ज्ञान-विज्ञानं विमुक्तये

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002

SUBMISSION OF INFORMATION OF FINAL REPORT UNDER THE MAJOR RESEARCH PROJECT

Period of report: from 01.04.2013 to 31.03.2017

UGC Reference No. F. No. 42-527/2013 (SR) Dated-22-03-2013

Title of research project

"Production of organic liquid biofertilizer (Vermiwash) from municipal solid wastes and their effect in combination with biopesticides on the productivity of important crops of eastern Uttar Pradesh."

Principal Investigator

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Annexure – IX

UNIVERSITY GRANTS COMMISSION
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SUBMISSION OF INFORMATION ALONG WITH FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. Title of the Project: "PRODUCTION OF ORGANIC LIQUID BIOFERTILIZER (VERMIWASH) FROM MUNICIPAL SOLID WASTES AND THEIR EFFECT IN COMBINATION WITH BIOPESTICIDES ON THE PRODUCTIVITY OF IMPORTANT CROPS OF EASTERN UTTAR PRADESH."

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR : DR. KESHAV SINGH, ASSISTANT PROFESSOR, DEPARTMENT OF ZOOLOGY, D.D.U. GORAKHPUR UNIVERSITY GORAKHPUR-273009, U.P, INDIA
3. NAME AND ADDRESS OF THE INSTITUTION: D.D.U. GORAKHPUR UNIVERSITY GORAKHPUR-273009, U.P, INDIA
4. UGC APPROVAL LETTER NO. AND DATE: F. No. 42-527/2013(2013) DATED: 22.03.2013
5. DATE OF IMPLEMENTATION: 01.04.2013
6. TENURE OF THE PROJECT: 03 Years
7. TOTAL GRANT ALLOCATED: 10,29,803=00
8. TOTAL GRANT RECEIVED: 9,47,603=00
9. FINAL EXPENDITURE: 9,34, 237=00

10. TITLE OF THE PROJECT: "PRODUCTION OF ORGANIC LIQUID BIOFERTILIZER (VERMIWASH) FROM MUNICIPAL SOLID WASTES AND THEIR EFFECT IN COMBINATION WITH BIOPESTICIDES ON THE PRODUCTIVITY OF IMPORTANT CROPS OF EASTERN UTTAR PRADESH."

11. OBJECTIVES OF THE PROJECT: ANNEXURE - A

12. WHETHER OBJECTIVES WERE ACHIEVED: YES

13. ACHIEVEMENTS FROM THE PROJECT: ANNEXURE- B

14. SUMMARY OF THE FINDINGS: ANNEXURE- C

15. CONTRIBUTION TO THE SOCIETY: ANNEXURE- D

16. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT: NO

17. NO. OF PUBLICATIONS OUT OF THE PROJECT: 05, ANNEXURE- E (REPRINTS ATTACHED)

OBJECTIVES OF THE PROJECT:

1. Preparation of vermicompost with inoculation of earthworm *Eisenia fetida* in the vermibed of different combinations of municipal solid waste and different animal wastes.
2. Preparation of vermiwash from different vermicomposts obtained from the mixture of municipal solid waste (MSW) and animal dung.
3. Preparation of combination of biopesticides of neem plant parts with vermiwash.
4. Chemical analysis of prepared vermiwash.
5. Observation of effect of foliar application of prepared mixture of vermiwash in combination with biopesticides of neem (*Azadirachta indica)* and neem plant parts on the growth, flowering and productivity of important crops.

Year wise plan of work and target have been achieved:

First Year:

Collection and preparation of vermicompost of animal dung and municipal solid wastes separately as well as mixed form. Biochemical analysis of Na^{+}, K^{+}, Ca^{++}, P, N, pH and electrical conductivity were measured of each vermibed at initial and final stage.

Second Year:

Vermiwash was extracted from each vermibed with rich population of earthworms. Different biopesticide were collected from neem plant part and prepared the mixture of different concentrations.

Third Year:

Measurement of growth, flowering, and productivity as well as pest infestation of some important crops after foliar application of mixture of vermiwash with biopesticides.

ANNEXURE- B

ACHIEVEMENTS FROM THE PROJECT:

1. Chemical analysis of initial feed material and vermiwash

The significant physico-chemical changes were observed in vermiwash of different combination of MSW with animal dung (cow, goat, buffalo, horse) with respect to initial feed mixture. The significant decrease in the levels of carbon, C/N ratio and pH was observed in these combinations.

However, the nitrogen, phosphorous, potassium and calcium increases significantly in final vermicompost of all the combination of animal dung with municipal solid wastes. The carbon content was significant highest (609.82±1.45 g/kg) in initial feed material of MSW and significantly lower (434.54±1.57 g/kg) in goat dung alone. In combination of cow dung with MSW in equal ratio, the maximum significant (28.31±1.85 g/kg) level of total Kjeldahl nitrogen was observed in vermiwash of final vermicompost of combination of MSW with goat dung in 3:1 ratio with respect to all the combination of feed materials.. The highest decrease 6.53 % pH and 84.74 % C/N ratio were obtained in cow dung alone.

The level of pH is shifted from neutral to slight basic in vermiwash obtained from all the combinations of feed materials of combinations of MSW with animal dung. The level of Total potassium was significantly highest (8.85±0.65g/kg) in vermiwash obtained from final vermicompost of feed material of combination of MSW with goat dung in 1:1 ratio whereas, the total available phosphorus was significantly high (10.85±0.45 g/kg) in vermiwash of MSW with horse dung in 3:1 ratio and (66.29 %) significant increase in total calcium in combination of MSW with goat dung in 3:1 ratio.

2. Effect of combination of vermiwash with biopesticide on the gram *(Cicer aritenum*) plant and infestation of *Helicoverpa armigera* (Hübner)

There was maximum significant germination 98.00±2.27 %.of gram seed was observed after soaking the seeds in mixture of vermiwash of MSW and buffalo dung with aqueous extract of neem leaf

.The foliar application of vermiwash obtained from MSW and buffalo dung with neem plant parts were significantly increased the growth of gram plant. There was time dependent significant growth was observed after sprays of vermiwash with different aqueous extract of neem plant parts. The maximum growth of gram 34.57±1.25 cm was observed in after 60 days by sprays of combination of vermiwash obtained from MSW and buffalo dung with neem leaf. Among all the treatments, the earliest flowering 24.00±1.42 days was observed after sprayed of mixture of vermiwash obtained from MSW and buffalo dung with aqueous of neem fruit.

The effect of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem plant parts on pod pest infestation of *Helicoverpa armigera* of gram (*Cicer aritenum*) plant was observed at 15 days interval. There was significant reduction in pod pest infestation of *Helicoverpa* ***armigera was observed after*** foliar spray of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem plant parts. The significant lowest pod pest infestation of gram pod borer was observed in combination of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit after 90, 105 and 120 days .The maximum number of pod per plant was observed 37.90±2.42 after foliar spray of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit followed 37.70±2.65 by vermiwash of MSW and buffalo dung with aqueous extract of neem bark. The maximum productivity of gram plant was observed 773.23±20.64 g/m^2 after foliar application of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit.

3. Effect of vermiwash with neem plant parts on the infestation of *Earias vittella* (Fabricius) and productivity of Okra (*Abelmoschus esculentus*) (L.) Moench

The significant effect of foliar application of mixture of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem plant parts on seed germination, gwroth, productivity and pod pest infestation of Okra (*Abelmoschus esculentus*) was observed . The earliest seed germination and highest growth of okra plant was observed after treatment of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem bark. The maximum productivity was observed 3.81±0.28 kg/plant after treatment of The effect of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit followed 3.56±0.29 kg/plant by vermiwash with neem bark. There was significant reduction in pod pest infestation of *Earias vittella* Okra of (*Abelmoschus esculentus*) was observed after after foliar application of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit after 90 days .

4. Effect of vermiwash with neem plant parts on the productivity of Brinjal and infestation of *Leucinodes orbonalis* (Pyraustidae: Lepidoptera):

The foliar application of aqueous mixture of combination of vemiwash with neem oil, leaf and bark have increased the brinjal plant growth early flowering ,increased productivity as well as caused a significant reduction in percent pod infestation of pest . The binary combination of vermiwash with neem oil, leaf and bark results significant growth of brinjal plant .The highest growth of brinjal was (30.01±0.86cm) observed after spray of vermiwash of buffalo dung and municipal solid wastes (MSW) with neem oil in comparison to all other treatments.The flowering period of brinjal in control was (74.07±0.79)days. Early flowering was observed in all the treatment of vermiwash with neem plant parts. The earliest flowering of brinjal was (60.01±0.56) days after foliar spray of vermiwash of buffalo dung and MSW (2:1) with neem oil followed by buffalo dung and MSW (2:1) with neem bark (62.26±0.10) days and neem leaf (63.14±0.59) days.

