Vermicomposting of eggshell powder using *Eudrilus eugeniae*

Sindhu. M

(17PZO016)

Thesis submitted to

Avinashilingam Institute for Home Science and Higher Education for Women,

Coimbatore – 641 043

In Partial Fulfilment of the Requirements for the Degree of

Master of Science in Zoology

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Signature of the Supervisor

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ABBREVATIONS

AMD -Acid Mine Drainage

B - Bagasse

BET - Brunauer Emmett and Teller

BMSW – Biodegradable Municipal Solid Waste

C - Calcium

C- Carbon

CD – Cow dung

CRD - Completely Randomized Design

DSW -Distillery Sludge Waste

DTPA - Diethylenetriaminepentaacetic Acid

EC - Electrical conductivity

FT-IR - Fourier transform infrared spectroscopy

FW - Floral Waste

FYW- Farmyard Waste

GP - Germination Percentage

IAA- N-indole-3-acetic acid

K – Phosphurs

KAR1- Karrikinolide

KW - Kitchen Waste

MHR- Medicinal Herbal Residues

MM360- Metro-Mix 360

MSW - Municipal Solid Waste

MW - Market Waste

N- Nitrogen

OC - Organic carbon

P - Potassium

P- Pressmud

PGPSs - Plant Growth-Promoting Substances

POME- Palm Oil Mill Effluent

PPF- Palm Pressed Fibre

SEM - Scanning Electron Microscope

SW- Smoke-Water

ST - Sugarcane Trash

T- Trash

TG – Thermogravimetric

TFW - Tea factory waste

TLR - Tea Leaf Residues

TSW -Tapioca Solid Waste

TW- Temple Waste

UNEP - United Nations Environment Program

UV–vis - Ultraviolet Visible Spectroscopy

VC - Vermicompost

VCL - Vermicompost Leachate

VW- Vegetable Wastes

1. INTRODUCTION

In most developed and developing countries it remains a major challenge for municipalities to collect, recycle, treat and dispose of increasing quantities of municipal solid waste (MSW), the most complex solid waste stream, as opposed to more homogeneous waste streams resulting from industrial or agricultural activities (Wang and Nie 2001). Generally, MSW generation is positively related to levels of income and urbanisation, with higher incomes and more urbanised economies generating higher levels of solid wastes (Hoornweg 1999 and Omran *et al.*, 2009). Although higher-income countries generate more MSW, they recycle more and have the resources to deploy new technology to treat their waste, which actually decreases waste generation (Kathiravale *et al.*, 2008).

Concerns about the state of the environment and problems of solid waste disposal are issues that are increasingly demanding attention globally, and open dumping of waste in and around cities (Abdoli 1993; Yousefi *et al*. 2004). Organic waste can be used as a valuable resource for renewable energy production and as a source of nutrients in agriculture. Macro- and micronutrients present in organic waste represent a low-cost, ecofriendly alternative to mineral fertilizers for crop growth (Moral *et al.,* 2009). Vermicomposting as well as composting are two of the best known environmentally appropriate technologies for recycling a large variety of hazardous waste and organic waste of different nature (Dom´ınguez and Edwards, 2010a).

A priority has been given to the management of MSW because improper treatment and disposal have a negative impact not only on the environment but also on human health (Taylor and Kosson, 1996; Sakai *et al*., 1997; Koufodimos and Samara, 2002). Most of the BMSW is disposed of in landfills, but this practice has a negative effect on the environment so it is necessary to find and to apply alternative treatment methods to this waste stream in order to divert it from landfill disposal (Crowe *et al.*, 2002).

Solid waste generation is suggested by UNEP to reflect the lives of people and the activities in the country. With that perspective the waste generation would be a combined function of the living standards of the inhabitants and the region's natural resources (United Nations Environment Program, 2005).

If, these wastes are correctly disposed so that it do not contribute to the problem of pollution. Waste is defined as unwanted material which has no value in normal use or for ordinary use. Solid wastes are those undesirable, useless and annoying materials and substances that comes from human and animal activities. Waste is any unavoidable material resulting from domestic activity or industrial operation for which there is no economic demand and which must be disposed (Uchegbu, 2002). Waste is also considered as any unwanted material. The problem has further increased in cities because of shortage of dumping sites and exacting environmental legislation, so scientists are seeking for management alternatives, which should be ecofriendly, cheap and fast (Isirimah, 2002; Gobo and Ubong, 2001; Uchegbu,2002).

Vermicomposting is a simple friendly technology that maintain sustainable agriculture and waste management programs. Almost all of the existing organic farms and sustainable agriculture programs in the country have vermicomposting as part of their systems. Vermicomposting involves physical and biochemical action of earthworms in altering organic materials into two useful products- the earthworm biomass and high quality organic soil conditioner. The physical action includes substrate mixing and loosening, maintaining aerobic condition and actual grinding. The biochemical action is the breakdown of the substrate by beneficial microorganisms in the earthworm's gut. The goals of vermicomposting are to continually increase the number and weight of worms and to convert the substrate material into vermicompost in the shortest time and highest recovery as possible (Rupani, *et al.,* 2013).

Vermicomposting biotechnologies involve the bio-oxidation and stabilization of organic matter through the joint action of earthworms and microorganisms under aerobic and mesophilic conditions. Vermicomposting has greater mass-reduction capacity than composting over a shorter processing time and generates products with higher humus content and significantly lower phytotoxicity (Lorimor *et al*., 2001). Vermicompost is also more marketable than compost due to its more attractive appearance and higher nutrient content and microbial activity (Nogales *et al*., 2008).

Vermicomposting also can be classified as a simple biotechnology process of composting by using certain earthworms to enhance the process of waste conversion and to manufacture better end product (Garg *et al.* 2006) stated that the percentage of nitrogen, phosphorous and potassium in vermicompost was found to increase while pH and total organic carbon declined as a function of the vermicomposting period.

As the vermicompost contain more valuable products, so it is an important difference between vermicomposting, composting and other methods of waste disposal (Garg *et al.*, 2006). In process of vermicomposting microbes do the biochemical degradation of organic matter and earthworm grinds as mechanical blenders, by comminuting the organic matter; they modify its biological, physical and chemical quality, gradually increasing the surface area exposed to microorganisms and reducing its C: N ratio (Yadav and Garg, 2011).

Compared to compost, vermicompost is produced in less time and has greater fertilizer value with a higher humus content and less phytotoxicity (Sim and Wu 2010). The surrounding conditions need to be favorable for the earthworms to break down organic wastes (Yadav and Garg 2011). Nevertheless, the utilization of earthworms to stabilize solid wastes has been well documented. Vermicomposting of wastes such as animal manure, sewage sludge, agricultural wastes, and industrial wastes showed that it is an efficient technology for waste management (Yadav and Garg 2011, Suthar, 2007).

Earthworms are long, narrow, cylindrical, bilaterally symmetrical, segmented animals with no bones. The body is dark brown, glistening and covered by delicate cuticle. They weigh over 1400-1500 mg next 8-10 weeks. On an average, 2000 worms weigh 1 kg and one million worms weigh approximately 1 ton. Usually the life span of an earthworm is about 3 to 7 years depending upon the type of species and the ecological situation (Maheswari and Priya 2018). Earthworms protect millions of 'nitrogen-fixing' and 'decomposer microbes' in their gut. Earthworms considered as farmers friend and an indicator of soil quality because they contribute enriched soil to agricultural field. These worms are major producers of natural manure without any factories and gift of farmers. (Annapoorani, 2014).

The organic matter degraded by due to activity of the earthworm is called vermicompost and it can be used as top soil or as organic manure in fields to prevent organic carbon deficiency. Though more than 400 species are listed under Indian earthworms, only about 20 species are employed for waste disposal through vermicomposting technology (Karmegam and Daniel 2011). The epigeic earth worm *Eisenia fetida* because of its rapid growth rate, early sexual maturity and extensive reproduction, has been extensively used to produce vermicompost from different plant residues, city refuse and sewage sludge (Devi *et al.*, 2012).

In this process, earthworms and micro-organisms convert organic wastes into a useful product known as vermicompost (Sim and Wu, 2010). Earthworms affect the soil biological activity through organic matter decomposition and nutrient mineralization. They are the important drivers for substrate conditioning, whereas microbes are responsible for the biochemical degradation of organic matter. Among all of the different species of earthworms, *epigeic* earthworms are the most suitable for the vermicomposting process. *Epigeic* earthworms are litter dwellers and live in or near the soil surface. These species feed on decaying organic matter and have high reproduction rates. Examples of *epigeic* earthworms are *E. fetida, E. andrei, E. eugeniae*, and *P. excavatus* (Domínguez, 2004 & Yadav and Garg 2011). Epigeic earthworms are also less susceptible to toxicity than endogeic or anecic earthworms (Suthar, 2013).

Epigeic earthworms are natural colonizers of organic waste and the following properties make them suitable for vermicomposting: high rates of consumption, digestion and assimilation; tolerance to a wide range of environmental factors; short life cycle, high reproductive rates, and endurance and resistance to handling. Earthworms exhibited all these characteristics, and only four species had vermicomposting ability: *E. andrei*, *E. fetida*, *P. excavatus*, and *E. eugeniae* (Dom´ınguez and Edwards, 2010b).

Earthworm species suitable in place of vermicomposting are *E. eugeniae*, *E. foetida, L. mauritii*, *P. excavatas* and *P. elongate*. Among them, *E. foetida* is considered the finest for decomposing organic wastes, because of its wide temperature tolerance (Edwards & Baxter 1992). Worm cast contain five times more nitrogen, seven times more phosphorus and eleven times more potassium than usual soil, the main minerals desired for plants growth. It also contains a lot of beneficial soil micro-organisms, which have at least as much to do with the plant growth and soil fertility.

Vermicomposting is a process of decomposition organic solid waste deposits by the aerobic activity of earthworms and microorganisms (Lim *et al*., 2016). Vermicompost has also been reported to contain biologically active substances such as plant growth regulators (Tomati., *et,al* 1987). The most gifted earthworm species used for vermicomposting are *E.*

foetida, E. andrei, E. eugeniae and *P. excavatus. E. foetida* is normally used for cow dung vermicomposting in Northern India. Studies are not available on the use of *E. foetida* for vermicomposting of other animals' waste. In order to utilize this species successfully for outdoor vermicomposting of different animal wastes, its survival, growth and fecundity in different wastes should be known. The life cycle of *P. excavatus* for different animal wastes has been documented (Edwards, *et al* 1998, Kale *et al.*, 1982).

Seed germination and growth are two important physiological processes that occur in a seed. Superior seed germination and seedling growth promises good yield of crop plants. In vitro experiments using different plant growth regulators in varied concentration on pulse crops are carried with an objective to improve quality of species and enhance crop production. Thus, different plant growth promoting hormones have distinct role in germination process and growth of pulse crop plants. (Sharma and Jain 2016)

In agricultural system, production of crops depends upon growth of plant. The foundation of growth of every plant is based upon germination of seed. Ideal conditions such as nutrient availability, soil condition, pH, temperature and adequate moisture are required to initiate the germination of the seed and seedling growth (Chachalis and Reddy 2000; Taylorson 1987). Several studies have assessed the impact of vermicompost amendments on potting substrates with regard to seedling emergence and the growth of marketable fruit and yield of some vegetable crops (Arancon *et al.*, 2004; Atiyeh *et al.*, 2000a, 2000b).

The integrated plant nutrient system helps in improving and maintenance of soil fertility for sustaining crop productivity. Cultivation of pulses benefit of the succeeding crop to the extent of 40 kg N/ha (Witham *et al.*, 1971). Use of organic manures alone, as a substitute to chemical fertilizers is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties. Use of organic manures along with inorganic fertilizers leads to increase in productivity and also sustain the soil health for a longer period (Gawai and Pawar, 2006).

The changes in soil properties improve the availability of air and water, thus encouraging seedling emergency and root growth (Gopinath *et al.*, 2008). Plant growth regulators are known to play a positive role in enhancing yield potential in plants. Foliar application of plant growth regulators are influences the plant architecture and yield potential.

The application of Naphthalene Acetic Acid at 50 ppm significantly increased the grain yield in green gram (Kalita, 1989).

