica and Glyphidrilus tuberosus. Highest species richness of earthworm was recorded agricultural land followed by fallow land and least numbers earthworms were encountered in the forest present at Chandili dangri hill slope. Highest density (Ind m^{-2}) and Species richness, moisture content, pH, OC, Potassium, Phosphorus content was observed in crop land soil followed by fallow land. All the studied parameters were least in sloppy forest sandy soil. High decomposition and mineralization of SOC in surface soil during previous year cropping and accumulation of soil nutrients with the age of fallow period might have made the soil favourable for earthworm species. Therefore, encouraging farmers to return agricultural residues to decompose in their fields and keeping the abandoned crop land fallow could improve soil quality parameters for higher earthworm density and sustainable production.***

Keywords: forest site, agriculture systems, pasture land, fallow land, species richness

1. Introduction

Land contains terrestrial ecosystems, and land use is an important activity in the survival and development of human beings. Changes in land use patterns can cause changes in the land cover pattern, which may affect the structure of the ecosystem, thus affecting the service functions and values of the ecosystem [1][2] Environmental degradation caused by inappropriate land use is a worldwide problem that has attracted attention for sustainable agricultural production [3]. The rate of agricultural intensification in the tropics is greater than in other regions of the world, so that some ecosystems are under particular threat of major changes or loss of biodiversity. The conversion from natural to managed ecosystems generally induces a substantial decrease in soil C-stock and leads to modified belowground biodiversity [4]. When forests are converted into agricultural use, either temporarily or permanently, the forest soil provides a rich heritage for the new crops or trees, from its structure (including old tree root channels [5], chemical content (especially when the litter layer and biomass were turned into ash), organic matter content and scarcity of weed seeds .As reported by Eggleton et al. [6] and Araujo et al [7], removal of vegetation of natural ecosystem adversely affects the abundance and diversity of termite and earthworm in soil (Ayuke et al.) [8]. Due to this often the agricultural fields on tropics are abandoned to remain as fallow lands after loss of fertility. The importance of macrofauna for promoting tropical soil fertility has been the focus of research by several workers [9] The activities of soil organisms have dramatic effects on various ecosystem functions such as soil structure, dynamics and decomposition of organic matter [10]. Soil macrofaunal members, especially earthworm, termite and ant, by virtue of their mechanical activities like communiation and fragmentation [11] often produce agromineral biogenic structure in soil and are considered as ecosystem engineers [12][13]. Earthworms are the most dominate organism found in all type of soil habitat. The studies of Emmerling [14] showed that land use and soil organic matter content were the main factors affecting the distribution of soil macrofauna. Dlamini and Haynes [15] also found agricultural land use has significant effect on the size, composition and diversity of earthworm communities in agricultural soils. In return, management of earthworm populations is becoming more important for sustaining soil productivity and fertility in agro-ecosystems [16]. Increased human activities caused by increase in population density had been altering the agricultural landscape in Southeast Asia over the last two decades. The changes in land use affect the diversity and population of earthworms associated with change in the natural habitat [17]. It has been well documented that SOM, NPK, soil texture and pH frequently regulated the earthworm population. Their diversity in relation to different land use systems in Sambalpur district was poorly documented. The aim of our study was to evaluate the diversity of earthworm in different land use systems both natural and with anthropogenic interference.

2. Materials and methods

2.1 Study Sites

The study was carried out in Sambalpur district of western Odisha which is the largest and oldest sites of the state. Sambalpur is located at 21°.27' North Latitude and 83°.58' East Longitude. The average elevation is 150.75 metres (494.6 ft) above the mean sea level. The district experience extreme type of climate with hot and dry summer followed by humid monsoon and severe cold in winter. The temperature varies between 10 to 46ºC. The district gets rainfall from south-west monsoon. The annual average rain fall of the district is 1495.7 mm [18]. Broadly speaking 4 types of soils are available in the district. The red forest soil is available in Rairakhol and Kuchinda sub division, which are suitable for orchards and dry land crops like Arhar. The brown forest soil is available in Kuchinda area, which is suitable for fruit crops, Sandy soil suitable for Ground nut & pulses are available in several areas.

