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Design and Development of Rapid Composting Pit for Agricultural Residues

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***Abstract*: It has been reported that agricultural production in India leads to the generation of the high volume of agriculture residue, which in turn results in large land accumulation. In addition, the dependency of farmers on chemical fertilizers depletes the soil quality and causes severe health effects on humans and animals. Therefore, in order to overcome these problems, it was thought to develop a farmer-friendly composting process for which a rapid composting pit was developed. The objective of this study was to design an optimum size-composting pit in an economical manner, which would besides reducing the above problems faced by farmers, also reduces the cycle time of composting. In this study compost prepared in two pits by using different feeding materials were tested and analyzed for different parameters (such as colour, moisture content, temperature, ash content, phosphorous, C/N ratio, lignin). It was found that the compost formed in both the pits were rich in macro as well as micro nutrients and it proved to be a good soil conditioner.**

Keywords: Compost, Feeding material, Rapid Composting.

1. INTRODUCTION

India is an Agro Based economy. About 60% of the Indian population relies directly or indirectly on agriculture. India has an estimated potential of producing about 4.3 million tones of compost each year from Municipal Solid Waste (MSW), which could help in reducing the wide gap between availability and requirement of organic manure for soils in India (Composting Report). The organic content of MSW tends to decompose causing odour nuisance which also pollutes the environment. In order to ensure a safe disposal of the MSW, it is desirable to reduce its pollution potential for which several processing methods are available. Composting is one of the most efficient and commonly used methods of processing biodegradable solid waste under controlled (predominantly) aerobic conditions. It results in the production of a stable product i.e. compost which can be used as a low grade manure and soil conditioner in agricultural and horticultural areas depending upon its quality. Compost obtained is rich in macro nutrients such as Nitrogen, Phosphorous and Potassium as well as micro nutrients and thus can be utilized for the growth of plants. When it is used in conjunction with chemical fertilizers optimum results are obtained. Among different methods of composting such as (Indore method, Bangalore method, passively aerated composting method, In-vessel composting method, NADEP method of composting and Vermicomposting) NADEP method of composting have been as base method selected for the Designing rapid composting for agricultural residues in this study.

1.1 SITE SELECTION

Field of a local marginal Farmer been selected for the Construction of Pit which is situated at Kapsi Village, Nagpur.

1.2 FEEDING MATERIAL SELECTION

Paddy and Citronella grass both are the major crop in the selected field. Rice Straw and Oil extracted Citronella grass were selected for the feeding as they were present in an abundant amount in the selected agricultural field as residues. The particle size of rice straw used was approximate 1 feet in length and that of Citronella grass used was about 1-2 feet long. Two types of mixtures were adopted for feeding. These were:

a. Rice straw and
b. Rice straw: citronella grass (1:1 w/w).

2. MATERIAL & METHOD

2.1 DESIGN OF RAPID COMPOSTING PIT

Two pits were constructed for the process. One of Rice Straw and other of a mixture of Rice straw&citronella grass. Construction of pits completed in 4 days. Both the rectangular pits were made of brick masonry (using 172 bricks each of

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standard size 273mm x 104mm x 73mm with 0.915m^3 of mortar) with a concrete base. The size taken of the pit adopted was 10′ (length) **x** 6′ (breadth) x 1′ (height). Perforated Pipes each of 2.5″ diameter were laid in the tank for providing passive aeration. 4″ thick PCC plinth was also laid in order to make the base leak-proof. Plan of Rapid Composting pit is shown in **Figure 1.**

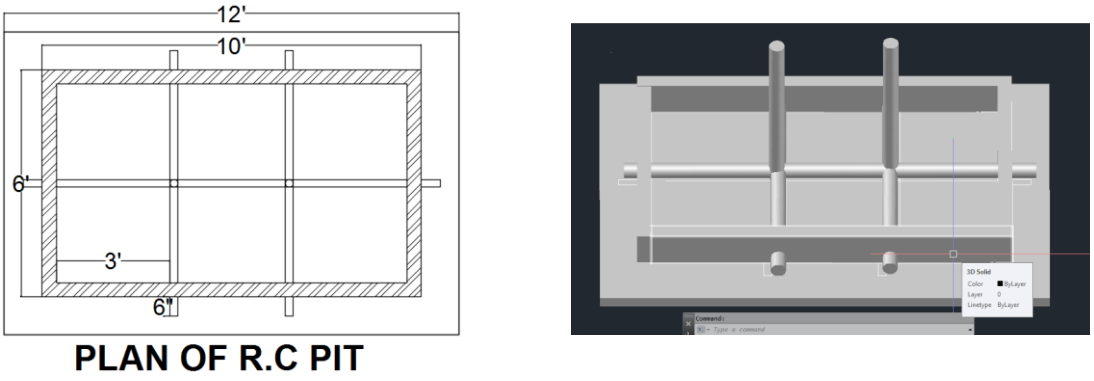

Figure 1: Plan of Rapid Composting (Line Diagram & 3D view)

