Vol 5 Issue 9 Oct 2015 ISSN No : 2230-7850

International Multidisciplinary
Research Journal

Indian Streams Research Journal

Welcome to ISRJ

RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

Indian Streams Research Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial board.Readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

International Advisory Board

Editorial Board

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.isrj.org

Indian Streams Research Journal
ISSN 2230-7850

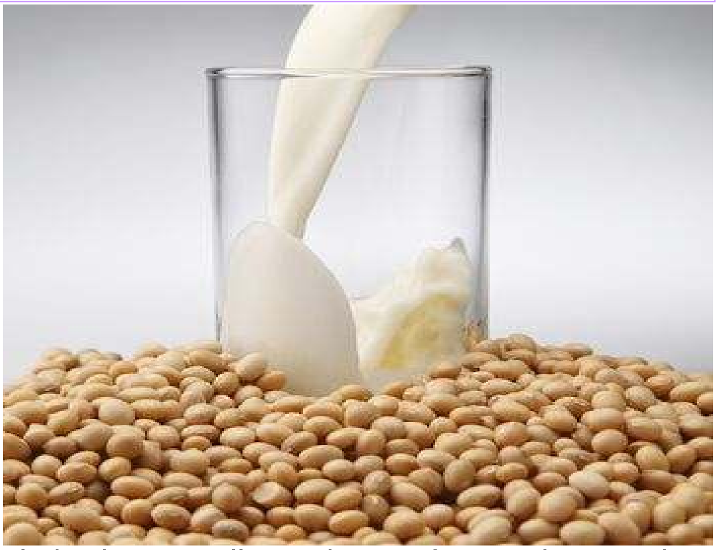
Impact Factor : 3.1560(UIF)
Volume - 5 | Issue - 9 | Oct - 2015

EFFECTIVE BIO-CONVERSION OF SOYA SLUDGE FROM SOYA MILK MANUFACTURING UNIT BY VERMICOMPOSTING

Veena Das
Assistant, CSIR-NEERI, Nagpur, Maharashtra, India

Co - Author Details :

Shanta Satyanarayan
Ex-Deputy Director, CSIR-NEERI, Nagpur, Maharashtra, India



ABSTRACT

Soya sludge is generated during soyamilk production. This sludge is the bean skin which is discarded after milk extraction. This waste has 30 – 35% solids and 65 – 70 % moisture. This sludge being highly proteinous in nature putrefies faster in general environment, leads to odour nuisance. Hence needs immediate scientific disposal, as it cannot be stored for more than few hours. An attempt has been made to subject this sludge to vermicomposting using an endemic variety of earthworm *Eudrilus euginiae.* Results showed that this sludge is an excellent substrate for vermicomposting. Volatile Solids reduction of 98.52% was obtained. Final product was granular, dark brown in colour with pleasant earthy smell.

Scanning Electron Microscopy was carried out on final manure to evaluate its maturity / stabilization. Results showed good matrix formation resulting in efficient porosity and water holding capacity. Maturity of the final compost was further confirmed by the microbial analysis. Micro analysis indicated no pathogenic bacteria and no fungal cell's presence. Overall results indicate efficient production of nutrient enriched vermicompost out of soya sludge waste.

KEYWORDS :*Soya sludge waste,* Eudrilus euginiae*, vermicomposting, scanning electron microscopy*

INTRODUCTION:

Soil health can be maintained by amending it with soil organics at regular time period, which will increase the soil productivity. Many biodegradable waste biomasses are generated in industrial / food industries. These waste biomasses require proper disposal procedures. It will be very useful to recycle the nutrient content of the solid organic matter, thus reducing the burden on the use of chemical fertilizers and also increase the lifespan of soils, in terms of its physical properties and environmental quality. Vermicomposting is the suitable answer for this problem. This technology is very ecofriendly, cost effective and sustainable in nature. Many unusual waste biomasses have been successfully vermicomposted using exotic and endemic variety of earthworms.