Black gram (*V. mungo* L.) is one of the most important pulse crops next to chickpea, lentil and mung bean both in area and production (AIS, 2017). In order to maintain increased productivity, seed quality should be maintained properly. Seed storage is an important factor on which the seed qualities greatly depend. Without proper storage seed quality degraded rapidly with absorbing moisture from the surrounding environment, which invites different diseases. (Islam *et al*., 2018)

T. foenum-graecum L. belongs to the family Leguminosae commonly used as spices in India, is an important source of dietary protein. It has important medicinal properties too. In India fenugreek seeds are being used traditionally for treating diabetes. Presence of sapogenins and mucilaginous fibres in the seed possess the anti-diabetic and hypocholesterolaemic properties (Mansour and El-Adway, 1994).

Fenugreek is important seed species crop. It's occupies the prime place among seed species. It is rich source of protein and vitamin. It is high market value and fair salinity tolerance attract the farmer to include this crop in their cropping strategy particularly in area having salinity problem. Phosphorus is back bone of energy related activities and development of root system. Most of the Indian soil have inadequate supply of phosphorus hence need to supplement of P in the form of fertilizer for optimum crop production. Application of organic manure in conjunction with inorganic fertilizer in an integrated manner, appears to be the best alternative. Integrating chemical fertilizer with organic manures has been found to be quite promising not only in continuing higher productivity but also in providing great strength in crop production (Nambiar and Abrol, 1989). Farm yard manure or vermicompost when integrated with reduced doses of inorganic fertilizers result in improved soil fertility, growth and yield of plant (Subbian and Palaniappan, 1992).

In the present study an attempt has been made to document the work done in vermicomposting of eggshell powder and cow dung mixture.

In above views, the present study was formulated with the following objectives.

1. To study the vermicomposting ability in different concentration of eggshell powder.

2. To observe the different reproductive stages of the worms in eggshell powder.
3. To access the effectiveness of eggshell powder cast potential for spourting ability.

2. REVIEW OF LITERATURE

2.1. Vermicomposting using kitchen waste

Huang *et al.,* (2016) analyzed the optimal growth condition of earthworm *E. fetida* and their vermicompost features by recycling five different fresh fruit and vegetable wastes (FVW). Banana peels, cabbage, lettuce, potato, and watermelon peels were chosen as food for earthworms. The vermicompost obtained was analyzed which showed lower contents of total carbon and weaker microbial activity in final vermicomposts. Banana peels was harmful for the survival of *E. fetida*. This is caused by the high electrical conductivity and carbon to nitrogen ratio. The leachate generated in that treatment carried away great amounts of nutrients from reactors. This higher organic matter may be also responsible for the higher microbial population during the decomposition of banana peels. Thus the study evidences that vermicomposting efficiency differs with the types and loadings of fresh fruit vegetable wastes.

Elena (2015) examined the efficiency of vermicomposting may be measured by the worm number and/or biomass and the vermicompost produced. The individual weight and concentration of nutrients NPK were highest in *G. sepium* and chicken manure substrate.

Huang *et al*., (2014) studied the physicochemical properties and microbial profiles of fresh fruit and vegetable wastes during vermicomposting. Two decomposing systems of fruit and vegetable wastes with and without earthworms for 5 weeks were compared to control treatment. Vermicomposting treatment resulted in a rapid decrease of electrical conductivity and losses of total carbon and nitrogen from the 2nd week. Quantitative PCR and denaturing gradient gel electrophoresis combined with sequencing analysis displayed the enhancement of bacterial and fungal densities.

Shah *et al.*, (2013) experimented the vegetable waste, upon biodegradation in presence of earthworm *Eudrilus eugeniae* or *Eisenia fetida,* tended to ooze turbid water which caused earthworm mortality. This effect was successfully quenched by the use of soil and sustainable vermireactor operation was achieved.

Fernandez *et al*., (2013) investigated the feasibility of vermicomposting for vegetable greenhouse waste recycling. *E. andrei* was used for vermicomposting heterogeneousplant (HP), tomato-plant (P), and damaged tomato-fruit (T) greenhouse vegetable wastes. Earthworm growth and reproduction were monitored over a 12-week period, and variations in chemical parameters, enzyme activity, phytotoxicity test, and genetic fingerprinting of bacterial communities were evaluated. The tomoto fruit waste was successfully stabilized, as indicated by the significant decrease in its TOC content (approximately 13-26%) and C:N ratio (approximately 16-36%) and its high germination indices (approximately 39-72%).

Hemalatha (2012) observed the increase in population causes an increase in the quantity and type of urban and rural wastes. As far as rural wastes are concerned, there are enormous quantities of organic materials that are not utilized. The partially decomposed organic waste and industrial sludge's were converted into castings by earthworms. The castings was obtained on the top surface of the bin were in the range from 20 to 30 days depending on the type of waste and sludge used. The castings obtained were sieved, dried, tested and used as manure. Thus the vermicomposting process helps in the disposal of organic waste and industrial waste in a safe, economic and useful manner

Gómez *et al.*, (2010) examined this study was conducted in order to evaluate the feasibility of *E. andrei* for vermicomposting heterogeneous-plant (HP), tomato-plant (P), and damaged tomato-fruit (T) greenhouse vegetable wastes. The similar enzyme activities levels and bacterial community finger printings recorded in diverse vermicomposts obtained from T waste indicate that this type of waste favoured the existence of analogous bacterial communities responsible for the high degree of stabilization and maturity detected.

Adi *et al.,* (2009) reported vermicomposting using *L. rubellus* for 49 days was conducted after 21 days of pre-composting. The data reveal that coffee grounds can be decomposed through vermicomposting and help to enhance the quality of vermicompost produced rather than sole use of kitchen waste in vermicomposting.

Muthukumaravel *et al.,* (2008) revealed municipal solid wastes are mainly from domestic and commercial areas containing recyclable toxic substances, compostable organic matter and others. With rapid increase in population, the generation of municipal solid wastes has increased several folds during last few years. Disposal of solid wastes can be done by methods like land filling, incineration, recycling, conversion into biogas, disposal into sea and composting. Vermicomposting is one of the recycling technologies which will improve the quality of the products. Nutrient values were determined from the compost and compared with that of the control. It was found that NPK values were maximum in compost obtained from vegetable waste with the use of cow dung.

Nair *et al.,* (2006) reported the combination of the thermocomposting and vermicomposting to improve the treatment efficiency and assess the optimum period required in each method to produce good quality compost. The results showed that pre-thermocomposting improved vermicomposting of kitchen waste. A 9-day thermocomposting prior to vermicomposting helped in mass reduction, moisture management and pathogen reduction.

Tripathi *et al.,* (2004) examined an epigeic (surface dweller) earthworm species *E. fetida 1*`and an anecic (deep burrower) earthworm species *L. mauritii* have been tested for decomposition of kitchen waste plus cow dung. There was moderate mineralization and faster decomposition by *E. fetida* in comparison to moderate mineralization and moderate decomposition by *L. mauritii*. These results indicate *E. fetida* may be a better adapted species for decomposition of kitchen waste plus cow dung under tropical conditions.

2.2. Vermicomposting using agrowaste

Thomas *et al.*, (2018) observed the bioconversion of residue biomass to value added vermicompost by *Eudrilus* species. The biomass materials from cassava plants, banana, are canut palm, coconut palm, rubber and teak as well as weeds were vermicomposted with a conversion efficiency of > 60%. Bioconversion resulted in an increase in pH, electrical conductivity and major plant nutrients (N, P) while C: N and C: P ratios decreased in all crop residues.

Kamalraj *et al*., (2017) studied the utilization of agro wastes for vermicomposting and its impact on growth and reproduction of selected earthworm species in Puducherry, India. The decomposition rate of substrate in *E. eugeniae* in T3, T5 and T7 and in *P. excavatus* in T2, T4 and T6 of same combination of substrates have been recorded. Earthworm growth and biomass production by weight of *E. eugeniae* was higher (68.5%) than *P. excavates* (66.9%). The results indicate that *E. eugeniae* outperformed *P. excavatus* in growth and decomposition rate of substrates and proves to be a better species for vermicomposting and may be an efficient management approach for the locally available agro wastes to convert them into enriched manure for sustainable agriculture.

Singh *et al.*, (2014) analyzed the reduction of bioavailability of heavy metals during vermicomposting of phumdi biomass of Loktak Lake (India) using *E. fetida*, research was carried out on bioavailability and leachability of nutrients (Na, K, Ca and Mg) and heavy metals (Zn, Cu, Mn, Fe, Ni, Pb, Cd and Cr) during vermicomposting of phumdi biomass for 45 days using *E. fetida* earthworm. The toxicity characteristic leaching procedure test was performed to determine the leachable heavy metals during the vermicomposting process. The possibility of using earthworms to mitigate the metal toxicity and to enhance the nutrient profile in phumdi biomass vermicompost, is advantageous in sustainable land renovation practices.

Lim *et al.*, (2014) observed earthworms were introduced as biodegraders of palm oil mill effluent (POME), which is a wastewater produced from the wet process of palm oil milling. POME was absorbed into amendments (soil or rice straw) in different ratios as feedstocks for the earthworm, *E. eugeniae*. However, earthworm growth was reduced in all treatments by the end of the treatment process. Rice straw was a better amendment/absorbent relative to soil, with a higher nutrient content and greater reduction in soluble chemical oxygen demand with a lower C/N ratio in the vermicompost. Among all treatments investigated, the treatment with 1 part rice straw and 3 parts POME (w/v) (RS1:3) produced the best quality vermicompost with high nutritional status.

Mahantaa *et al.*, (2012) observed vermicomposts prepared from rice straw, Eichhornia crassipes, Ipomoea carnea, and their mixed biomass, were enriched with microbial inoculants and evaluated for their effect on growth and yield of rice, and nutrient availability and microbial population in soil. The results suggest that the locally available plant biomasses, particularly *Ipomoea carnea*, a weed abundantly available in northeast India, can be easily converted into an environment-friendly nutrient source by vermicomposting, using plantgrowth-promoting microorganisms such as *A. chroococcum* and *A. brasilense*.

Kavitha *et al.*, (2010) investigated the potential of banana-agro waste mixed with cow dung using earthworm *E.eugeniae*. Five treatments containing banana waste (BW) and cow dung (CD) in different ratios, were run under laboratory conditions. The maximum growth and reproduction was obtained in 0.20 kg BW + 0.80 kg CD treatment (T5). The earthworm mortality was higher in treatment with 1.00 kg BW alone (T1). Greater proportion of BW in feed mixtures significantly affected the growth and reproduction. In all the treatments, a decrease in pH ratio, but increase in N, P and K was recorded. Ph ranged between 6.9 ± 0.01 (T4) and 7.5 ± 0.03 (T2) in feed materials. The shift in pH during the study could be due to microbial decomposition during the process of vermicomposting .

Manuel *et al*., (2010) experimented that vermicomposting involves stabilization of organic material by the joint action of earthworms and microorganisms. Although microbes are responsible for biochemical degradation of organic matter, earthworms are the important drivers of the process by conditioning the substrate and altering the biological activity (Aira *et al*., 2007).This worm species can break down cellulose material without as much help from soil bacteria and when they eat, they leave behind worm castings that can be used as organic fertilizer (Senapathi, 1988). Vermicomposting of other organic substrates like coffee ground (Adi and Noor *et al*, 2008), kitchen waste (Fauziah *et al.*, 2009), vegetable waste (Garg and Gupta, 2010) and tomato fruit waste.

Khwairakpam and Bhargava (2009) investigated that vermicomposting is the good method of converting organic wastes into environmentally friendly products. It is a bio oxidative process entails the combined action of earthworms and microbes. Earthworms ingest, break and digest waste and converts into finer, humified, microbially active material by the activity of earthworms and microbes. Agro-residue based pulp and paper mills, bagasse is used as a raw material. Disposal of bagasse by dumping is unattractive process because of large requirement of land and pollution concerns.

2.3. Vermicomposting using aquatic weeds

John and Kakamega (2016) investigated the production of organic compost from water hyacinth in the Lake Victoria Basin: A Lake Victoria Research Initiative (VicRes), utilized water hyacinth to develop compost as a potential soil improvement source using four different composting treatments of water hyacinth biomass (H only control, H+ cattle manure, H+EM, H+ Molasses). Resulting in increase of essential elements in water hyacinth organic compost makes it an important source for control of acidic soil pH and soil nutrient replenisher.

