Mysore J. Agric. Sci., 57 (4) : 290-297 (2023)

Preparation and Characterization of Lake Biomass Compost Enriched with different Sources

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Received : Febuary 2023
Accepted : November 2023

ABSTRACT

A study was conducted in the Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru. For the compost preparation lake biomass such as water hyacinth and alligator weed was collected from the selected lakes and used as raw materials. Cow dung, the major accelerator for compost preparation and microbial inoculum (*Pleurotus sajorcaju, Phanerochaete chrysosporium* and *Trichoderma harzianum*) was used as components to hasten the rate of decomposition. Initial chemical composition of sources and after preparation of lake biomass compost (LBC), were analysed for physico-chemical and biochemical changes at different stages of composting. The matured compost was nearly neutral (6.93) with dark brown colour and there was increase in nutrient composition of compost during all the stages of composting, highest nutrient content of nitrogen (1.73 %), phosphorus (0.92 %) and potassium (2.87 %) along with secondary and micronutrients along with reduction in lignin and cellulose content at the end of composting process. Further, the LBC was enriched with different sources (neem cake, single super phosphate and microbial consortium) for 15 days. After enrichment compost was analysed for many parameters. Results of the study revealed that there was increase in nutrient composition of enriched compost compared to the compost without enrichment. Maximum nutrient content was recorded in MNSE-LBC (microbial consortium + neem cake + SSP enriched lake biomass compost) followed by SSPE-LBC (single super phosphate enriched lake biomass compost) with maximum nitrogen, phosphorus and potassium of 1.91, 1.52 and 3.10 per cent, respectively. Hence, lake biomass compost can serve as organic source to supply nutrients to crops specially for urban farmers who are in need of organic sources and the waste generated from the lakes can be better utilized.

Keywords : Lake biomass, Enrichment, Characterization, Water hyacinth, Alligator weed

Now a days, waste from industries, untreated sewage and effluents from agricultural lands are released into the natural streams that gradually merge into the water bodies, causing an algal bloom, aquatic weed proliferation that results in large-scale fish suffocation deaths and foaming due to enrichment. These effects may pose health and environmental risks along with making the water body habitat to many dangerous aquatic animals which are under threat for their survival. The biomass controls further degradation of water bodies, breaks down various contaminants and enhances ecosystem's spatial niches. The ecological and monetary significance of aquatic plants are enormous. They support the movement of mineral nutrients from the bottom sediments and offer shelter for fish and aquatic macroinvertebrate. When there is a high availability of nutrients, aquatic plants exhibit a rapid growth rate and assimilate nutrients straight into their tissues, which are available to plants. It may be possible to address this problem in a sustainable way by using biomass waste as raw material for other processes. Such weed biomass is a valuable industrial bioresource due to the high nutritional contents and presence of other valuable composition (fibres, protein, lipids, carbs, minerals, vitamins, etc.) (Suthar and Singh, 2017). Recent studies suggested that lake biomass could be used for preparation of compost, bioenergy production and the extraction of some beneficial industrial products. Further, lake biomass can be used to create enhanced lake biomass compost, which farmers can use as a source of organic manure because it contains 95 per cent moisture, crude oil, crude protein, crude fibre and mineral components such as nitrogen, potassium, phosphorus, iron, manganese, zinc, sodium, calcium and magnesium (Umar *et al.,* 2007). As the production of biomass from lakes is vast and abundant, it has potential to use in agriculture as source of nutrients after composting to reduce the heavy metal contamination of lake biomass which are accumulated by inlet of untreated sewage water, industrial wastes or byproducts and also some of the agricultural effluents.

Composting is the biological decomposition and stabilisation of organic matter under circumstances that allow the development of the thermophilic temperature as a result of biologically produced heat, with a final product that is sufficiently stable for storage and application to land without having a negative impact on the environment. Farmers use different sources for composting like kitchen waste, urban sewage waste, crop residues and weeds from agricultural land and also from the lakes. This helps to recycle the waste produced from urban regions along with providing good organic source of nutrients for urban farmers. The compost produced might be insufficient to supply all the nutrients in required amount to the crops therefore the enrichment of the compost using different organic or inorganic sources will produce a good compost with better nutrient composition. This enriched compost can be a good source of nutrients which supplies the sufficient quantity of nutrients (Kavitha and Subramaniam, 2007) to the urban farmers. In addition to this composting of the lake biomass will help those cities where the issues caused by aquatic weeds are severe enough to be solved by getting rid of such plants. Compared to dried aquatic vegetation or crop residues, composting as an alternative treatment has the advantage of creating a product that is simple to work into the soil. This is due to the decomposed structure of the product.