Raw biomass disposed on land leads to groundwater pollution, mosquito, fly nuisance, termites and odour problems etc. So it is preferable to provide them with easy eco-friendly and cheaper treatment method i.e. vermicomposting, which will reduce the disease spreading and increase the soil fertility.

Vermicomposting process comes under cleaner disposal techniques but it depends on the earthworm species utilized for this process. Many difficult to degrade and very hardy materials like coconut leaves and arcanut branches have been vermicomposted (1). These wastes contain high amount of lignin which resists decomposition. It is well known that coconut leaves contain around 31.0% lignin and offers high resistance to natural decomposition. However, certain group of earthworms that survive in organic matter can enhance the decomposition process of such materials. Equally arcanut tree leaves are also very hard and resist vermicomposting, but by simple manipulation with cattle dung it was successfully vermicomposted (2). These two biomasses are suitable for briquetting also, but vermicomposting has an edge over it. Another hardy weed is parthenium, which also contains toxins called parthenin and phenols, making it a doubtful biomass for vermicomposting but it has been proved beyond doubt that it can, not only be successfully vermicomposted but toxin contents can also be eradicated (3). Only shredding and handling of this weed needs careful attention as it creates allergic reaction in humans and is difficult to treat easily, so this waste needs proper management. Parthenium is mixed with optimum quantity of cattle dung and then vermicomposted. Around 30-35% organic carbon and 32-48% phenol content is reduced.

Vermicomposting is now being advocated in both rural and urban areas. Vermicomposting plays a very crucial role in improving the agricultural yield. Vermicomposting is an appropriate alternative for safe, ecofriendly, hygienic, cost effective disposal of huge volumes of degradable organic matter.

One of the highly fibrous and cellulosic wastes like banana tree peels have also been effectively vermicomposted using a species of earthworm Eudrilus euginiae (4, 5).

Pulp and paper industry is also a high cellulosic waste, which does not support earthworm growth by itself. So this waste was mixed with nitrogen rich waste materials and was successfully vermicomposted (6).

Special organic wastes like guar gum industrial wastes, arcanut and cocoa wastes have been vermicomposted easily (7). Groundnut shells which are very hard and contain lignin, has been reported to be vermicomposted in combination with rice husk (8). Recently, citronella oil meal (after oil extraction) was studied for its feasibility in vermicomposting. As being a grass variety, they contain good amount of silicates making them very sharp and restricts its use as fodder. Studies showed efficient vermicomposting of citronella oil meal with healthy growth of earthworms (9).

Night soil has been used for decades for the biogas production. This is an excellent substrate containing around 84% volatile matter and produces biogas, which contains around 62% methane. But its handling makes it aesthetically unsuitable, unsafe and restricts its use. Handling of the slurry is also problematic due to the presence of cysts of helminthic parasites. But recently night soil (human faeces) has been used for vermicomposting (10). Its disposal on land is very dangerous and it not only pollutes ground water but also is a source of many infectious diseases. If properly managed this nutrient rich substrate would result in easily available form of nutrients for plants. It has been reported that vermicomposting technology is one of the efficient methods for reducing pathogen concentration in night soil (11).

An unconventional waste organic sludge has been identified for vermicomposting. This sludge is generated during soyamilk production. This spent soya sludge is almost comparable to night soil, in its nitrogen content and C/N ratio. Percent volatile solids concentration of total solids is around 96.56% in soya sludge while in night soil it is in the range of 82.6 – 84.6%.

Soyabean (Glycine max) is a species of legume, native to East Asia, widely grown for its edible bean, which has numerous uses in food product industry. This plant is categorized as an oil seed rather than a pulse by the UNFAO. Fat free (defatted) soyabean meal is a significant and cheap source of protein for animal feeds. Soyabean produces significantly more protein per acre than most other plants. Protein content of this bean is around 40% (12).