Sridevi *et al.,* (2016) observed that the bioconversion of water hyacinth into enriched vermicompost and its effect on growth and yield of peanut, bioconversions of water hyacinth through vermicomposting were attempted. In the present study water hyacinth integrated with cow dung (1:3) was allowed for composting for a period of 45 days by using earthworm species *E. foetida*. Physicochemical characteristics, nutrients (nitrogen 2.85 %, phosphorus 2.10 % and potassium 3.05 %) and employed as good organic manure for the pot culture of the leguminous crop namely peanut and was found to be a better growth and yield.

Osoro *et al.,* (2014) examined the effects of water hyacinth compost on growth and yield parameters of maize. Water hyacinth compost increased the growth parameters of maize. The field results indicate that maize production without fertilizer application in some farms is possible, compost from water hyacinth which is locally available, plentiful and cost free can be effectively used as an organic soil amendment for soil restoration and crop production.

Ganeshkumar *et al.,* (2014) observed A new process for the rapid and direct vermicomposting of the aquatic weed salvinia (*Salvinia molesta*), *Eudrilus eugeniae* and *Eisenia fetida*, provided efficient vermicast production with no mortality, persistent gain in body mass, and good fecundity over the 270- day-long course of the reactor operation and it was possible to almost completely dampen the influence of natural biodegradation of the feed or grazing by the earthworm born in the vermireactors this has made it possible to link vermicast production directly to the ability of the earthworm to feed upon, and digest, salvinia. The findings have very significant implications in improving process economics and consequently process utility.

Deka *et al.,* (2013) experimented on vermicomposting of water hyacinth. Vermicomposting was carried out in laboratory condition in two seasonal trials covering summer and winter period employing the indigenous earthworm species *P. excavates.* Earthworm species can efficiently convert the substrate mixture to enrich with available nutrients N, P, K, Ca, Mg, Fe, Mn, Zn and Cu. Summer was found to be more productive as compared to the winter.

Singh and Kalamdhad (2013) reported the reduction of bioavailability and leachability of heavy metals during vermicomposting of *E. crassipes* employing *E. fetida* earthworm. Five different proportions of cattle manure, water hyacinth, and sawdust were prepared. Very poor biomass growth of earthworms was observed in the highest proportion of water hyacinth. The water soluble, diethylenetriaminepentaacetic acid (DTPA) extractable and leachable heavy metals concentration were reduced significantly in all trials except trial 1. Leachability test confirmed that prepared vermicompost is not hazardous for soil, plants, and human health.The vermicomposting of water hyacinth by *E. fetida* was very effective for reduction of bioavailability and leachability of selected heavy metals.

Dhal *et al.,* (2012) reported the composting of water hyacinth using saw dust/rice straw as a bulking agent, Due to its fast growth and the robustness of its seeds, it has caused major problems in the whole area. Advantage of producing a product that is easy to work into the soil compared with dried water hyacinths, because of the decomposed structure. High rate pile composting of water hyacinth in combination with cattle manure and saw dust/rice straw as a bulking agent. Results suggested that the optimal degradation of water hyacinth can be possible in the presence of large amount of cattle manure; and rice straw could be a better option as a bulking agent in comparison with saw dust.

Zirbes *et al.,* (2011) revealed the valorisation of a water hyacinth in vermicomposting using *P. excavatus* in Central Vietnam. The feasibility of vermicomposting water hyacinth mixed with pig manure in different proportions was tested using tropical composting. Higher water hyacinth proportions induced earthworm's mortality and significantly affected the numbers of hatchlings and cocoons produced during vermicomposting period. Water hyacinth could be potentially useful as raw material in vermicomposting and biofertilizing if mixed with 75% of pig manure.

Kafle *et al.,* (2009) observed the preparing of compost from invasive *E. crassipes* in Rupa Lake Area, Nepal aimed at water hyacinth create great environmental and economic problems covering major wetlands of the world. Experiment on making compost from this invasive weed in Begnas and Rupa Lake areas of Pokhara was done. Laboratory test results show that the compost obtained from Water hyacinth has acceptable composition of N, P, K and pH; and can be used in agricultural land for crop production. Laboratory tests of the compost for toxic elements are also highly recommended. Periodic laboratory tests of raw compost in certain time intervals of the experiment are highly recommended to determine the appropriate stage of composting. Identification of Carbon to Hydrogen ratio in the compost is crucial for agricultural application.

Khwairakpam and Bhargava (2009) investigated that vermicomposting is the good method of converting organic wastes into environmentally friendly products. It is a bio oxidative process entails the combined action of earthworms and microbes. Earthworms ingest, break and digest waste and converts into finer, humified, microbially active material by the activity of earthworms and microbes. Agro-residue based pulp and paper mills, bagasse is used as a raw material. Disposal of bagasse by dumping is unattractive process because of large requirement of land and pollution concerns.

Sannigrahi (2009) aimed at managing aquatic weeds through vermicomposting. *P. excavates* earthworms were used in vermicomposting aquatic weeds like *P. stratiotes, E. crassipes* and *T. angustata*. It marked 0.71-1.36% total nitrogen,0.38-0.75% total phosphorus and 0.86-1.44% total potassium indicating its suitability as a product of high quality rich organic manure which increase soil fertility.

Banerjee and Mata (1990) examined the composition of Indian aquatic plants in relation to its utilization as animal forage. It reported 39.6% extract of water lettuce is nitrogen free. Ayoade *et al*. (1982), reported from the research, "Trial of *P. stratiotes L*.as animal feed", P stratiotes L. contains 6.9% organic matter, and 27.8% nitrogen free extract.

2.4. Vermicomposting using industrial waste

Chen *et al*., (2018) observed the characterization of microbial community succession during vermicomposting of medicinal herbal residues. Vermicomposting was used to stabilize medicinal herbal residues (MHR). Four inoculating density of earthworms was studied, specifically 0 (W1), 60 (W2), 120 (W3) and 180 (W4) earthworms per kilogram of substrate. The C:N ratios were less than 20 by the end of the first week. This indicates that earthworms promote the stabilization of MHR. In the initial stage, richness and diversity of the microbial community decreased due to earthworm inoculation, and then began to increase. The abundance varied according to earthworm density, indicating that earthworms change the microbial composition.

Mahaly *et al* .,(2018) studied on bioconversion of solid wastes has been identified as an efficient technology and management of distillery sludge waste (DSW) combined with tea leaf residues (TLR) using the eco-biological tool. It was observed that the values of pH, total nitrogen, total phosphorus, total potassium, available nitrogen, available phosphorus, available potassium, total calcium and total magnesium were increased with a declined trend in electrical conductivity, total organic carbon and C/N ratio from its initial value.

Vellaikkannu *et al.,* (2017) investigated the role of earthworm in converting tea leaves waste into a valuable product is assessed. The tea leaves waste was mixed with cow dung and earthworm *Eudrillus eugeniae* and left for vermicomposting for 30 days. The vermibeds are properly maintained throughout the research. The result indicated that vermicomposting with *E. eugeniae* is better for changing tea leaves wastes into nutrient rich vermicasting in a short period of time. i.e. 30 days. Thus, the recycling of wastes through vermitechnology reduces the problem of non-utilization of agro wastes. Vermicompost provide a slow, balanced nutritional release pattern to plants in particular, releases of available N, Soluble K, Exchangeable Ca, Mg and P.

Mousavi *et al.,* (2017) observed recycling of rural wastes employing by *E. fetida*. So that any change in the composition due to changes in the presence or absence of macro and micronutrients can influence the compost production process and reproduction of worm.

Rai *et al.,* (2016) analysed *E. crassipes* as a potential phytoremediation agent and an important bioresource for Asia Pacific region. The infesting nature of *E. crassipes* disturbed the whole environment. Review discussed the cost-effective and ecofriendly way of utilizing this invasive plant in a way to incur the daily needs and also help in controlling. Accumulation and absorption of the heavy metals and other nutrients under phytoremediation from the aquatic bodies, bio fuel and biogas production through fermentation and decomposition, fertilizer production through composting / vermicomposting, production of feeds for animal and many more utilities which are beneficial.

Bhat *et al.,* (2016) investigated the management of sugar industrial wastes through vermitechnology and the role of earthworms in recycling of sugar industrial wastes. These wastes when mixed with other organic substrates become ideal mixtures for growth of earthworms. Earthworm technology can convert sugar industrial wastes into valuable fertilizing material. The final product (vermicompost) produced during the process of vermicomposting is nutrient rich organic fertilizer with plant available nutrients such as nitrogen, potassium, calcium and phosphorus.

Manohar *et al.*, (2016) revealed the paper has attempted to evaluate for development of efficacy vermicompost by using three varieties of earthworms. The use of earthworms in the degradation of different types of wastes is continuing from the past so many years. These wastes include industrial, agricultural of plant debris and domestic waste papers and cattle dung. Increase was found in all the parameters like, Total nitrogen (%), Available phosphorus (%) and Exchangeable potassium (%) while a decrease was found in pH and C: N ratio as the timing of vermicomposting increased from 0 days to 60 days.

Moorthi *et al.*, (2016) examined vermi-technology of organic solid waste with using earthworm *E. Eugeniae*, The disposal of biodegradable waste without adequate treatment results in significant environmental pollution. Vermicomposting is considered as excellent organic source to bioconversion of distillery solid waste, has reduced levels of contaminants and tends to hold more nutrients over a longer period without impacting the environment. The effects of enduring organic manures, distillery solid waste (DSW) and sugarcane trash (ST) bioconversion of vermicomposting. The present study thus indicates that combinations of DSW + ST were economically feasible and improve the nutrient assessment method of vermicomposting.

Manju and Kalaiselvi (2016) analysed nutrient profile of vermicompost of bagasse mixed with organic wastes that contains plant nutrients. Sugarcane industries produce large amount of waste in the form of bagasse and pressmud. The study bagasse is supplemented with various agro industrial residues, waste cotton and leguminous pod residues to produce vermicompost using *E. eugeniae*. Significant difference was noted between baggase mixed with leguminous and non-leguminous crop residues. The result concludes that the bagasse mixed with leguminous crop residues shows higher nutrients than other treatments.

Abbiramy *et al.*, (2015) analysed the degradation of tea factory waste by mushroom cultivation and vermicomposting, The TFW (Tea factory waste) was subjected to mushroom cultivation for partial degradation and then the spent waste was utilized for vermicomposting (*E. eugeniae*) combined with cow dung in different ratios. The TFW was converted into value added vermicompost and a cost effective method was gained for the degradation of industrial tea waste by producing mushrooms as by-products.

Kapoor *et al.,* (2015) investigated the solid waste, and also it is cost effective technique is a bio-oxidative process, which involves earthworms. For this mainly *E. fetida* species of earthworms are used. The process of Vermicomposting promotes plant growth, improves soil quality and helpful in managing different kinds of agricultural, industrial and domestic wastes. Therefore, Vermicomposting is highly nutritive 'Organic Fertilizer'. It retains soil nutrients for long time.

Lim *et al*., (2015) investigated vermicompost produced from palm oil mill effluent was evaluated for its maturity using: (i) spectroscopic analysis (Fourier transform infrared spectroscopy (FT-IR) and ultraviolet visible (UV–vis) spectroscopy); (ii) structural characterization (scanning electron microscope (SEM) and Brunauer, Emmett and Teller (BET) surface area) and (iii) thermogravimetric (TG) analysis. The TG analysis showed lower mass loss in the vermicompost in comparison with the initial wastes and control, suggesting higher stability in feedstock which had undergone vermicomposting process. The first derivative curve from TG analysis also showed degradation of various compounds, which was consistent with the spectroscopic characterization.

Bhandarkar *et al.,* (2014) carried out vermicomposting from bagasse by using *E. eugeniea*, Intensive land use for residential, commercial and industrial activities led to adverse impact on the environment, Excessive use of sugar cane in our day life has converted the bagasse on our day to day life has solid waste. The conventional composting methods, though effective and provide revenue in return takes long time. Release of energy means more bacterial biomass, which in-turn speed-up waste decomposition to an higher rate than that possible under anaerobic conditions.

