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"ROLE OF DIFFERENT SPECIES OF EARTHWORMS IN SOIL FERTILITY AND CROP PRODUCTIVITY IN BILASPUR DIVISION OF CHHATTISGARH"

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ABSTRACT

The present investigation was undertaken to explore and evaluate the contributions of different earthworm species—Metaphire posthuma, Eisenia foetida, Lampito mauritii, and Perionyx excavatus—toward improving soil fertility and enhancing crop productivity, with specific emphasis on their gut microbial communities in the Bilaspur Division of Chhattisgarh. Earthworms are vital to soil ecosystems, often referred to as "ecosystem engineers," yet the influence of their gut-inhabiting bacteria on nutrient cycling and plant growth has received limited attention, particularly in indigenous species like Metaphire posthuma. A thorough review of literature revealed that earthworm casts are enriched in nitrogen, phosphorus, potassium, calcium, and microbial biomass, while the gut environment selectively fosters beneficial microbes that significantly alter soil biochemistry. Field surveys and identification were conducted to select dominant earthworm species, followed by laboratory-based culturing, bacterial isolation from earthworm guts, morphological and biochemical characterization, and 16S rDNA sequencing for identification. Results showed that gut bacteria, particularly from Metaphire posthuma, significantly enriched soil nutrients, with nitrogen levels in casts increasing by up to 3–6 times compared to the control soil. Bacterial strains belonging to the genus Bacillus, including Bacillus cereus and Bacillus weihenstephanensis, were found to be dominant. Compost prepared using gut bacteria notably improved germination and fruit yield, with some treatments yielding up to five times the fruit production compared to untreated controls.

Keywords*: Different, Earthworms, Crop Productivity, Bilaspur, Chhattisgarh*

INTRODUCTION

A lot of people think that agriculture is the most significant part of India's economy since it has always been there. Nearly half of all workers are involved in some kind of agriculture. The agricultural and allied sectors account for 16.96% of GDP and 10% of export earnings. This comprises the livestock, agriculture, forestry, and fisheries subsectors. Agriculture and allied sectors represent this proportion of the overall share. The 12th five-year plan, which will cover the years 2012–2017, has set a 4% growth target for the agriculture sector. The overall output of food grain for the 2015–2016 fiscal year was 252 million metric tonnes. Currently, 18.0% of the global population relies on India's 4.2% water resources and 2.3% land mass for subsistence. According to estimates, India's resource availability per capita is four to six times lower than the global average. As the world's population rises and land is redirected for uses other than agriculture, this will fall even more. Since gaining independence, the country's cropping intensity has only increased by 25%, to 136%. On top of that, 65 percent of the overall planted area is on rain-fed drylands.

With 159.7 million hectares (394.6 million acres) of land suitable for agricultural production, the United States of America boasts the claim of having the greatest arable land area in the world. The world's biggest gross irrigated agricultural land is located there, with 82.6 million hectares, or around 215.6 million acres. India is among the world's top three producers of several crops, including wheat, rice, pulses, cotton, peanuts, fruits, and vegetables. Over the last sixty years, India's agricultural industry has seen a growth in both total production and the average agricultural output per hectare. India has made some remarkable strides in recent years in terms of agricultural yields, but they still pale in comparison to the maximum yields that can be attained on the fields of industrialised nations and other emerging nations throughout the world. On top of that, we face a lot of challenges due to the fact that we are the second most populated country on Earth. Unprecedented degradation of land and groundwater resources has occurred with a slowdown in the pace of increase of the total productivity factor. We must reverse this decline and double agricultural production by 2050 if we are to meet the ever-increasing demands of our growing population. Following the start of the green revolution in the late 1960s, the country has achieved tremendous strides in agriculture in the decades that followed. This allowed the country to end starvation, become food independent, erase poverty, and improve the economic situation for millions of rural families. However, things started to go sideways for the business during the mid-90s, when output growth slowed down significantly.