Soya Sludge is generated during soya milk production. Beans are soaked overnight in cold water and it is then ground to a fine paste and then milk is extracted using water and filtered. The filtered milk is pasteurized and flavoured and sold. The sludge is the bean skin, which is discarded after milk extraction, which has 30-35% total solids with 65-70% moisture and hence this sludge putrefies faster in general environment and creates odour nuisance. Animals also do not eat it eagerly, once it starts emitting dirty odour. This sludge needs immediate disposal as it cannot be stored for more than few hours. This is an excellent substrate for biogas production and also for vermicomposting.

This sludge for the first time was used in an anaerobic biogas plant as an amendment to increase biogas production from cattle dung (13). Taking a cue from the importance of this sludge from the above reference it was tried for vermicomposting in combination with cattle dung and soil. Literature on this waste biomass for vermicomposting individually or in combination is very scanty.

Nitrogen content of soya sludge is around 2.8% and C/N ratio is 19.24. It is very clear, that this sludge is rich in nitrogen and may lead to ammonia production on unscientific disposal.

Soya sludge is highly degradable in nature and well suited for vermicomposting. When very fresh, pH of soya sludge is around 10.5 but in few hours, it reduces to the range of 5.5 – 5.8, due to decomposition. This soya sludge cannot be stored for long periods. It has to be immediately processed by drying it in shade to reduce moisture content to avoid decomposition.

Based on the detailed literature survey, it was envisaged to study the feasibility of vermicomposting this soya sludge. This article discusses in detail the vermicomposting procedure of soya sludge and the results obtained there in.

MATERIALS AND METHODS

Fresh Soya Sludge was procured from a local soya milk manufacturing unit. Raw material procured was subjected to routine physico-chemical parameters and heavy metal analysis was carried out by Inductively Coupled Plasma Technique - as per the standard methods (14). Cattle dung was procured from a local cow shed. Table 1 shows the characteristics of soya sludge. Required garden soil was brought from a local nursery. Its important parameters are indicated in Table 3. Volatile solids reduction was also calculated to know the efficient activity of the earthworms. Volatile solids reduction was calculated as per the literature (15).

Table-1: Characteristics of Raw Soya Sludge

Parameters	**Values**
pH	10.2
Conductivity (µs/cm^2)	386
Alkalinity as $CaCO_3$	2300 – 2450
Chloride as Cl (mg/l)	16.9
Sodium as Na (mg/l)	1.3
Potassium as K (mg/l)	65.4
Sulphate as SO_4(mg/l)	75.48
% Nitrogen as N	2.8
% Phosphate as PO_4	0.35 – 0.60
% Total Solids	96.2
% Total Volatile Solids	92.90
% Volatile Solids of Total Solids	96.56
% Moisture	3.8
C/N Ratio	19.24
heavy metals (in mg/l)	
Cadmium	0.0016
Cobalt	0.0030
Chromium	0.0141
Copper	0.0054
Iron	1.3796
Manganese	0.0133
Nickel	0.0144
Lead	0.0013

Earthworm species of Eudrilus euginiae was obtained from a vermiculture centre of a NGO –

Centre of Science for villages at Wardha, Maharashtra State, India. Vermicomposting experiments were carried out in earthenware pots (in duplicate). Soya sludge as such and also in combination with dried cattle dung and soil were studied. Fresh cattle dung was brought from a cow shed and was allowed to dry in shade. Fresh soya sludge has high content of moisture and it needs reduction to suit vermicomposting. Soya sludge was spread on a fine cotton cloth for few hours to reduce its water content. Experiments were carried out with 1:1:1 ratio of soya sludge, soil and cattle dung mixture. This mixture was allowed to pre-decompose for a period of ten days. After pre-decomposition of ten days, 15 numbers of healthy earthworms were introduced in each of the pots and moisture content was maintained. Pots were covered with mulch to prevent direct sunlight and rain water addition. Pot was maintained in shade.

Regular monitoring of the pots was carried out. Vermicompost obtained was subjected to routine physico-chemical parameters. Results are shown in Table 2. Few parameters of importance in vermicompost quality like density, porosity and water holding capacity were also estimated as per literature. (16) Results are indicated in Table 3.