Nattudurai *et al.,* (2014) examined the the growth of *C. tetragonaloba* (L) Taub to analyze the efficacy of vermicomposting of coirpith with cow dung by *E. eugeniae* Kinberg with 60 days maintenance. It was clearly evident from the study thatvermicomposting of coir pith greatly increase N, P and K values and dramatically decrease C: N ratio which enhanced growth promoting effect in the crop.

Sarma *et al.,* (2014) examined the study on the efficiency of low cost vermicomposting structure revealed that among the different low cost vermicomposting units T2 was efficient in terms of quantity of vermicompost harvested, vermiworms and numbers of cocoons produced followed by T3. Production of vermiwash was high.

Pigares and Prabha (2014) experimented the electric potential from vermicomposting of spent tea waste by employing exotic earthworm *E. eugeniae*, vermicompost is also rich in metal ions, acids and salts that has the potential to be used as an electrolyte. The main aim of this investigation is to exploit the potential lying in earthworm species to convert spent tea waste into high quality vermicompost that can be used as an electrolyte to generate electric current. The total macronutrients (N, P, K and Ca) and micronutrients (Fe, Cu, Mn and Zn) showed elevated levels in vermicompost when compared to control which contributed to the chemical reaction at the electrodes to create a potential difference across the electrodes thus giving a voltage, reveals that the vermicomposting has a great future in generation of electrical energy from biodegradable waste.

Shamini and Fauziah (2014) analysed the waste to value added product, vermicomposting of sugarcane bagasse and leaves using African night crawlers (*E. Eugeniae*), aimed to investigate the possibility of treating sugar cane leaves and bagasse via vermicomposting by using *E. eugeniae* (African night crawler) worms. The study compared degradation potential between sugar cane bagasse and leaves. Result indicated that active burrowing potential of the worm into the soil was able to degrade the sugar cane leaves and sugarcane bagasse, the 1:1 treatment showed greater reduction of waste with increasing number of worms as compared with 9:1 treatment and produce the value added compost as the final product.

Vermicompost is increasingly considered in agriculture and horticulture as a promising alternative to chemical fertilizers. The vermicompost is generally granular in shape due to earthworm fragmentation and decomposition of material (Lim, 2016). The nutrient content (N, P, K, Ca, Na) in vermicompost is generally higher than compost produced from without earthworms . (Bhat and Singh 2013).

Gurav and Sinalkar (2013) observed the preparation of organic compost using waste tea powder, Tea powder can be a great source of biodegradable garbage but it can make a good source of compost as well. The research is about preparing compost using waste tea powder which is generally thrown away and analyzing the physico-chemical parameters of the compost. The compost prepared by using waste tea powder has increased concentration of essential nutrients needed for plant growth and development as compared to the regular soil which are chloride, sulphate, total phosphorus, available phosphorus, organic matter, calcium and magnesium. This compost also reduces environmental pollution and also gives better yield of crops.

Achsah and Prabha (2013) observed the potency of vermicompost using *M. paradisiaca* (banana peel) waste and *E. eugeniae*. Physicochemical parameters like pH and the level of macronutrient content namely nitrogen, phosphorous and potassium has been studied. The earthworms can grow only in pH 6.9 to 7.2. Test confirmed the presence of high concentration of N, P, K. The efficacy of vermicompost has also been checked on the vegetable plant *S. lycopersicum* (tomato). The growth parameters has been studied which concluded that vermicompost obtained from the degradation of banana peel waste is an effective bio fertilizer which would facilitate the uptake of the nutrients by the plants resulting in higher growth and yield.

Rupani *et al.*, (2013) evaluated the efficiency of earthworm (*E. foetida*) for decomposition of different types of organic substances (kitchen waste, garden waste, newspaper, hair and eggshell) into valuable vermicompost. It was found that vermicomposting significantly modified the nutrient properties (N, P and K) of different waste reveals that vermicomposting (*E. foetida*) is a suitable technology for decomposition of different types of organic wastes into value added material.

Karmakar *et al*., (2012) carried out vermicomposting of organic wastes from seven different sources and evaluation of nutrient in them followed by chemical analyses were conducted. These seven sources include coconut coir, water hyacinth, mixed materials, cabbage, banana pseudo stem, cow dung and rice husk. Three composting species of earthworms, that are *E. fetida*, *E. .eugeniae and P. excavates* were chosen for the experiment. Lowest nutrient content was observed in vermicompost of coconut coir. The results indicate that organic wastes (mixed materials, parts of cabbage, water hyacinth, coconut coir, cow dung, rice husk, banana pseudo stem) were successfully processed through vermicomposting technology.

Brando´n *et al.*, (2012) analyzed the earthworm species and the quality and/or substrate availability are expected to be major factors influencing the outcome of these interactions and tested whether and to what extent the epigeic earthworms *E. andrei*, *E.fetida* and *P. excavatus*, widely used in vermicomposting, are capable of altering the microbiological properties of fresh organic matter in the short-term.

Pandit and Maheshwari (2012) screened the optimization of vermicomposting technique for sugarcane waste management by using *E. fetida*, Earthworms are crucial drivers of the process, by fragmenting and conditioning the organic solid substrate and dramatically altering its biological activity. Vermicomposting of sugarcane waste is a cheap, excellent and ecofriendly method of sugarcane waste management.

Pandit *et al.*, (2012) reported day by day vigorous changes in the human population, indiscriminate growth of urban cities, industrialization, and agricultural practices have led to an increased accumulation of solid organic waste materials in the environment. The review assesses the following topics in detail: Vermicomposting biotechnology, earthworm species for waste management, raw materials for vermicomposting, environmental factors effecting vermicomposting, applications of vermicompost and future prospects.

Nedunchezhiyan *et al.*, (2011) analyzed the effect of tuber crop wastes on nutritional and microbial composition of vermicomposts and duration of the process. Vermicomposting of cassava and sweet potato wastes for March–August during 2010 was conducted. It showed higher levels of nitrogen (1.12–2.23%), phosphorus (0.26–0.88%) and potassium (0.33–1.29%). 40–43 days was taken for the complete conversion. Earthworm weight and population showed higher rate in vermicompost made from cassava thippi. The nature of the feeding material determined the nutrient content, microbial diversity, earthworm population and time required for complete vermicomposting.

Sangwan *et al*., (2010) analysed this paper reports the potential of vermitechnology to convert sugar industry waste PM mixed with cow dung (CD) into vermicompost, employing an epigeic earthworm *E. fetida*. Vermicomposting resulted in a decrease in carbon concentration and an increase in nitrogen, phosphorus and calcium concentrations of the vermicompost. Investigations indicated that vermicomposting could be an alternative technology for the management of PM into useful fertilizing material, if mixed at maximum 50% with CD.

Sim *et al.*, (2010) investigated there is an urgent need globally to find alternative sustainable steps to treat municipal solid wastes (MSW) originated from mismanagement of urban wastes with increasing disposal cost. Furthermore, a conglomeration of ever-increasing population and consumerist lifestyle is contributing towards the generation of more MSW. In this context, vermicomposting offers excellent potential to promote safe, hygienic and sustainable management of biodegradable MSW. The benefits of vermicomposted MSW to plants, suggestions on how to enhance the vermicomposting of MSW as well as risk management in the vermicomposting of MSW.

Kaur *et al.*, (2010) study was envisaged for fast bioremediation of toxic paper mill sludge into a soil ameliorating agent. Although a rich source of organic carbon this sludge cannot be directly applied in fields and is recycled very slowly in landfills as it is deficient in other nutrients. Higher decline in organic carbon and higher content of nitrogen and phosphorous along with lower electrical conductivity and higher pH of the products of vermicomposting indicated that *E. fetida* helped in fast conversion of toxic paper mill sludge into a soil conditioner in 100 days.

Chen and Fu (2010) evaluated direct vermicomposting of fresh sewage sludge by using two epigeic earthworm; *E. foetida and B. parvus* The results showed that it was feasible to use both the earthworms to convert fresh sewage sludge without any pretreatment and blending into good quality fertilizer. Significant increase in nitrogen and phosphorus while decrease in pH, TOC and the C/N ratio was observed. It also caused significant reduction in concentration of heavy metals in sewage sludge. Direct vermicomposting can be one promising disposal technique for sewage sludge.

Ansari and Jaikishun (2010) studied an investigation into the vermicomposting of sugarcane bagasse and rice straw and its subsequent utilization in cultivation of *P. vulgaris L.* In Guyana, experiments were aimed at production and quantitative comparison and rate of production of vermicomposts from sugarcane bagasse, rice straw and a combination of sugarcane bagasse and rice straw. The combination of bagasse and rice straw showed the highest percentage of production. The vermicomposts were assessed for nutrient value and subjected to studies on plant growth parameters of *P. vulgaris L.* and were compared with treatments using cow dung and chemical fertilizer. The results indicated that vermicompost is a competitive biofertilizer and showed better growth patterns in *P. vulgaris L.* with vermicompost had better fruit quality in terms of physical dimension, biochemical constituents. Improvement in the soil quality in the experimental plots with trated with vermicompost produced from bgasse and rice straw.

Malathi *et al.,* (2010) observed the physico-chemical characteristics and microbial influence on tapioca solid waste vermicomposting. The study has investigated the suitable ratio of tapioca solid waste (TSW) and cow dung (CD) to obtain high quality vermicompost. The combined effects of poly culture worms and microbes were assessed by analyzing the physico-chemical properties of the final compost on the 75th day. The increased levels of nutrients suggest that the suitable ratio of TSW and CD treatment mixture was 1:1, 2:1 and 3:1.The per cent increase in N, P, K, were significantly high in the 3:1 ratio sample. There was an increase in the macro nutrients (N, P, K) in media treated with a combination of earthworms with microorganisms. The study showed that vermicomposting is the best method for tapioca solid waste composting.

Kumar *et al*., (2010) analysed the composting of sugar-cane waste by-products through treatment with microorganisms and subsequent vermicomposting. The waste byproducts of the sugar-cane industry, bagasse (b), pressmud (p) and trash (t) have been subjected to bioinoculation followed by vermicomposting to shorten stabilization time and improve product quality. Producing a nutrient-enriched compost product useful for sustaining high crop yield, minimizing soil depletion and value added disposal of waste materials.

Warman *et al.,* (2010) evaluated the vermicompost derived from different feedstocks as a plant growth medium. Feedstock combinations, three durations of vermicomposting (45, 68 or 90 days), and two seed germination methods for radish, marigold and upland cress, served as the independent variables. Seed germination was greater in the water extract method. Vermicomposts from all feedstocks increased leaf area and biomass compared to the control, especially in the 10% vermicompost :soil mix. Thus, seed germination and leaf area or plant biomass for these three species are contrasting vermicompost quality indicators.

Pattnaik *et al.*, (2009) analysed major nutrient status of vermicompost of vegetable market waste (MW) and floral waste (FW) processed by three species of earthworms namely, *E. eugeniae, E. fetida*, and *P. excavatus* and its simple compost were assessed across different periods in relation to their respective initiative substrates. Moreover, the vermicompost produced by *E. eugeniae* possessed higher nutrient contents than that of *E. fetida, P. excavatus*, and compost. The MW showed higher nutrient contents than the FW. Thus, vermicomposting is the paramount approach of nutrient recovery of urban green waste.

Suthar *et al.*, (2007) examined the composting potential of two epigeic earthworms (*P. excavatus* and *P. sansibaricus*) was studied in 2002 to breakdown the domestic waste under laboratory conditions. The maximum earthworm mortality was in vermibed having *P. sansibaricus* (□50% higher than by *P. excavatus*) (*t*-test: $P = 0.423$), since both species did not show a drastic difference in waste mineralization rate, but comparatively, *P. excavatus* exhibited better growth and reproduction performance, which further support the suitability of the species for large scale vermiculture operations.

Aira *et al.* (2006) studied the effect of C to N ratio of pig slurry in microbial biomass, growth and reproduction of the earthworm *E. fetida*. High growth rate and cocoon numbers can't be achieved if they lived in the substrate with high carbon to nitrogen ratio. In the low C to N ratio treatment the population was composed mainly by mature earthworms (60%), with a higher mean weight. In the high C to N ratio treatment, the population was composed mainly by juvenile and hatchling earthworms (70%).