The potential for production is being negatively affected by the declining and deteriorating natural resource foundation of agriculture, which includes things like clean water and fertile land. However, industrial demand is on the rise, and the demand for agricultural goods is also on the rise due to factors including rising per capita income and population. Consequently, in order to get the agricultural sector revitalised and back on track for greater growth, it is necessary to find out how bad the problem is. Along with the aforementioned, other concerns associated with agriculture include fertilisers and pesticides.

Although it is true that these chemicals promote growth, the pressure to accomplish more has resulted in a significant decline in the quality of the land used for agriculture and has also resulted in the creation of a great deal of health risks. There is a glimmer of promise in this approach that comes from organic farming. Organic agriculture has been a source of food for India for decades, and the country's population is becoming more conscious of the dangers that chemicals pose to human health, which has led to the sector's expansion. In addition to achieving a higher price in the market, organic agriculture is characterised by its use of techniques that are both clean and environmentally friendly, since it does not include the use of synthetic fertilisers or pesticides.

OBJECTIVES

1. To study the morphological and internal variability in Earthworms,
2. To study the feeding habit of earthworms species,

3. To assess the conversion ratio of different Earthworm species,

MATERIALS AND METHODS

STUDY AREA

The agro-climatic area of Chhattisgarh, which includes both plains and hills, would be the site of the research. In 2022–23, when the monsoon season begins, samples will be taken. Various types of habitats, including GNY Gothans, wetlands, uplands, and forest soil, will be sampled. Field visits will also be organised to visit dairy animals, agricultural farms, gardens, and moist soils. Care shall be used while digging up the earthworms so as not to harm or kill them. Once the earthworms have been envisioned, they will be transferred to a bucket. Before being preserved in 4% formalin for observation, the earthworms will be rinsed under running water to eliminate dirt. Thirty samples will be collected in all.

ADMINISTRATIVE DIVISION AND IMPORTANCE

As to the 2011 census, the district is comprised of 5 Tehsils, 4 Blocks, 7 urban centres (towns), and 708 inhabited villages. The district has a total size of 3508.48 square kilometres. There are 1625502 people living in the Bilaspur district as per the 2011 census. Of this number, 1043356 (64.19% of the total) reside in rural areas, while 582146 (34.81% of the total) call an urban area home. On a square kilometre, there are 463 people. One of the things that made the districts more important was the Bilaspur Railway Division. Its prominence is aided by S.E.CL., N.T.P.C., Seepat, and a number of other enterprises.

SAMPLE COLLECTING AREA

Block Name	Sampling Villages
KOTA	Ratanpur, Khaira, Pachara, Birgahani, Bansajhal, Semra, Ringwar, Pudu, Senkar, Tendubhata, Navagaon, Umariya Dadar, Lamnajhar, and other near villages

The external observation consists of

: 1. Body colour of earthworm

2. Body shape and length

3. Number of segments

4. Shape of prostomium

5. Shape and length of clitellum

6. Length of clitellum from head

EARTHWORM SAMPLING

Dig a hole that is 25 X 25 cm^2 and fill it up to a depth of 30 cm to capture earthworms. We will sample from the top layer (0–15 cm) to see how the distribution and number of earthworms change with depth. After sorting by hand, the earthworms will be rinsed with water and stored in 4% formalin. When calculating Earthworm Population Density (EPD), the formula is:

$$\text{EPD} = \frac{\text{Total number of earthworms in sampling area}}{\text{Sampling area m}^2\ (0.0625)}$$

Experts will examine the surface and interior morphological body features of the collected and formalin preserved earthworms in order to identify them.

Materials:

The research relied on two epigeie earthworm species—Eisenia foetida (exotic) and Perionyx excavatus—and two anecic worms—Metaphirposthuma and Lampito mauritii—found in Indian soils. The worms were cultivated in a controlled environment. An authority in the taxonomy and identification of earthworms, the vermicomposting unit Zoological Survey of India in Kota provided the Eisenia foetida and Perionyx excavatus.