Table2: Characteristics of Vermicompost

Parameters	Values
pH	7.31
Conductivity (µs/cm^2)	1058
Alkalinity as $CaCO_3$	326
Chloride as Cl (mg/l)	20.0
Sodium as Na (mg/l)	2.0
Potassium as K (mg/l)	74.1
Sulphate as SO_4(mg/l)	7.12
% Nitrogen as N	4.2
% Phosphate as PO_4	0.81
% Total Solids	75.35
% Total Volatile Solids	22.00
% Volatile Solids of Total Solids	29.19
% Moisture	24.65
C/N Ratio	3.03

heavy metals (in mg/l)	
Cadmium	0.0553
Cobalt	0.8421
Chromium	0.6291
Copper	3.7950
Iron	451.373
Manganese	21.47
Nickel	0.9235
Lead	0.1257
Zinc	13.0769

Table3: Physical parameters of vermicompost and soil

Parameters	**Name of Sample**	
	Soil	**Compost**
Bulk density (in g/cm^3)	1.6966	1.0021
Porosity (in %)	46.8815	72.624
Water Holding Capacity (in %)	38.7447	70.213

SEM studies of vermicompost were carried out to evaluate the maturity of the compost and its granulation pattern. Scanning Electron Microscopy [Model, JEOL, JSM 6380A, USA] was used. Samples were prepared by standard procedure (17), where a drop of sterile distilled water on a clean sterile glass coverslip was taken and then a smear was prepared on the coverslip and fixed with the help of flame. After fixing the coverslip was dipped overnight in Millonigs buffer. The cover slip was later removed from the buffer solution and dehydrated in different grades of alcohol. Coverslip was then air dried and cleaned with tissue paper. Finally the samples were ultra sound de-agglomerated in etalon for ten minutes gold splattered and then subjected to SEM analysis.

To further evaluate the extent of maturation of vermicompost, an aqueous suspension of the vermicompost was prepared for microbial analysis. It was allowed to stand for 24 hours and then it was filtered through Whatman Filter Paper No. 42. Filtered sample solution was subjected to routine microbial test.

RESULTS AND DISCUSSION

Fresh soya sludge depicted a pH in the range of 10.2 to 10.5. This soya sludge was rich in total nitrogen content which is around 2.8% but it is not in easily available form for the plants. It is hence important to stabilize this waste before its use on land. This stabilization can be achieved by vermicomposting / simple composting. Vermicomposting process significantly changes the physical and chemical properties of soya sludge. Vermicomposting of soya sludge brought the pH from original 10.2 to near neutral of 7.5, which clearly indicates efficient working activity of the earthworms in combination with the microorganisms present in the guts of worm.

Considering the high nitrogen content of the soya sludge preliminary studies were carried out by taking soya sludge (fresh) and few earthworms were released into it. But within half an hour's time earthworms became restless and ultimately became immobile and finally they died. It became very clear from this result that anaerobic fermentation sets in the fresh soya sludge heap and ammonia generates, as it is highly proteinous in nature and results in the death of earthworms. It can be inferred that the soya sludge in raw state is not accepted by the earthworms. Hence, it is necessary to pre-decompose the sludge prior subjecting it to vermicomposting as is always followed. Partial degradation, anaerobic/aerobic of the organic wastes is essential for the earthworms to be active and bioconvert the organic biomass. Raw biomass during decomposition generates heat, which is not tolerable by the earthworms to carry out degradation activity.

Predecomposition helps in elimination of anaerobic conditions, production of ammonia and volatile acid formation in the inner layers of the soya sludge. These factors are detrimental for the survival of earthworms. Hence initial stabilization of the raw biomass is needed to make the substrate palatable to the worms. It is also reported in literature that pre-decomposition of the biomass is essential to prevent death of earthworms (18).

Time period taken for vermicomposting of soya sludge in combination with soil and cattle dung was around 35 days, apart from ten days of pre-decomposition. Beautiful vermicast was observed on the surface of the pots. Cattle dung provided microbes for faster vermicomposting. These microorganisms convert nutrients already present in the soil into plant available forms. Vermicompost contains worm castings and also worm mucus which help prevent nutrients from washing away with initial watering but holds moisture better than plain soil.

