Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: www.environmentaljournal.org
Volume 1, Issue 4: 442-454

Open Access **Research Article**

Aerobic Sponge Method Vermitechnology for Macro-Level Conversion of Organic Garbage

Sunitha N. Seenappa
Director, ECO-BELT R and D PVT. LTD., 232, Managanahalli, Hosur Post, Bidadi Hobli,
Ramanagara 562190, Karnataka, India.

Corresponding author: drsunithanseenappa@gmail.com

Abstract:

Earthworms in the second decade of 21st century are the most significant figure in the realm of biodegradation of agricultural wastes, agro-industrial wastes, urban organic garbage and sewage sludge. The degraded product as their excreta find resolvable route to sustainable agriculture, a most relevant solution for the developed-developing country like India to enhance sustainability of soil organic matter for balance of physical-chemical-biological properties. Earthworms virtually stand alone as a symbol of "clean technology" in the field of organic waste transformations and also stand alone as a symbol of "sustainable organic agriculture technology". Although several protocols and techniques have been shown and implemented in India we still lack a suitable, modifiable and appropriate feasible technology for organic garbage into vermicompost at the levels of ward, community and corporate/municipality, which is the need of the hour. India being an agrarian country needs valuable, processed organic inputs to sustain its soils. Indian wet garbage accounting for average 60% of the country's total organic garbage generated, must be considered as resourceful by-product for human endeavor, to make it a ready source for vermicomposting and finding a return route to productive soils. Business partnership considering organic garbage as "organic wealth", for innovation and entrepreneurship, research, education and technology development, all within a framework of a partnership between city Corporations, private research and development units and Universities as sustainable workable models for all seasons need to be implemented in India, independent of Govt. agencies for fruitful ventures. Currently handling of garbage by the Corporations and Municipalities need a thorough brush –up which is operating on the grounds of political scenario rather than on the grounds of techno-commercial ventures. This paper calls for the attention of theoretical scientists to look for macro-level practicalities and also challenges its current, innovative Aerobic Sponge Method Vermitechnology (ASMV), its implementations anywhere with authenticity in terms of feasibility and sustainability on the grounds of working modalities along with sustainable returns through "organic garbage filth to organic cabbage growth" motto.

Keywords: ASMV technology, Aerobic Sponge Bed, conventional vermitechnology, *Eudrilus eugeniae*, open land access, wet garbage.

1.0 Introduction:

Earthworms are greatly appreciated by White (1789) for their evolved system in soil burrowing and feeding activities. Later Savigny (1826) studied extensively on the diversity of earthworms. It was the great naturalist Darwin (1881) who laid the actual foundation on the research of earthworms and revealed these animals' importance in the economy of nature. Voluminous work on earthworms has been carried out due to improved laboratory equipment and evolved techniques, followed by the side-by-side research being done under natural habitats i.e., under field conditions. The enormous quantities of available scientific data show the valuable facts and figures on various aspects. Degradation of organic wastes through earthworms to abate organic pollution (Abe *et al*., 1978; Balasubramanian and Bai, 1995; Barois *et al*., 1994; Butt, 1993; Elvira *et al*., 1996; Mato *et al*., 1994; Murugesan and Sukumaran, 1994; Loehr *et al*, 1984, 1992); potentialities to convert organic wastes into resourceful vermicompost for sustainable agriculture (Bhadauria and Ramakrishnan, 1989; Cegarra *et al*., 1987; Edwards, 1983a; 1985; Ferriere, 1980; 1992; Flaig *et al*., 1977; Lofty, 1974; Mackay and Kladivko 1985; Bano and Kale, 1987; Manna *et al*, 1997; Mitchell, 1997; Rhee, 1963; Mba, 1989, 1996; Sunitha and Kale, 1995a; 1995b); presence /absence of earthworm activity in the soil to reveal the fertility/toxicity level to indicate soil health (Barley, 1959; Edwards and Bohlen, 1996; Ewer and

Hall, 1972); ability to store/destroy/transformation of toxic substances like pesticides and heavy metals in earthworms' body physiology (Bouche, 1971; 1977;1977b; 1982; Cuendet and Ducommun, 1990); earthworms association with microbial population to study on earthworm-microbial interactions (Allevi *et al*., 1987; Dash *et al*., 1979b); being soil dwellers and their ability to make complicated burrows, feeding activities with valuable excreta/casts to help to study the physico-chemical properties on soil (Boltson and Phillipson, 1976; Coleman and Sasson, 1978; Edwards *et al*., 1988).

Stabilizing and fermenting enormous bulk quantities of biodegradable organic anthropogenic wastes by the usual methods of composting is limited in performance and continual sustainability (Haimi and Huhta, 1987; Sharma, 1995; WASTE WISE, 1995; Steinford *et al*., 1996; Gandhi *et al*., 1997; Subler *et al*, 1998; Wawolumaya and Maclaren, 1998). Nature has created compost earthworms of selected species that has been successfully shown to work on biodegradability of plant and animal origin under laboratory conditions (Neuhauser *et al*., 1988; Edwards, 1988; Mba, 1989; Reinecke *et al*, 1992; Mato *et al*, 1994; Kale *et al*, 1994; Manna *et al*, 2003; Suthar and Singh, 2008) to guarantee to march towards zero pollution with the possibilities of bulk productions of stabilized vermicompost for arable lands (Sinha *et al*, 2008). Research and Development in the field of organic garbage, urban sewage sludge and an array of agro-industrial waste management has found so far very few species (among 3,000 species) of earthworms as waste converters/stabilizers/degraders. Some of the known species are *Eudrilus eugeniae, Eisenia fetida, Eisenia andrie, Perionyx excavatus, Perionyx sansibaricus, Dendrobaena veneta, Lumbricus terrestris* and *Pheretima asiatica.* (Lee, 1985; Edwards, 1996).