Collection Method:

The gathering of earthworms may be accomplished by a variety of techniques, including chemical extraction, electrical extraction, heat extraction, and vibration approach. However, the most effective approach for collecting earthworms is to simply excavate dirt using a digging equipment that is designed for the purpose. This technique has a few limitations, including the fact that it is hard, time-consuming, and there is a possibility that specimens may be destroyed when digging. Nevertheless, this approach is a simple one, does not call for any particularly sophisticated apparatus, and yields the greatest results. An earthworm collection was carried out by digging into the ground during the monsoon season, when the soil is wet and pliable. In addition to the earthworms being sifted by hand, the damp and fragile dirt that had been pulled out was gently broken.

Preservation:

The earthworms that were collected were narcotised in ethyl alcohol at a rate of 70% and then fixed in formalin at a dosage of 10%.

Identification

1. For the purpose of identifying Mposthuma and L. mauritii, morphological and internal characteristics were taken into consideration.

Table 1 : Morphology of Mposthuma and L. mauritii

External Characters	Mposthuma	L. mauritii
Number ofsegments	91-124	157-201
Prostomium Shape	Epilobic	Prolobic
Spermathecal pores	4 pairs	3 pairs
Extent ofclitellum	14-16 segments	13/14 - 17/18
Cast type	Small heaps of ovoidal loose pellets	Small heaps ofsmall globular pellets
Habit	Rolls into a coil	Does not roll up

Pinning the earthworms on a dissecting tray that contained water was done after the morphological examination was completed. The pins were placed at the anterior and posterior ends of the earthworms. After that, it is dissected in great detail so that the following taxonomic characteristics may be seen.

Table 2 : Mposthuma and L. mauritii taxonomy

Identifying Characters	Mposthuma	L. mauritii
Seminal vesicles	XI and XII	XI and XII
Prostates	XV to XXI	XVIII
Spermatheca	4 pairs	3 pairs

2. Both P. excavatus and E. foetida exhibit the characteristics listed below:

Table 3 : Taxonomy of P.excavatus and E.foetida

Identifying Characters	P.excavatus	E.foetida
Number ofsegments	123-178	80-131
Prostomium Shape	Epilobic	Epilobic

Shape and Extent of clitellum	Cylidrical, Between XIII - XVII segments	Saddle shaped, made of 6-8 segments
Colour	Dorsally deep purple to reddish brown, ventrally pale	Reddish usually in transverse and mid segmental bands alternating with white or yellowish band in intersegmental furrows

Figure 1 Earthworm photos from dirt

(Left: Metaphireposthuma, Right: Lampito mauritii.)

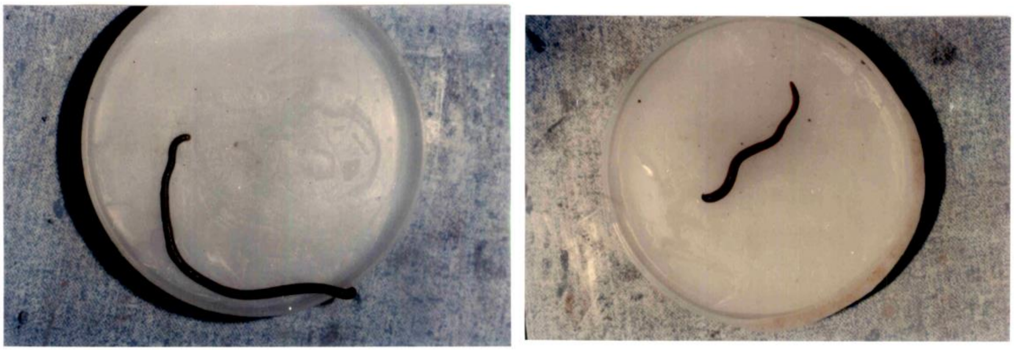

Figure 2 Common composting earthworms:

(Left : Perionyx excavatus, Right : Eiseniafoetida)

Figure 3 Photos exhibiting Metaphireposthuma and Lampito mauritii morphological differences

RESULT AND DISCUSSION

Within the context of the Bilaspur Division of Chhattisgarh, a series of tests were carried out with the purpose of determining the extent to which various species of earthworms contribute to the enhancement of soil fertility and agricultural production. The outcomes of these studies are presented in this chapter. Following the identification of earthworm species that were discovered in Kota, the research proceeded to select and cultivate species that were acceptable for the study, as well as conduct an examination of the soil preferences of these earthworms. The subsequent research concentrated on isolating and identifying the gut bacteria that were found in these earthworms.