Volatile solids reduction obtained was very efficient. High reduction of percent volatile solids is an indicator revealing, efficient maturing of the compost. Volatile solids reduction also indicates stable final product. Earthworms have degraded the organic wastes to the maximum extent. During vermicomposting C/N ratio reduced from original value of 19.24 to 3.03. Reduction of C/N ratio after vermicomposting indicates loss of carbon through microbial respiration in the form of carbon dioxide, during vermicomposting period of soya sludge. The value of C/N ratio depends on the type of waste and its degradation rate and on the fate of carbon and nitrogen during vermicomposting. As per the literature, it is clear that C/N ratio cannot be used as a maturity criterion for the vermicomposting, if the waste is rich in nitrogen, as is the situation in the present case. Concentration of total nitrogen in the compost is around 4.2%, i.e. it is more than normal vermicomposts. It may be due to high nitrogen content of the soya sludge.

In the present study, total nitrogen content increased compared to the initial concentration in the feed due to the decomposition of waste by earthworms to accelerate the nitrogen mineralization process. Earthworm enriches the nitrogen content of vermicompost through decaying tissues of dead worms if any, and microbial mediated nitrogen transformation during vermicomposting activities, results in further increase in nitrogen (19).

Electrical conductivity increased during vermicomposting to 1058 µs/cm2 which is well within the tolerable limits for the plants. Standard Electrical Conductivity tolerable by most plants is around 1 ms/cm2.Increase in Electrical Conductivity during vermicomposting is due to the increase in the soluble salts level resulting from the mineralization action of earthworms and microbes present in the guts of earthworms and those in the feed organic wastes. Decrease in the organic carbon, in the raw food material may be responsible for the increase in the Electrical Conductivity of the vermicompost. Photograph 1 shows the general appearance of the raw soya sludge. While Photograph 2 shows good granular dark brown to black colour vermicompost. This compost presented good earthy smell.

Photograph 1: Shows General appearance of raw soya sludge.

Photograph 2: Shows the quality of final vermicompost.

It is seen from the results as shown in Table 2 that the values of available phosphorus and potassium content have increased during vermicomposting period. Increase in phosphorous content in vermicompost clearly indicates earthworm mediated phosphorous mineralization (20). It is reported in literature that an increase in rise of phosphate content of vermicompost may be due to the presence of alkaline phosphates in the worm casts. (21)

There was significant increase in the heavy metals after vermicomposting. Major increase was found in case of Iron, Copper, Zinc and Manganese.

It can be inferred from the physical parameters as shown in Table 3 that bulk density is in very optimum range and was around 1.0021 g/cm3, which is very suitable for efficient root growth of plants. Percent porosity was around 72.6242% while the water holding capacity is around 70.213%.

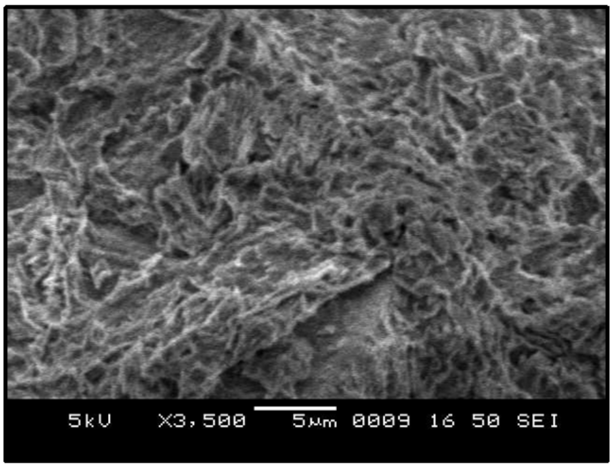
Final vermicompost depicted uniform granular structure and showed fluffy nature on handling while water holding capacity and porosity were in efficient range. Earthworms heartily grazed on this soya sludge. No death of earthworms was observed during vermicomposting period.