Given a thorough studies under lab to land implementations (micro-level to macro-level) conversion of organic garbage into conventional vermicomposting dwindle for reasons; namely, limited facilities, limited monetary benefits at the level of daily wages, interruptive unsustainable support from the Govt. agencies, the severity of limited practicality of theoretical vis-a-vis practical scientists at large for the fruitful utilization of organic garbage generated round the clock. The present research document and its sustainable indigenous technology for the bioremediation of organic garbage is the modified version of conventional vermitechnology as ASMV (Aerobic Sponge Method Vermitechnology). The subject of present study for wet garbage at macro-level is shown to be simpler adaptations using ASMV technology and is nuisance-free in terms of leachate, fly menace and odor - the most relevant problematic parameters in handling bulk quantities of organic garbage. For the efficient work of ASMV, one need to be dependant on dry LARM (leachate absorbing raw material) like cocopith (waste of coir industry)/bagasse (waste of sugar cane mills)/jute waste (from jute industry) for Southern parts of India, North-Western parts of India and Eastern parts of India respectively. The right kind and efficient earthworm candidate used for ASMV is *Eudrilus eugeniae* for its ability to feed and defecate in open access land under huge mass of aerobic partial decomposed organic garbage with dry LARM in standardized proportions by weight. Thus produced defecated vermicompost used for agricultural lands for all crops without chemicals or with 0.5% - 10% chemical fertilizers (Sunitha *et al*., 1997; Jadav *et al*., 1997; Karmegam *et al*., 1999).

2.0 Materials and Method:

Details of the laboratory research are not explicitly presented here. The indigenous Aerobic Sponge Method Vermitechnology (ASMV) development at macro-level field conditions is documented here. The studies done were strictly semi-scientific, under semi-natural conditions for an easy access of ASMV technology in all seasons of rainy, winter and summer under Indian circumstances for eco-conscious citizens, entrepreneurs, business persons and Govt. agencies. ASMV technology operated at two phases: In phase-I, segregation of recyclable/nonbiodegradble garbage from unseggregated garbage within the premises of the allotted site/ at the source was done and simultaneously loaded back for its suitable placement. The details of the Phase – I operation was irrelevant for the present research paper hence only Phase – II of organic garbage conversion into vermicompost with ASMV is explained here.

Phase-II, ASMV technology was implemented for the total conversion of organic garbage into vermicompost by employing the classical compost earthworm *Eudrilus eugeniae.* The ratio of dry LARM use was based on micro-level research and worked out to be 10: 2 (10 parts of organic garbage to 2parts of dry LARM) on weight basis. For 3 – model macro-level studies, 10 tons of wet garbage to 2 tons of dry

LARM was used as standardized measure for the present study. Based on the data an average of organic garbage generated at 3 – levels **(Table: 1),** Day-to-day collections of segregated wet garbage was dumped in a layer wise manner and ensured a bottom and surface layer with dry LARM sandwiched by the organic garbage. The ratio of organic garbage and dry LARM became a natural aerobic sponge bed that created aerobicity and arrested anaerobicity; leachate got bound to the dry LARM, fly menace got no record because anaerobicity and putrification was not in the picture thus fly menace was solved at one go. The average organic garbage procurable/day/month/annum, the used quantum of dry LARM, 20% reduction of the biosolid material on initial aerobic decomposition and further 40% reduction of biosolids after vermi-processes, the obtainable vermicompost in 3-level models and an outlay of the requirements for the entire work operation has been shown in detail in **Table:1.** The nutrient status of the vermicompost shown in **Table: 2** was an indication of best organic nutriments for arable lands, vegetable crops and ornamental nurseries.

3.0 Results and Discussion:

Based on the research work and successful operation of organic garbage conversion in 2 model version of 4 – member family and 10 – member family using ASMV for micro-level studies (Sunitha, 2011a, 2011d), in the present study as an advancement of organic garbage conversion at the macro-level research for 3 –sets of models namely – decentralized unit (individual ward level) for an urban population of > 1Lakh, Centralized unit (zonal level) for a population of > 10Lakhs and Corporation unit (100 wards level) for a population of > 1Crore **(Table : 1)** had been worked out and shown the workability (**Fig. 4, 5, 6, 7 and 10**). The organic garbage with its 90% moisture during decomposition oozed out as leachate that always lead to putrification with anaerobic conditions and emancipation of obnoxious odor due to putrification to harbor nuisance - causing flies were trickily overcame in the present study by implementing ASMV by use of dry LARM **(Fig: 1)** that acted as natural, eco-friendly, biodegradable, leachate absorbent and so-much-so-that the dry LARM with leachate became rich nutrient binder and enhanced faster aerobic degradation in the form of a self – made organic aerator sponge **(Fig: 8 and 9).** This technique had not been specified and modulated in the earlier works of Kale *et al* (1994), although shown the best utilization of ligno-cellulose material (Senapati, 1992) like cocpith and other farm wastes for biodegradation by the compost earthworms of *Eudrilus Eugeniae* and *Eisenia fetida*.

Biology of compost earthworms, vermicomposting and conventional vermitechnology has been worked out under laboratory conditions by several workers (Kaplan *et al*., 1980a; Graff, 1982; Hartenstein, 1983; Haimi and Huhta, 1987; Neuhauser, *et al*., 1988; Edwards, 1988; Edwards and Bater, 1992; Kale and Bano, 1984; Kale and Sunitha, 1993; Kale *et al*., 1994; Sunitha and Kale, 1995a and 1995b; Lotzof, 2000; Vermi Co, 2001; Sunitha, 2001; Pattnaik and Reddy, 2009). Under laboratory conditions, the success of organic garbage degradation by earthworms has been 100%; however under field conditions the same has been known to be workable to a limited extent and sustainability has been meager due to varied disturbances under Indian circumstances be it monetary limitations, mechanical limitations, labor – oriented uncertainties, inappropriate guidelines, crucial changes not made from lab to land implementations, political disturbances, non co-operation of citizens, technical problems of leachate, putrification, fly nuisance, improper aerobic degradation, anaerobicity situations during the compost earthworm activity which made the worms to surface out leading to preying, etc.

In the present paper, a different approach and methodology has been explained to show continual, successful macro level activities to convert organic garbage either under community based organizations/ward level/corporation level. This paper has been proven based on experiences in lines of technology transfer, working implementations and change of working modalities at varied aspects and overcame lacunae, problems faced at every level with rectifications of conventional vermicomposting of the organic garbage for the continual and successful operations on the grounds of sustainability to use ASMV throughout the year irrespective of seasonality and the end product of stabilized, granular vermicompost **(Fig: 11)** best suited for dry land crops, commercial crops and vegetable crops with the addition of 0.5% - 10% chemical fertilization (Tomar *et al*, 1998; Sukumaran, 2008; Suhane *et al*, 2008; Ansari and Abdhullah, 2008; Sunitha, 2011b, 2011c).