Utilization of lake biomass/aquatic weeds will help in augmenting the organic resources through biomass composting besides, it will help in managing them. Present investigation was taken with an objective of preparation and characterization of enriched lake biomass compost and study its effect on soil properties.

Material and Methods

Study Area

Bangalore is located in the Deccan plateau, closer to the south east of Karnataka state extends from $12^0 49'5''$ N to $13^0 8'32''$ N in latitude and $77^0 27'29''$ E to $77^0 47'2''$ E in longitude. Bangalore which receives an annual average rainfall of 850 mm is placed on the ridge with the topography of 962 m AMSL. Bangalore city (spatial quantity in 1980's was 161 Km^2) had around 274 lakes, which helps in harvesting and recharging of groundwater sources, moderating micro climate, supporting nearby livelihood (fish, fodder, etc.), irrigation and domestic water needs and also for other endeavor facilities. Among these lakes, nine lakes were selected based on the abundance of lake biomass (Fig. 1).

Preparation of Lake Biomass Compost

For the preparation of lake biomass compost, lake biomass *viz*., alligator weed and water hyacinth and cow dung were added. Lignin and cellulose decomposing microbial inoculum *i.e*., *Pleurotus sajorcaju, Phanerochaete chrysosporium* and

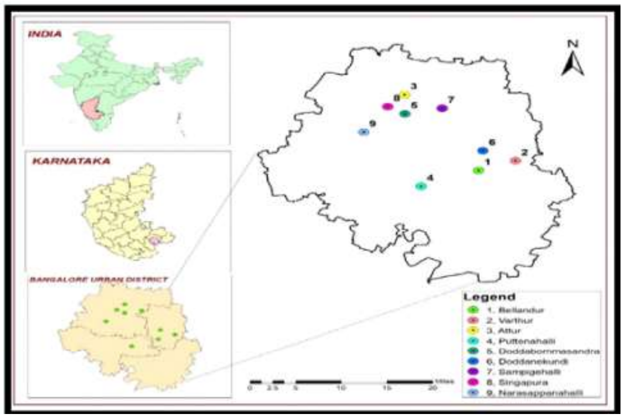

Fig. 1 : Location map of the study

Trichoderma harzianum were added at 500 g per quintal of lake biomass.

Lake biomass compost was prepared in compost bag of 48' length, 12' breadth and 12' height. Holes were made at the height of 12 cm above the bottom on four sides of composting bag. Raw material *viz*., water hyacinth and alligator weed were spread on the composting bag upto a layer of 4-5 cm. Additives such as cow dung slurry, microbial inoculum were sprinkled on the layer for hastening the rate of decomposition. Over this another layer of raw material of 4-5 cm was made and additives were again sprinkled over it. This procedure was repeated so that leaving only 10 cm at top. Moisture was maintained at 80 per cent of maximum water holding capacity of the material. The top layer was sealed using moist cow dung and kept undisturbed for 30 days.

First turning was carried out on 30th day and subsequent turnings were given at an interval of 30 days upto 90 days. Samples were collected for analysis at time of each turning. At the end of the 90 days, the compost was removed and dried in shade. After drying, the compost weighed and weights were recorded to calculate the per cent mass loss and per cent recovery. The samples collected at each interval were analysed for pH, organic carbon, total nitrogen, total phosphorus, total potassium, total calcium, total magnesium, total sulphur, micronutrients and heavy metals following the standard procedures.