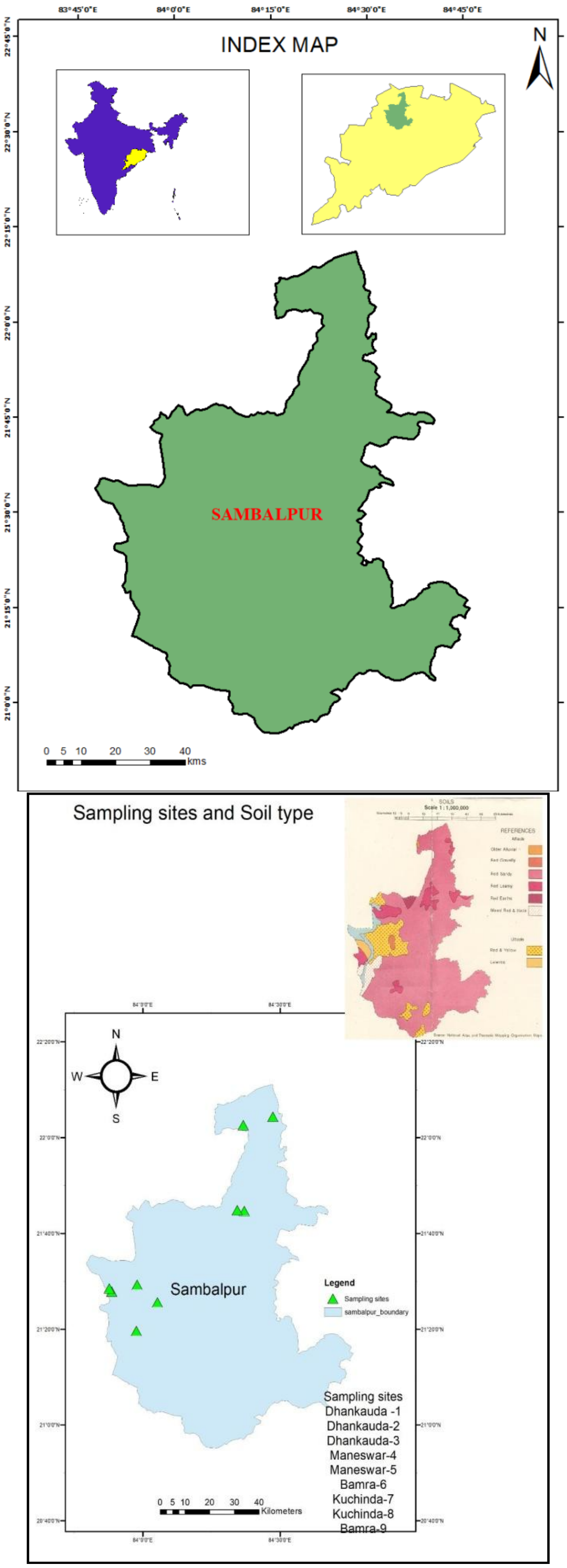

Image: Study sites from Sambalpur district

Experiment design

Soil sampling was carried out in between the months of June 2019 to December 2019, the sampling sites wear randomly selected on the basic different soil types. Total nine sample sites were taken out form four different main land use systems. Those were natural forest site, agriculture systems, pasture land and current fallow lands. Each sampling plot was done by putting liner 40× 5 transect line and 5 pit monolith point wear taken by 8 meter apart from each other. Monoliths wear separated into 0-10cm, as suggest by TSBF [19]. Species richness (Menhinick's index) was calculated as:

$D = \frac{s}{\sqrt{N}}$, where s equals the number of different species represented in our sample, and N equals the total number of individual organisms in our sample [20]

Soil physicochemical analysis

Soil conductivity, pH and organic carbon content of the soil from where earthworms were collected were analyzed. pH, Conductivity of the soil and organic carbon content were estimated using the standard procedures of Trivedy and Goel [21]. Total nitrogen content of the soil was analyzed using Kjeldahl distillation method [22]. Phosphorus content of soil was done following the method of Kurtz [23]. Potassium content was analyzed by flame photometry method.

Statistical Analysis

One way ANOVA test was conducted to find out any significant difference in the soil properties at different sites of same community followed by Least Significant Difference (LSD) for exploration of the differences among means.

3. Results and Discussion

Relationship between earthworm in different land use type

A total five species have been found from the selected land use study sites including four family namely *Megascolecidae*, *Acanthodrilidae*, *Almidae*, *Moniligastridae* with that our work added two new species after [24] from Sambalpur districts namely *Glyphidrilu tuberosus* [25] and *Drawida japonica* [26] (Table 1). Highest species richness of earthworm has been recorded from the pasture land fallowed by agricultural land and fallow land. However least numbers earthworm was encountered in the forest present at the slope of Chandili dangri hill, Burla. Further it was recorded that *Octochaetona surensis*, *Eutyphoeus incommodus*, *Lampito mauritii* were the species only found in red loamy soil type of pasture land. *Drawida japonic* and *Lampito mauritii* were found in red sandy soil type of fallow land. *Lampito mauritii* was the most dominant species found in all land use on the basis of their density (Table 2). The agricultural land show a higher abundance of earthworms than in other land use types.

