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Evaluation of different organic substrates for the performance of *Eudrilus euginae* (**Phy**:Annelida **Fam:** Eudrilidae)

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Abstract

Banana trash, waterhayacynth, and paddy straw stand in subsequent position by recording seven and six mineral compositions lacking with four and five minerals at the partial decomposition of these substrates at 30 days before treatment imposition. Among the seven substrates tested for the evaluation of the performance of *E.euginae* banana trash seems to be a better substrate in terms of composting duration and quantity produced. The maximum 21.21 kg vermicompost recovered from the T4: banana trash (100kg)+ cow dung(20kg) +cow urine(3lit) followed by T2: vegetable waste(100kg)+ cow dung(20kg) +cow urine(3lit) and T3: Green manure (100kg)+ cow dung(20kg) +cow urine(3lit). The growth and development of earthworm *E.euginae* and the lowest recovery of vermicompost recorded T1: Parthenium 100 kg +cowdung 20kg +cow urine 3lit and T5: *Waterhayacynth* 100 kg+ cow dung 20 kg +cow urine 3lit (4.16 and 5.07 kg)

Key words: *Eudrilus euginae*, Micronutrients, vegetable waste, Banana trash, parthenium, *Waterhayacynth*, Farmwaste, cowdung and cowurine

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Introduction

The African night crawler, also known as Earthworm *Eudrilus euginae*, is a species of earthworm that is originally from tropical West Africa. It is now found in warm regions all around the world under vermicompost. According to research, the growth of individual earthworms increases as the population density lowers, but the greatest overall earthworm biomass production occurs at the highest population density. Vermicompost is one of the best methods of converting organic waste into nutrient-rich manure. *Eisenia foetida*, *Eisenia andrei*, *Eudrilus eugeniae*, and *Perionyx excavatus* are some of the most promising earthworm species used for vermicomposting. Earthworms are eco-friendly as they eat and mix a lot of soil and organic matter, then deposit it in the form of casts. They enhance the incorporation and decomposition of organic matter, increase soil aggregate stability, improve porosity and water infiltration, and increase microbial activity. Earthworms contribute to the cycling and release of detritus-bound nutrients and act as ameliorators of the physical properties of soil. *Eudrilus eugeniae* is an ideal litter-dwelling species for large-scale breeding programs due to its high growth, maturation, and reproductive rates. These species can be relatively easily maintained at high densities in organic media (in the absence of mineral soil), and once processed, these organic media may also have a commercial value (as a soil amendment). Vermicomposting is a sustainable, socially safe, and cost-effective alternative to traditional chemical fertilizer use. Vermicomposting increases soil nutrients, plant nutrient availability, enhances soil structure and drainage, promotes plant development, and reduces plant disease and insect pest attacks (biocontrol). Nutritional variability of substrates, days of conversion for vermicompost production of different organic substrates used for vermicomposting, and multiplication ability of earthworms vary from substrate to substrate. The aim of this experiment is to avoid unnecessary wastage of organic substrates to reduce environmental pollution and to reuse the waste. The study evaluates the efficiency of the *E.eugeniae* in the bio-conversion of different organic substrates into vermicompost and studies the physical and nutrient status of composts produced from both the substrates by the *Eudrilus euginae*. Vermicompost is a good quality manure that contains essential nutrients needed by crops such as nitrogen, phosphorus, potassium, calcium, magnesium, and micronutrients viz., iron, zinc, copper, and manganese. It increases crop productivity and quality.

Materials and Methods:

The field experiment was conducted at the Agricultural Research Station in Gangavati during the 2019-20 and 2020-21 for a period of three seasons. The experiment was laid out using a Randomized Block Design with three replications, consisting of seven treatment combinations. Cow dung (20 kg) and cow urine (3 L) were mixed with 100 kg of different organic substrates for experimentation.