Enrichment of the Lake Biomass Compost

At final stage of decomposition of the organic material, compost was enriched with different sources for 15 days. For the enrichment of compost, microbial consortium (2 ml in 100 ml water per kg of compost), neem cake (20 g per kg of compost), single super phosphate (10 g per kg of compost) and combination of all were employed. The microbial consortium comprised of *Azotobacter chrococum, Bacillus megatherium, Pseudomonas* and *Trichoderma harzianum.*

Characterization of Compost

The compost samples collected at different intervals *viz.,* 30 and 60 days and 90th day of composting were assessed for different parameters.

Physical Properties

The physical properties of compost like reduction in volume, odour (visual observation), colour (visual observation) and texture were recorded based on visual interpretation.

Chemical Properties

Chemical properties *viz*., pH and Electrical conductivity (Jackson, 1973), Organic carbon (Walkey and Black, 1934), Total nitrogen (Piper, 1966), Total phosphorus (Piper, 1966), Total potassium (Piper, 1966), Total Calcium and Magnesium (Piper, 1966), Total sulphur (Piper, 1966), Micronutrients **(**Lindsey and Norwell, 1978) and Heavy metals **(**Lindsey and Norwell, 1978) were analysed for each samples collected at different intervals of composting using standard methods.

Analysis of Biochemical Properties

Lignin and cellulose in the raw organic materials were estimated using the procedures outlined by Sadasivam and Manickam (1996) with slight modifications. Extraction, fractionation and quantification of humic substances were done by using standard method.

The Lignin and Cellulose were Calculated using the Formulae

Lignin = Residue after extraction with 72% H_2SO_4 - Ash

Cellulose = ADF - Residue after extraction with 72% H_2SO_4

Results and Discussion

Initial Chemical Characterization of the Raw Materials used for Compost Preparation

The chemical composition of raw materials used for preparation of the compost are given in Table 1. Water hyacinth and Alligator weed collected from the selected lakes of Bengaluru were the two lakes biomass used for the composting. The biomass samples were dried in shade for 3 to 4 days for compost preparation. The moisture content of Water hyacinth was high (97.8 %) as compared to Alligator weed (83.5 %). The nitrogen content of water hyacinth was relatively higher than that of the alligator weed as reported by Akanbi *et al*. (2007).

Table 1

Initial chemical composition of the raw materials used for compost preparation

Parameter	Water hyacinth	Alligator weed	Cow dung
pH	5.56	5.69	6.93
EC (dS m^{-1})	0.01	0.08	0.89
Organic carbon (%)	45.50	43.00	20.60
Total Nitrogen (%)	2.65	2.63	0.91
Total Phosphorus (%)	0.65	0.43	0.43
Total Potassium (%)	2.73	2.57	0.25
Total Calcium (%)	1.16	0.96	0.45
Total Magnesium (%)	1.16	0.64	0.38
Total Sulphur (%)	0.16	0.42	0.26
Copper (mg kg^{-1})	34.60	22.30	4.83
Zinc (mg kg^{-1})	23.20	18.30	3.20
Iron (mg kg^{-1})	761.10	423.20	20.50
Manganese (mg kg^{-1})	256.00	192.60	81.80
Boron (mg kg^{-1})	0.092	0.41	0.06
Cadmium (mg kg^{-1})	1.05	1.032	0.007
Chromium (mg kg^{-1})	20.81	18.95	0.12
Lead (mg kg^{-1})	23.92	20.88	0.11
Nickel (mg kg^{-1})	17.81	16.78	0.05
Lignin (%)	11.20	18.10	14.10
Cellulose (%)	17.00	21.90	11.10

Water Hyacinth

Water hyacinth recorded a pH of 5.56, electrical conductivity of 0.01 dS m^{-1} and 45.50 per cent organic carbon. It contains 2.65 per cent nitrogen, 0.65 per cent phosphorus, 2.73 per cent potassium, 1.28 per cent calcium, 1.16 per cent magnesium and 0.16 per cent of sulphur. The micronutrients like copper, zinc, iron, manganese and Boron were found to be 34.60, 23.20, 761.1, 256.00 and 0.09 mg kg^{-1}, respectively. Heavy metals *viz*., chromium, lead, nickel and boron recorded the concentrations of 20.81, 23.92, 17.81 and 1.05 mg kg^{-1}, respectively. It had a lignin content of 11.20 per cent and 17.00 per cent of cellulose with the C:N ratio of 17.16.