Kaushik *et al.*, (2003) analysed vermicomposting with *E. foetida* of solid textile mill sludge mixed with cow dung in different ratios in a 90 days composting experiment and resulted in significant reduction in C:N ratio and increase in TKN. Total heavy metal contents were lower in the final product than initial feed mixture. Solid textile mill sludge can be potentially useful as raw substrate in vermicomposting if mixed with up to 30% cow dung (on dry weight basis). The growth and cocoon production of the worm species in different feed mixtures were also investigated.

Bansal *et al.,* (2000) investigated we studied vermicomposting with *E. foetida* of mustard residues and sugarcane trash mixed with cattle dung in a 90-day composting experiment. However, the difference were not significant. Total P, K and Cu contents did not differ in compost prepared with earthworm inoculation from the uninoculated treatments.

2.5. Vermicomposting using eggshell powder

Mashangwa *et al.,* (2017) reported excessive release of metals and metalloids into the environment is a major global environmental concern and there is need for environmentally friendly and cost effective methods for their removal. The adsorptive removal of zinc, lead, copper, and nickel ions from synthetic aqueous solutions and various metals from three acid mine drainage (AMD) sites using chicken eggshells. The study demonstrated the efficacy of chicken eggshells and presents it as a viable low-cost adsorbent for bioremediation.

Lee *et al.,* (2016) to investigate the suitability of orange skin to be reused as feedstock of *E. eugeniae* for 60 days. The maturity and quality of vermicompost are assessed through fertilizer parameters such as C/N ratio. All treatments expressed a significant decrease in C/N ratio (28.62- 45.40%) after 60 days of vermicomposting. Moisture content was in the range of 52 to 80% thought out the experiment. The vermicompost pH of orange skin was in the range of 8.7 to 9.0 after 60 days of vermicomposting. The decreased of EC in orange skin treatments (35.06- 39.97%) was also observed after 60days of vermicomposting.

2.6. Vermicompost using seed germination

Rekha *et al.,* (2018) observed of vermicompost was compared with plant growth enhancers on the exo-morphological features of *C. annum*. A significant plant growth was recorded in plants treated with vermicompost, the significant improvement in all the parameters, like length of shoot, length of inter node, number of leaves and number of branches was observed in plants at the end of 3rd, 4th and 5th weeks of treatment. These results clearly indicate that vermicompost can be exploited as a potent biofertilizer.

Mitoo *et al.,* (2018) examined the effect of four levels of phosphorous viz., 0, 20, 30, 40 kg P ha-1 and three levels of sulphur viz., 0, 10 and 20 kg S ha-1 on seed yield of fenugreek (cv. BARI Methi-1). Recorded data were analysed by using ANOVA technique and the mean differences were adjudged by DMRT at 5% level of probability. There was highly significant correlation between seed yield of fenugreek at different levels of phosphorus and sulphur.

Islam *et al.*, (2018) examine the influence of various storage containers and periods on the germination percentage of black gram seed. Three seed containers, *viz.* sealed tin container, poly bag and gunny bag were used to store the seeds, as well as seeds were stored for three different storage periods, *viz.* 15, 30 and 45 days and thereby conducted germination tests. The results revealed that storage and storage periods considerably influenced the germination percentage (GP) of black gram seed.

Cybulska *et al.,* (2018) experimented the phytoremediation of selected plant species on the compost substrate obtained from the poultry waste as compared to other commercial composts available on the market. Analyses used the Phytotoxic containing three test species: sorghum *S. saccharatum*, bittercress *L. sativum* and white mustard *S. alba*. It particularly refers to the stimulation of the growth of underground parts of mustard and bittercress, respectively 65% and 86% of the control value, and the aboveground parts, that were higher by 46% and 38%, respectively.

Lal *et al.,* (2017) carried out the standardization of organic module for production of *T. foenum graecum* L. was conducted during *rabi* season of 2009-10 to 2012-13 (four years). Similarly significant differences were recorded in the performance of fenugreek varieties under different organic modules and the highest plant height, maximum number of branches and pods per plant, highest number of seeds per pod with maximum grain yield (1568.36 kg/ha), gross returns (103512), net returns (71399) with higher B: C ratio (2.22) were recorded in fenugreek variety AFg-1 than variety RMt-305.

Ievinsh *et al.*, (2017) observed *Cannabis sativa L.* cultivars grown for industrial use have recently emerged as a sustainable alternative source of industrial fibre and bioenergy, and is a highly valuable food and animal feed resource. The aim of the present study was to evaluate the effect of vermicompost extract, vermicompost mineral nutrient composition, and vermicompost-derived humic and fulvic acids on seed germination and growth of hemp seedlings. For practical purposes, application of vermicompost and vermicompost-derived extracts for stimulation of hemp growth could be useful at concentrations 5%, 0.05 mg·mL–1 and 1%, for vermicompost extract, humic acids and fulvic acids, respectively.

Baliah *et al.*, (2017) analysed the application of microbially enriched vermicompost has significant effect on the growth of Okra *A. esculentus* (L.) Moench. The application of enriched vermicompost has positive effect on the biochemical characters of Okra such as total chlorophyll, carotenoid, protein, amino acids, glucose content and NR activity. Biochemical characters such as total chlorophyll, carotenoid, protein, amino acids were higher in *A. brasilense* enriched vermicompost where as in case of glucose and NR activity was higher with Pseudomonas fluorescens enrichment.

Wang *et al.*, (2017) assessed a greenhouse pot test was conducted to study the impacts of replacing mineral fertilizer with organic fertilizers for one full growing period on soil fertility, tomato yield and quality using soils with different tomato planting history. We conclude that vermicompost can be recommended as a fertilizer to improve tomato fruit quality, yield and soil quality.

Nagar *et al.*, (2017) investigate the effects of water extracts from different leaf litter and cattle dung vermicompost on seed germination and seedling growth of *V. radiata.* The effects of aqueous extract of different vermicompost on seed germination and seedling length were compared with distilled water and urea treated seeds. The results showed that although seedling length is recorded in each treatment but better results were obtained in vermicompost treated seed.

Rupani *et al.*, (2017) studied vermicomposting of acidic palm oil mill effluent (POME) mixed with the palm pressed fibre (PPF) which are found difficult to decompose in the environment. Different percentages of the vermicompost extract obtained from POME–PPF mixture were also examined for the germination of *V. radiata* seed. The results showed that 75% vermicompost extract demonstrated better performance for the seed germination.

Gadi *et al*., (2017) experimented the effect of organic manures farm yard manure, vermicompost and polutry manure, inorganic fertilizers Nitrogen, Phosphorus and Potash and growth regulator (Gibberellic acid) on yield attributes and yield in *V. radiata* (L.). Application of 10-40-20 NPK kg/ha+10 kg/ha N through poultry manure+GA3 75+75 ppm was recorded significantly maximum number of pods per plant, number of grains per pod, test weight(g), grain yield and straw yield in green gram as compared to the all other treatments .

Sharma *et al.,* (2016) reported the influence of Gibberllic acid in varied concentration on seed germination behavior. Different parameters like germination%, radicle and plumule length, fresh and dry weight etc were evaluated on two cultivars of urad bean. Both the varieties responded to treatments of Gibberllins but variations in the germination response were observed. Variety V2 showed overall better germination behavior than variety V1.

Bhardwaj *et al.,* (2016) observed on recycling organic waste using vermitechnology and use of organic and inorganic fertilizer for exploring the effect on growth and yield of *V. radiata*. The vermicompost applied plot showed a comparatively better results of moong dal production than cow-dung and chemical fertilizers. This study suggests that vermicomposted manures may be a potential source of plant nutrients for sustainable crop production.

Joshi *et al*., (2016) analysed the effect of organic manures like farmyard manure, vermi-compost, poultry manure, neem cake and castor cake on growth and green pod yield of cowpea during summer season of 2013-14 in randomized block design with four replication. The plant population per meter row length at 25 DAS and at final picking and number of branches plant-1 and plant height at 30 DAS showed no significant difference between different treatments, but at 60 DAS and at final picking significantly higher .

Sarma *et al.,* (2015) tested this study was designed to understand the effects of different soil organic amendments on germination and seedling vigour of Okra *A. esculentus* L. The study revealed that compared to biochar, vermicompost and farmyard manure significantly enhanced the germination and growth of okra seedling, but the stimulation was best in vermicompost-amended plots.

Singh *et al.,* (2014) analysed Smoke-water (SW), karrikinolide (KAR1) and vermicompost leachate (VCL) have been reported to possess gibberellic acid-like activity. The effects of these plant growth-promoting substances (PGPSs) on biochemical changes occurring during seed germination of *P. vulgaris* were assessed. The tested PGPSs significantly influenced various biochemical parameters that play a significant role in seed germination and plant growth. This study indicates that PGPSs may act via stress-relieving biochemical pathways during seed germination.

Kumari *et al.,* (2014) revealed the potential of bioconversion of industrial herbal waste to vermicompost using *E. eugeniae*. Vermibeds were made using a mixture of herbal waste and cow dung (1:1) in comparison with the use of cow dung alone as substrate, resulting in vermicomposts 1 and 2, respectively. The ability of earthworms to survive, grow and breed in the vermibed fed with the herbal waste indicates the sustainability and efficiency of a heterogeneous kind of organic waste.

Alidadi *et al.,* (2014) revealed the effect of different amounts of vermicompost and cow manure on germination, growth and yield of tomato plant, and compare them at the greenhouse of Mashhad Municipality compost plant under field condition in 2012. The analysis of the variance result revealed that the effect of the type and amount of fertilizers on tomato field was siginificant at 1% level. The results of the study showed that using the vermicompost dosage of cow manure of 500 g/m2 could significantly increase the tomato yield. The vermicompost as a potential source of plant nutrients for sustainable tomato production can reduce health and environmental problems.

Alam *et al.,* (2014) studied the net house at Bangladesh Agricultural Research Institute, Gazipur during the season, 2011 to evaluate the seed germination and seedling growth of tomatoes as affected by different organic fertilizers. However, there was no significant variation among the treatments in respect of root and shoot length ratio. The results suggest vermicompost is suitable for raising healthy seedlings in organic tomato production.

Manh *et al.,* (2014) investigated during winter season to determine the effect of vermicompost on productivity of muskmelon seedling (*C. melo* L.) in National Pingtung University of Science and Technology. The result showed that using substrate that mixture of vermicompost with rice hulls ash and coconut husk following rate 1:1:1 respectively gave highest value of germination rate, plant height, leaf area, plant biomass and the concentration of P, K, Ca and Fe. Factors contributed to the in increasing of muskmelon seedling growth may be result of an improvement of physical and chemical properties of the substrate when combination between vermicompost, rice hull ash and coconut husk.

Singh *et al.,* (2013) studied recycling of temple waste (TW) mainly comprising of floral offerings was done through vermitechnology using *E. fetida* and its impact on seed germination and plant growth parameters was studied by comparing with kitchen waste (KW) and farmyard waste (FYW) vermicompost (VC).

Srivastava *et al*., (2013) analysed the toxicity of arsenic in soil and ground water is one of the most important environmental problems particularly in South-East Asia. In the present study, response of black gram (*V. mungo* L.) to arsenic with or without phosphate application was investigated. Joint application of phosphate with arsenic resulted in significant alterations in most of the parameters tested under the purview of arsenic treatment alone which lead to better growth in black gram.

Lee *et al.,* (2012) experimented a series of trials was conducted to test the effect of small quantities of vermicompost on the growth of three leafy vegetables grown in oasis cubes for aqua ponic production. Results showed compost treatments enhanced germination and growth rates, with the greatest response observed from cow manure worm castings. The incorporation of small quantities of compost into seedling production would shorten the time from seeding to transfer of the growth out phase by 7-10 days when using Oasis® cubes.