These bacteria are known to play an important part in the process of nutrient cycling and the breakdown of organic materials from the environment. For the purpose of determining the extent to which earthworm casts contribute to soil enrichment, quantitative analysis was performed on the nutritional content of earthworm casts as well as the enzymatic activity of related gut microorganisms. More specifically, the influence of these microbial communities on the germination of seeds, the development of seedlings, and the effectiveness of composting was investigated in a methodical manner. Finally, an evaluation was conducted to determine the function that gut bacteria play in raising crop output and improving soil quality metrics. This evaluation provided a thorough knowledge of the ways in which various earthworm species and the microbiota associated with them contribute to sustainable agricultural practices in the area.

EARTHWORM SPECIES SELECTION, CULTURE AND DETERMINATION OF THEIR SOIL PREFERENCE

Table 4 : Adults discovered three months after introduction (mean of three findings) (ten in each).

Soil type	*M. posthuma*	*L. mauritii*	*E.foetida*	*P.excavatus*
Laterite	10.0	10.0	0	08.3
Clavev	08.3	10.0	10.0	10.0
Loamv	10.0	10.3	06.3	12.3
Sandv loam	11.0	10.7	0	08.0
Saline	09.0	09.3	0	10.0

Table 5: Cocoon count after three months (mean of three)

Soil type	*M. posthuma*	*L. mauritii*	*E. foetida*	*P.excavatus*
Laterite	2.0	1.0	0.0	0.0
Clavev	0.0	1.0	1.0	2.0

Loamv	2.3	2.0	0.0	1.0
Sandv loam	1.7	2.3	0.0	0.0
Saline	0.0	0.0	0.0	1.3

During the last twenty years, there has been a rise in the amount of study conducted on earthworms as a result of developments in ecotoxicology and soil restoration. Therefore, the practice of rearing earthworms in a laboratory setting has become attractive; nevertheless, the implementation of this practice has been hampered by the perception of problems. The effects of hydrogen ion concentration may have a significant impact on earthworms. A significant factor that restricts the dispersal of earthworms in various soils is the presence of this species. Certain species, such as Lumbricus terrestris and Allolophora caliginosa, are able to flourish in soil with a pH ranging from 52 to 5.4, although the majority of species require a pH that is close to neutral. Dendrobeaena octaedra is able to withstand pH levels as high as 4.5. The ideal pH range for Eisenia foetida is between 7.0 and 8.0. There is a significant relationship between temperature and the activity of earthworms.

The environment has an upper fatal temperature that varies from 40 to 50 degrees Celsius. In order to avoid the soil that has an improper temperature, earthworms will migrate away from it. When exposed to light, earthworms are susceptible to suffering injuries and may even perish. They are especially sensitive to light that is ultraviolet in wavelength. As a general rule, organisms with pigmentation are less tolerant to light. Only during the night or when the light intensity is very low do species that feed on the surface come out to explore the surface. Because of the physical abrasion that occurs on the surface of their bodies, earthworms are often not found in soils that have a coarse texture. Due to the fact that clayey soils often have a low oxygen content, they are not found in clayey soils either. The vast majority of earthworm species are sensitive to high concentrations of salt present. The populations of earthworms on ground that has been cultivated are often below average. It's possible that this is the result of mechanical harm that occurred throughout the cultivation process. There are a variety of effects that fertilisers have on the earthworm population.