The significant increase in productivity of brinjal was observed in all the combination of vermiwash obtained from different combination of animal dung and MSW with neem plant parts. The significant maximum productivity of brinjal (7.16±0.59) was obtained after foliar application of combination of vermiwash obtained from buffalo dung and MSW with neem oil .

5. Combined effect of liquid biofertilizer with biopesticide on yield of tomato (*Solanum lycopersicum* L.) and infestation of *Helicoverpa armigera:*

The combination of vermiwash obtained from animal dung and MSW with biopesticides neem (*Azadiracta indica*) oil, aquous extract of leaf, bark and vermiwash alone caused significant growth, start early flowering , enhance productivity as well as significant reduction ($P>0.05$) in pest infestation of tomato crop. The highest growth of tomato (50.09±1.29 cm) was observed in foliar application of mixture of vermiwash with neem oil in ratio of (2:1). The significant early flowering was observed in all the treatments of vermiwash with aqueous extract of neem plant parts.

The maximum significant early flowering period of tomato was (90.90±1.03) days in treatment of vermiwash of buffalo dung and MSW (2:1 ratio) with neem oil. The significant increase in productivity of tomato was observed in all the combinations of vermiwash of buffalo dung and municipal solid wastes singly and in binary combination with neem- oil, aqueous leaf and bark extract. The combinations of buffalo dung and MSW with neem oil have maximum productivity of tomato (8.01 kg/m_2) in comparison to all the treatments. The significant reduction in infestation of *H. armigera* was observed in foliar application of all the combinations of vermiwash with neem plant parts. The minimum pest infestation of *H. armigera* was obtained in vermiwash obtained from combination of buffalo dung and MSW (2:1 ratio) with neem oil.

All experiments were replicated six times. The t-test was applied between the different parameter of vermiwash of initial feed mixture and final vermiwash. Correlation matrix calculated among chemicals of vermiwash of combination of MSW with different animal dung . DMRT was used for determination of significance in each column of growth, flowering and productivity of crops. The significant ($P< 0.05$) was found after analysis of variance(ANOVA) applied in between different treatment and different parameters.

It can be concluded from results that the vemicomposting is a best method for wastes management and production of biofertilizer. The vermiwash obtained from the combination of MSW and buffalo dung with aqueous extract of neem plant parts (leaf, bark, fruit and oil) is the best combination of liquid biofertilizer with bio-pesticide because it have significant effect on seed germination, growth, flowering, productivity and reduction in pest infestation rate of of Okra , Gram, tomato and Brinjal crops. Farmers can be aware for the use of binary combination of biofertilizers with bio-pesticides for better reduction in pest infestation and productivity of crops, because it is the best alternative of synthetic chemical fertilizers and pesticides.

Annexure- C

SUMMARY OF THE FINDINGS:

The municipal solid wastes (MSW) caused environmental hazards and various ill effects on human life and their domestic animals. Management of MSW through vermicomposting by the help of epigeic earthworm *Eisenia fetida* had an appropriate alternative technology for recycling and production of organic fertilizers. The significant decrease in pH, C/N ratio and organic carbon whereas, significant increase in the level of potassium, phosphorus and calcium in different combinations of vermiwash of MSW with animal dung with respect to the initial feed mixture were observed. The organic carbon was significantly decreased 67.42 % in combination of MSW with goat dung in ratio of 3:1). The pH of initial mixture in all combinations was tending to acidic/neutral nature. The nitrogen content in vermiwash was also significantly increased 68.02% in combination of MSW with goat dung in 1:1 ratio) whereas, maximum organic nitrogen observed 28.31 in combination of MSW to goat dung in 3:1 ratio). The C/N ratio in all vermiwash was ranged 6.80 to 25.30 and significantly decreased after vermicomposting .

The foliar applications of combinations of vermiwash obtained from animal dung and MSW with aqueous extract of neem (*Azadiracta indica*) leaf, bark and fruit as well as vermiwash alone caused significant growth, start early flowering , enhance productivity as well as significant reduction (P>0.05) in pest infestation of Okra , Gram, tomato and Brinjal crops. Okra (*Abelmoschus esculentus*) is a popular and worldwide commercially cultivated vegetable crop. The significance germination 97±5.21% of okra seeds was obtained after treatment of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem bark than the other combinations. The maximum growth of Okra 42.42±0.79 cm was observed in after 90 days by sprays of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem bark. The combination of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit) was important for high productivity of Okra. The maximum productivity of Okra plant was observed 773.23±20.64 g/m2 in treated with vermiwash with aqueous neem fruit. The lowest pest infestation of okra pod borer (*Earias vittella)* was observed after spray by vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit combination.

The highest growth of tomato (50.09±1.29 cm) and maximum significant early flowering were observed after foliar application of mixture of vermiwash with neem oil in ratio of (2:1) whereas, the maximum significant early flowering period obtained after treatment of vermiwash of buffalo dung and MSW (2:1 ratio) with neem oil. The combinations of buffalo dung and MSW with neem oil in ratio 2:1 have also maximum productivity (8.01 kg/m2) and minimum pest infestation of *Helicoverpa armigera* of tomato crop. The foliar application of combinations of liquid biofertilizers with biopesticides is an appropriate technology for sustainable agriculture.

In India, Gram (*Cicer aritenum*) pulse is major sources of protein in human diet but its production decreased day to day due to infestation of *Helicoverpa armigera*. The significant germination, growth and productivity (g/m2) was observed after the foliar spray of vermiwash with aqueous extract of neem (*Azadirachta indica* A. Juss.) fruit with respect to control. The maximum reduction infestation of *H. armigera* pod per plant was observed 37.90±2.42 after foliar spray of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit followed 37.70±2.65 by vermiwash of MSW and buffalo dung with aqueous extract of neem bark. The maximum productivity of gram plant was observed 773.23±20.64 g/m^2 after foliar application of vermiwash obtained from MSW and buffalo dung with aqueous extract of neem fruit.

Lucinoides orbonalis is a serious pest of Brinjal which caused 70-80% economic loss productivity in eastern Uttar Pradesh . The foliar application of mixture of combination of vermiwash obtained from animal dung and municipal solid wastes (MSW) with biopesticides (neem leaf, bark and oil) have significant increase in early flowering, growth, and productivity as well as reduction in pest infestation of Brinjal. The combination of vermiwash of buffalo dung and MSW (2:1 ratio) with neem oil is a best combination for better growth, early flowing and productivity as well as pest infestation reduction.

It is evident from the results, the vermibiotechnology is a better technology for management of MSW with animal dung and production of liquid biofertilizer (vermiwash). The use of vermiwash with biopesticides is better for growth, flowering and productivity as well as reduction in pest infestation of crops. The production and use of vermiwash and biopesticides are less expensive, non hazardous and eco-friendly for human as well as animal health.

Annexure- D

Contribution to the society from project work:

Indiscriminate use of chemical fertilizers disturbs the soil texture and physico-chemical properties of soil as well as affects the human health and environment. The biological wastes caused environmental hazards and various ill effects on human life and their domesticated animals, if their proper management and disposal practices are not available. The vermicomposting is a best technology for the recycling of wastes and production of biofertilizers from different wastes by use earthworms *Eisenia fetida*. Through chemical analysis, farmers can be suggested that the final product of which combinations of feed materials having potential amount of nutrients and that recognized combinations of wastes are suitable for particular deficient soil as biofertilizer for organic farming and also helps in obtaining chemical composition of vermicomposts. Organic farming through vermicomposting is a better option for management of wastes by the earthworms and improvement of soil quality. It is one of the interesting aspects, since it contribute to a broad relationship among food, environmental quality and safety of human and animal health. *Eisenia fetida* is a suitable earthworm species for vermicomposting because it can tolerate wide variation of ecological factor, high feeding and fecundity rate. Earthworms play an important role in stabilization of inorganic plant nutrients to organic form and increased the soil fertility.