Alligator Weed

Alligator weed had a pH of 5.69, electrical conductivity 0.08 dS m^{-1} and 43.00 per cent organic carbon. It recorded 2.63 per cent nitrogen, 0.43 per cent phosphorus, 2.57 per cent potassium, 0.96 per cent calcium, 0.64 per cent magnesium and 0.42 per cent sulphur. The content of copper, zinc, iron, manganese and boron were 22.30, 18.30, 423.02, 192.60 and 0.41 mg kg^{-1}, respectively. The heavy metals like chromium, lead, nickel and cadmium were recorded 18.95, 20.88, 16.78 and 18.10 mg kg^{-1}, respectively. It also contained 18.10 per cent lignin and 21.90 per cent cellulose with the C: N ratio of 16.34.

Cow Dung

Cow dung recorded a pH of 6.93, electrical conductivity 0.89 dS m^{-1} and 20.60 per cent organic carbon. It recorded 0.91 per cent nitrogen, 0.43 per cent phosphorus, 0.25 per cent potassium, 0.45 per cent calcium, 0.38 per cent magnesium and 0.26 per cent sulphur. The content of copper, zinc, iron, manganese and boron were 4.83, 3.20, 20.50, 81.80 and 0.06 mg kg^{-1}, respectively. The heavy metals like chromium, lead, nickel and cadmium were recorded 0.129, 0.118, 0.055 and 0.007 mg kg^{-1}, respectively. It had a lignin content 14.10 per cent, 11.10 per cent cellulose and C:N ratio of 22.60.

Characterization of Lake Biomass Compost at different Intervals

Physico-chemical properties of lake biomass compost were improved after the complete decomposition of raw materials (Table 2). There was decrease in the moisture content and bulk of the organic materials. The compost attained a neutral pH of 6.93 and EC of 0.71 dS m^{-1} (Farhan *et al.,* 2010 and Nalubega *et al.*, 2009). The nutrient parameters like total nitrogen (1.73%), total phosphorus (0.92%), total potassium (2.87%), total calcium (1.88%), total magnesium (1.52%), total sulphur (0.92%) and micronutrients *viz*., copper, zinc, iron, manganese and boron (43.30, 256.60, 828.70, 359.30 and 0.88 mg kg^{-1}, respectively) content were increased at the end of the composting might be due to the reduction in moisture and bulk of materials concentrated the nutrients in the compost (Mathur *et al.*, 2016). Whereas, the heavy metal *viz*., Cadmium, chromium, lead and nickel (0.93, 15.82, 19.89 and 14.82 mg kg^{-1}, respectively) content in compost reduced compared to raw materials might be attributed to the transformation of soluble form of metals to non-soluble or residual form by microorganisms (Veena & Sathish, 2022).

The biochemical composition (Table 3) of the raw materials mainly contains lignin and cellulose which was reduced at the end of the composting giving a L/N ratio of 7.08 and (L+C)/N ratio of 14.94. The humic (8.70%) and fulvic acid (2.40%) content of the compost increased indicating the complete decomposition and nutrient content (Bhargavi, 2001 and Preethu *et al.*, 2007).

TABLE 2

Changes in nutrient concentration of lake biomass compost during different stages of composting

Parameters	Days of composting		
	30 days	60 days	90 days
Moisture (%)	75.00	65.00	35.50
pH	5.93	6.65	6.93
EC (dS m^{-1})	0.73	0.86	0.71
Total Nitrogen (%)	1.93	1.85	1.73
Organic Carbon (%)	33.10	22.40	19.20
C:N ratio	17.30	14.10	10.90
Total Phosphorus (%)	0.64	0.73	0.92
Total Potassium (%)	2.58	2.69	2.87
Total Calcium (%)	1.29	1.56	1.88
Total Magnesium (%)	1.28	1.41	1.52
Total Sulphur (%)	0.27	0.83	0.92
Copper (mg KSg^{-1})	39.40	41.60	43.30
Zinc (mg kg^{-1})	224.80	243.10	256.60
Iron (mg kg^{-1})	818.40	820.30	828.70
Manganese (mg kg^{-1})	323.00	337.61	359.30
Boron (mg kg^{-1})	0.56	0.67	0.88
Cadmium (mg kg^{-1})	2.49	1.26	0.93
Chromium (mg kg^{-1})	23.39	18.46	15.82
Lead (mg kg^{-1})	25.87	23.63	19.89
Nickel (mg kg^{-1})	21.48	18.85	14.82