Treatments details:

Sl.no	Treatment. No	Treatment details
1	T1	Parthenium 100 kg +cow dung 20kg +cow urine 3lit
2	T2	Vegetable waste 100kg + cow dung 20kg + cow urine 3 lit
3	T3	Green manure 100 kg + cow dung 20 kg + cow urine 3 lit
4	T4	Banana trash 100 kg+ cow dung 20 kg + cow urine 3 lit
5	T5	*Waterhayacynth* 100 kg+ cow dung 20 kg +cow urine 3lit
6	T6	Paddy straw 100kg +cow dung 20 kg + cow urine 3litr
7	T7	Farmwaste 100kg + cow dung 20 kg + cow urine 3 litr

To determine the nutrient potential of various substrates, a sample of approximately 1kg was taken from each substrate and analyzed biochemically twice. The first analysis was performed after partial decomposition of the substrate had occurred, which was about 15-30 days before treatment imposition. The second analysis was performed at the end of the vermicompost production process, which was around the 50^{th} to 60^{th} day. After partial decomposition, approximately 200 grams of adult *Eudrilus euginae* earthworms were introduced to each treatment pit. The duration of vermicompost conversion was recorded for all treatments, along with the multiplication ability of the adult *Eudrilus euginae* earthworm population, their weight, larval population, larval weight, and the yield of vermicompost produced from all the collected substrates. Treatment-wise data collected from each substrate was subjected to statistical analysis. The percentage recovery of vermicompost was calculated by using the final weight of the product divided by the initial weight of the substrates added to the treatment plot, as per the formula mentioned below.

$$\text{Recover \%} = \frac{\text{final weight of the vermicompost}}{\text{Initial weight of the added material}} \times 100$$

After the experiment, a second bio-chemical analysis was conducted on the vermicompost. Each pit's vermicompost was weighed, sieved, and air-dried separately. Then, the nutrient composition and various chemical properties like pH, EC (dsm), carbon %, nitrogen %, phosphorus %, potassium %, zinc, and Iron were analyzed at the Organic farming research lab(OFR) at the University of Agricultural Sciences campus Raichur. The data was analyzed statistically to draw useful conclusions

Results and discussions: Based on experimental results over the past three years (2019, 2020, and 2021), banana peels and vegetable scraps have been found to be the most effective organic substrates for producing vermicompost. Compared to other substrates, they have shown superior abilities in terms of earthworm (specifically *Eudrilus engine*) multiplication and reproduction potential, vermicompost production, conversion duration, and nutrient quantity and quality. The primary objective of this study is to reduce environmental pollution and waste by utilizing locally available organic substrates, such as farm or domestic waste, to produce nutritionally rich vermicompost. This will ultimately result in a decrease in the use of chemical fertilizers and their negative impact on the environment.

Table 1: Evaluation of different substrates for the performance of *Eudrilus euginae*.

Sl.no	Treatments	Sample qty (Kg/lit)	30 days before treatment imposition of organic substrates(mg/kg)									
			Al	Barium	Ca	Co	Chro	Fe	K	Lithium	Mg	Mn
1	**Parthenium + cowdung+cowurine**	100+20+3	721.41	3.21	196.37	ND	ND	590.70	713.77	ND	248.53	36.89
2	**Vegetable waste+ cowdung+cowurine**	100+20+3	3305.80	16.08	336.91	0.09	3.93	2635.4	1092.20	0.06	871.07	71.63
3	**greenmanure+ cowdung+cowurine**	100+20+3	111.75	15.88	320.77	ND	ND	177.90	477.75	ND	389.70	21.04
4	**Bananatrash+ cowdung+cowurine**	100+20+3	141.98	ND	38.99	ND	ND	194.88	2085.32	ND	871.85	21.89
5	**Waterhayacynth+ cowdung+cowurine**	100+20+3	133.18	5.05	ND	ND	ND	241.93	240.96	ND	164.87	109.66
6	**Paddystraw+ cowdung+cowurine**	100+20+3	20.37	ND	ND	ND	ND	55.58	446.01	ND	140.29	25.60
7	**Farmwaste+ cowdung+cowurine**	100+20+3	566.36	0.31	178.65	ND	ND	610.73	286.63	ND	246.87	23.87

*Note: ND= Not detected

A study was conducted between 2019 and 2021 to test the performance of *Eudrilus euginae* on various organic substrates. The study included seven different substrates, and the results showed significant differences in the adult and larval populations, as well as the weights of both, across all the substrates. The treatment that consistently produced the best results in all three years was T4: Banana trash (100kg) + cow dung (20kg) + cow urine (3lit), which resulted in the highest adult and larval populations and weights. The second and third best treatments were T2: Vegetable waste (100kg) + cow dung (20kg) + cow urine (3lit), and T3: Green manure (100kg) + cow dung (20kg) + cow urine (3lit), respectively.