Table 1: data showing for 3-sets of macro-level models for the implementation of ASMV

Details	**Decentralized unit at individual ward level (covering a population of > 1Lakh)**	**Centralized zonal level unit (covering 10 wards, a population of (> 10 Lakhs)**	**Corporation level unit [covering 100 wards, a population of (> 1 Crore)**
Categories of wet garbage generators	1. Retail fruit and vegetable markets 2. Restaurants and hotels 3. 25,000 urban houses 4. Road-side vendors 5. Road-side snack suppliers	1. Retail fruit and vegetable markets 2. Restaurants and hotels 3. 2,50,000 urban houses 4. Road-side vendors 5. Road-side snack suppliers	1. whole sale market yards of fruits and vegetables 2. Retail fruit and vegetable markets 3. 25,00,000 urban houses 4. Road-side vendors 5. Road-side snack suppliers
Type of wet garbage generation/day	decomposed fruits and vegetable wastes, Paper cartoon wastes, Filler wastes like hay, trash, Food waste, Urban household wet garbage, Cattle dung from semi-urban areas, Park and avenue tree waste	decomposed fruits and vegetable wastes, Paper cartoon wastes, Filler wastes like hay, trash, Food waste, Urban household wet garbage, Cattle dung from semi-urban areas, Park and avenue tree waste	decomposed fruits and vegetable wastes, Paper cartoon wastes, Filler wastes like hay, trash, Food waste, Urban household wet garbage, Cattle dung from semi-urban areas, Park and avenue tree waste
Average quantity of wet garbage generated per day per month per annum (in MT)	Per day: 30 Per month: 900 Per annum:11,000	Per day: 300 Per month: 9,000 Per annum: 1,10,000	Per day: 3,000 Per month: 90,000 Per annum: 10,80,000
Recommended location for implementation of ASMV technology	Open access land within 1Km radius	Open access land within 5Kms radius	Open access land 40Kms away
Required area of open access land	2 acres	10 acres	150 acres
Requirement of permanent structures (with area in sq.ft.) at the site	Godown, (2,500) vermicompost yard, (10,000) Office, (1,000) Laboratory, (500) Parking area,(10,000)	Godown, (25,000) vermicompost yard,(1Lakh) Office,(1,000) Laboratory, (500) Parking area, (10,0000)	Godown, (2.5Lakh) vermicompost yard, (10Lakh) Office, (1,000) Laboratory, (5000 Parking area, (10,000)
Requirement of permanent tank with zinc sheet roofing for AOSB	30 structures Size : 30'X10'X2'	150 structures Size : 30'X10'X2'	1,500 structures Size : 30'X10'X2'
Requirement of vehicles (in numbers)	Tippers (2) Luggage autos (5) Motor bikes (2)	Tippers (20) Luggage autos (50) Motor bikes (10)	Tippers (200) Luggage autos (500) Motor bikes (200)
Requirement of machineries (in numbers)	Horizontal vibrating sieves (2)	Horizontal vibrating sieves (20)	Horizontal vibrating sieves (20)
Requirement of Electricity (in Kwatts)	10/day	50/day	500/day
Requirement of water (in gallons)	2,000/day	20,000/day	5 Lakh
Requirement of Technicians	5	15	25

Requirement of skilled labors	Males: 10	Males: 100	Males: 1,000
Requirement of unskilled labors	Females: 40	Females: 400	Females: 4,000
Outsourcing material in MT either Cocopith /bagasse/jute waste/milled agrowastes (ligno cellulose base) as dry LARM requirement in tons /day /month/annum	Per day: 6 Per month: 180 Per annum: 2,200	Per day: 60 Per month:1,800 Per annum: 22,000	Per day:600 Per month: 18,000 Per annum: 2,16,000
Quantity of organic garbage with dry LARM prior to partial aerobic decomposition in MT	Per day: 36 Per month: 1,080 Per annum:13,200	Per day: 360 Per month: 10,800 Per annum: 1,32,000	Per day:3,600 Per month: 1,08,000 Per annum 12,96,000
Quantity in MT on 20% Reduction of wet garbage + LARM after initial aerobic decomposition in 30 days	Per day: 28.8 Per month: 864 Per annum: 10,560	Per day: 288 Per month: 8,640 Per annum: 1,05,600	Per day: 2,880 Per month: 86,400 Per annum: 10,36,800
Quantity on 40% Reduction of wet garbage + LARM after vermicomposting in 60 days in MT	Per day: 17.28 Per month: 519 Per annum: 6,336	Per day: 173 Per month: 5,184 Per annum: 63,360	Per day: 1,728 Per month: 51,840 Per annum: 6,22,080
Obtainable quantity of vermicompost after sieving in MT	Per day:15.5 Per month: 467 Per annum: 5,702	Per day:155.75 Per month: 4,665 Per annum: 57,024	Per day: 1,572 Per month: 46,656 Per annum: 5,59,872
Assuming 100% sales through Govt. Subsidy (at the rate of Rs. 2,000/MT)	Rs. 31,100 = 00 Rs. 9,34,200 = 00 Rs. 1,14,04,800 = 00	Rs. 3,11,400 = 00 Rs. 93,31,200 = 00 Rs. 11,40,48,000 = 00	Rs. 31,44,960 = 00 Rs. 9,33,12,000 = 00 Rs. 111,97,44,000 = 00

Fig 1: Cocopith from coir industry, an abundancy in Southern India. Three decade ago, due to disposal problem was burnt to ashes; currently utilized for cocopeat processes and as decomposed filler material in the nurseries for the ornamentals.

Fig 2: Partial or aerobically degraded segregated organic garbage and cocopith in the ratio of 10:2 by weight. A material view prior to vermicomposting processes/during partial aerobic decomposition

Fig 3: Eudrilus eugeniae – a well known candidate for bioremediation in waste technology. Growth and reproduction was directly proportional to the ratio of nitrogenous based and lignocellulosic based wastes. From the commercialization point of faster degradation and enhanced reproductive potentialities this particular species is a competitor over other compost species.