Table 1: Systematic position of earthworm species present in Sambalpur district

Order	Family	Genura	Species
1.Opisthopora	*Megascolecidae*	*Lampito*	*L,mauritii* (kinberg.1867)
	Acanthodrilidae	*Octochaetona*	*O,surensis* (Michaelsen,1910)
		Eutyphoeus	*E,incommodus* (Beddard,1901)
	Almidae	*Glyphidrilus*	*G,tuberosus* (Stephenson,1916)
2.Moniligastrida	*Moniligastridae*	*Drawida*	*D. japonica* (Michaelsen, 1892)

Earthworms abundance was significantly affected by the land use systems as observed in the present study. [27] and [28] reported that soil organic matter was an important factor governing earthworm variations in different land use systems because soil organic matter was a major food resource for earthworms. High correlation between species richness of earthworms with organic carbon and available potassium corroborate the above findings.

Soil physicochemical properties in different land use systems

Soil chemical characteristics of different land use practices differed significantly between land use systems (Table 3).The Soil pH levels in different sites were in between 6.57±0.4 (pasture land 4) and 7.13±0.15 (pasture land 4). Electrical conductivity was highest in cropland soil one (426.13±87.47) but lowest found in cropland soil three (263.6±28.08). The % organic carbon was highest in the cropland soil of site two (56.6±20.01), but lowest in fallow land soil (14.81±4.64). Total Nitrogen (TN) was highest in crop land two with red and loamy soil (1.04±0.003). Phosphorous was lowest in pasture land two (0.04±3.02) was highest in cropland soil two (0.25±0.27). Potassium showed highest value in the fallow land soil (521.2±26) and lowest in pasture land soil one (72±17.89). One way ANOVA revealed significant variation in pH, OC%, K, and P among different land use systems (F= 3.07, 9.53, 12.37, 9.61, $p< 0.05$). Post hoc LSD tests indicated significant differences among mean values of different soil properties.

Lowest organic carbon in one of the paddy field (1.11g%) could be due to enhanced decomposition and mineralization of SOC in surface soil during previous year cropping. 15 year old fallow land had a higher amount of C and N due to the age, the young forest system accumulated more SOM, coming specifically from plant and root organic wastes, which generated a higher SOC contribution [29]. All the nutrients in forest soil were low due to its soil type being red and sandy and due to its topography being sloppy surface that could cause loss of nutrients by wash out. The soil of 15 year fallow land showed high OC, TN, and AK. The reason could be gradual establishment of plants with increasing year of abandonment prevented much of the leaching in WHC and decrease the bulk density resulting gradual inputs of organic residues from colonizing plants that increased the carbon and nitrogen contents of soil as by [30]. Though the soil of fallow land was red and sandy, but the high nutrient explained content could be due to the combined effect of climate, topography, type of vegetation and thus the fallow land soil in present investigation harboured a good number of earthworms. The red loamy soil of 3rd pasture land also showed high organic carbon (2.11±0.49 g%).

A significant positive correlation (r= 0.934**) was recorded between soil organic matter and earthworm count (Table 4). This result was in accordance with the findings of [31] that a strong positive correlation between earthworm population density and soil organic matter content across 10 sites they studied. [32] also recorded an increased earthworm number with the increase in organic carbon content in the Egyptian soil. Soil with low organic matter content cannot support food for higher numbers of earthworms and resulted in their lower count as described by [33]. [34] Observed positive correlation between earthworm biomass and soil potassium content [35] also noticed a positive correlation between earthworm density with soil organic matter, nitrogen, phosphorus, and potassium in organic olive groves. The significant differences in soil parameters in same land use systems could be due to different soil types, change in land use practice, climate etc. as revealed from one Way ANOVA

Table 2: Earthworm density and species richness in different land use practices

Collection sites	Land use systems	Soil type	*Lampito mauritii*	*Octochatona surensis*	*Eutyphoeus incommodus*	*Glyphidrilus tubersus*	*Drawida japonica*	Total	Density (Ind m^{-2})	Species Richness
Chndli dangri RF	Forest land	Red sandy	x	10	x	x	x	10	32	0.32
Kanta pali	Fallow land	Red sandy	17	x	x	x	23	40	128	0.32
Sambalpur University	Pasture land1	Red sandy	x	x	x	12	x	12	38	0.29
Bate mura	Pasture land2	Red and black	25	x	x	x	x	25	80	0.2
Sargidehi	pasture land3	Red loamy	30	x	x	x	x	30	96	0.18
Sagra	Pasture land4	Red sandy	x	25	x	x	x	25	80	0.2
Karan juro	Crop land1	Red and black	35	17	17	x	x	71	227	0.36
Kusmi	Crop land2	Red loamy	x	x	04	x	x	04	13	0.5
Bamra	Crop land3	Red sandy	x	17	x	x	x	17	54	0.24