The results suggest that banana trash, vegetable waste, and green manure are the best substrates for *E. euginae* multiplication, with banana trash being the best choice in terms of composting duration, quantity, and conversion percentage. However, the ability of *E. euginae* to multiply varies greatly with the substrate used. Treatments T6: Paddy straw (100kg) + cow dung (20kg) + cow urine (3lit), and T7: Farm waste (100kg) + cow dung (20kg) + cow urine (3lit), showed quite a fluctuating situation with regards to adult and larval populations and weights, possibly due to differences in nutrient status, EC, pH, carbon, and nitrogen content in the substrates. On the other hand, treatments T1: Parthenium (100kg) + cow dung (20kg) + cow urine (3lit), and T5: *Waterhyacinth* (100kg) + cow dung (20kg) + cow urine (3lit), resulted in a significant reduction in the adult and larval populations and weights throughout the three-year study.

Table 2: evaluation of substrates for the Performance of *Eudrilus euginae* adult, larval population, larval population, larval weight 2019-21

Tmt. no	Treatments	Sample qty (Kg/g/ml)	Adult population			Adult weight			Larval population			Larval weight		
			2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
T1	Parthenium + cowdung+cowurine	100+20+3	08.00 (2.98)	20.33 (4.61)	95.32 (9.73)	46.66 (6.89)	15.00 (3.98)	68.89 (8.16)	5.66 (2.56)	65.00 (8.14)	79.09 (8.86)	10.00 (3.14)	10.33 (3.36)	11.12 (3.33)
T2	Vegetable waste+ cowdung+cowurine	100+20+3	374.66 (19.36)	381.00 (19.54)	390.89 (19.77)	392.66 (19.84)	460.00 (21.47)	469.07 (21.65)	200.33 (14.17)	265.00 (16.30)	270.35 (16.44)	29.00 (5.47)	32.00 (5.74)	38.44 (6.19)
T3	greenmanure+ cowdung+cowurine	100+20+3	281.33 (16.76)	331.00 (18.21)	342.34 (18.50)	220.00 (14.86)	285.33 (16.92)	284.66 (16.86)	171.33 (13.11)	171.66 (13.14)	236.14 (15.10)	27.33 (5.30)	28.86 (5.46)	34.08 (5.83)
T4	Bananatrash+ cowdung+cowurine	100+20+3	636.00 (25.17)	838.00 (28.96)	854.78 (29.23)	455.00 (21.34)	589.33 (24.29)	626.89 (25.03)	305.00 (17.43)	472.00 (21.74)	514.74 (22.66)	33.00 (5.82)	40.66 (6.45)	47.12 (6.86)
T5	Waterhayacynth+ cowdung+cowurine	100+20+3	08.33 (3.02)	13.00 (3.74)	78.29 (8.81)	39.00 (6.28)	16.00 (4.09)	54.49 (7.18)	5.33 (2.50)	43.00 (6.68)	58.84 (7.63)	8.33 (3.05)	7.83 (2.96)	10.02 (3.16)
T6	Paddystraw+ cowdung+cowurine	100+20+3	281.33 (16.76)	233.33 (15.30)	213.49 (14.61)	220.00 (14.86)	169.00 (13.03)	169.01 (16.86)	171.33 (13.11)	122.00 (11.09)	158.63 (12.45)	16.40 (4.15)	19.60 (4.53)	22.95 (4.78)
T7	Farmwaste+ cowdung+cowurine	100+20+3	211.0 (14.54)	175.33 (13.27)	262.68 (16.20)	137.66 (11.76)	175.33 (13.27)	180.90 (13.44)	153.33 (12.41)	166.66 (12.94)	173.46 (13.17)	17.00 (4.23)	23.40 (4.93)	26.51 (5.14)
	Sem±		30.45	4.60	5.79	10.34	5.79	8.09	15.15	3.52	24.11	1.91	1.11	0.87
	CD		94.88	14.33	17.38	32.23	17.38	24.28	47.20	10.96	72.35	5.96	3.46	2.61
	CV		21.40	2.69	3.05	8.79	3.05	5.15	19.33	3.26	19.09	16.44	8.29	5.41