Arancon *et al.,* (2012) tested Greenhouse experiments were conducted to evaluate the effects of different concentrations of vermicompost water extracts (teas) and seed soaking duration on germination of tomato *S. lycopersicum* and lettuce *L. sativa* seeds. Soaking duration generally had a significantly positive and linear effect on germination of tomato seeds across the concentrations of vermicompost tea. Germination rates of tomato seeds were significantly greater after 8, 12, and 24 hours of soaking. However, within each soaking duration, concentrations of vermicompost teas had variable effects on seed germination. The presence of N-indole-3-acetic acid (IAA), cytokinin, gibberellins, and humic acids in the teas could have been responsible for the faster germination of tomato seeds when soaked at lower concentrations and longer soaking times.

Palanichamy *et al.,* (2011) tested the advancement in green revolution and hardcore food processing technologies, there is high production of food. Experimental in hard core food processing technology in observed in human generating food waste that the earthworms feed on these wastes and produce worm castings which can act as a solid fertilizer with more quantity of nitrogen, phosphorous and exchangeable potassium. Apart from managing these wastes our intention is also to extract vermin wash from biodegradable wastes, a liquid biofertilizer, so that it can help in accelerating the growth of plants by about five times with input of phosphorus, molybdenum, nitrides and other micronutrients in correct quantifiable proportions. There is also one necessary advantage that is the wastes need not to be burnt which emits carbon dioxide and other harmful gases.

Ievinsh (2011) reported vermicompost preparations are increasingly used in agricultural practice. Crop plants are sensitive to negative effect of vermicompost at early stages of development. The effects of vermicompost on seed germination and seedling growth of different vegetable crop species. Vermicompost substitution inhibited seed germination and seedling growth with almost linear decrease of growth with increasing concentration of vermicopost in the substrate. It is reported that both solid vermicompost and vermicompost extract contain number of active substances of both phenolic and humic nature.

Warman *et al.,* (2010) screened this study determined feedstock effects on earthworm populations and the quality of resulting vermicompost produced from different types of feedstocks using different vermicomposting durations. Seed germination was greater in the water extract method; however, most of the vermicompost extracts suppressed germination of the three seed species compared to the water controls.

Gutie´rrez *et al.,* (2007) examined the effects of earthworm-processed sheep-manure (vermicompost) on the growth, productivity and chemical characteristics of tomatoes (*L. esculentum*) (c.v. Rio Grande) were investigated in a greenhouse experiment. Addition of sheep-manure vermicompost decreased soil pH, titratable acidity and increased soluble and insoluble solids, in tomato fruits compared to those harvested from plants cultivated in unamended soil. Sheep-manure vermicompost as a soil supplement increased tomato yields and soluble, insoluble solids and carbohydrate concentrations.

Arancon *et al.,* (2005) observed commercially processed vermicomposts, produced from food wastes, paper wastes and cattle manure, were applied to 8.25m2 field plots, at rates of 10 or 20 t/ha in 1999 and 5 or 10 t/ha in 2000, to evaluate their effects on the growth and yields of peppers *C. annuum* var. King Arthur. Application of vermicomposts to soils increased their microbial biomass and dehydrogenase activity. Humic materials and other plant growth-influencing substances, such as plant growth hormones, produced by microorganisms during vermicomposting, and produced after increased microbial biomass and activity in soils, may have been responsible for the increased pepper growth and yields, independent of nutrient availability.

Arancon *et al.,* (2004) investigated vermicomposts, produced commercially from food wastes, were substituted at a range of different concentrations into a soil-less commercial bedding plant container medium, Metro-Mix 360 (MM360), to evaluate their effects on the growth and yields of peppers in the greenhouse. Factors such as: an improvement of the physical structure of the potting medium, increases in populations of beneficial microorganisms and the potential availability of plant growth-influencing-substances produced by microorganisms in vermicomposts, could have contributed to the increased pepper yields obtained.

3. MATERIALS AND METHODS

3.1. Selection and collection of test animals

The exotic, epigeic earthworm, *E. eugeniae* (Kinberg) is selected and collected from the agricultural farmyard in sennanoor and maintained in vermibed prepared with mixture of red soil and cowdung in the ratio 1: 1. Sample of *E. eugeniae* was obtained from the vermibed and brought to the laboratory condition (29˚C 1 70% R.H) for 10 days. (Figure 1) shows the bulk sample of *E. eugeniae* along with an adult clitallate worm.

3.2. Selection of egg shell powder concentrations

Exposure of earthworms to different concentrations of egg shell powder was used. Concentrations of egg shell powder selected for the study were respectively under T1, T2, T3, T4, T5 and T6 test conditions.

Table 1 Composition of various treatments

Treatments	Soil (g)	Egg Shell Powder (g)	Cowdung (g)	Total (g)
Control	500	-	1000	1500
T1	-	500	1000	1500
T2	-	600	900	1500
T3	-	700	800	1500
T4	-	800	700	1500
T5	-	900	600	1500
T6	-	1000	500	1500

Figure 1.a Eggshell

Figure 1.b Eggshell powder

3.3. Predigestion process

The vermibed was prepared by mixing dried cowdung with egg shell powder was used in different concentrations. During predigesting period water was sprinkled for aerobic degradation. After 30 days of predigestion the composting worms were collected from the mass culture. Six treatments were maintained in triplicates. In the prepared vermibed 10 worms/ Kg was introduced. Experiments were carried for 60 and 90 days.

3.4. Preparation of pre-digested eggshell powder and cow dung mixture

Red soil were collected at different points in the university campus of Avinashilingam Institute for Home Science and Higher Education for Women and brought to the laboratory. The mixture of red soil and dried cow dung were prepared at the ratio of 1 : 1 w/w, sprinkled with minimum quantity of tap water and kept in large PVC tanks for predigestion.

Predigestion of organic mixture were carried out for a period of 21days (Ramalingam and Thilagar, 2000) by regular mixing and turning of the eggshell powder - cowdung mixture was used for further investigation.

3.5. Observation of worms

During interval of every 30days, worms in control and treatment trays were observed for the morphological changes of worms with minimum disturbance. The mixtures were photographed at the end of the treatment period of 60 and 90 days.

3.6. Studies on seed germination

Experiments were carried out in the Laborartory of Department of Zoology. Red Soil and different treatment of vermicompost, homogenized to a fine texture and removing inert matter before being used for seed sowling. Green gram, Black gram and Frenu greek were grown in earthen parts. Red soil and vermicompost 1:1 (75g: 75g=150g). 10 Seeds of each treatment (green beans, okra and sesame seeds) were sown in each pot for germination. Three replication of each treatment was arranged in a completely randomized design (CRD). Watering was done every evening until completion of the experiment.

The twelve treatments comprised one control, three level of inorganic source control C0, T1, T2, T3, T4, T5 and T6 seeds were applied 10 as per treatments. Soil was well mixed with the help of hand and then applied, green gram, black gram and fenugreek.

Application of vermicompost as nutrient supplement to germination of green gram, black gram and fenugreek seeds were used as control and treatments wise T1, T2, T3,T4, T5 & T6, which contains red soil 25 grams and vermicompost 25 grams. Seeds were brought from Tamil Nadu Agricultural University, Coimbatore, 10 healthy and nutritious seeds were soaked in water at room temperature 24 hours. Fully water soaked seeds were selected and each seed distance between 1cm sowed in earthen parts in all the treatments. Sprinkled with water twice a day and observed carefully.

4. RESULTS AND DISCUSSION

Vermicompost is a good soil fertilizer made up of worms digested excretory product kown as worm caste which contains essential nutrients for plants to germinate, growth and development. It increase the soil richness, water holding, softening, aeration and porosity of the soil due to the movement of earthworms turns upside movements of top soil and sub-soil.

During the pre-decompostion mixture of different concentration were kept in individual trays (45cm × 30cm × 15cm). In each tray eggshell powder and cow dung mixture were thoroughly mixed, then added and mixed to make compost because some of the solid waste produce warmth leads to high temperature maintained for 30 days water. Into each tray 10 clitellated *E. eugeniae* were introduced and maintained under laboratory condition (28 ± 1º C) and at 60 to 70 % of moisture by regular sprinkling with water every day. The trays were covered with the cotton cloth in order to prevent the escape of the worms and were very sensitive to light and ventiliation of air in soil medium. The worms were kept in laboratory conditions for a maximum periods of 90 days.

Observation of worms during treatment period

At an interval of 30 days worms in each trays were noticed with minimum disturbance for the morphological changes. After 60^{th} day of vermicomposting process, the egg shell powdered and cowdung mixture were stabilized. Gradually changed the texture of eggshell powder and cowdung mixture because the interaction of earthworms enhanced the degradation and realized the nutrition rich cast material. At the end of treatment period 90^{th} day, the mixture in trays were separately analysed for the number of adults worms surviving, number of young ones and number of cocoons were recorded and were used for further analysis.

Figure 1 shows the egg and eggshell powder for vermicomposting treatment.

Figure 2 shows the Bulk sample of *E. eugeniae* along with the adult clitellated worm measured about 18 ± 1.25 cms, young ones were more in number nutritious healthy, more active and reddish blue colour, cocoons were pale yellow colour with more pigmented, lemon shaped and many in number.

Figure 3 provides the texture pre-decompost with eggshell powder and cowdung mixture after 60 days.

Figure 4 gives the texture of vermicompost after 90 days.

Figure 5. Experimental setup of vermicomposting using seed germination of selected seeds

From figure 2 we can find out the mass aggregation showed maximum number, and was gradual length and weight gain was significant in all trays.

Control and treatment does not showed any increased temperature and wormth. These was a positive appearance of treatment and the worms were good and healthy suppressed movement in day time and active movement in night time.

In the case of composting ability showed high range and in the process of reproductive analysis recorded normal and active cocoons, young ones and adults are multiple in number. This results proves the egg shell powder and cow dung mixture was the best substrate for vermicomposting.

Table 2 Vermicomposting of eggshell powder resulting in number of cocoon

Treatments	Number of adults introduced	Number of Cocoons
Control(T0)	10	32
500 (T1)	10	32
600(T2)	10	33
700(T3)	10	36
800(T4)	10	38
900(T5)	10	38
1000(T6)	10	40
‘r’ value	-	0.854

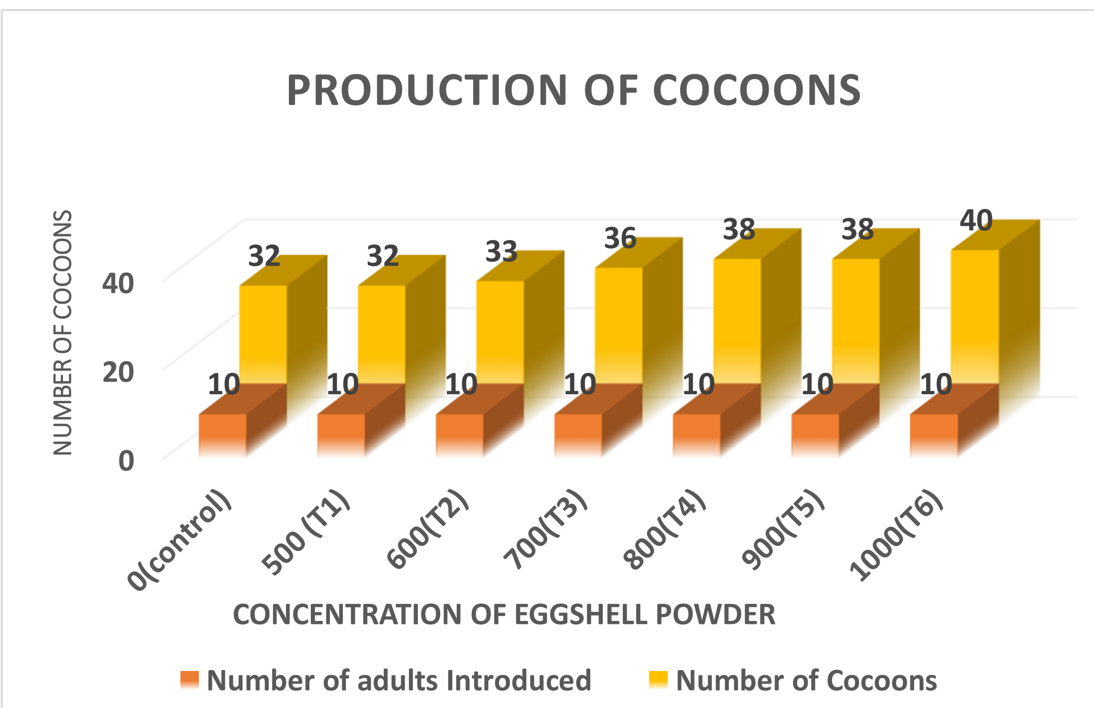


Table 3 Vermicomposting of eggshell powder resulting in number of young ones

Treatments	Number of adults introduced	Number of young ones
0(control)	10	163
500 (T1)	10	163
600(T2)	10	166
700(T3)	10	182
800(T4)	10	193
900(T5)	10	195
1000(T6)	10	207
'r' value	-	0.840