It is evident from the present study that different combinations of vermiwash obtained from final vermicompost of different combinations of MSW and animal dung with different biopesticides have significant effect on growth, start early flowering and enhanced the productivity as well as reduction in pest infestation of *important crops.* The vermiwash (liquid biofertilizer) and biopesticides are easily producible, biodegradable, less expensive and non hazards to environment and human health. These products were ecologically safe and culturally more acceptable among farmers and live –stock keepers. These vermic products will be easily biodegradable, less expensive and more natural than synthetic biofertilzer. This type of small industry will also improve the socio-economic condition of the farmers in village. So we can say that vermiwash is a biotechnological tool which is ecologically sound and culturally most acceptable among farmers.

Annexure-E

Details of the Publications resulting from the project work:

1. Harendra Kumar Chauhan and **Keshav Singh** (2014). Estimation of physico-chemical properties of liquid biofertilizer (Vermiwash) of different combinations of MSW with animal dung through vermicomposting by earthworm *Eisenia fetida*. **Global Journal of Biology, Agriculture & Health Sciences *3(4* ISSN: 2319 – 5584 (In press).**

2. Harendra Kumar Chauhan and **Keshav Singh** (2014). Potency of Vermiwash with *Azadirachta indica* A. Juss on Yield of Gram (*Cicer arietinum*) and Infestation of *Helicoverpa armigera* (Hübner). **American-Eurasian Journal of Toxicological Sciences** 6 (4): 87-93, DOI: 10.5829/idosi.aejts.2014.6.4.85165. (ISSN 2079-2050).

3. **Keshav Singh** and Harendra Kumar Chauhan(2015).Potancy of Vermiwash with Neem plant parts on the Infestation of *Earias vittella* (Fabricius) and Productivity of Okra (*Abelmoschus esculentus*) (L.) Moench. **Asian J. Res. Pharm. Sci**., Vol. 5: (1): 36-40. **ISSN- 2231–5659 (Online), ISSN- 2231–5640 (Print).**

4. Shashi Kant. Tiwari and **Keshav Singh** (2015). Potency of combination of liquid biofertilizer with biopesticide on productivity of Brinjal and infestation of *Leucinodes orbonalis* (Pyraustidae: Lepidoptera), **Int. J. Pure App. Biosci.** 3 (5): 62-72. doi: 10.18782/2320-7051.2108.

5. Shashi Kant. Tiwari and **Keshav Singh** (2016).Combined effect of liquid biofertilizer with biopesticide on yield of tomato (*Solanum lycopersicum* L.) and infestation of *Helicoverpa armigera* (Hubner**). J. Bio. Innov.** 5(1), pp: 144-163, ISSN 2277-8330.

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RESEARCH ARTICLE

Potancy of Vermiwash with Neem plant parts on the Infestation of *Earias vittella* (Fabricius) and Productivity of Okra (*Abelmoschus esculentus*) (L.) Moench

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ABSTRACT:
Okra (*Abelmoschus esculentus*) is a popular and worldwide commercially cultivated vegetable crop. Abundant use of chemicals in agriculture for the productions of vegetable leads to concentration on plant and soil. The municipal solid wastes (MSW) caused environmental hazards and various adverse effects on ecosystem, if proper management is not available. There was recycling of MSW through vermibiotechnology and vermiwash production. The aim of present study was to determine the effect of vermiwash with neem plant parts on the germination, growth, productivity of okra and its pest infestation. The significance germination of okra seed in vermiwash with aqueous extract of neem bark (VW+NB) 97±5.21% than other combinations and early germination was observed (11.48±0.49 days). The maximum height of okra 42.42±0.79 cm was observed in after 90 days by sprays of VW+NB. The combination of VW+NF was important for high productivity of okra. The maximum productivity of okra plant was observed 773.23±20.64 g/m^2 in treated with VW+NF. The lowest pest infestation of okra pod borer (*Earias vittella)* was observed after spray by VW+NF combination.

KEYWORDS: Wastes, *Eisenia fetida,* vermiwash, vermibiotechnology, *Earias vittella* growth and productivity, okra.

1. INTRODUCTION:
Abundant use of chemical fertilizers and pesticides leads to concentration of chemicals and metals, which ultimately affect the ecosystem. The agricultural production based on chemical fertilizers and pesticides are dangerous for soil fertility and conservation (Brady and Weil, 2002). The excessive use of phosphatic, nitrogenous and potash fertilizers pollute the water and food items, causing serious health problems and eutrophication in aquatic (Bhattacharya, 2004). Vegetables play a very important role in global food security. The low proportion of vegetables in dietary composition play important role in improvement of malnutrition.

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Okra (*Abelmoschus esculentus* (L.) *Moench*) is a popular and worldwide commercially cultivated vegetable crop, commonly called bhendi or ladies finger in India. Besides being a vegetable, it acts as clarifying agent in jiggery preparation (Chauhan, 1972). Crude fiber derived from the stem of okra plant is used for rope making. Okra is said to be very useful against genitourinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). It occupies an area of 3.70 lakh ha with an annual production of 36.57 lakh t and encourage yield of 9.88 t/ha during 2005-06 (Anon., 2005). Major okra producing states are Uttar Pradesh, Bihar, West Bengal, Andhra Pradesh, Karnataka and Assam (Anon., 2004). Okra belong to family Malvaceae which have been infested by nineteen insect pests and four mites (Anon., 2000) causing both quantitative and qualitative loss to the crop.

Shoot and fruit borer of okra, *Earias vittella* is a notorious pest causing more than 40-50 per cent losses in cotton and okra crops, it caused 69% loss in okra alone. *E. vittella* occurs generally as an early to mid-season pest attacking tender terminal shoots, boring into the stem and feeding on flowers and green bolls (Kranthi et al.,2004). The fruit borers include shoot and fruit borers *Earias vittella* (Fabricius) alone causes damage ranging from 52.33 to 70.75 per cent whereas, in general the overall damage due to insect pest amounts to 48.97 per cent loss in pod yield (Pareek and Bhargava, 2003;Kanwar and Ameta, 2007).

Neem (*Azadirachta indica*) commonly called 'Indian Lilac' or 'Margosa', belongs to the family Meliaceae, tribe Melieae. Neem is the most versatile, multifarious trees of tropics, with immense potential. It possesses maximum useful non-wood products (leaves, bark, flowers, fruits, seed, gum, oil and neem cake) than any other tree species (Roxburg, 1874; Girish and Shankara Bhat 2008). Biswas et al. (2002) reported that the nimbidin has anti-inflammatory, antiarthritic, antipyretic, hypoglycaemic, antigastric ulcer, spermicidal, antifungal, antibacterial, diuretic whereas, nimbin has spermicidal, nimbolide- ntibacterial, antimalarial, antifungal, antimalarial. The municipal solid wastes (MSW) caused environmental hazards and various effects on human life and their domestic animals, if their proper management and disposal practices are not available. Although some research works have been done on the potential of earthworms in vermicomposting of solid wastes particularly household and agro-wastes. The epigeic earthworm species *Eisenia fetida* is a suitable earthworm species for vermicomposting which have short life cycle, small size and high rate of conversion of organic wastes as well as reproduction (Nath and Singh, 2012; Chauhan and Singh, 2012). Different microorganisms (bacteria, actinomycetes, algae and fungi) were colonized in the intestine of earthworm and as a result the concentration of various enzymes, plant hormones, growth stimulator, and vitamins were increased directly or indirectly during vermicomposting (Suthar, 2010). Vermicomposting of MSW by the help of *Eisenia fetida* had an appropriate alternative for safe, hygienic and cost effective disposal of municipal solid wastes and convert to good quality liquid biofertilizers.

The aim of present work to observed the suitable combination of vermiwash from municipal solid wastes with neem based biopesticides for the proper germination, growth, productivity and minimize the pest *Earias vittella* infestation.

2. MATERIAL AND METHODS:

2.1. Collection of MSW and experiment set up for vermicomposting

Municipal solid wastes (MSW) and buffalo dung were collected from the local municipality and form house of Gorakhpur city. Vermibeds were prepare from municipal solid wastes and buffalo dung (in 1:1 ratio) and for pretreatment exposed to the sunlight for 5 to 10 days to remove the various harmful organism and noxious gases. After pretreated, adult earthworms *Eisenia fetida* were inoculated in each vermibed for vermicomposting. The vermireactors had covered with a fine mesh screen in order to prevent the worms in bed and allow gas exchange and also moisten daily up to 40-50 days for maintaining the moisture (50% to 60% RH). After one week interval vermibed were turned manually. The tea like granules, brown color have been appearance on the upper surface of each vermibed after 90 days; fresh vermicompost collected for extraction of vermiwash (Nath et al., 2009).