Based on the investigation, out of the seven substrates tested, banana trash proved to be the best substrate in terms of composting duration and quantity produced. Table 3 shows the amount of vermicompost recovered from the different substrates. The highest amount of vermicompost (21.21 kg) was recovered from T4, which was a mixture of banana trash (100kg) and cow dung (20kg), followed by T2, which was a mixture of vegetable waste (100kg) and cow dung (20kg), and T3, which was a mixture of green manure (100kg) and cow dung (20kg). On the other hand, the lowest amount of vermicompost was recorded for T1 and T5 (4.16 and 5.07 kg, respectively). During all three seasons, the organic carbon and organic matter content in T4 banana trash and T2 vegetable waste decreased with time during vermicomposting. Additionally, cow dung provided extra food for the microbes, which increased the microbial activity and the composting process. These findings were in agreement with Zaller and Kopke's study in 2004. Cow urine also enhanced the microbial activities in the substrates, which favored the composting duration and conversion rate of the vermicompost by the *E.euginae*.

Table3: bio-conversion of different organic substrates by *Eudrilus euginae*

Tmt. no	Treatments	Composting duration (days)	Compost harvested (kg)
T1	Parthenium 100kg+ cow dung 20kg+cow urine 3lit	63.33(8.01)	4.16
T2	Vegetable waste100kg+ cow dung 20kg+cow urine 3lit	59.33(7.76)	18.05
T3	greenmanure100kg+ cow dung 20kg+cow urine 3lit	59.00(7.74)	15.37
T4	Bananatrash100kg+ cow dung 20kg+cow urine 3lit	57.66(7.65)	21.21
T5	*Waterhayacynth*100kg+ cow dung 20kg+cow urine 3lit	58.66(7.72)	5.07
T6	Paddystraw100kg+ cow dung 20kg+cow urine 3lit	88.00(9.43)	8.27
T7	Farmwaste100kg+ cow dung 20kg+cow urine 3lit	86.33(9.34)	9.98
	Sem±	2.54	0.49
	CD	7.93	1.52
	CV	6.53	6.38

Chemical composition of the vermicompost: The bio-chemical analysis conducted at the end of vermicompost production using seven organic substrates indicated significant variation in nutrient composition due to vermicomposting activities of *E. euginae*.

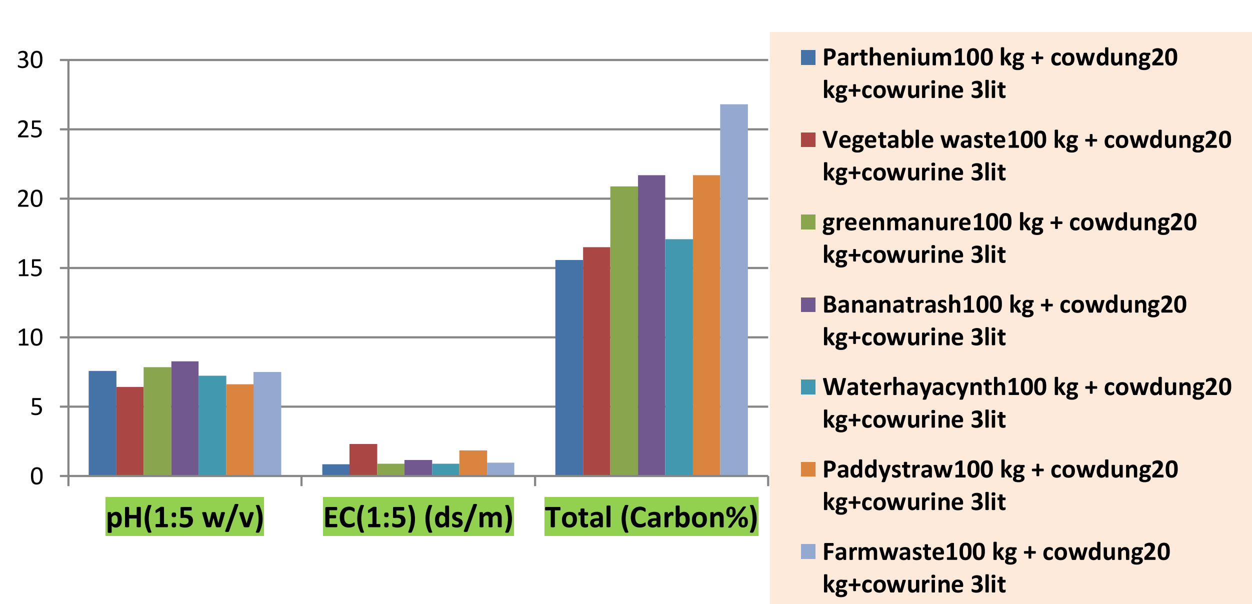
pH, electrical conductivity and carbon content: The pH levels of all the treatments can be considered mostly alkaline. The pH values of vermicompost varied from 6.44 (vegetable waste) to 8.27 (banana trash). Vermicompost made from parthenium, green manure, *waterhyacinth*, and farmwaste had pH values of 7.59, 7.84, 7.26, and 7.50 respectively. However, vegetable waste and paddy straw had lower pH values of 6.44 and 6.61. These results are in agreement with those of Selvamuthukumaran and Neelanarayanan (2012) and Viji and Neelanarayanan (2013). The present investigation reveals that the pH value of vermicomposts depends more on the substrate used for vermicompost production than the species of earthworm used for vermicompost production. A decrease in pH may be due to the mineralization of nitrogen and phosphorus into nitrites/nitrates and orthophosphates, as well as the transformation of organic waste into organic acids.