Fig 8: A proportionate addition of organic garbage with cocopith. Leachate absorption seen as wetness. Work under open access land, fly menace no entry. Purifications and anaerobicity were not a factor of existence. Aerobic decomposition hastened by overnight experienced by the fruity odor of the biosolids. The entire material of biosolids formed Aerobic Sponge bed. An easiest workable operation under Indian conditions. Is cost-effective, no need of aerators to create aerobic conditions. Anaerobicity gets arrested by overnight. The proportions of organic garbage and dry LARM create aerobic sponge thus the geven for this indigenous technology - ASMV – Aerobic Sponge Method Vermitechnology.

Fig 9: A view of the Aerobic Sponge bed of the biosolids of organic garbage and dry LARM after partial aerobic degradation followed by the feeding and defecating activities of the compost earthworm Eudrilus eugeniae.

Fig 10: A view of vermicomposted product of biosolids of organic garbage and dry LARM, prior to the segregation of earthworms and sieving processes.

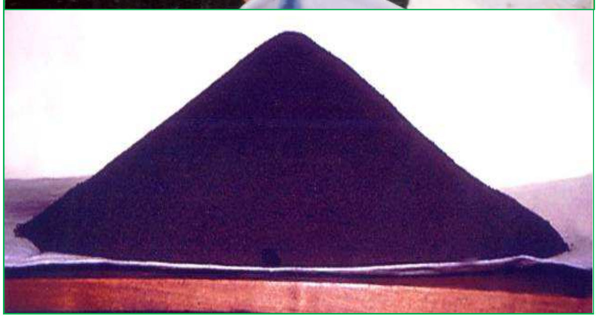

Fig 11: The final product vermicompost after sieving with 0.5mm mesh. Ready for use as organic nutrients.

Fig. 4: Segregated organic garbage at community level, a work implemented as a technology transfer project with Waste Wise Trust, under Urban Waste Expertise Program (UWEP) at Mahadevapura, Bangalore, India. The study carried out for segregated organic garbage of 0.5-1 ton per day basis using ASMV.

Fig. 5: A view of the segregated organic garbage prior to the coverage with quantified dry LARM

Fig. 6: Release of compost earthworm Eudrilus eugeniae to the 2-layered Tarpaulin vermi bag of dimension 50’ X 10’ X 2.5’, after the aerobic degradation of organic garbage with requisite quantity of dry LARM.

Fig. 7: A view of the vermibed enclosed by the bottom layer of Tarpaulin of 200G.S.M. and a middle layer of mosquito net during aerobic degradation as well as vermiprocesses

Both the species of compost earthworms *Eudrilus eugeniae* and *Eisenia fetida* were the candidates suitable for organic garbage conversion into vermicompost under laboratory studies (Bano and Kale, 1988; Kale and Sunitha, 1993; Mitchell, 1997; Periasami and Vasuki, 2010; Sunitha, 2011a; Norbu, 2002). However under macro-level field conditions for the conversion of organic garbage into resourceful vermicompost through ASMV, in the present study *Eudrilus eugeniae* **(Fig : 3)** alone were preferred and recommended for faster handling, sorting, feeding and conversion efficiencies mainly due to open land access with Aeorbic Sponge Bed (AOSB) size within the concrete tank of 5’ X 8’ X 3.5’ **(Fig: 4 and 5)** and another version of above land working module of 2 – layered Tarpaulin vermi bag with in-between mosquito net. The vermi bag of size 50’ X 10’ X 2.5’ that seemed to be well fitted for this particular species with voracious feeding and conversion efficiencies, an indication of its tropical forest litter inhabitancy and its other dual purpose of holding capacity of 15 tons of organic garbage with 3tons of dry LARM (10:2 proportion by weight) and zipping with mosquite net for immediate and proper aerobic microbial activity that readily arrested nuisance-causing fly entry and exudation of leachate. The material view shown in **Fig: 2.** A complete study of bioenergetics of *Eudrilus eugeniae* under laboratory conditions studied by Sunitha (2001) supported the better use of this species under three seasonality.

Table 2: shows nutrient status in vermicomposted wet garbage

Sl. No.	Particulars	Values In %
01.	Total organic matter	31.0
02.	Total organic carbon	18.0
03.	Total nitrogen	1.78
04.	Total phosphorus	0.54
05.	Total potassium	0.60
06.	Total magnesium	2.35
07.	Total sulfur	0.65
08.	Total dissolved solids	0.90
09.	C:N ratio	15:1
10.	pH	7.30
11.	Moisture	40.0
	HCl [0.1 N] soluble constituents:	
12.	Iron	200 ppm
13.	Phosphorus	0.25
14.	Potassium	0.31
15.	Calcium	1.61
16.	Magnesium	0.42
17.	Sodium	0.54
	Available nutrients:	
18.	Phosphorus	0.069
19.	Potassium	0.056
20.	Calcium	0.91
21.	Magnesium	0.23
22.	Sulfur	0.08
23.	Sodium	0.12

ASMV developed for organic garbage for Indian subcontinent as an innovative, cost- effective, easiest method without fly nuisance, without leachate and without obnoxious odor was a challenging technology over other workers developed in the same lines of research be it, indoor, outdoor, laboratory, and/or pilot scale(Datar *et al*, 1997; Lotzof, 2000; Sinha *et al*, 2002; UNSW, ROU, 2002b; Georg, 2004; Visvanathan *et al*, 2005; Sinha *et al*, 2008; Sinha and Chanr, 2009; Pattnaik and Reddy, 2009; Sinha *et al*., 2002; 2009; 2010). The ASMV technology developed for open land access was named as Aerobic Sponge Method Vermitechnology (ASMV) for organic garbage with a modified version of conventional vermitechnology feasible to implement in all seasons of rainy, winter and summer under Indian circumstances. The 2-layered Tarpaulin vermibags were development especially meant for organic garbage; the bottom layer of Tarpaulin of 200G.S.M. was of high durability and had the capacity to withstand the wear and tear during hydraulic unloading by vehicles for day-day-day organic garbage. The middle layer of mosquito net covered over the organic garbage sandwiched with dry LARM created formation of aerobic sponge bed and enhanced aerobic degradation by overnight and arrested entry of flies and obnoxious odor. The top layer of Tarpaulin of 200G.S.M. was used before the onset of rains to protect entry of rain water (**Fig: 6 and 7).** To avoid earthworms becoming an easy prey for birds, cats, bandicoots and wild boars was overcame by the maintenance of cleanliness of the Phase I and Phase II operations of ASMV and also by ensuring everyday regular human activity which kept at bay the enemies of compost earthworms (**Fig. 7**).