Final vermicompost resulted in percent volatile solids reduction of 98.52%, indicating very efficient activity by the earthworms. Final vermicompost had 22.0% organic matter which is well within the stipulated range of 20 – 25%. Moisture content in the raw soya sludge was around 69.70% and hence the sludge needed drying to reduce the moisture level to required limit. After the moisture content was reduced, then it was used for vermicomposting.

In general, it is very clear that soya sludge is a very suitable substrate for vermicomposting after moisture reduction. Very efficient manure could be obtained. Burden on chemical fertilizer thus can be reduced considerably.

Scanning Electron Microscopy(SEM) was applied to the vermicomposted soya sludge (Photograph 3), to study the changes that occurred in the texture of the soya sludge. In the vermicomposted soya sludge the protein and lignin was efficiently disintegrated by the earthworms. Earthworms break the waste substrate in the guts with the help of micro-organisms present in it. Micro-organisms gradually attack the raw substrate and degrade it. In this process, micro-organisms present in the raw organic matter also work in tandem.

Photograph 3: SEM of vermicomposted Soya Sludge



Vermicomposted sludge shows the presence of uniform matrix with irregularities which indicates that vermicomposting has been efficiently achieved. This also shows that good porosity and water holding capacity has resulted. Vermicompost of soya sludge was very light to touch and showed fluffy nature.

To further confirm the microbial quality of vermicompost a water suspension of the compost was prepared as quoted in literature [22]. This suspension was filtered through Whatman Filter Paper No. 42. This filtered liquid was subjected to routine microbial test. Results are shown in Table 4. It is seen from the results, that the vermicompost is free of fungal cells and pathogenic bacteria confirming the efficient vermicomposting activity.

Table 4: Microbial Quality of the vermicompost

S. No.	Microbes	c.f.u/ml
1.	Total count of bacteria	0.01×10^{8}
2.	Total count of fungi	Nil
3.	Total Actinomycetes	0.01×10^{7}

* No Pathogenic bacteria found.
** Beneficial thermophilic bacteria were found.

CONCLUSION

It can be inferred from the studies that soya sludge is a very suitable substrate for vermicomposting except that the moisture content is to be reduced prior subjecting it to vermicomposting. Fresh soya sludge does not support survival of earthworms and they die immediately, reason being the setting in of anaerobic condition in the fresh soya sludge. Soya sludge has to be pre-decomposed in combination with soil and cattle dung and then earthworms should be introduced. Compared to other biomasses, this biomass of soya sludge took on an average only 35 days excluding pre-decomposing period of ten days for complete vermicomposting. Good volatile solids reduction was obtained indicating efficient vermicomposting.

SEM analysis has confirmed the maturity of the manure obtained. Increase in surface area of the material by micro-organism is seen thereby increase in porosity and water holding capacity has been achieved. Microbial quality of the vermicomposted soya sludge showed no fungal cells or pathogenic bacteria. It is hence very easy to handle the vermicompost. Vermicompost depicted good earthy smell.

REFERENCES

1)CPCRI Report, 2009. Coconut leaf vermicompost and vermiwash, Kasargod, Kerala.
2)Chaudappa P., Biddappa C. C. and Sujata S., 1999. Effective recycling of organic waste in arcanut (Arca catechu L.) and cocoa (Theombrome cacoa L.) plantation through vermicomposting. Indian Journal of Agric. Sci. 69, pp 563 - 566.
3)Rajiv P., Rajeshwari S., Yadav H., and R. Rajendran V., 2013. Vermiremediation: Detoxification of parthenin toxin from parthenium weed. http/link springer.com
4)Kibatu T., Tilahun B. and Alemayehu A., 2015. Banana and manure waste as growth, reproduction and vermicompost of Journal of Environmental and Applied Bioresearch. Jan. 28, Vol. 3, No. 1, pp 15-19.
5)Kavitha P., Ravikumar G. and Manivannan S., 2010. Vermicomposting of banana agro-waste using an epigeic earthworm, (Kinberg). Int. Journal of Recc. Sci. Res. 1: pp 032-035.
6)Elvira C., Sampedro L., Dominguez J. and Mato S., 1997. Vermicomposting of wastewater sludge from paper pulp industry with nitrogen rich materials. Soil Biol. Biochem., Vol. 29, No. 3/4, pp 759 – 762.
7)Suthar S., 2006. Potential utilization of Guar gum industrial waste in vermicompost production. Bioresource Technology 97: pp 2474-2477.