Table 3: Soil characteristics in different land use practices

Land use system	Soil type	Soil Moisture (g%)	PH	EC	OC	TN	K	P
FOR	Red sandy	$17±0.4^{a}$	$6.9±0.26^{a}$	$329.43±42.25^{a}$	$1.79±0.63^{a}$	$0.11±0.01^{a}$	$116±3.88^{a}$	$0.2±0.06^{a}$
FAL	Red sandy	$19.09±0.57^{b}$	$6.67±0.12^{b}$	$316.33±47.14^{a}$	$2.99±0.04^{b}$	$0.9±0.03^{b}$	$521.2±26.14^{b}$	$0.06±0.02^{b}$
PAL1	Red sandy	$18.1±0.56^{a}$	$6.9±10.2^{a}$	$380.33±68.49^{b}$	$1.27±0.36^{a}$	$0.9±0.02^{b}$	$72±17.89^{c}$	$0.09±0.06^{b}$
PAL2	Red and black	$17.43±0.64^{a}$	$6.7±0.1^{ab}$	$362.33±40.37^{a}$	$1.13±0.3^{c}$	$0.99±0.02^{c}$	$200±12.38^{d}$	$0.04±3.02^{b}$

PAL3	Red loamy	18.43±0.11^{a}	7.13±0.15^{c}	366.73±58.29^{a}	2.11±0.49^{a}	0.95±0.024^{c}	132±25.32^{a}	0.12±5.27^{a}
PAL4	Red sandy	18.06±0.9^{a}	6.57±0.4^{bd}	285.87±74.1^{a}	1.70±0.52^{a}	0.68±0.06^{d}	242±53.58^{e}	0.15±0.01^{a}
CRO1	Red and black	22.9±0.43^{c}	7.03±0.49^{c}	426.13±87.47^{b}	3.89±0.44^{d}	1.04±0.003^{c}	393±67.21	0.05±0.01^{b}
CRO2	Red loamy	16.93±0.3^{d}	7.06±0.25^{c}	348.73±41.38^{a}	1.38±0.39^{a}	0.51±0.047^{e}	212±50.2^{e}	0.18±0.25^{a}
CRO3	Red sandy	17.4±0.2^{a}	6.9±0.26^{a}	263.6±28.08^{a}	1.84±0.36^{a}	0.89±0.01^{b}	192±41.62^{d}	0.25±0.27^{a}
'F' value		55.79*	3.07*	2.38	9.53*	210.94*	67.66*	1.61*
LSD		1.6	0.17	54.16	0.64	0.05	41.17	0.145

Table 4: Correlation of soil parameters with species richness of earthworms

	SR	SM	OC	TN	K	P	EC	pH
SR	1	.934**	.921**	.445	.780*	.569	.493	.087
SM	.934**	1	.883**	.552	.589	.387	.597	.178
OC	.921**	.883**	1	.416	.741*	.678*	.301	.111
TN	.445	.552	.416	1	.413	-.034	.264	-.024
K	.780*	.589	.741*	.413	1	.612	.014	-.316
P	.569	.387	.678*	-.034	.612	1	-.263	.102
EC	.493	.597	.301	.264	.014	-.263	1	.503
pH	.087	.178	.111	-.024	-.316	.102	.503	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

($F= 56.24$, $p< 0.001$ and 5.44, $p< 0.05$ for organic carbon in three crop lands and four pasture lands respectively). Gradual establishment of plants with increasing year of abandonment is supposed to prevent much of the leaching in WHC and decrease the bulk density. As the fallow period gets extended, the inputs of organic residues from colonizing plants increased the carbon and nitrogen contents of soil thereby increased the earthworm density in fallow land.

We observed highest abundance of earthworm in one of the paddy fields before tillage followed by 15 year old fallow land with high organic carbon and soil moisture. However the forest soil collected from hill slope showed lowest nitrogen and organic carbon content with only one earthworm species. The findings of this study suggest that land-use practices strongly affect soil physicochemical properties as well as earthworm diversity and density. Among different soil parameters, moisture and organic carbon content was found to drive the distribution of earthworms in different land use systems. Conversion of natural land to manmade land use type can lead to a rapid reduction or loss of earthworm diversity, and threaten ecosystem services as well as human well-being.

4. Conclusion

This study clearly indicates the influence of land use practice affects the abundance of earthworm species and soil physicochemical properties. Thus, it can be suggested that conservation of earthworm diversity and management of different land use systems should receive urgent attention for sustainable production. In addition the farmers should be encouraged to return agricultural residues to decompose in their fields which can improve soil quality parameters of cropland for sustainable agricultural production and maintenance of earthworm population.

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