4.0 Conclusion:

Although several protocols and techniques have been shown and implemented, India still lacks a sustainable, suitable, modifiable and appropriate feasible technology of organic garbage into vermicompost which is the need of the hour. India being an agrarian country needs valuable, processed organic inputs to sustain its soils; First World Countries' technology part as energy production from organic garbage doesn't required for an agrarian country like India. Even landfills and dump sites must be discouraged. Indian wet garbage accounting for average 60% of the total garbage generated from the urban areas must be considered as resourceful by-product for human endeavor to make it a ready source for vermicomposting using the indigenous ASMV technology to find a sustainable, return route to productive soils. Goldstein (2004) report an on-going project for its master plan since 1970's in handling recyclable garbage and organic garbage hand-in-hand through business partnership for innovation and entrepreneurship, research, education and technology development, all within a framework of a partnership between Burlington County and Rutgers University. Such models need to be implemented in India, independent of Govt. agencies for fruitful ventures. Currently handling of garbage by the Corporations and Municipalities need a thorough brush –up which is operating on the grounds of political scenario rather than from the techno-commercial point of view. This paper challenges and calls for the attention of theoretical scientists to look for macro-level practicalities and also authenticate the said ASMV technology for its implementations anywhere with 100% possibility for its feasibility and sustainability on the grounds of working modalities with sustainable returns **(Table: 1)** through "organic garbage filth to organic cabbage growth" motto.

5.0 Acknowledgement:

The author acknowledges Srihari Khoday, Managing Director, Khoday India Ltd, Bangalore, India for providing space and infrastructure facilities to carryout macro level research and development for the safe conversion of organic garbage into resourceful vermicompost; Anselem Rosario, Executive Director, Waste Wise Trust, for providing space and services to carryout indigenous ASMV technology at community level; Dr Savitha S.K., Medical Officer, Health, Bangalore Mahanagara Palike for supporting a survey study of organic garbage at the ward level and Seenappa C., Executive Director, Eco-Belt R and D Pvt. Ltd, Bangalore, India, for his practicality, suggestion, co-operation and encouragement throughout the research and development of ASMV technology for organic garbage.

References:

1) Abe, R.K., Braman, W.L., Rogerson, A.C., and Simpson, O.C. (1978). Organic recycling and earthworms. *In Organic Recycling in Asia. Papers presented at the FAO/SIDA workshop on the use of organic materials as fertilizers in Asia, held in Bangkok, 26 Oct – 5 Nov, 1976. Food and Agricultural Organization of the UN Rome.*
2) Allevi, L., Citterio,B., and Rerrari,A. (1987). Vermicomposting of rabbit manure: modifications of microflora. *In Compost: Production, Quality and Use. (eds. M.De. Bertodi., M.P. Fereanti., P.L. Hermite., and F. Zucconi). pp.115 – 126.*
3) Ansari, Abdullah A., 2008. Effect of Vermicompost on the Productivity of Potato (Solanum tuberosum). Spinach (Spinacia oleracea) and Turnip (Brassica campestris). World Journal of Agricultural Sciences, 4 (3): 333-336.
4) Balasubramanian, P.R., and Bai, R.K. (1995). Recycling of cattle dung, biogas plant – effluent and water hyacinth in vermiculture *In Bioresource Technology 52(1): 85 – 87.*
5) Bano, K., and Kale, R.D. (1987). Productivity and reproduction trend in a tropical earthworm *Eudrilus eugeniae*. *In Proc. of the 5th Ind. Symp. of Invert. Repro. (Ed. S. Palanichami) A.P.A. College, Palani.*
6) Bano,K., and Kale, R.D. (1988). Reproductive potential and existence of endogenous rhythem in reproduction of earthworm, *Eudrilus eugeniae*. *In Proc. Zool Sci. Calcutta, 39: 9 – 14.*
7) Barley, K.P. (1959). The influence of earthworms on soil fertility. II.Consumption of soil and organic matter by the earthworm Allolobophora caliginosa (Savigny). *In Aust. J Agric. Res. 10: 179 – 185.*
8) Barois, I., Salazar, T., and Aranda, E. (1994). Comparative vermicompost production of *Eisenia andrei*, *Eisenia fetida* and *Perionyx excavatus* using coffee pulp. *In V Int. Sym. on Earthworm Biol. Ohio State Univ. Ohio.*
9) Bhadauria, T., and Ramakrishnan, P.S. (1989). Earthworm population dynamics and contribution to nutrient cycling during cropping and fallow phases of shifting agriculture (Jhum) in North – east India. *In Ind. J. Appl. Ecol. 26: 505 - 520.*
10) Bouche, M.B. (1971). Relations entre les structures spatiales et fonctionelles des ecosystems, illustrees par le role pedobiologique des vers de terre. *In la Vie dans les Sols (C. Deamere Debouteville, ed.) pp. 189 – 209.*
11) Bouche, M.B. (1977). Strategies lombriciennes, in Soil organisms as components of ecosystems. (eds. U. Lohm and T. Persson). *In Ecol. Bull. (Stockholm), 25, 122 – 132.*
12) Bouche, M.B. (1977b). Strategies lombrikcinennes. in soil organisms as components of ecosystems (U. Lohm and T. person, eds.) *Biol. Bull (Stockholm) 25, 122 – 132.*
13) Bouche, M.B. (1982). Ecosysteme prairial. 24.3 Un exemple d'activite animale: Le role des lombriciens. *Acta Oeco., Gen. 3, 127 – 154.*