2.4. Extraction of vermiwash

Vermiwash were extracted from prepared fresh vermiwash with earthworms by the help of vermiwash collecting device. The apparatus is made from plastic drum having capacity of two liter and a tap at the bottom. The drum is filled with broken bricks, about 3 cm thickened which is followed by sand layer of 2-3 cm thickness lastly filled with vermicompost with earthworms, simultaneously one liter fresh water was added in to the drum and after 10 hours a container kept below the tap for the collection of vermiwash (Nath et al., 2009).

2.5. Extraction of neem (Azadirachta indica A. Juss.) plant parts

Neem leaves, bark and fruit were collected from the campus of DDU Gorakhpur University, Gorakhpur U.P. India, dried in direct sunlight for two weeks, with periodic turning. The dried each 100 g leaves (NL), barks (NB) and fruits (NF) materials were grounded and sieved through 2 mm sieve and ground material was soaked in kerosene (100 ml) over night and extract was squeezed using a thin muslin cloth. Then extract was made up to 5000 ml by using water and slightly worm to obtain 5 per cent (further used as stock solution) of NL, NB and NF respectively. Neem based bio-pesticides mixed with vermiwash (1:1 ratio) which further diluted by with water (VW+NB stock solution: water in 1:10). Prepared vermiwash with biopesticides spread in okra crop at the interval of 15 days, and first spray 10 days after showing.

2.6. Measure the growth, production of Okra (Abelmoschus esculentus) and Earias vittella pest infestation

The Okra seeds (*Abelmoschus esculentus*) variety- Arka Abhay, showed in agricultural field of Zoology research building II, Department of Zoology, D. D. U. Gorakhpur University Gorakhpur, UP India. In the cultivated field, randomly selected six spots, each square meter area was used for sowing the pulse crops. The effect of vermiwash with neem bio-pesticides was measured on the germination, for this seeds soaked in different combinations for 24 h and observed result in per cent.

For measurement of okra growth (cm.) randomly selected plant from each spot and use Auxanometer at the interval of 15 days after 30 days of sowing. The productivity was measured as kg/plant of okra crops. The different combinations of vermiwash with neem biopesticides was sprayed over the crops after each 20 days interval for the measurement of growth whereas, at the time of starting of flowering after each 10 days interval the different combinations of vermiwash with biopesticides was sprayed over the crops and control have no treatment.

2.7. Statistical Analysis
All the experiments were replicated six times for the purpose of obtaining consistency in the result and finding out the mean with standard error. DMRT used for determined the significance in each column as growth, flowering as well as productivity of crops (Dhamu and Ramamoorthy, 2008).

3. RESULTS:
The effect of vermiwash and with neem based biopesticides on germination of Okra (*Abelmoschus esculentus*) seed was observed for 24 h. There was significant germination of okra seed in vermiwash (VW) with aqueous extract of neem plant parts 90±2.87 to 97±5.21% than control 75±3.32%. The early germination of okra seeds were observed significantly by treated with vermiwash with neem plant parts (15.12±0.64 to 12.25±0.36 days) than control (15.12±0.64 days) (Table 1).

The data displayed in Table 2 foliar spray of vermiwash obtained from MSW and buffalo dung with neem plant parts were significantly increased the height of okra plant. There was time dependent significant growth was observed after sprays of VW with different aqueous extract of neem plant parts. The maximum height of okra 42.42±0.79 cm was observed in after 90 days by sprays of VW+NB combination and also this combination showed high growth rate of okra plant (Fig. 1).

Table 1. Effect of vermiwash of MSW of buffalo dung with aqueous extract of neem plant parts on the germination per cent and period (days) of okra seed.

Particulars	Germination (%)	Germination period (days)
Control	80	15.12±0.64b
VW	90	12.25±0.36a
VW +NL	92	11.67±0.87a
VW +NB	95	11.48±0.49a
VW +NF	93	11.78±0.96a

Liquid extract of neem based leaf (NL), bark (NB), and fruit (NF), VW= vermiwash of buffalo dung with municipal solid wastes (MSW). Each value is the mean ± SD of six replicate. *Mean differences in column followed by common letter are not significant at P<0.05 (DMRT).

Table 2. Effect of different vermicomposts of MSW of buffalo dung with aqueous extrat of neem part on the growth (cm) and productivity (kg/plant) of okra crop.

Wastes combinations	Growth (in cm)					Productivity (kg/plant)
	30 days	**45 days**	**60 days**	**75 days**	**90 days**	
Control	11.46±1.02	13.24±1.03	17.20±1.01	26.35±1.46	27.20±0.86	1.32±0.26
VW	14.97±1.69	19.14±1.25	31.26±1.45	33.67±2.88	35.54±0.98	2.96±0.21
VW +NL	15.84±1.26	21.28±1.57	33.09±1.46	38.00±1.41	39.20±0.41	3.23±0.54
VW +NB	16.18±1.38	23.72±1.28	32.76±1.26	40.83±1.83	42.42±0.79	3.56±0.29
VW +NF	15.15±1.23	24.29±1.45	34.24±1.74	39.21±1.41	39.98±0.62	3.81±0.28

Table 3. Effect of different combinations of vermiwash of municipal solid wastes and neem plant parts on productivity of okra plant and pest infestation of *Earias vittella.*

Particulars	**Pod pest infestation (%) after**			
	30 days	**45 days**	**60 days**	**75 days**
Control	1.07± 0.05b	2.28± 0.05b	8.36± 0.78b	16.59± 0.54c
VW	0.77± 0.03ab	1.10± 0.03ab	5.65± 0.58ab	10.30± 0.87b
VW +NL	0.21± 0.03a	0.44± 0.02a	1.12± 0.13a	0.67± 0.04a
VW +NB	0.20± 0.02a	0.38± 0.03a	1.72±0.31a	0.13± 0.02a
VW +NF	0.04± 0.05a	0.13± 0.05a	1.15±0.22a	0.12± 0.04a

Liquid extract of neem based of leaf (NL), bark (NB), and fruit (NF). Each value is the mean ± SD of six replicate. *Mean differences in column followed by common letter are not significant at P<0.05 (DMRT).

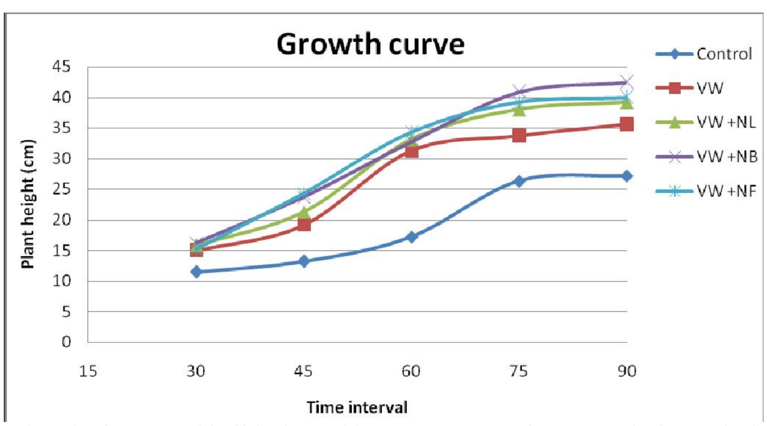

Fig. 1 Effect of different vermi wash of MSW and buffalo dung with aqueous extract of neem part leaf (NL), bark (NB), and fruit (NF) on the growth (cm) of okra (*Abelmoschus esculentus*) crop.

The effect of VW and with aqueous extract of neem plant parts on *Earias vittella* pest infestation (kg/plant) of Okra (*Abelmoschus esculentus*) plant was observed. The effect of foliar spray of vermiwash obtained from MSW and buffalo dung alone and with neem based biopesticides on the productivity of Okra (*Abelmoschus esculentus*) plant was studied. The maximum productivity was observed 3.81±0.28 kg/plant in treated with VW+NF followed 3.56±0.29 kg/plant by VW+NB. The productivity of okra plant (2.96±0.21 to 3.81±0.28 kg/plant) was observed in treated with vermiwash with aqueous extract of neem plant part than control (1.32±0.26 kg/plant) (Table 2).

There was significant reduction of *Earias vittella* pest infestation (individual@100 pods) after foliar spray of vermiwash with aqueous extract of neem plant parts. The significant lowest pest infestation of okra pod borer was observed in combination of VW with NF after 90, days (Table 3).