2.2 PREPARATION of BIOLOGICAL ACTIVATOR

20 litres of Biological Activator was prepared for feeding each pit in the following manner. A solution was made by adding 2 kg jaggery in 2 litres of water. Two kg of old compost, 200 g Component 1 and 200 mg Component 2 were added & mixed thoroughly. 1 litre each suspended culture of selected microorganisms and 10 litres of water was added in the mixture. The solution was then kept for fermentation for 5 days. After Fermentation, the solution was scaled up to 20 litres.

2.3 COST ESTIMATION OF RAPID COMPOSTING PROCESS

The overall cost for the process was calculated for the year 2015-16.

Labour required : two masons per pit are adequate
No. of Working Hours : 8 hours per day
Pay per Labor : Rs. 400 per day
No. of Working days : 2 days
Total Labor Cost : Rs. 1600/-

Total Construction Cost: Rs. 3700

Jaggery = 2 kg x Rs. 38/kg = Rs. 76/-
Jute Bags = 15 nos. x Rs. 18 per bag = Rs. 270/-
Plastic Cover (Tirpaal) = Rs. 410/-
Culture Cost = Rs. 500/-
Total accessories cost = Rs. 1256/-

Total Cost for Composting: Rs. 6556/-

	Dimensions	No. of bricks	Concrete (in m^3)	Mortar (in m^3)	Cement (50 kg per bag)	Sand (in m^3)	Coarse Aggregate (in m^3)	62.5 mm dia PVC pipe	62.5 mm dia Tees
Plinth	**12′ x8′ x4″**	–	**0.83**		**2.4**	**0.332**	**0.665**		
Brick work	**10′x6′x1′**	**172 units**	-	**0.085**	**0.5**	**0.2**	–		
Total		**172**		**0.915**	**2.9≈3**	**0.532**	**0.665**	**35′**	**2**
Cost per unit (Rs.)		**5**		–	**310**	**672**	**1175**	**18/feet**	**70**
Total Cost		**860/–**			**930/–**	**358/–**	**782/–**	**630/–**	**140/–**

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2.4 METHODOLOGY ADOPTED

In Pit-1: 250 kg of rice straw was feed in 5 layers of approx. 50 kg each. Sufficient amount of water and activator was sprinkled on each layer.
In Pit-2: 220 kg of rice straw and citronella grass was feed in 5 layers of approx 45 kg each. Sufficient amount of water and activator was sprinkled on each layer.

Pits were then properly covered with jute bags. Visual Monitoring of both the pits was done and the growth of fungi was observed. The temperature of the pits was recorded regularly up to 7 days and then periodically at an interval of 10 days. Periodical assessment of variation in physiochemical parameters of feed material was done. At a regular interval of 10 days concentration of parameters such as moisture content, Ash content, Total Volatile Solids, Carbon, Hydrogen, Nitrogen, Sulphur, Sodium, Potassium, Phosphorus and Lignin was determined in the laboratory.

Figure 2: Feeding of Rice straw-Citronella grass (Pit-2)

Figure 3: Feeded Pit

3. RESULTS & DISCUSSION

After 60 days of Rapid Composting Period, Compost formed in both the pits was taken to a lab for various tests and results generated were as follows:-

3.1 Color & Odor:
Compost in both the Pits was Dark brown in colour and had an earthy odour as shown in Figure 4 and Figure 5.

Figure 4: Compost formed in Pit-1

Figure 5: Compost formed in Pit-2

3.2 Temperature
The variation in temperature of composting materials in Pit-1 and Pit-2 with time has been illustrated in **Figure 6** and **Figure 7** respectively.