14) Boltson, P.J., and Phillipson, J. (1976). Burrowing, feeding, egestion and energy budgets of *Allolobophora rosea* (Savigny) (Lumbricidae). *Oecologia, 23, 225 – 245.*
15) Butt, K.R. (1993). Utilization of solid paper mill sludge and spent brewery yeast as a feed for soil-dwelling earthworms. *In Biosource Technology, 44, 105 – 107.*
16) Cegarra, J., Pernandez, F.M., Tercero, A., and Roig, A. (1987). Effects of vermicomposting on some components of organic wastes. Priliminary studies. *In Wilhem Michaelsen Memorial International Symposium on Terrestrial Oligochaeta, Hamburg.*
17) Coleman, D.c., and Sasson, A. (1978). Decomposer subsystem, in Grasslands, systems analysis and man. (eds. A.J. Breymeyer and G.M. Van Dyne), *Cambridge university Press, Cambridge, pp. 609 – 655.*
18) Cuendet, G., and Ducommun, A. (1990). Earthworm populations and surface activity in relation with sewage sludge and other fertilizers. *In Rev. Suisse Zool 97 (4): 851 – 870.*
19) Darwin, C. (1881). The formation of vegetable mould through the action of worms, with observations of their habits. *J.Murray, London.*
20) Dash, M.C., Senapati, B.K., and Behera, N. (1979b). Microfungi associated with the decomposition of earthworm tissue in pasture. *In Soil. Biol. Bull. India 1, 21 – 23.*
21) Edwards, C.A. (1983a): Earthworms organic wastes and food. *In Span. Shell Chem. Co., 26 (3), 106 – 108.*
22) Edwards, C.A., Burrows, I., Fletcher, K.E., and James, B.A. (1985). The use of earthworms for composting food wastes. *In Composting of Agricultural and other Wastes. (eds. J.K.R.Gasser), Elsevier, Amsterdam, pp.229 – 242.*
23) Edwards, C.A. (1988). Breakdown of animal, vegetable and industrial wastes by earthworms. In: Edwards, C.A. and Neuhauser, E.F. (Eds.), *Earthworms in waste and environmental management. SPB Academic Publishing bv, The Hague. Pp. 21 – 31.*
24) Edwards,W.M., Norton, L.D., and Redmond, C.E. (1988). Characterizing macropores that affect infiltration into non-tilled soils. *In Soil Sci. Soc. Am. J. 43, 851 – 856.*
25) Edwards, C.A. and Bater, J.E., (1992). The use of earthworms in environmental management. *Soil Biol. Biochem. 24, 1683-1689.*
26) Edwards, C.A., and Bohlen, P.J. (1996). Biology and Ecology of Earthworms. 3rd edn. *Chapman and Hall, London, U.K.*
27) Elvira, C., Goicoehea, M., Sampedro, L., Mato, S., and Nogales, R. (1996). Bioconversion of solid paper – pulp mill sludge by earthworms. *In Bioresource Technology 57 (2): 173 – 177.*
28) Ewer, D.W., and Hall, J.B. (1972). Ecological Biology. 1. Organisms and their environments. *Longman Group Limited, London.*
29) Ferriere, G. (1980). Fonctions des lombriciens VII. Une methode d' analyse de la matiere organique vegetable ingeree. *In Pedobiologia: 20, 263 – 273.*
30) Ferreira, M.E., and Cruz, M.C.P.O (1992). Effects of a compost from munici;al wastes digested by earthworms on the dry matter production of maize and on soil properties. *In Cientifica (Jaboticabal) 20(1): 217 – 227.*
31) Flaig, W., Nagar, B., Sochtig, H and Tietjen, C. (1977). Organic materials and soil productivity. *In FAO Soils Bulletin, United Nations, Rome.*
32) Gandhi M., Sangwar V., Kapoor K.K. and Dilbaghi N. (1997). Composting of household waste with and without earthworms. *Envt. And Ecology 15(2): 432-434.*
33) Georg. (2004). "Feasibility of Developing the Organic and Transitional Farm Market for Processing Municipal and Farm Organic Wastes Using Large-Scale Vermicomposting," *Good Earth Organic Resources Group, Halifax, Nova Scotia, 2004. http://www.alternativeor- ganic.com*
34) Graff, O. (1982). Vergleich der regenwurmarten Eisenia fetida und Eudrilus eugeniae hinsichthich ihrer eignung zur proteingewinnumg aus abfallstoffen. Pedobiologia. 23, 277-282.
35) Haimi, J and Huhta, V. (1987). Comparison of composts produced from identical wastes by "vermistabilization" and conventional composting. *Pedobiologia 30, 137-144.*
36) Hartenstein, R. (1983). Assimilation by the earthworm Eisenia fetida. In: Satchell, J.E. (Ed*.). Earthworm Ecology: from Darwin to Vermiculture. Chapman and Hall, London. Pp. 297 – 308.*
37) Jadav, A.D., Talashilkar S.C. and Pawar A.G. (1997). Influence of the conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. *Journal of Maharashtra Agril. Univ. 22(2): 249-250.*
38) Kale, R.D., and Bano, K. (1984). Time and space relative population growth pattern of earthworm *Eudrilus eugeniae*. *Abstracted in Natl. Symp. On*

soil pest and soil organism. Oct. 29 – 31. BHU, Varanasi, pp.24 – 25.

39) Kale, R.D., and Sunitha N.S. (1993). Utilization of earthworms in recycling of household refuses – A case study. *Publ. by Cosortium on Rual Tech. (CORT), N. Delhi. pp. 75 – 79.*

40) Kale, R. D., Bano, K., Sunitha, N. S. And Gangadhar, H. S. (1994). Adhoc scheme on promotion of vermicomposting for production of organic fertilizers (sponsored by ICAR, New Delhi). *(Consolidated Tech. Rep., Uni. Agric. Sci. Bangalore (India). Adhoc scheme sponsored by ICAR, New Delhi.Sanction no. ICAR No.-F.No. 13(3)91-SW&DFdt. 26. 3. 1991).*

41) Kaplan, D., Hartenstein, R., Neuhauser, E.F. and Malecki, M.R. (1980a). Physicochemical requirements in the environment of the earthworm Eisenia fetida. *Soil Biol.Biochem., 12, 165 – 171.*

42) Karmegam, N., Haermelai K. and Daniel T.(1999). Effect of vermicompost on the growth and yield of green gram (Phaseolus aureus). *Tropical Agriculture 76(2):143-146.*

43) Lee, K.E. (1985). Earthworms: Their ecology and relationships with soils and land use. *Academic Press, Harcourt Brace Jovanovich, Publ.*