8)Kitturmath M. S., Giraddi R. S., Viraktamath S. A. and Sattigi H. N., 2004. Evaluation of different feeding additives for bio-degradation of groundnut shell and rice husk using earthworm *Eudrilus euginiae* (Kinberg). Karnataka Journal of Agri. Sci. 17: pp 52-56.
9)Das V. and Satyanarayan S., 2015. Citronella oil meal recycling through vermicomposting using *Eudrilus euginiae.* International Journal of Plants, Animals and Environment Science.
10)Yadav Kunwar D., Vinod T. and Mansoor Ahammed, 2010. Vermicomposting of source separated human faeces for nutrient recycling. Waste Management 30: 50-56.
11)Eastman B. R., Kane P. N., Edwards C. A., Trytek L., Gunadi B., Stermer A. L., Mobley J. R., 2001. The effectiveness of vermiculture in human pathogen reduction for USEPA, Biosolids stabilization. Compost Science and Utilization 9 (1), pp 38 - 49.
12)Adiba Khanam Sheikh, 2015. Soya milk and Tofu manufacturing wastewater treatment by anaerobic fixed film fixed bed reactors using special media matrix. Doctoral thesis submitted to RTM University, Nagpur, Maharashtra, India.
13)Satyanarayan S., Ramakant and Shivayogi, 2010. Biogas production enhancement by soya sludge amendment in cattle dung digesters. Biomass and Bioenergy 34, pp 1278 - 1282.
14)Clesceri L. S., Franson M. A. H., Eataon A. D., Greenberg A. E., 2012. Standard Methods for the examination of Water and Waste water. 22nd Edition, 2012. APHA, AWWA and WPCF, Washington D. C., U.S.A.
15)Anaerobic Sludge Digestion, 1986. Water Pollution Control Federation (WPCF). Manual of Practice Vol. 16.
16)Mckenizie N. J., Jacquier D. J., Isbell R. F., Brown K. L., 2004. Australian soils and landscapes. An illustrated compendium. CSIRO Publishing, Collingwood, Victoria.
17)Bond A. J., Fan F. R. and Mirkin M., 1995. Scanning Electrochemical Microscopy in Physical Electrochemical Microscopy Principles, Methods and Applications. Marcel Dekker, New York.
18)Gunadi B., Blount C., Edwards C.A., 2002. The growth and fecundity of *Eisenia foetida* (Savigny) in cattle solids precomposted for different periods. Pedobiologia 46, 15-23.
19)Suthar S., 2007. Vermicomposting potential of *Periyonix sansibaricus* (Perrier) in different waste materials. Bioresource Technology 98: pp 1231 – 1237.
20)Suthar S., 2009. Growth and fecundity of earthworms *Periyonix excavates* and *Periyonix sansibaricus* in cattle waste solids. Environ. Sci. Technol. 29, pp 78 – 84.
21)Bayon L.R.C. and Binet F., 2006. Earthworm changes the distribution and availability of Phosphorus in organic substrates. Soil Biol. Biochem. 38: pp 235 – 246.
22)Pandey R. and Kalra A., 2010. Inhibitory effects of vermicompost produced from agro waste of medicinal and aromatic plants on egg hatching in *Meloidogyne incognito* (Kofoid & White) Chitwood. Current Science Vol. 98, No. 6, pp 833 – 835.

Indian Streams Research Journal
258/34 Raviwar Peth Solapur-413005,Maharashtra
Contact-9595359435
E-Mail-ayisrj@yahoo.in/ayisrj2011@gmail.com
Website : www.isrj.org