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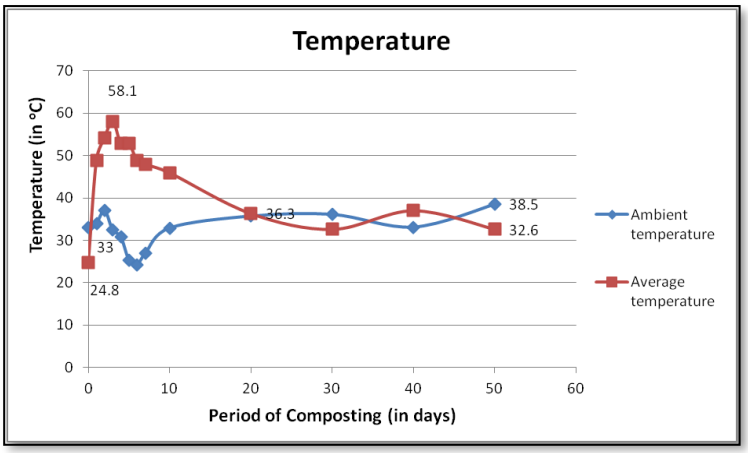

Fig.6: Variation in temperature during the composting process (Pit-1)

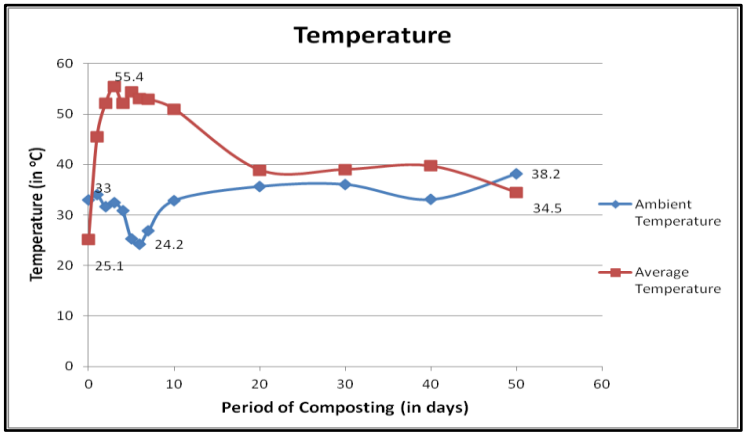

Figure 7: Variation in temperature during the composting process (Pit-2)

It was observed that after feeding, temperature shoots up the next day. This temperature rise was a result of intense microbial activity, which was further favored by the high concentration of easily decomposable organic matter. The thermophilic phase of microorganisms initiated on 2nd day in both the Pits and thus the temperature reached above 55 ºC in both the Pits i.e. 58.1ºC in Pit-1 and 55.4ºC in Pit-2 respectively. This temperature rise makes the compost pathogen free.

3.3 Moisture Content

The variation in moisture content of composting materials in Pit-1 and Pit-2 with time is presented in Table-1.

Table-1 Variation of Moisture content with time during composting

S. No.	Period of Composting (in Days)	Moisture Content (in %)	
		Pit-1	Pit-2
1.	0	8.04	8.13
2.	10	8.57	10.84
3.	20	27.96	29.84
4.	30	37.88	42.05
5.	40	45.32	53.19
6.	50	58.68	54.58
7.	60	10.67	07.33

It can be observed from Table-1 that the initial moisture content of feed was low as the matter taken up for feeding was dry. Moisture lost during the composting process can be viewed as an index of decomposition rate, because heat generated during the process accompanies decomposition. After observing moisture content of 10th day sample, it was found to increase moisture content in both the pits to maintain it nearly 40% -50% which was best suited for the composting process. At the end of the process, Compost was sun-dried which showed a sudden decrease in the moisture content of the final products.

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3.4. Total Solids, Total Volatile Solids and Ash Content

The ash content is an important indicative parameter for decomposition and mineralization of any composting material (Khwairakpam and Bhargava, 2009b). The ash content increment in the Pit-1 and Pit-2 with respect to the period of composting has been presented in the form of a graph in Fig.8.