4. DISCUSSION:

The vermiwash with aqueous extract of neem plant parts showed significant germination of Okra (*Abelmoschus esculentus*) plant may be due to presence of different plant hormones and micro-macro nutrients in vermiwash. Vermiwash of different wastes are rich source of enzymes, vitamins, plant growth hormones (such as IAA, gibberellins, cytokinins) and also provide nutrients (such as phosphorus, potassium, calcium etc.) (Pathak and Ram, 2004; Ansari and Sukhraj, 2010; Gopal et al., 2010; Nath and Singh, 2011; 2012). The significantly increased the growth of okra plants was observed due to foliar spray of vermiwash and neem based biopesticides. Zambare et al. (2008) have observed that vermiwash supplemented with enzyme of proteases, amylases, urease, phosphatases, nitrogen fixing bacteria like *Azotobacter* sp, *Agrobacterium* species and *Rhizobium* sp which may be important of okra growth. In this study it was observed that no major role of neem based biopesticides on the growth of okra plant because there was no significant growth in treatment with VW and with different part of neem based biopesticides. Nath and Singh (2011) observed the significant growth of cauliflower after foliar spray of vermiwash of animal dung with agro and kitchen wastes. The effect of vermiwash and different neem based biopesticides were observed in the flowering of okra plant may be due to the presence of important inorganic and organic nutrient for flowering present in vermiwash. The hormones auxines promotes the plant growth and gibberellins stimulate the early flowering in long photo-period plant (Krishnamoorthy and Vajranbhiah, 1986; Edwards, 1998). Vermiwash/vermicompost was enriched in certain metabolites and vitamins which important for plant growth and productivity (Lalitha et al., 2000; Ansari, 2008a; b).

The effect of foliar spray of vermiwash obtained from municipal solid wastes and buffalo dung with neem based biopesticides showed significant productivity of okra plant may be due to vermiwash and neem based biopesticides which also protect the pod/grains. The maximum no. of pod per plant was observed in treated with VW+NF > VW+NB showed that neem based fruit biopesticides were more protective than bark. Large amount of humic acids was produced during vermicomposting (Albanel et al., 1988) and, humic acid extracted in vermiwash. The highest no. of seed per pod was observed in VW > BF which reviled that vermiwash was responsible for no. of grain in okra pod. There was no significant difference of fresh seed weight because in control even small no. of pod and or grain observed but it size and weigh large. Presence of essential nutrients which were absorbed by plants and increase metabolic rate and enhance the crop productivity (Edwards et al., 2006).

There was significant pest infestation in control >VW after 100 days, this observation showed effect of neem based biopesticides. The significant low pest infestation of okra pest was observed 100 days by treatment with VW+BF which showed the maximum use fruit as pesticides. Ponnusamy (2003) reported that the reduction in bug population by application of neem based biopesticides on rice crop. Nath et al. (2008) recorded that significant reduction in the population of *Helicoverpa armigera* larvae after spray of vermiwash with neem based pesticides on the *Cajanus cajan* crop. Wondafrash et al. (2012) was also observed that the water extract obtained from neem leaf extract caused significant decrease in feeding and survival behavior of insect pest. The active component azadirachtin reduced the feeding behavior of larvae of various lepidopterous insects. Oligophagous species were more sensitive than polyphagous ones (Schmutterer, 1984). The volatiles of neem seed kernel prevented contract and repelled the moths H. armigera (Rembold et al., 1984). Heyde et al. (1984) demonstrated that the spraying of 1-50% emulsion of neem oil significantly reduced the food intake of homopterous insects. The increase the productivity of okra crop may be due to presence of replant active compound, non-isoprenoids, sulphurous compounds, polyphenolics such as flavonoids and their glycosides, dihydrochalcone, coumarin and tannins, aliphatic compounds, phenolic acids, etc. (Govindachari, 1992; Biswas et al 2002; Siddiqui et al., 2004).

5. CONCLUSION:

The use of vermiwash and biopesticides are less expensive, non hazardous and eco-friendly for human as well as animal health. The present study is information about the management of MSW through recycling and production of vermiwash. With the help of vermiwash and biopesticides enhance growth, flowering and productivity as well as reduction of Okra (*Abelmoschus esculentus*) pest infestation. The used of vermiwash and neem based biopesticides have significant per cent germination of seed, growth, early flowering, productivity and reduced the reduced the *Earias vittella* pest infestation.

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ESTIMATION OF PHYSICO-CHEMICAL PROPERTIES OF VERMIWASH OF DIFFERENT COMBINATIONS OF MSW WITH ANIMAL DUNG THROUGH VERMICOMPOSTING BY EARTHWORM *EISENIA FETIDA*

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Abstract

The municipal solid wastes (MSW) caused environmental hazards and various ill effects on human life and their domestic animals. Managment of MSW through vermicomposting by the help of epigeic earthworm *Eisenia fetida* had an appropriate alternative technology for recycling and production of organic fertilizers. The significant decrease in pH, C/N ratio and organic carbon whereas, significant increase in the level of potassium, phosphorus and calcium in different combinations of vermiwash of MSW with animal dung with respect to the initial feed mixture were observed. The organic carbon was significantly decreased 67.42 % MG_{25} (MSW with goat dung in ratio of 75:25). The pH of initial mixture in all combinations was tending to acidic/neutral nature. The nitrogen content in vermiwash was significantly increased 68.02% in MG_{50} (MSW with goat dung in ratio of 50:50) where as maximum organic nitrogen observed 28.31 in MG_{25} (MSW to goat dung ratio 75:25). The C/N ratio in all vermiwash was ranged 6.80 to 25.30 and significantly decreased in initial feed mixture. Data obtained from present study is helpful to prepare the specific type of combination of vermiwash for particular nutrients. The aim of present study was to investigate the production and characteristics of vermiwash of MSW with different animal dung by earthworm *Eisenia fetida*.

Key word: Municipal solid wastes, animal dung, *Eisenia fetida*, vermicomposting, vermiwash, physico-chemical analysis.

Introduction

The municipal solid wastes (MSW) caused environmental hazards and various ill effects on human life and their domestic animals, if their proper management and disposal practices are not available. The need of MSW management which caused serious concern due to the dumping sites near the road/population side and they also create noxious gases and other pollution problems. Although some research works have been done on the potential of earthworms in vermicomposting of solid wastes particularly household, MSW, livestock excreta and agro-wastes in to potent organic fertilizers (Nath *et al.* 2009; Bhartiya and Singh 2012; Chauhan and Singh 2012; 2013).

Indiscriminate use of chemical fertilizers and pesticide in agriculture has been disturbed the soil texture and physicochemical properties as well as affect the human health and environment (Gupta 2005; Mall *et al.* 2005; Meena 2007). Loss of tests and flavors in food materials takes place and more susceptible to diseases with loss of their storage and keeping quality (Eastman *et al.* 2001). Nutrients like protein, amino acids, ascorbic acid reduced in foodstuffs by use of nitrogenous, phosphatic fertilizers in soil due to used of chemical fertilizers and pesticides (Marinari *et al.* 2000).

The epigeic earthworm species *Eisenia fetida* is a suitable earthworm species for vermicomposting which have short life cycle, small size and high rate of conversion of organic wastes as well as reproduction (Nath *et al.* 2009; Chauhan and Singh 2012). Different microorganisms (bacteria, actinomycetes, algae and fungi) were colonized in the intestine of earthworm and as a result the concentration of various enzymes, plant hormones, growth stimulator, and vitamins were increased directly or indirectly during vermicomposting (Suthar 2010).

Vermicomposting of MSW by the help of epigeic earthworm had an appropriate alternative for safe, hygienic and cost effective disposal of municipal solid wastes and convert to good quality liquid biofertilizers. The aim of present study was to investigate the production and characteristics of vermiwash of MSW with different animal dung by earthworm *Eisenia fetida*.

Materials and Methods

Collection of wastes

Municipal solid wastes were collected from the local municipality from the Gorakhpur city. Animal wastes viz. buffalo, cow, goat and horse dung was collected from different form houses of Gorakhpur city. Municipal solid wastes and different animal dung (buffalo, cow, goat and horse dung) were sprayed in layer of about 0.25 to 0.75 m for aeration and solarization. After this wastes were exposed to the sunlight for 5 to 10 days to remove the various harmful organism and noxious gases.

Collection of earthworm

Earthworm *Eisenia fetida* used for experiment was obtained from Vermiculture Research Centre, Department of Zoology, D. D. U. Gorakhpur University, (U.P.) India.