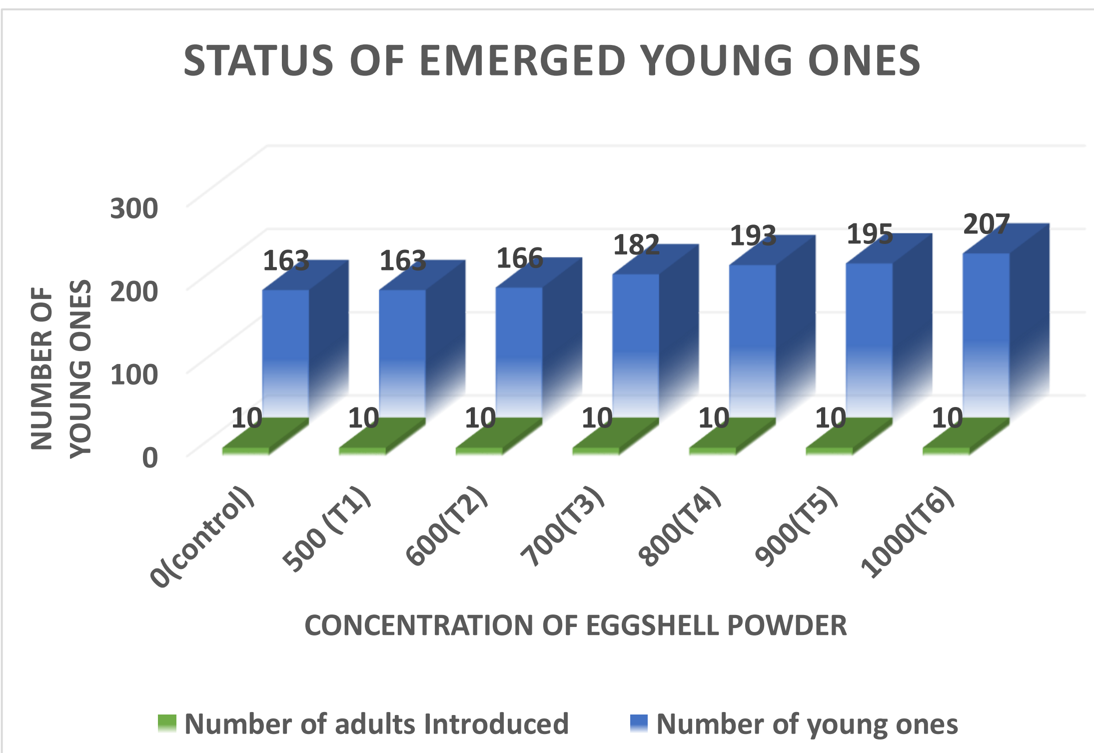


Table 4 Vermicomposting of Eggshell powder resulting in number of adults

Treatments	**Number of adults Introduced**	**Number Of adults survived**
0(control)	10	35
500 (T1)	10	35
600(T2)	10	38
700(T3)	10	40
800(T4)	10	44
900(T5)	10	46
1000(T6)	10	50
‘r’ value	-	0.869

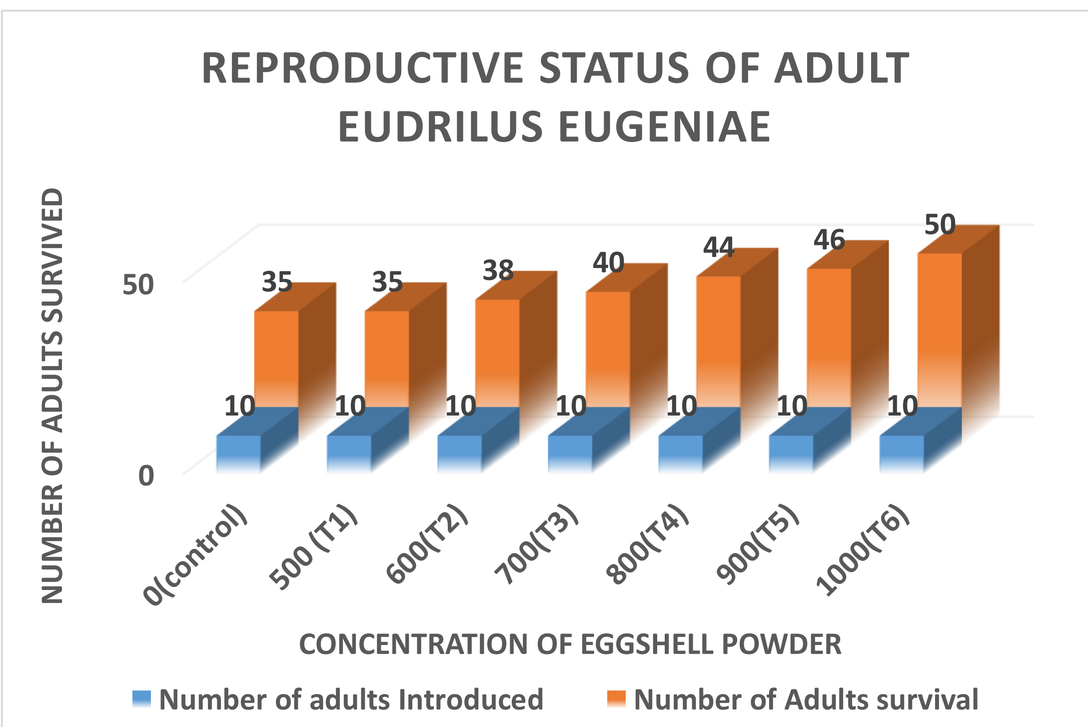


Table 2: Given the data on the different concentration of egg shell powder and cow dung mixture for a prolonged period of 90 days and it was observed that gradual increase of adults, cocoons and young ones. Compost process was carried out for 30 days with egg shell powder and cow dung mixture in wet condition. Which was used for predecomposting process with earthworms.

Correlation coeffection (r) between egg shell concentration and adult survival, between egg shell concentration and cocoon production, between egg shell concentration and young one production uniformly ranged between 0.84 to 0.86, there by indicating a positive impact of egg shell on the reproduction of the worms under normal condition.

Figure 1 shows the bulk sample of *E. eugeniae* along with the adult cilatillated worm measured about 18 ± 1.25 cms, young ones were more in number nutritious healthy, more active and reddish blue colour, cocoons were pale yellow colour with more pigmented, lemon shaped and many in number.

Figure 2. a Adult of *E.eugeniae*

Figure 2. b Young ones of *E.eugeniae*

Figure 2. c Cocoons of *E.eugeniae*

Figure 3 Provides the texture of pre-decompost with eggshell powder and cow dung mixture after 60 days.

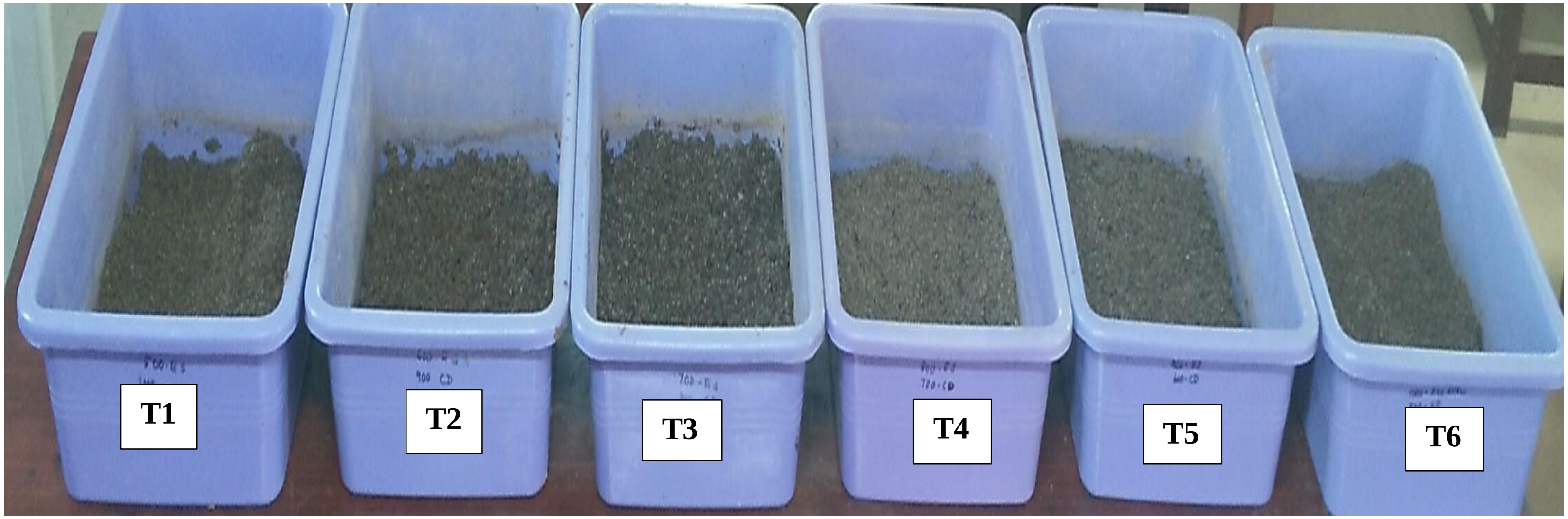
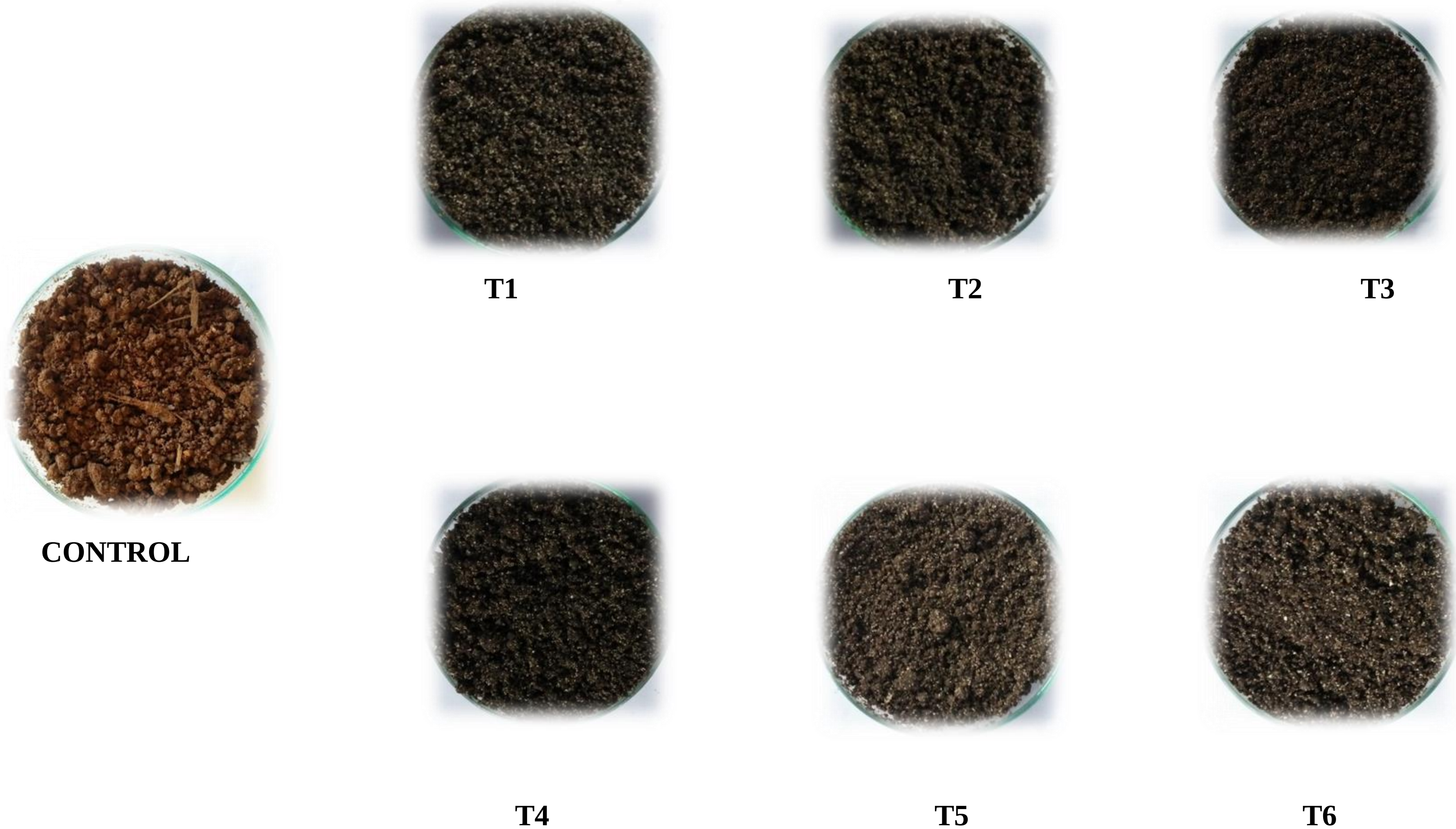


Figure 4 Texture of vermicompost after 90 days.