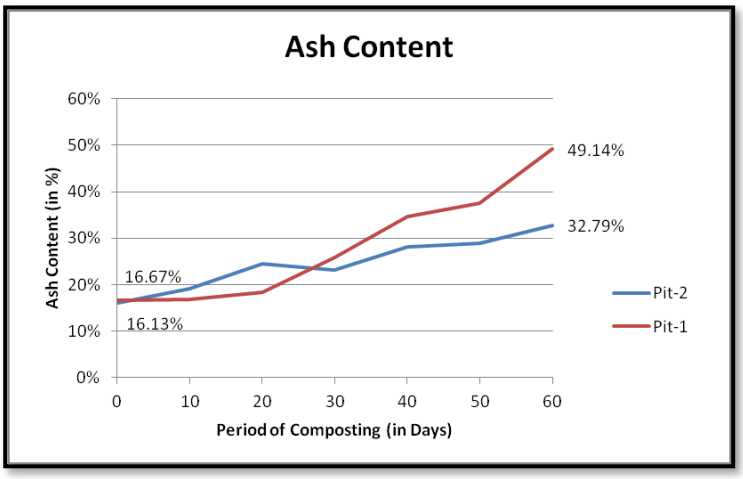

Fig.8 Ash Content v/s Period of Composting

The results of the analysis indicated that ash content of Pit-1moderately multiplied three folds than its initial value while that of Pit-2 becomes doubled than its initial value. The enhanced mineralization of agro waste materials due to composting may be the reason for higher Ash content in the final product. Decrease in Total Volatile Solids in the pits i.e. 29.71% loss in Pit-1 and 19.86% loss in Pit-2 also indicated the degradation of organic material.

3.5 Carbon Content and Nitrogen Content

C/N ratio is the key parameter for the maturity of the compost. Degradation of carbon and mineralization of nitrogen, both are important aspects of composting. Carbon degraded by 32.65% in Pit-1 while 30.99% in Pit-2. Nitrogen mineralized with the course of time, nitrogen content reached up to 1.988% in Pit-1 and 1.876% in Pit-2, which is more than 1%, compared to the compost formed as per standards. Fig. 9 has showed a variation of C/N ratio in both the pits with time during the process of composting.

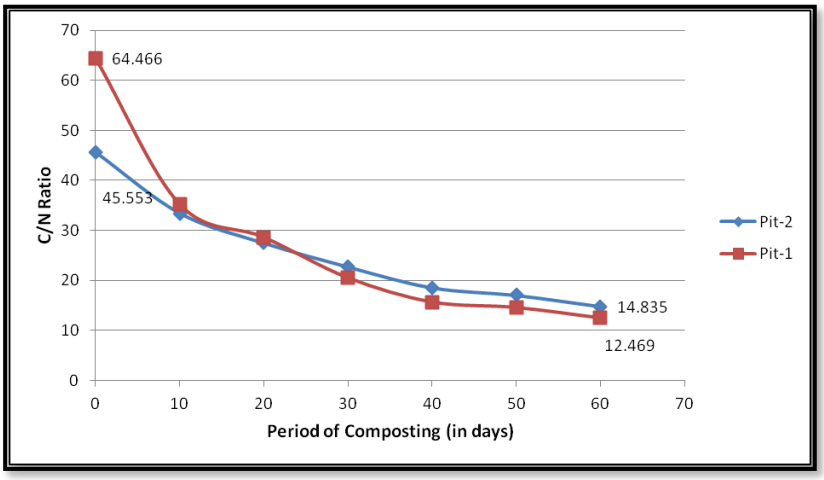

Fig. 9 C/N Ratio v/s Period of Composting

The results clearly indicate that there was a continuous decrease in the values of C/N ratio after 10 days of the stabilization process. The decrease in C/N ratio was 80.66% in Pit-1 as compared to 67.43% in Pit-2. The initial level of C/N ratio was 64.466 in Pit-1, which reduced to a final value of 12.469. Similarly, the value of C/N ratio in Pit-2 reduced to 14.835 from an initial value of 45.553. This shows a significant amount of carbon degradation as well as Nitrogen mineralization. C/N ratio reached below 20, which revealed that the compost formed, was as per Municipal Waste (Management & Handling) Rules, 1999.

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3.6 Phosphorus Content

Phosphorous content gradually increased during the composting process. The change in phosphorus throughout the composting period has been tabulated in Table 2. Variation in Phosphorous was due to the net loss of dry mass. The initial amount of Phosphorus present in Rice Straw was less than that of Rice straw-Citronella grass mixture. There was only a slight increase of 29.28% in phosphorus in Pit-1 i.e. from 102.68 mg/kg to 132.74 mg/kg whereas the increase in the concentration of Phosphorous in Pit-2 was 24.24% i.e. from an initial value of 161.37 mg/kg to 200.48 mg/kg.