Experiment set up for vermicomposting

Vermibeds of animal dung with MSW in different ratios were prepared on the cemented earth surface. Five proportions of MSW with different animal dung were taken for preparation of vermibeds (Table 1). The size of each vermibed was (30 cm 9 30 cm 9 10 cm). Thus, formed vermibeds were moistened daily and incubated 50 adult individual of E. fetida placed in each vermibed. They were covered with jute pockets and moisten daily up to 40–50 days for maintaining the moisture (50–60 % RH). After 1-week interval, vermibed was turned manually. After 50–60 days, tea-like granular vermicompost appears on the upper surface of each vermibed (Nath *et al.* 2009).

Extraction of vermiwash

Vermiwash were extracted from vermicompost of different combination of MSW and animal dung in different ratio (100:0, 75:25, 50:50, 25:75, 0:100 w/w) with abundant earthworms by the help of vermiwash collecting device. The apparatus is made from plastic drum having capacity of two liter and a tap at the bottom. The drum is filled with broken bricks, about 3 cm thickened which is followed by sand layer of 2-3 cm thickness. The vermiwash collecting device was filled by 1kg vermicompost with more *Eisenia fetida* earthworms population, simultaneously 1l fresh water was added in to and after 10h a container kept below the tap for the collection of vermiwash. The watery extract fresh vermiwash drained out off use for the chemical estimation and stored at 10°C for further use (Nath *et al.* 2009).

Chemical Analysis

The pH was determined by using a double distilled water suspension of each waste in the ratio of 1:10 (w/v) that has been agitated mechanically for 30 minutes and filtered through Whatmans No.1 filter paper. Organic carbon was measured by the method of Nelson and Sommers (1982). Kjeldahl nitrogen determined after digesting the sample with conc. H2SO4 and. HClO4. (9:1 v/v) according to the method of Bremner and Mulvaney (1982). Total Phosphorus was analyzed by using the colorimetric method with molybdenum in sulfuric acid (Garg *et al.* 2005). Total potassium determined after digesting the sample in diacidic mixture (conc. HNO3: conc. HClO4=4:1, v/v), by flame photometer (Elica, CL 22 D, Hyderabad, India).

Statistical Analysis

All experiments were replicated six times. The t-test was applied between the different parameter of vermiwash of initial feed mixture and final vermiwash. Correlation matrix calculated among chemicals of vermiwash of combination of MSW with different animal dung (Dhamu and Ramamoorthy, 2008).

Results

The significant physico-chemical change was observed in vermiwash of different combination of MSW with animal dung (cow, goat, buffalo, horse) with respect to initial feed mixture (Table 2-3 and Fig. 1-2). Significant decrease in the levels of carbon, C/N ratio and pH was observed in all the combinations of feed materials. Table 4 showed the linear correlation coefficients between the different chemical parameters. There were moderate-to-high correlations between the different parameters.

However, the nitrogen, phosphorous, potassium and calcium were increases significantly in vermiwash in all the combinations of livestock's excreta with municipal solid wastes. The carbon content in initial feed material was significant high (609.82±1.45 g/kg) in MSW and lower (434.54±1.57 g/kg) in MG_{100}. The total Kjeldahl nitrogen was significant highest (14.25±1.26 g/kg) in pre treated vermibed of MC_{50} whereas after vermicomposting significant highest (28.31±1.85 g/kg) was observed in vermiwash of MG_{25}. The maximum increase Kjeldahl nitrogen (68.02%) was noted in MG_{75} during vermicomposting. The pH was observed 7.24±1.15 to 7.85±1.55 in initial feed material of different combination of MSW whereas, 6.87±1.03 was noted alone in MSW for vermicomposting. The maximum 6.53 % decrease in the level of pH in MC_{100} and the C/N ratio in 84.74 % at level of 12.77±1.82 were noted. The level of pH was shifted from neutral to slight basic in vermiwash obtained from all the combinations. The C/N ratio in initial feed material was ranged from 34.82±1.87 in MC_{50} to 83.25±1.58 in MG_{100} combinations and after vermicomposting in vermiwash was significantly decreased 6.80±1.38 to 25.30±1.58 level (Table 2, Fig. 1).

Total potassium was significant lowest (5.24±0.53 g/kg) in initial feed mixture of MC_{100} while highest (8.85±0.65 g/kg) in vermiwash of MG_{50}. Phosphorus content ranged from 3.87±0.47 g/kg in MC_{75} to 9.35±0.51 in MH_{25} before vermicomposting. The total available phosphorus was significantly high (10.85±0.45 g/kg) in vermiwash of MH_{25}. The total calcium was observed significantly high (6.21±0.43 g/kg) in vermiwash of MG_{25}, whereas maximum significant increase (66.29 %) calcium was observed in combination of MG_{25} (Table 3, Fig. 2).

Table 4 shows the correlation matrix between different chemical parameters. There was some positive and negative correlate observed. Total Kjeldahl nitrogen was closely correlate with C/N ratio and total potassium was positively correlate to pH, total phosphorus, and total calcium ($p<0.001$).

Discussion

The significant change were obtained in physico-chemical properties of vermiwash of vermicompost of animal dung with MSW with respect to control. The feed materials of earthworm have became physico-chemicaly changed after vemicomposting due to the vermic activity of earthworm *Eisenia fetida* (Gupta 2005).Earthworms also play an important role in stabilization of inorganic to organic plant nutrients form and increase the soil fertility (Ranganathan 2006). The vermicomposting process increases the mineralization rate. In vermiwash add the organic nutrients many times along with plant growth hormones and vitamins (Atiyeh *et al.* 2002). During vermicomposting increases the soil nutrients, micro-flora, and convert organic wastes into valuable products in end product (Ndegwa and Thompson 2001; Garg and Kaushik 2005; Payal *et al.* 2006).

When organic wastes pass through the gut of worm, the nutrients get converted from unavailable form to available forms, which consequently enrich the worm cast with higher quality plant nutrient (Gupta and Garg 2008). The carbon content was significant highest in initial feed material of MSW, it may be due to presence of high amount of organic compound in MSW (Kaviraj and Sharma 2003) and due to feeding action of earthworm and degradation by microbes in the intestine of earthworm (Kaushik and Garg 2003; Suthar 2007; Venkatesh and Eevera 2008).

The C/N ratio decreased in the all combination of MSW with animal dung due to microbial decomposition is one of the major factors (Nath *et al.* 2009; Chauhan and Singh 2012). This reduction in the form of release of carbon as CO_2, in which there is a greater availability of feed, followed by a long period of slow degradation (Nath *et al.* 2009; Garg and Gupta 2011; Chauhan and Singh 2013). Reduction of C/N ratio results in addition of animal dung in MSW and influencing vermicomposting rate, similar result observed by (Parthasarathi and Ranganathan 2000; Muthukumravel *et al.* 2008). The shifting of pH from base to acidic or neutral was observed due to mineralization of nitrogen and phosphate into nitrate and orthophosphate respectively (Garg *et al.* 2006; Nath *et al.* 2009; Chauhan and Singh 2012).

The maximum decrease in pH level was observed in MC_{100}. During vermicomposting the decrease in pH is also likely due to production of CO2, ammonia and organic acid by activity of earthworm and micro-organism in its intestine (Komilis and Ham 2006; Sharma *et al.* 2011).

There was significant increase total Kjeldahl nitrogen in vermiwash compare to initial feed material may be due degradation of organic carbon and addition of some gut products in the form of castings, urine and dead tissues of the earthworm (Tripathi and Bharadwaj 2004). The significant phosphorus was observed in vermiwash of MH_{25} which was probably because of the solublization and stabilization of phosphorous done by micro organism present in earthworm gut the phosphatase enzyme also increase the total phosphorous (Aira *et al.* 2002; Suthar and Ram 2008). The micro-organisms during vermicomposting produce soluble potassium similar result reported by (Kaviraj and Sharma 2003). The vermiwash of MG_{25} showed highest calcium level was noticed due to the high rate of mineralization during vermicompost by *Eisenia fetida* (Garg *et al.* 2006; Nath *et al.* 2009, Chauhan and Singh 2012). The vermiwash of MSW showed higher level of micro and macro nutrients than initial feed mixture.

Conclusion

The present study is information about the management of MSW and production of liquid biofertiliser (vermiwash). The earthworm *Eisenia fetida* caused significant increase in the levels of nitrogen, potassium, phosphorus, calcium and decrease in the levels of organic carbon, C/N ratio and pH through vermic-activity during vermicomposting. Thus vermicomposting can be a better technology for the conversion of toxic health hazardous wastes into valuable biofertilizer. Vermicomposting is less expensive, non hazardous and eco-friendly for human as well as animal health. The specific nutrients rich vermiwash of the specific combination of the MSW and animal dung can be helpful in specific nutrient deficient crops.