44) Loehr, R.C., Martin, J.H., Neuhauser, E.F., and Malecki, M.R. (1984). Waste management using earthworms-engineering and scientific relationships. *Final Report, Project ISP-8016764. National Science Foundation.*

45) Loehr, R.C., Martin, J.H.J.R., and Neuhauser, E.F. (1992). Land treatment of an aged oily sludge: Organic loss and change in soil characteristics. *In Water Research 26 (6): 805 – 815.*

46) Lofty, J.R. (1974). Oligochaetes. Biology of plant litter decomposition. *Edited by C.H. Dickenson and G.J.F. Pugh. Vol.I Academic Press. London & N.Y.*

47) Lotzof. M. (2000). "Vermiculture: An Australian Technology Success Story," *Waste Management Magazine, Australia, February 2000.*

48) Mackay, A.D., and Kladivko, E.J. (1985). Earthworms and rate of breakdown of soyabean and maize residues. *In Soil. Biol. Biochem. 16: 851 – 857.*

49) Manna, M.C., Singh,M., Kundu, S., Tripathi, A.K., and Takkar, P.N. (1997). Growth and reproduction of the vermicomposting earthworm *Perionyx excavatus* as influenced by food materials. *In Biology & Fertility of Soils 24 (1): 129 – 132.*

50) Manna, M. C., Jha, S., Ghosh, P. K. and Acharya, C. L. (2003). Comparative efficiency of three epigeic earthworms under different deciduous forest litters decomposition. *Bioresource Tech., 88 (3), 197-206*.

51) Mato, S., Sampedro, L., and Elvira, C. (1994). The role of earthworms (*Eisenia andrei*) in vermicomposting of solid paper-mill sludge: monitoring the changes. *In V Int. Symp. on Earthworm Biology, Ohio State University, Ohio.*

52) Mba, C.C. (1989). Biomass and vermicompost production by the earthworm Eudrilus eugeniae (Kinb*). In Rev. Biol. Trop. 37 (1). 11 – 14.*

53) Mba, C.C. (1996). Treated cassava peel vermicomposts enhanced earthworm activities and cowpea growth in field plots. In Resources conservation and Recycling. 17 (3): 219 – 226.

54) Mitchell, A. (1997). Production of Eisenia fetida and vermicompost from feedlot cattle manure. *In Soil Biology & Biochemistry. 29 (3-4) 763 – 766.*

55) Murgesan, A.G. and Sukumaran, N. (1994). Bioconversion of industrial sludge into manure through vermiculture Biotechnology. *In V Int. Sym. on Earthworm Biol. Ohio.*

56) Neuhauser, E.F., Loehr, R.C. and Maleckie., M.R. (1988). The potential of earthworms for managing sewage sludge. In: Edwards, C.A. and Neuhauser, E.F. (Eds.), *Earthworms in waste and environmental management. SPB Academic Publishing bv, The Hauge. Pp-20.*

57) Nora Goldstein, (2004). Landfill gives birth to ecoindustrial complex. *BioCycle December 2004, Vol. 45, No. 12, p. 24*

58) Norbu T. (2002). Pretreatment of municipal solid waste by windrow composting and vermicomposting. *Thesis submitted in partial fulfillment of the requirement for the degree of Master of Science. Asian Institute of Technology School of Environment Resource and Development, Thailand.*

59) Pattnaik, S. and Reddy, V.M. (2010). Nutrient status of vermicompost of urban green waste processed by three earthworm species – Eisenia fetida, Eudrilus eugeniae and Perionyx excavatus. *Applied and Environmental Soil Science. Volume 2010, Article ID 967526, 13pages, doi: 10.1155/2010/967526. Research Article.*

60) Periasamy A. and Vasuki B. 2010). Management of organic wastes by earthworms: dual benefit for environment and society. *International Journal of Global Environmental Issues 2010 - Vol. 10, No.3/4 pp. 327 - 338*