Table-2 Variation of Phosphorous content with time during composting

S. No.	Period of Composting (in Days)	Phosphorous Content (in mg/kg)	
		Pit-1	Pit-2
1.	0	1026.8	1613.7
2.	10	1096.7	1710.0
3.	20	1122.6	1589.2
4.	30	1243.4	1694.8
5.	40	1187.9	1849.7
6.	50	1179.0	1922.2
7.	60	1327.4	2004.8

3.7 Lignin Content

Lignin degradation during composting is governed by- temperature, the original lignin content and the thickness of the material. During the Thermophilic phase, rapid degradation of lignin was measured. In Pit-1 the lignin concentration was reduced to 14.5% in 10 days period from an initial concentration of 21.5% whereas, in Pit-2 the concentration reduced to 16.4% in 10 days period of composting from an initial concentration of 25.8%. Lesser degradation was observed in Pit-2 because of long leaf size (not more than 2 feet) of citronella grass.

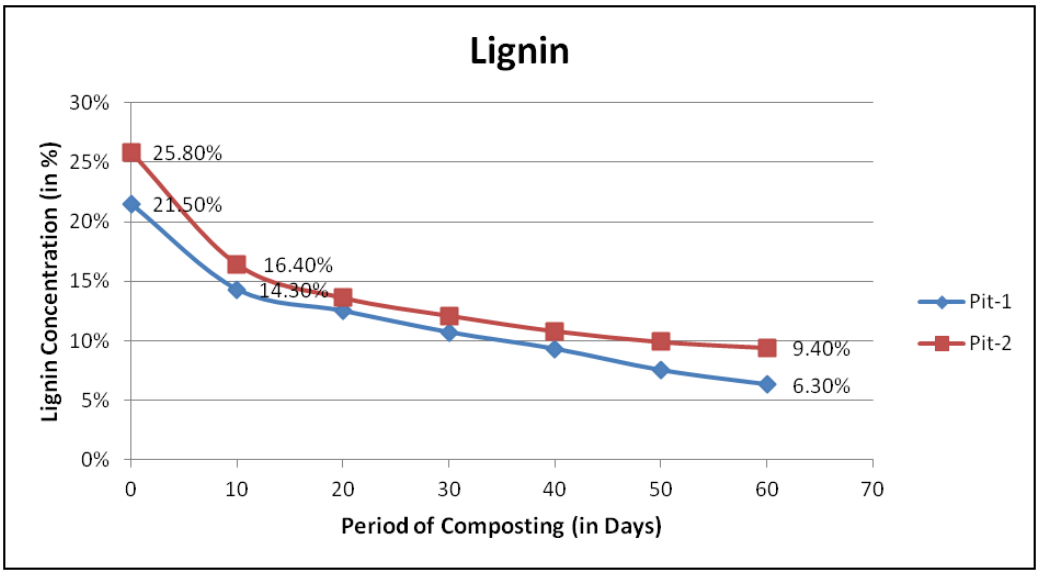

Fig. 10 Lignin Concentration v/s Period of Composting

4. CONCLUSIONS

It can be concluded that Rapid Composting is one of the best techniques for treatment of Agricultural Residues. Composting Process reduces the volume of waste as well as convert it into a useful product i.e. compost. Following conclusions were drawn from the work conducted under this study-

a. Rapid Composting method is more efficient in terms of composting cycle time. Composts in this method were matured in 60 days compared to other conventional methods which normally take more than 90 days.
b. The problems of fly breeding, odour generation, and rodents were eliminated because of the aerobic design of Pit.
c. The temperature increased rapidly from mesophilic to thermophilic phase and then gradually reduced through the maturation phase.