The use of lime is advantageous to earthworms, particularly in soils that are acidic. It is usually true that plant protection compounds are hazardous to earthworms to diverse degrees; however, the reaction to these chemicals varies from one chemical to another. The findings of this research demonstrated that M. posthuma and L. mauritii, both of which are anecic, were able to thrive in almost all of the soil types that were tested, particularly in laterite, loamy, and sandy loam soil that was employed. In contrast, P. excavatus, a type of compost that is often found in India, was unable to thrive in soil that was either laterite or sandy. E. foetida was discovered to be the earthworm species that would only survive in clayey and loamy soil. It was the most sensitive of all the earthworm species. It is anticipated that its survival rate will be high throughout the winter months due to the fact that it is an alien earthworm, more specifically a European earthworm, that lives in chilly native nations. Laterite, sandy, or salty soil, all of which have a tendency to lose water rapidly, would not be suitable for its survival. In most cases, the manufacturing of cocoons begins at the age of six weeks and continues until the end of the sixth month.

It is possible for one pair of earthworms to make one hundred cocoons during this time span if optimal circumstances are present. When it comes to the density and biomass of Lampito mcuritii in various organic inputs, the mean doubling time is 38.05 and 33.77 days respectively. On the other hand, when it comes to Perionyx excavatus, the mean doubling time is 11.72 and 16.74 days respectively. According to the results of our experiment, the manufacture of cocoons by four distinct earthworms in various soils demonstrates that practically all of the earthworms are able to make cocoons in loamy soil.

It was possible for M. posthuma and L. mauritii, two of the top soil dweller species, to reproduce in laterite, loamy, and sandy loam soils on a constant basis. However, epigeic litter dwellers such as P. excavatus and E. foetida were unable to proliferate in soil that is characteristically dry, such as sandy or laterite soil. For composting operations, earthworm cultivators prefer to begin with a high number of earthworms since, according to them, it takes about the same amount of time to care for a single culture box or bed as it does to care for numerous boxes. Once everything is set up, the most important thing to do for the next sixty to ninety days is to water the cultures once a week or as needed. This will be the primary focus of attention. However, the current research demonstrated that prior to beginning any composting experiment, it is necessary to determine the soil that various species of earthworms that are capable of being cultivated like in order to properly prepare the culture bed.

ISOLATION OF GUT BACTERIA FROM EARTHWORM SPECIES

Table 6 Investigation of earthworm bacterial colony

Colony Type	No. ofCFUs isolated from			
	Metaphire posthuma	Lampito mauritii	Perionyx excavatus	Eisenia foetida
Licheniform, moderate size, irregular margin, flat, pink	30.9	36.23	23.52	26.71
Round pinhead size,entire margin, pink	4.08	1.07	1.02	0.52
Mucoid, small, round, yellow	5.66	0.00	1.38	0.00

Round, small, flat, translucent, dull pink	6.75	7.23	12.56	21.14
Water drop like, moderate, dull pink	11.69	32.61	14.36	23.76