The values of electrical conductivity (EC) varied among all the different organic substrates. The values of electrical conductivity ranged from 0.86 to 2.33 in the vermicompost produced by the earthworm species *E. euginae*. The EC value of 2.33 and 1.18 was recorded in vermicompost produced in T2: vegetable waste cowdung (20kg)(3lit) and T4: banana trash cowdung (20kg)(3lit), respectively. The lowest values were recorded in T1: parthenium+ cowdung (20kg)(3lit), T3: green manure+ cowdung (20kg)(3lit), T5: *waterhyacinth* (20kg)(3lit), and T7: farm waste (20kg)(3lit).

Organic carbon: There was a significant difference in the amount of organic carbon found in the various materials used to produce vermicompost. The percentage of organic carbon ranged from 15.6 to 26.8 percent in treatments T1 (parthenium + cow dung) and T7 (farmwaste + cow dung), respectively. Vermicompost made from green manure, banana trash, paddy straw, and farmwaste showed high organic carbon content, with percentages of 20.9, 21.70, 21.7, and 26.8, respectively. On the other hand, substrates like parthenium, vegetable waste, and *waterhyacinth* used to produce vermicompost from the earthworm *E. euginae* showed the lowest organic carbon content, with percentages of 15.6, 16.5, and 17.1, respectively (as shown in Fig. 1).

Various scientific reports suggest that the continuous and proper use of vermicompost, along with good management practices, can lead to an increase in soil organic carbon, improved soil moisture retention, and enhancement of various physical properties of the soil, such as bulk density, root penetration, insect pest resistance, and aggregation (Atiyeh et al., 2002).

Fig1: pH, EC and organic carbon percent in vermicompost produced from different organic substrates



Nitorogen : The investigation found that the percentage of nitrogen varied greatly among the different organic substrates. Among the seven substrates tested, the highest percentage of nitrogen was found in T1 Parthenium 100kg+cow dung 20kg + cow urine 3lits at 1.65%, followed by T2 vegetable waste 100kg+cow dung 20kg + cow urine 3lits at 1.52%, T5 *waterhyacinth* 100kg+cow dung 20kg + cow urine 3lits at 1.30% and T4 banana trash 100kg+cow dung 20kg + cow urine 3lits at 1.29%. Similarly, T3 green manure 100kg+cow dung 20kg + cow urine 3lits and T6 paddy straw 100kg+cow dung 20kg + cow urine 3lits recorded nitrogen percentages of 1.17% and 1.13% respectively. On the other hand, the lowest percentage of nitrogen at 0.95% was recorded by T7 farmwaste 100kg+cow dung 20kg + cow urine 3lits.

The study found that the vermicomposting process considerably enhances the amount of nitrogen in organic waste substrates through earthworm-mediated nitrogen mineralization. Earthworms enhance the nitrogen levels of substrates by adding their excretory products, mucus, body fluid, and enzymes. Even the decaying tissues of dead worms in vermicomposting systems contribute to the process. This conclusion is supported by Suthar's research in 2007.