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d. The problem of Land acquisition was minimized as cycle time was less compared to other conventional methods. Therefore, more production of compost can be done by increasing the number of composting cycles per year.
e. The large Particle size of both rice straw (length ≈ 1') and citronella grass (length ≈ 2') decelerated the degradation process.
f. Thermophilic phase was found retained for more time in Pit 2 than in Pit 1 because of the density of citronella.
g. Lower ash content of Rice straw-Citronella grass mixture (Pit 2) revealed that oil content in citronella hindered organic matter degradation.
h. Composting period recommended being reduced up to 30 to 40 days in comparison to 60 days for potassium-rich compost.
i. Optimum Moisture Content was obtained in between 40%-50% for accelerating the process and should not be increased more than 60% to avoid leachate formation.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Bernal, M., Parades, C. and Ceggara, J. Maturity and Stability Parameters of Composts Prepared with a wide Range Of Organic Wastes, *Bioresource Technology*, **63**, 91-99, **(1998)**.
[2] Boelens, J., Wilde, B., and Baere, L. Effects on Household Biowaste Collection, Composting Process and Compost Quality, Proceedings of Organic Reclamation and Composting Association Conference, Brussels, Belgium, **(1995)**.
[3] Central Pollution Control Board, (CPCB), Report on management of municipal solid waste, Delhi. India, **(2000)**.
[4] Chandra, R., Kumar, N. and Tyagi A.K. Nutrient dynamics and decomposition rates during composting of sulphitation pressmud by different methods, *Journal of Environmental Science & Engineering*, **49(3)**, 183-8, **(2007)**.
[5] Chang, J.I. and Chen, Y.J. Effects of bulking agents on food waste composting, *Bioresource Technology*, **101(15)**, 5917-5924, **(2010)**.
[6] Composting in SWM – a report http://www.cleanindiajournal.com/composting_in_swm%E2%80%93a_report/
[7] Dhal, G.C., Singh, R., Khwairakpam, M., and Kalamdhad, A.S. Composting of water hyacinth using Saw dust/Rice straw as a bulking agent, *International Journal of Environmental Sciences*, **2(3)**, 1223-1238, **(2012)**.
[8] Goyal, S., Dhull, S. K., and Kapoor, K.,K. Chemical and biological changes during composting of different organic wastes and assessment of compost maturity, **(2004)**.
[9] Kalamdhad, A.S. and Kazmi, A. A. Rotary drum composting of different organic waste mixtures, *Waste Management & Research*, **27(2)**, 127-138, **(2009)**.
[10] Khwairakpam, M., Bhargava, R. Vermi technology for sewage sludge recycling, *J. Hazard. Mater*, **161**, 948–954, **(2009)**.
[11] Kumar, S., Goyal, S.K. and Kumar A. A Study on Design & Development of NADEP Compost Tank, *Progressive Agriculture*, **11(1)**, 207-209, **(2011)**.
[12] Liu, D., Zhang, R., Wu, H., Xu, D., Tang, Z., Yu, G., Xu, Z., and Shen, Q. Changes in biochemical and microbiological parameters during the period of rapid composting of dairy manure with rice chaff, *Bioresource Technology*, **88(5)**, 1345-1358, **(2011)**.
[13] Manual on Municipal Solid waste Management, Ministry of urban Development, **(2016)**.
[14] Raut, M.P., William, S.P., Bhattacharyya, J.K., Chakrabarti, T. and Devotta S. Microbial dynamics and enzyme activities during rapid composting of municipal solid waste – A compost maturity analysis perspective, *Bioresource Technology*, **99**, 6512–6519, **(2008)**.
[15] Singh, J. and Kalamdhad, A.S. Assessment of compost quality in agitated pile composting of water hyacinth collected from different sources, *International Journal of Organic Waste and Agriculture*, **(2015)**.
[16] Tatàno', F., Pagliaro, G., Giovanni, P., Floriani, E. and Mangani, F. Biowaste Home Composting: Experimental process monitoring and quality control, *Waste management*, **38**, 72-85, **(2015)**.
[17] Wang, X., Cui, H., Shi, J., Zhao, X., Zhao, Y. and Wei, Z. Relationship between bacterial diversity and environmental parameters during composting of different raw materials, *Bioresource Technology*, 198, 395-402, **(2015)**.
[18] Wani, K., Mamta , Rao, R. Bioconversion of garden waste, kitchen waste and cow dung into value-added products using earthworm Eiseniafetida., *Saudi Journal of Biological Sciences*, **20**, 149-154, **(2013)**.
[19] Website of Farmer and agriculture Department. , Govt. of Madhya Pradesh (India) http://www.mp.gov.in/en/web/guest/method-of-composting
[20] Yang, F., Li, G., X., Yang, Q., and Luo, W. Effect of bulking agents on maturity and gaseous emissions during kitchen waste composting, *Chemosphere*, **93(7)**, 1393-1399, **(2013)**.
[21] Manual on Municipal Solid waste Management, Ministry of urban Development, **(2000)**.