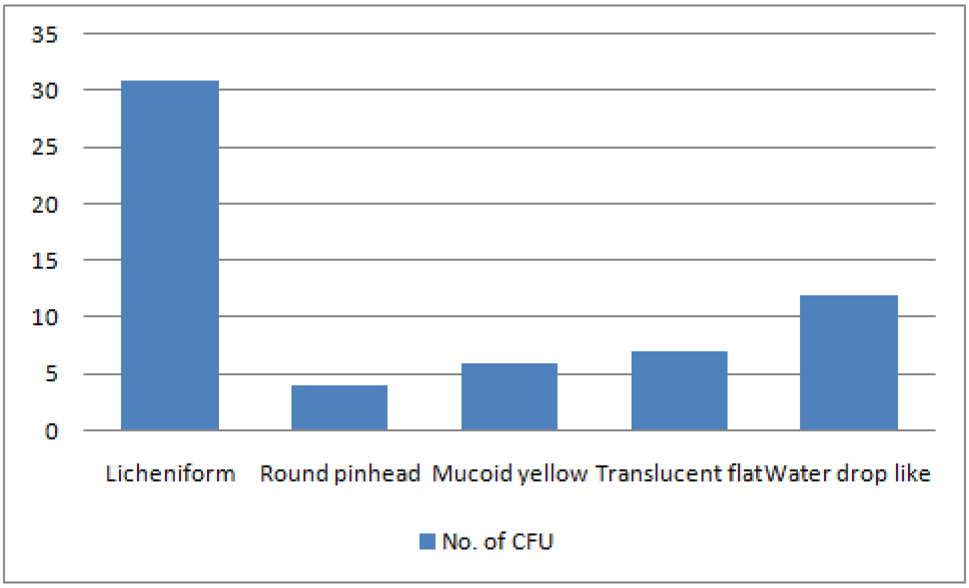

Figure 4 Metaphire posthuma bacterial colony

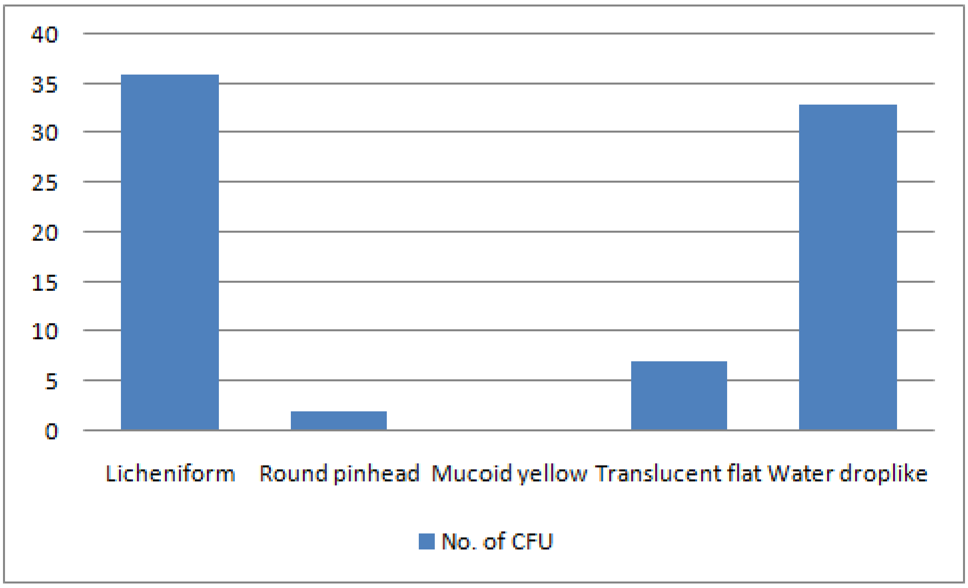

Figure 5 : Lampito mauriti bacterial colony

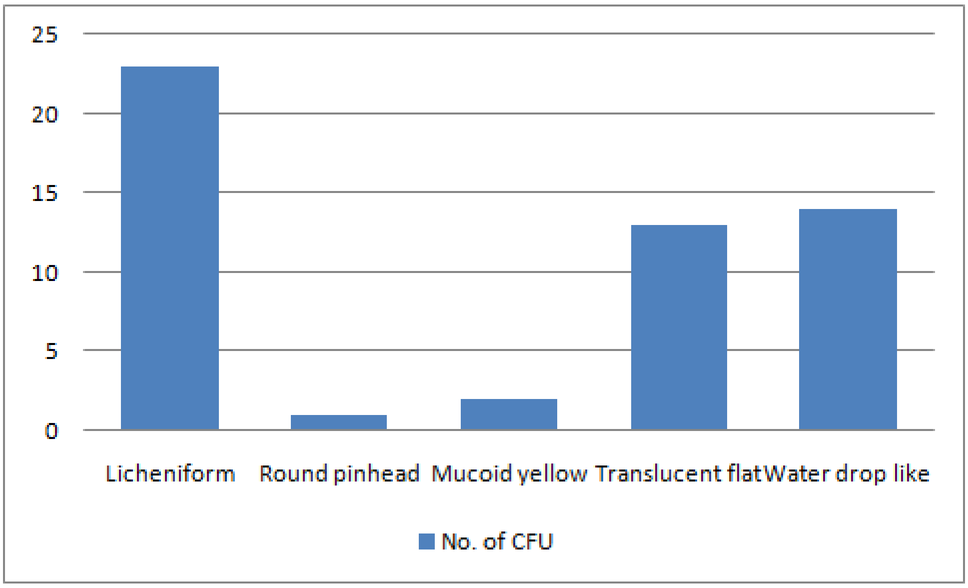

Figure 6 : Bacteria from Perionyx excavatus

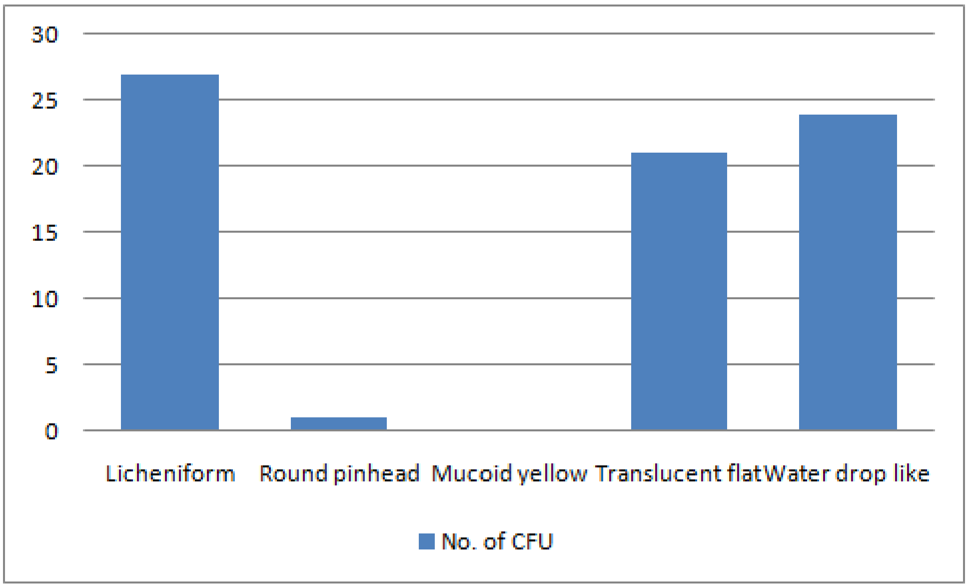

Figure 7 : Eisenia foetida bacterial colony

The microorganisms that live in aerated soils are exposed to the mobile anoxic microzone that is contained inside the stomach of the earthworm. During the process of gut passage, the in situ variables of the earthworm gut, which include anoxia and high concentrations of organic substrates, seem to significantly promote a subset of the soil microorganisms that are swallowed. These microorganisms include denitrifying and fermentative bacteria. Because of the one-of-a-kind microconditions that exist inside the earthworm stomach, the microorganisms that are consumed from the soil are selectively stimulated. There were four different kinds of earthworms that were examined for this research, and the bacterial colony that had a licheniform shape, moderate size, flat elevation, irregular edge, and pink colour was the one that was found to be the most prevalent in all of them (Figure 4 - 7). One may reasonably presume that it plays significant roles in the breakdown of organic matter and, thus, in the enrichment of soil quality.

CONCLUSION

The current study was carried out with the purpose of determining the extent to which different earthworm species and the bacteria that are associated with them have a role in enhancing soil fertility and crop production within the framework of the agroclimatic conditions that prevail in the Bilaspur Division of Chhattisgarh. The need to investigate environmentally friendly and sustainable solutions to the difficulties of falling soil health and production became the impetus for this study. This was especially true in locations where the excessive use of chemical fertilisers has resulted in the damage of the ecosystem over an extended period of time. It has been known for a long time that earthworms, which are sometimes referred to as "ecosystem engineers," play an essential part in the functioning of soil ecosystems. On the other hand, the unique intestinal microbial communities of these organisms, which have a considerable impact on the biochemical dynamics of the soil, had not been well investigated in this location. The purpose of this research was to fill in that information gap by using a rigorous strategy that included the identification of earthworms, the culture of earthworms, the isolation of gut bacteria, and the investigation of the influence that earthworms had on composting, soil nutrient enrichment, and plant development.

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