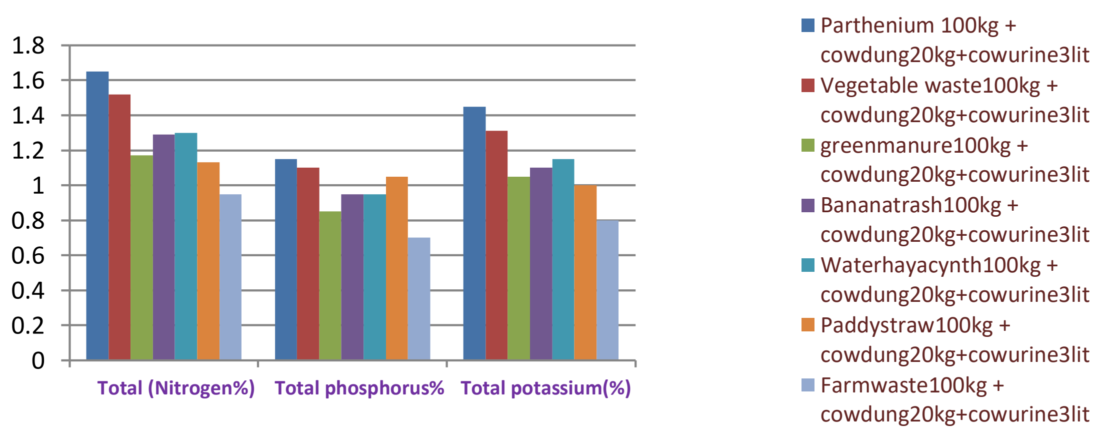
Table 4:nutritional value of vermicompost produced from different substrates at the end of vermicomposting

Tmt. no	Treatments	Ph(1:5 w/v)	EC(1:5) (ds/m)	Total (Carbon%)	Total (Nitrogen%)	C/N	Total phosphorus %	Total potassium (%)	Total Zn(mg/kg)	Total Fe (mg/kg)
T1	**Parthenium + cow dung + cow urine**	7.59	0.86	15.6	1.65	9.4	1.15	1.45	55.33	1245.2
T2	**Vegetable waste+ cow dung +cow urine**	6.44	2.33	16.5	1.52	10.9	1.10	1.31	60.96	1528.5
T3	**greenmanure+ cow dung + cow urine**	7.84	0.90	20.9	1.17	17.4	0.85	1.05	40.16	1499.9
T4	**Bananatrash + cow dung + cow urine**	8.27	1.18	21.70	1.29	18.6	0.95	1.10	51.69	1504.5
T5	**Waterhayacynth+ cow dung +cow urine**	7.26	0.91	17.1	1.30	13.1	0.95	1.15	49.43	1509.8
T6	**Paddystraw+ cow dung + cow urine**	6.61	1.87	21.7	1.13	19.2	1.05	1.00	50.00	1399.2
T7	**Farmwaste + cow dung + cow urine**	7.50	0.99	26.8	0.95	28.2	0.70	0.80	52.16	1501.2

Phosphorus : There are significant differences in phosphorus content among the various organic substrates used for producing vermicompost by the earthworm species *Eudrilus euginae*. The phosphorus content among the seven different organic substrates ranged from 0.70 to 1.15 percent. The highest percentage of P was recorded in T1 (1.15%), T2 (1.10%), and T6 (1.05%) treatments. The increased P level in vermicompost suggests phosphorus mineralization during the vermicomposting process, as stated by Suthar and Singh (2008). Acid production during the decomposition of organic matter by microorganisms is a significant mechanism for the solubility of insoluble phosphorus. Additionally, the percentage of a large number of microflora in the gut of earthworms might play a vital role in increasing phosphorus in the process of vermicomposting, according to Kaviraj and Sharma (2003).