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Annexure

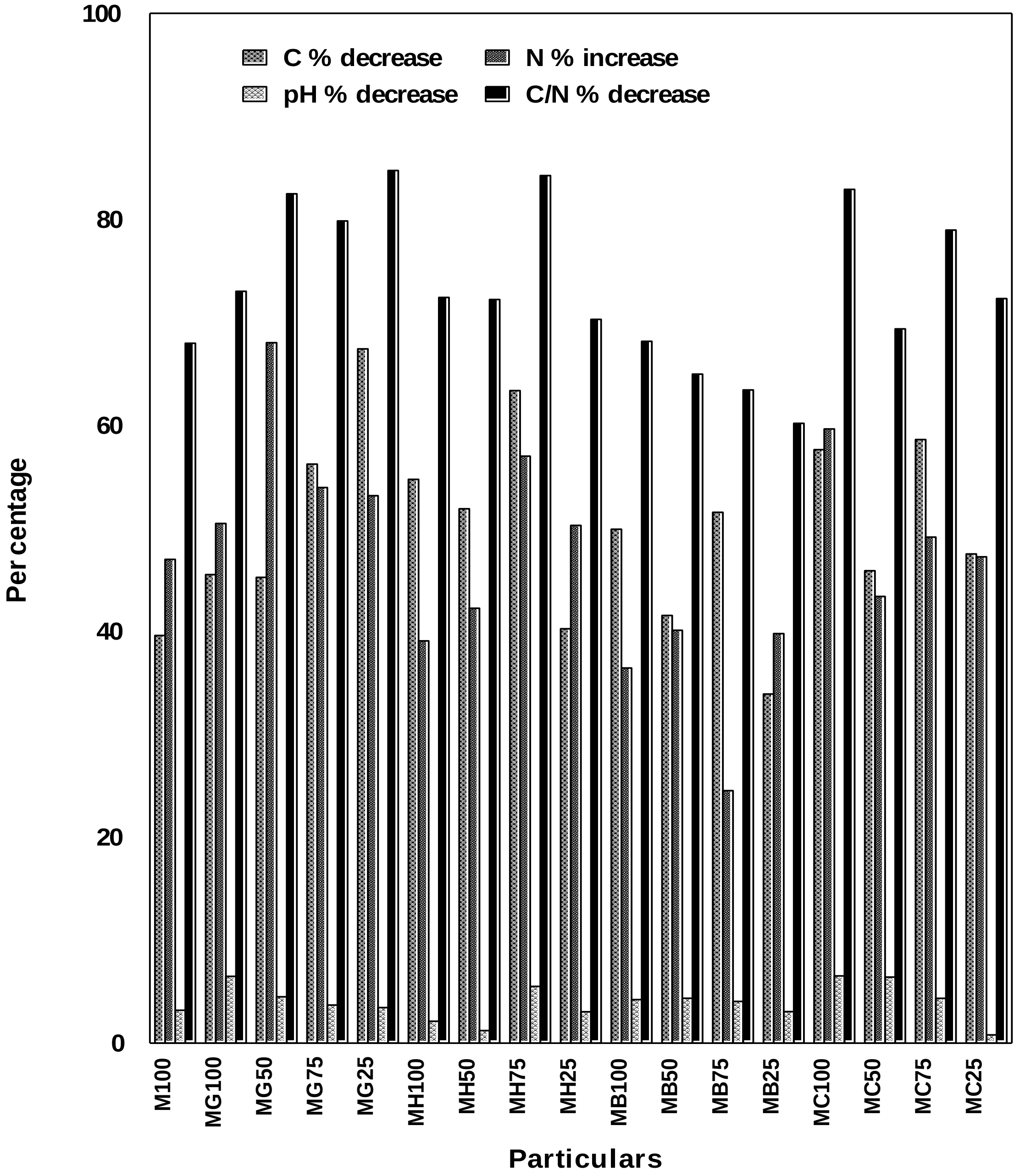

Figure 1. The per-cent age changes carbon (% decrease), nitrogen (% increase), pH (% decrease) and C/N ratio (% decrease) in vermiwash during management of MSW with different animal dung.

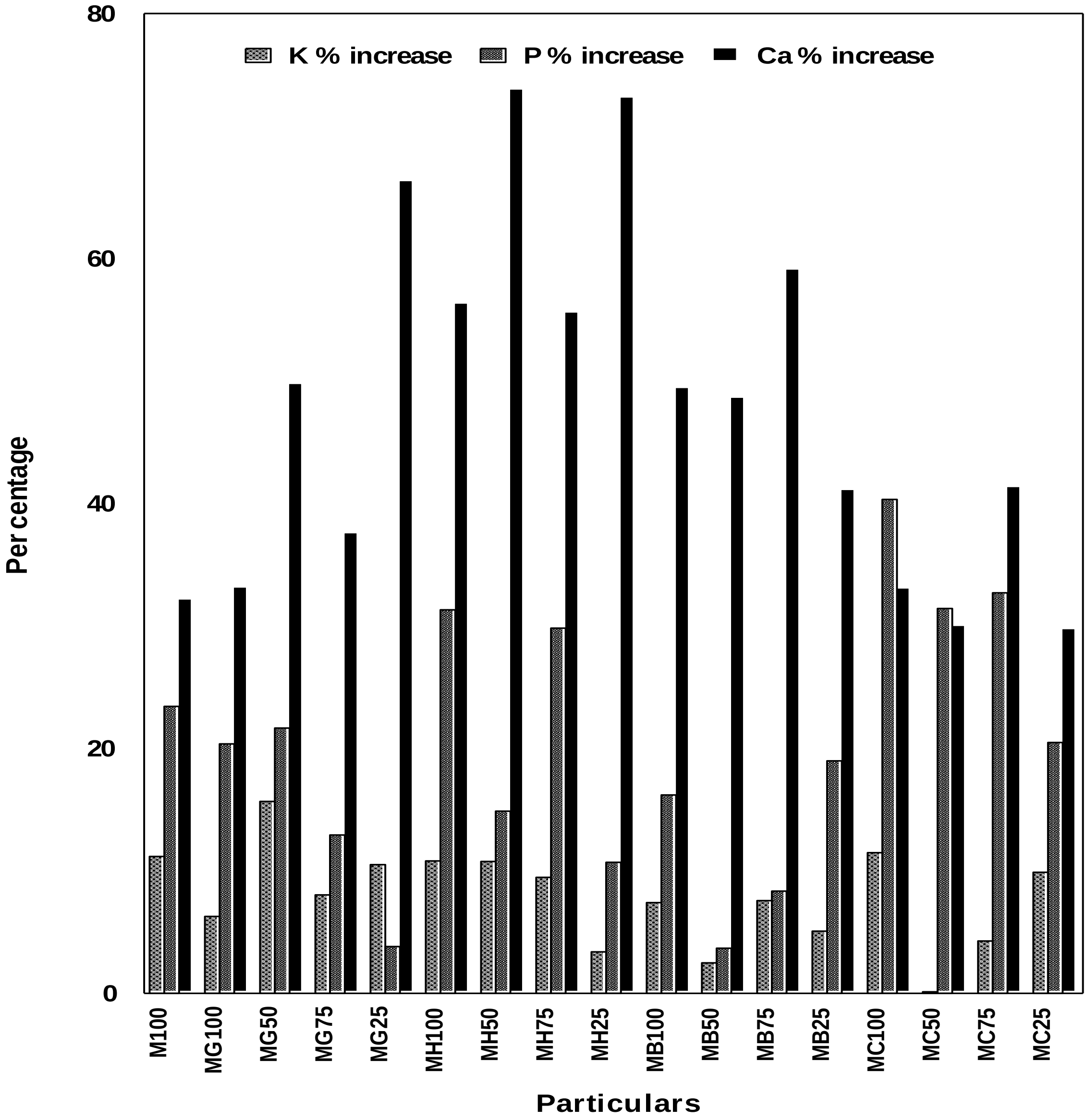

Figure 2. The per-cent age changes potassium, phosphorus and calcium (% increase) in vermiwash during management of MSW with different animal dung.

Table 1. Different combinations of municipal solid wastes with different animal dung for experiment.