61) Reinecke, A. J., Viljoen, S. A. and Saayman, R. J. (1992). The suitability of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* (Oligochaeta) for vermicomposting in Southern Africa in terms of their temperature requirements. *Soil Biol. Biochem., 24 (12), 1295-1307*.
62) Rhee, J.A. (1963). Earthworm activities and the breakdown of organic matter in agricultural soils. In Soil Organisms. (eds. J. Dieksen and J. Van der Drift), North Holland, Amsterdam, pp.55 –59.
63) Savigny, J.C. (1826). Analyse d'un memoire sur les lombrics.par Cuvier. Mem. *Acad. Sci. Inst. FR.5, 176 – 184.*
64) Senapati, B.K., 1992. Vermitechnology: An option for Recycling Cellulosic Waste in India. In: New Trends in Biotechnology. Oxford and IBH Publications Pvt. Co. Ltd. Calcutta, pp: 347-358.
65) Datar, M.T., M.N. Rao and S. Reddy, 1997. Vermicomposting: A Technological Option for Solid Waste Management. J. of Solid Waste Technology and Management, 24 (2): 89-93.
66) Sharma A.A. (1995). A methodology for locating small-scale composting plants with an application to the Kathmandu Valley, Nepal. *Asian Inst. Of Technology, B*angkok, Thailand, M.Sc., Thesis.
67) Sinha, R.K., Heart, A.S., Asadi, R and Carretero, E. (2002). "Vermiculture Technology for Environmental Management : Study of Action of earthworms Eisenia fetida, Eudrilus eugeniae and Perionyx excavatus on biodegradation of some community wastes in India and Australia. *The Environmentalist, Vol. 22, No.2, pp.261 – 268.*
68) Sinha, Rajiv K., Sunil Herat, Sunita Agarwal, Ravi Asadi and Emilio Carretero, 2002. Vermiculture Technology for Environmental Management: Study of Action of Earthworms Elsinia fetida, Eudrilus euginae and Perionyx excavatus on Biodegradation of Some Community Wastes in India and Australia. The Environmentalist, U.K., 22 (2): 261-268.
69) Sinha, R.K., Nair, J., Bharambe, G., Patil, S and Bapat, P.S. (2008). "Vermiculture Revolution: A Low-cost and Sustainable Technology for Management of Municipal and Industrial Organic Wastes (Solid and Liquid) by earthworms with significantly low greenhouse gas emissions". *In J.I. Daven and R.N. Klein, Eds. Progress in Waste Management Research, NOVA Science Publishers, Hauppauge. Pp.159 – 227.*
70) Sinha, R.K. and Chan, A. (2009). "Study of Emission of Greenhouse Gases by Brisbane Households Practicing Different Methods of Composting of Food & Garden Wastes: Aerobic, Anaerobic and Vermicomposting," *NRMA—Griffith University Project Report, 2009.*
71) Sinha, Rajiv K., Sunil Herat, Gokul Bharambe, Swapnil Patil, P.D. Bapat, Kunal Chauhan and Dalsukh Valani, 2009. Vermiculture Biotechnology: The Emerging Cost-effective and Sustainable Technology of the 21st Century for Multiple Uses from Waste and Land Management to Safe and Sustained Food Production, Environmental Research Journal, NOVA Science Publishers, NY, USA, Invited Paper, Vol: 3 (2/3).
72) Sinha, R.K., Herat, S., Valani, D., Singh, K and Chauhan, K. (2010). "Vermitechnology for Sustainable Solid Waste Management: *A Comparative Study of Vermicomposting of Food & Green Wastes with Conventional Composting Systems to Evaluate the Efficiency of Earthworms in Sustainable Waste Management with Reduction in Green- house Gas Emissions," NOVA Science Publications, Hauppauge, 2010.*
73) Sinha R. K.,, Herat, S., Valani, D. and Chauhan K. (2010). Earthworms – the environmental engineers: review of vermiculture technologies for environmental management and resource development. *International Journal of Global Environmental Issues 2010 - Vol. 10, No.3/4 pp. 265 - 292*
74) Steinford E.I., Neto P. J.T., Mara D.D. (1996). Low cost composting University of Leeds, Leeds, U.K. *Research Monograph in Tropical Public Health Engineering, No.4*
75) Subler, Scott., Edwards Clive and Metzger James, 1998. Comparing Vermicomposts and Composts. Biocycle, 39: 63-66.
76) Suhane, Ravindra K., K. Sinha, Rajiv and K. Singh, Pancham, 2008. Vermicompost, Cattle-dung Compost and Chemical Fertilizers: Impacts on Yield of Wheat Crops; Communication of Rajendra Agriculture University, Pusa, Bihar, India.
77) Sukumaran, N., 2008. Vermitechnology for Increasing Crop Yield; School of Life Sciences. Vels University, Pallavaram, Chennai, India (sukumaran06@gmail.com). Published in The HINDU.
78) Sunitha N.S., Kale, R.D. (1995a): Efficiency of earthworm *E. eugeniae* in converting the solid waste from aromatic oil extraction units into vermicompost. *Paper presented and Published in the III International Conference on Appropriate Waste Technologies for Developing Countries,*

Nagpur, pp: 1329 – 1336. . Journal of IAEM, 22: 267-269.

79) Sunitha N. S., and Kale, R.D. (1995b): Performance of the two epigeic earthworms namely *Eudrilus eugeniae* and *Eisenia foetida* on various agricultural wastes. *Paper presented and accepted at the V National Symposium on Soil Biology & Ecology. Visva- Bharathi University, Shanthiniketan – 731 235*
80) Sunitha N.D., Giraddi, R.S., Kulkarni K.A. and Lingappa S. (1997). Evaluation methods of vermicomposting under open field conditions. *Karnataka Journal of Agricultural Sciences. 10(4): 987- 990.*
81) Sunitha, N.S. (2001). Bioenergetics of tropical earthworm on exposure to domestic and industrial sludge. *Thesis submitted and awarded from Jnana Bharathi, Bangalore University, Bangalore*.
82) Sunitha, N.S. (2011a). Transformation of wet garbage of Indian urbanites at household level. *Universal Journal of Environmental Research and Technology, MS 2011 139 (Galley Proof).*
83) Sunitha, N.S. (2011b). Olericulturists' modified age old practice under open access land for sustainability. *Submitted to Universal Journal of Environmental Research and Technology. (Under Review).*
84) Sunitha, N.S. (2011c). Sustainable agriculture for Indian soils – from an entrepreneur desk with agricultural background. *Indian Farming. 7370-16007-1-SM.DOC. Under second Review.*
85) Sunitha, N.S. (2011d). Handy tips for handling garbage at home. *Karnataka Journal of Agricultural Sciences. 2163-6152-1-SM.doc. Awaiting assignment.*
86) Suthar S. and Singh.S. (2008). Vermicomposting of domestic waste by using two epigeic earthworms (P. excavatus and P. sansibaricus). *Int.J.Environ.Sci.Tech. 5(1), 99-106, Winter 2008.*
87) Tomar, V.K., R.K. Bhatnagar and R.K. Palta, 1998. Effect of Vermicompost on Production of Brinjal and Carrot. Bhartiya Krishi Anusandhan Patrika (Indian Agricultural Research Bulletin), 13 (3-4): 153-156.
88) UNSW, ROU, 2002b. Best Practice Guidelines to Managing On-Site Vermiculture Technologies, University of New South Wales Recycling Organics Unit, Sydney, NSW, Australia; (Viewed in December 2004) www.resource.nsw.gov.au/data/Vermiculture%20BPG.pdf
89) Vermi Co. 2001. Vermicomposting technology for waste management and agriculture: *an executive summary. P O Box 2334, Grants Pass, OR 97528, USA : Vermi Co.*
90) Visvanathan, C. Trankler, J., Joseph, K. and Nagendran, R. (2005). (Eds.) *"Vermicomposting as an Eco-Tool in Sustainable Solid Waste Management," Asian Institute of Technology, Annamalai University, Chidambaram, 2005.*
91) WASTE WISE (1995). The execution of field demonstration of small scale composting for the treatment of the organic fraction of municipal refuse. *Status report and special report to Mythri Foundation, Mythri, Bangalore, India, Mimeco.*
92) Wawolumaya, C. and Maclaren V. (1998). Community composting in Jakarta, Indonesia. Dept. of Geography, Centre for Human Resources and Envt. Univ. of Indonesia, Jakarta, Indonesia.
93) White, G., (1789). *The natural history of selborne. Benjamin White, London.*