Vemicomposting ability

The most effective use of earthworms in organic waste management could be gained and vermicompost contains enzymes which can break down the organic matter in the soil to release the nutrients and make it available to the plant roots. Earthworms multiply very rapidly because they are bisexual animals and cross-fertilization occurs as a rule. Given the optimal conditions of moisture, temperature and feeding materials earthworms can multiply approximately by 28. The adult worm might live for about two years. Vermicompost gives readily available nitrogen and many nutrition in soil, which facilitate uptake by plants.

The control and remaining worm worked treatments were analyzed for 60^{th} day each treatment was examined and results were analyzed. The texture of the control and worm worked mixture in all the treatment T0 to T6 was observed on 60 day. It could be observed that treatment mixture exhibited gradual increase and comparatively more granules of worm casts.

Figure 3 provides the nature and texture of control (Egg shell powder + cow dung) and partially composted mixture (60 days) and fully composted mixture (90 days) of all treatments. The experiment reveals that the decomposed mixture have water holding capacity is in high level and it was found that various macro and micro nutrients in the vermicompost. Egg shell powder particles are floating and not settled on the cowdung mixture. It takes thirty days for water holding capacity and became compost, introduced 10 earthworms to work delivered nutritious good yield.

Figure 5 Experimental setup of vermicomposting using seed germination of selected seeds

Germination studies using vermicompost

Earthworms use a wide variety of organic materials have sufficient nourishment from the waste and produce good organic matter. Demanded that organic residues comprising city, industrial, agricultural farms, household and kitchen wastes with dead or decaying materials can be used as bedding materials for vermicomposting. The data showed that application of vermicompost significant germination and increase in plant height, nutrient content and uptakes as compared to all treatments and control.

The experimental results of different treatments revealed significant responses of yield attributed. Application of egg shell powder significantly increased the growth parameters and enhanced the photo synthetic activity when compared to control. The sprouts grown well according to different concentrations when compare to control. Sprouts are randomly selected for the study length hypocotyl and diameter were observed was greenish and good.

DISCUSSION

Elvira *et al*., (1996), growing 8 individuals of *E. andrei* on a mixture of fresh cow dung manure and straw, found greater growth rates (16.75 mg day-1) and maximum weights (0.59 g) than in cow dung manure (12.25 mg day-1 and 0.43 g respectively). Hayawin *et al*. (2014), obtained show that both the species *E. fetida* and *E. eugeniae* are capable of growing and reproducing successfully in substrates, especially *E. fetida* compared to *E. eugeniae*. The growth and cocoon production was also better in *E. fetida* for this substrate. In the present study reveals egg shell powder and cow dung mixture give high nutrient yield and produced much worm casts and also observed cocoons and young ones.

Graff, (1974) and Watanabe and Tsukamoto, (1976) obtained growth rates of 60-80 mg per week for *E. fetida*. Reinecke *et al*., (1992) reported growth rates of 7 mg earthworm-1 day-1 for *E. fetida* fed on cattle manure for 150 days. Hartenstein and Hartenstein, (1981) achieved rates of 14 mg earthworm-1 day-1 for *E. fetida* hatchlings fed on wet activated sludge. Cluzeau *et al*., (1992) obtained growth rates of only 4.5 mg earthworm-1 day-1 in batch culture for immature *E. andrei* fed on horse manure and peat.

Domínguez *et al.,* (1997) and Domínguez *et al.,* (2000) found different growth and reproduction rates of *E. andrei* in different diets and they also found that earthworms invested preferentially their energy either to growth or to reproduction depending of the food quality and moreover earthworm's growth is limited by carbon availability Tiunov and Scheu, (2004). It could be explained that the different weight increases and growth rates of worms in vermicomposting could be due to the difference in substrate quality or due to fluctuating environmental conditions Vijaya *et al.,* (2012). The data on worm numbers showed that the worm counts were highest in sawdust and hog manure. Similar results were observed in the present study also increased feed that makes the worm active due to better nutrition leads to production of more vermicast.

The marked differences between rates of cocoon production in the different mixtures must be related to the quality of the bulking agent. The maximum rates of cocoon production were obtained in the mixtures with cardboard and paper (3.19±0.3 and 2.82±0.4 cocoons earthworm-1 week-1) respectively, values which are similar to those recorded for *E. fetida* (3.8 cocoons earthworm-1 week-1) Edwards, (1988) and for *E. andrei* (3.08 cocoons earthworm-1 week-1) Haimi, (1990). The survival, biomass production and reproduction of earthworms are the best indicator to evaluate the vermicomposting process Suthar, (2006). Above said results were go in line with the present study increased number of cocoons and young ones were found.

Hashemi *et al.*, (2013), while study of effect of bulking materials on the growth and reproduction of the earthworm *E. Andrei* in vermicomposting of sewage sludge, results showed the highest earthworm growth in the composition of sewage sludge and food waste and the least amount of growth in the food composition of sewage sludge and sawdust Domínguez *et al.,* (2000).

Results of the present research are in accordance with the results of (Warman and Anglopez, 2010) who investigated the effect of different types of feedstocks including kitchen paper waste, kitchen yard waste and cattle manure yard waste on the worm weight and concluded that worm weight in this feedstock was different and related to type of feedstock and durations of vermicomposting. Studies showed that the kind, palatability and quality of food directly affected the survival growth rate and reproduction potential of earthworms (Suthar 2010b and Deka *et al*. 2011).

Vermicomposting technique converting decomposable organic wastes into valuable vermicompost through earthworm activity is a faster and better process when compared with the conventional methods of composting. The excretory and waste products effects on the growth, reproduction and life cycle of a dominant earthworm species was described by many researchers in Indian crop fields. Vermicompost improve the physical, chemical and biological properties of soils including supply of almost all the essential plant nutrients for the growth and development of plants. The above studies show that vermicompost have their own roles play to higher productivity (Rajesh and Dubey, 2015). Dual inoculation might have contributed something towards enhanced plant growth and increased nitrogen or soluble phosphorus. Increased growth parameters with dual inoculation with *Rhizobium* and PSB were observed in mung bean (Varghese, 2011 and Meena *et al*., 2013).

The most effective use of earthworms in organic waste management could be achieved when a detailed understanding of biology of all potentially useful species and their population dynamics, productivity and the life cycles of earthworms are known. Detail studies on Indian species (Julka, 2001) and tropical species (Dash and Senapati, 1980) and knowledge about the reproductive strategies of earthworms have been done. In the present study pronounced the same results. The reports are in accordance with (Mishra *et al*., 2006) in *O. sativa* reported that incorporation of vermicompost in combination with rice residue significantly increased the growth.

Bachman and Metzger, (2008) revealed that vermicompost has efficiency to enhance germination rate. Vermicompost has also shown to stimulate germination of several ornamental and horticultural plant species such as green gram (*P. aureus*) (Karmegam *et. al*. 1999) tomato plants (*L. esculentum*) (Atiyeh *et al*. 2000 and Zaller, 2007) and petunia (Arancon *et. al*., 2008). In this study also application of eggshell powder increase the growth parameter, spourts grown well according to different concentration.

Vermicompost @ 4 t ha-1 significantly increased plant height (34.05, 50.2 and 58.9 cm) and number of branches/plant (3.69, 5.73 and 8.06) at 60, 90 DAS and at harvest over 0 and 2 t ha-1 vermicompost and reminded at par with vermicompost 6 t ha-1. The improved growth might be due to better soil physical condition, prolonged availability of macro and micro nutrients to crop during entire growing season. The beneficial effect of vermicompost on these parameters might be due to its contribution in supplying additional plant nutrients and increasing availability of native soil nutrients with increased microbial activity. The results of the present investigation proved with that of (Khiriya *et al.*, 2001 and Jat *et al.*, 2006). The positive response of vemicompost may probably due to enhanced supply of macro as well as micro nutrients which led to high assimilation of food and its subsequent partitioning in sink. It improved yield components due to vegetative and reproductive growth led to higher seed and yields (Chaturvedi and Chandel, 2005 and Suman *et al*., 2007).

5. SUMMARY AND CONCLUSION

- The study titled as "**Vermicomposting of egg shell powder using *Eudrilus eugeniae*"**, was conducted to assess the vermicomposting ability of *E. eugeniae*
- Vermicomposting of egg shell powder was assessed by analysis the physiochemical properties of the compost.
- In the present study, soil (500g) and cow dung (1000g) in 1:2 ratio were used for treatment T0 as control
- Egg shell powder (T1, T2, T3, T4, T5 & T6) served as substrate for treatments
- Substrate, soil and cow dung were setup in the ratio 1:2 in all treatment T1 to T6
- The test organism *E. eugeniae* was introduced into the all the treatments
- Treatments were maintained in favourable laboratory condition (28 ± 1ºC, 70% R.H) with sprinkling of water at intervals
- The decomposed mixture have water holding capacity is in high level and it was found that various macro and micro nutrients in the vermicompost
- Egg shell powder particles are floating and not settled on the cow dung mixture
- It takes twenty five days for water holding capacity and became compost
- Introduced 10 earthworms to work delivered nutritious good yield
- The survival and activeness of worms were noted in intervals of 30 days
- The nature and texture of control and pre-decompost with eggshell powder and cow dung mixture after 60 days is partially composted mixture of all treatments
- The nature and texture of control and pre-decompost with egg shell powder and cow dung mixture after 90 days is fully composted mixture of all treatments
- Vermicompost as nutrient supplement to germination of green gram, black gram and fenugreek seeds were used as control and treatments wise T1, T2, T3,T4, T5 & T6, which contains red soil 25 grams and vermicompost 25 grams
- 10 healthy and nutritious seeds were soaked in water at room temperature 24 hours
- Fully imbibed seeds were selected and each seed distance between 1 cm sowed in earthen parts in all the treatments
- Sprinkled with water twice a day and observed carefully
- Increased the plant growth parameters and enhanced the photo synthetic activity when compared to control

- The plant yield is good and greenish
- The Overall analysis of morphological parameters, egg shell powder and cowdung treatments gives the more reproduction in earthworm *E. euginae* and the compost soil gives the macronutrients, so this treatments gives the high yield in seeds germination

CONCLUSION

Vermicompost from eggshell powder was found in rich nutritent content and best for rapid multiplication of *E.euginae*, optimum eggshell powder – cow dung proportion has been found for all the trearment. In this connection eggshell powder can be taken as most suitable substrate for the production of organic fertilizer by vermicomposting process. Maintaining soil fertility as well as sustainability of crop production, by using eggshell powder vermicompost. The best treatment in regard to sprout, growth and yield parameters where found to be the best of nutrient uptake among all the treatments.

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