Particulars	MSW (municipal solid wastes)	Animal dung	Ratio (MSW:Animal dung) w/w
M_{100}	MSW	-	100:0
MG_{100}	MSW	Goat dung	0:100
MG_{75}	MSW	Goat dung	25:75
MG_{50}	MSW	Goat dung	50:50
MG_{25}	MSW	Goat dung	75:25
MH_{100}	MSW	Horse dung	0:100
MH_{75}	MSW	Horse dung	25:75
MH_{50}	MSW	Horse dung	50:50
MH_{25}	MSW	Horse dung	75:25
MB_{100}	MSW	Buffalo dung	0:100
MB_{75}	MSW	Buffalo dung	25:75
MB_{50}	MSW	Buffalo dung	50:50
MB_{25}	MSW	Buffalo dung	75:25
MC_{100}	MSW	Cow dung	0:100
MC_{75}	MSW	Cow dung	25:75
MC_{50}	MSW	Cow dung	50:50
MC_{25}	MSW	Cow dung	75:25

M(MSW) ,MG(MSW+Goat dung), MH(MSW+Horse dung), MB(MSW +Buffalo dung) ,MC (MSW +Cow dung)

Table 2. The concentration of carbon, nitrogen, pH and C/N ratio in initial feed mixture and vermiwash of municipal solid wastes with combinations of different animal dung.

Particulars	CIM (g/kg)	CVW (g/kg)	NIM (g/kg)	NVW (g/kg)	pHIM	pHVW	C/NIM	C/NVW
M_{100}	609.82±1.45	368.41±1.25*	7.72±1.58	14.56±1.25*	6.87±1.03	6.65±1.80*	78.99±1.24	25.30±1.58*
MG_{100}	434.54±1.57	236.82±1.98*	5.22±1.76	10.54±1.17*	7.55±1.12	7.06±1.19*	83.25±1.58	22.47±1.35*
MG_{75}	587.53±1.85	257.15±1.21*	9.27±1.15	20.13±1.52*	7.56±1.17	7.28±119*	63.38±1.34	12.77±1.82*
MG_{50}	562.80±1.78	308.25±1.06*	8.13±1.97	25.42±1.23*	7.78±1.13	7.43±1.14*	69.23±1.79	12.13±1.57*
MG_{25}	590.54±1.12	192.42±1.03*	7.26±1.20	28.31±1.85*	7.83±1.24	7.56±1.16*	44.54±1.36	6.80±1.38*
MH_{100}	477.65±1.57	216.15±1.45*	5.21±1.45	8.55±1.15*	7.51±1.14	7.35±1.14*	81.68±1.58	25.28±1.59*
MH_{75}	558.35±1.57	204.53±1.68*	7.52±1.16	17.49±1.65*	7.24±1.15	6.84±1.14*	74.25±1.28	11.69±1.64*
MH_{50}	530.86±1.24	255.38±1.54*	13.21±1.25	22.87±1.15*	7.34±1.16	7.25±1.26*	40.19±1.96	11.17±1.76*
MH_{25}	592.64±1.87	354.18±1.91*	11.56±1.14	23.25±1.79*	7.55±1.27	7.32±1.23*	51.27±1.82	15.23±1.57*
MB_{100}	514.25±1.78	257.64±1.72*	7.26±1.12	11.42±1.13*	7.56±1.19	7.24±1.12*	70.83±1.75	22.56±1.98*
MB_{75}	587.40±1.47	284.57±1.79*	13.82±1.24	18.31±1.13*	7.66±1.16	7.35±1.23*	42.50±1.68	15.54±1.84*
MB_{50}	556.93±1.54	325.65±1.87*	14.57±1.16	24.32±1.24*	7.57±1.17	7.24±1.15*	38.22±1.37	13.39±1.76*
MB_{25}	598.28±1.79	395.46±1.46*	14.13±1.24	23.46±1.14*	7.85±1.55	7.61±1.14*	42.34±1.88	16.86±1.98*
MC_{100}	485.48±1.56	205.64±1.85*	6.57±1.14	16.28±1.13*	7.35±1.19	6.87±1.15*	73.89±1.46	12.63±1.28*
MC_{75}	547.51±1.46	226.57±1.67*	9.45±1.12	18.58±1.15*	7.58±1.14	7.25±1.54*	57.94±1.67	12.19±1.82*
MC_{50}	496.19±1.64	268.56±1.75*	14.25±1.26	25.17±1.18*	7.63±1.16	7.14±1.14*	34.82±1.87	10.67±1.57*
MC_{25}	587.35±1.85	308.35±1.68*	13.64±1.25	25.85±1.17*	7.54±1.16	7.48±1.26*	43.06±1.56	11.93±1.47*

CIM= total organic carbon in initial feed material, CVW= total organic carbon in vermiwash, NIM= total Kjeldahl nitrogen in initial feed material, NVW= total Kjeldahl nitrogen in vermiwash, C/NIM=C:N ratio in initial feed material, C/NVM=C : N ratio in vermiwash.
Each value is the mean ± SD of six replicates. *Significant (P<0.05)'t' test between initial feed material and vermiwash.

Table 3. The concentration of potassium, phosphorus and calcium in initial feed mixture and vermiwash of municipal solid wastes with combinations of different animal dung.

Particulars	KIM (g/kg)	KVW(g/kg)	PIM (g/kg)	PVW (g/kg)	CaIM (g/kg)	CaVW (g/kg)
M_{100}	5.64±0.42	6.35±0.51*	4.87±0.39	6.36±0.42*	1.52±0.43	2.24±0.19*
MG_{100}	6.42±0.53	6.85±0.50*	4.34±0.33	5.45±0.46*	1.92±0.53	2.87±0.42*
MG_{75}	6.86±0.52	7.46±0.62*	4.85±0.37	5.57±0.47*	2.43±0.42	3.89±0.37*
MG_{50}	7.32±0.58	8.68±0.52*	5.75±0.43	7.34±0.53*	1.87±0.52	3.72±0.35*
MG_{25}	7.92±0.67	8.85±0.65*	8.32±0.45	8.65±0.59*	1.81±0.62	5.37±0.32*
MH_{100}	7.51±0.89	8.42±0.63*	7.24±0.43	10.54±0.61*	1.84±0.53	4.21±0.34*
MH_{75}	7.84±0.64	8.66±0.68*	5.86±0.43	8.35±0.59*	1.52±0.48	3.42±0.45*
MH_{50}	7.46±0.72	8.36±0.63*	8.87±0.52	10.42±0.65*	1.54±0.41	5.87±0.45*
MH_{25}	8.27±0.71	8.56±0.69*	9.35±0.51	10.47±0.52*	1.67±0.59	6.21±0.43*
MB_{100}	6.87±0.62	7.42±0.52*	5.38±0.49	6.42±0.45*	1.68±0.41	3.32±0.43*
MB_{75}	7.82±0.67	8.46±0.42*	5.38±0.43	5.87±0.54*	1.85±0.43	4.52±0.46*
MB_{50}	8.21±0.65	8.42±0.49*	7.56±0.51	7.85±0.52*	2.40±0.43	4.67±0.45*
MB_{25}	8.40±0.64	8.84±0.45*	8.79±0.54	10.85±0.45*	2.87±0.45	4.87±0.32*
MC_{100}	5.24±0.53	5.92±0.41*	4.32±0.39	7.24±0.53*	1.48±0.46	2.21±0.34*
MC_{75}	6.93±0.54	7.24±0.53*	3.87±0.47	5.75±0.41*	1.42±0.54	2.42±0.26*
MC_{50}	7.45±0.67	7.46±0.52*	5.26±0.45	7.67±0.50*	2.50±0.46	3.57±0.38*
MC_{25}	7.11±0.62	7.89±0.50*	7.69±0.53	9.67±0.52*	1.68±0.50	2.39±0.21*

KIM= total potassium in initial feed material, KVW= total potassium in vermiwash, **P**IM= P= total phosphorus in initial feed material, PVW= P= total phosphorus in vermiwash, **Ca**IM= total calcium in initial feed material, CaVW= total calcium in vermiwash,
Each value is the mean ± SD of six replicates. *Significant (P<0.05)'t' test between initial feed material and vermiwash.

Table 4. Correlation matrix between different biochemical parameters of vermiwash.

Parameters	CVW	NVW	pHVW	C/NVW	KVW	PVW	CaVW
CVW	1.000						
NVW	0.287	1.000					
pHVW	0.153	0.494	1.000				
C/NVW	0.238	-0.821	-0.309	1.000			
KVW	0.155	0.478	0.684	-0.323	1.000		
PVW	0.241	0.331	0.419	-0.123	0.583	1.000	
CaVW	0.187	0.415	0.531	-0.252	0.750	0.573	1.000

VW= vermiwash, C= total organic carbon, N= total Kjeldahl nitrogen (g/l), C/N=C to N ratio, K= total potassium, P= total phosphorus, Ca= total calcium (g/l).