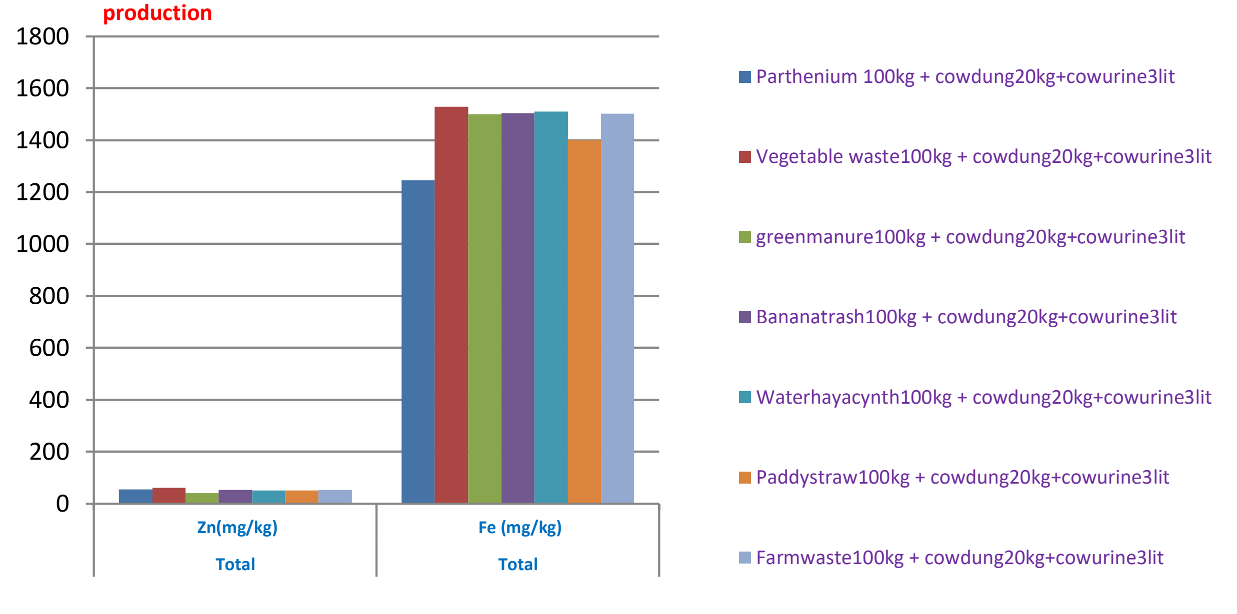
Potassium : The potassium content in seven different substrates ranged from 0.85% (farm waste) to 1.45% (T1 parthenium). The remaining treatments T2, T3, T4, T5, and T6 recorded potassium percentages of percent @1.31, 1.05%, 1.10%, 1.15%, and 1.0% respectively. These findings are consistent with Swathi and Vikram Reddy's (2010) research, which concluded that the use of different organic substrates for vermicomposting significantly affects the K content in the vermicompost. Vermicomposting has proven to be an efficient method for recovering high levels of potassium from organic waste, according to Manna *et al*. (2003) and Zhi-wel Song *et al*. (2019). The microorganisms in the worm's gut likely convert insoluble K into a soluble form by producing microbial enzymes, as suggested by Kaviraj and Sharma (2003).

Fig 2: percentage of nitrogen,phosphorus and potassium in different organic substrates used for vermicompost



Zinc and Iron : The vermicompost produced by different organic waste materials was analyzed for its zinc and iron content. The highest levels of zinc were recorded in T2 (vegetable waste) with 60.96, followed by T7(farmwaste) with 52.16, T4 (banana trash) with 51.69, T1(Parthenium) with 55.33, T5 (*waterhyacinth*) with 49.43, T6 (paddy straw) with 50.00, and T3 (green manure) with 40.16. On the other hand, the highest quantity of iron was recorded in T2 (vegetable waste) with 1528 mg, followed by T5 (*waterhyacinth*) with 1509 mg, T4 (banana trash) with 1504 mg, and T7(farmwaste) with 1501 mg. Comparatively lower proportions of iron were recorded in T3(green manure) with 1499 mg, T6 (paddy straw) with 1399 mg, and T1(Parthenium) with 1245 mg. These results are consistent with those found by Reddy and Reddy (1999).

Fig3: micronutrient zinc and iron composition in different organic substrates used for vermicompost production



Conclusion: According to experimental results from the past three years (2019, 2020, and 2021), banana trash and vegetable waste are the most effective organic substrates for producing vermicompost. In comparison to other substrates, they have shown superior abilities in terms of multiplication and reproduction potential of earthworms (specifically *Eudrilus euginae*), vermicompost production, conversion duration, and nutrient quantity and quality. The main objective of this study is to reduce environmental pollution and waste by utilizing locally available organic substrates (such as farm or domestic waste) to produce nutritionally rich vermicompost. This will ultimately decrease the use of chemical fertilizers and their negative impact on the environment.

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