TABLE 3

Changes in bio-chemical composition and humic and filvic acid content of compost during different stages

Parameters	Days of composting		
	30 days	60 days	90 days
Lignin (%)	21.60	17.61	12.40
Cellulose (%)	18.65	15.76	13.75
L/N ratio	11.19	9.518	7.08
(L+C)/N ratio	21.07	18.03	14.94
Humic acid (%)	7.50	7.90	8.70
Fulvic acid (%)	1.90	2.60	2.40

Characterization of Lake Biomass Compost After Enrichment.

After the preparation of compost it was enriched with different organic and inorganic sources for 15 days. The samples were analysed for different parameters. Among the different enriched lake biomass compost MNSE-LBC (Microbial consortium + Neem cake + SSP enriched Lake Biomass Compost) recorded the highest nutrient content followed by SSPE-LBC (Single Super Phosphate Enriched LBC), NCE-LBC (Neem Cake Enriched LBC) and ME-LBC (Microbial consortium Enriched LBC). The nutrient parameters like total nitrogen (1.91%), total phosphorus (1.52%), total potassium (3.10%), total calcium (2.64%), total magnesium (1.76%), total sulphur (1.28%) and micronutrients *viz*., copper, zinc, iron, manganese and boron (49.80, 268.70, 835.70, 377.10 and 0.19 mg kg^{-1}, respectively) content were highest in MNSE-LBC followed by SSPE-LBC might be due to the combined effect of microbial consortium, SSP and neem cake used for the enrichment, Supravanath *et. al.,* 2023, Whereas the heavy metal *viz*., Cadmium, chromium, lead and nickel (0.22, 13.83, 11.84 and 10.05 mg kg^{-1}, respectively) content in compost were relatively reduced compared to raw materials after enrichment might be attributed to the transformation of soluble form of metals to non-soluble or residual form by microbial activity (Plazza *et al*., 2007).

The increase in nutrient content of enriched lake biomass compost with organic and inorganic sources might be attributed to the addition of bioinoculants like *Azotobacter chrooccoccum, Pseudomonas fluorescence, Bacillus megatherium* and *Trichoderma harzianum* in composting, increased the contents of major nutrients significantly (Sarangthen and Singh, 2005 and Manna *et al*., 2000). Maximum increase in total nitrogen was recorded in composting where N_2 fixer was incorporated with phosphate enrichment (Manna *et al*., 2000). The inoculation of microbial culture increased the available nitrogen as well as other nutrients in the enriched compost as compared to compost without enrichment.

TABLE 4

Physico-chemical composition of matured and enriched compost

Parameter	LBC	NCE-LBC	SSPE-LBC	ME-LBC	MNSE-LBC
Colour	Dark brown				
Odour	Earthy smell				
Starch Iodine Test	Yellow coloured solution without precipitation				
Moisture (%)	35.50	35.30	35.40	35.20	35.40
pH	6.93	6.63	6.61	6.67	6.63
EC (dS/m)	0.93	0.94	0.92	0.95	0.91
OC (%)	19.20	19.30	19.20	19.30	19.40
C : N	10.90	10.96	11.09	10.26	10.15
Total N (%)	1.75	1.76	1.88	1.83	1.91
Total P (%)	0.92	1.22	1.49	1.16	1.52
Total K (%)	2.87	2.95	2.98	2.92	3.10
Total Ca (%)	1.88	1.97	2.24	1.91	2.64
Total Mg (%)	1.52	1.61	1.66	1.56	1.76
Total S (%)	0.92	1.16	1.19	1.22	1.28
Mn (mg kg^{-1})	359.3	371.40	375.60	370.00	377.10
Zn (mg kg^{-1})	256.60	267.40	266.50	267.10	268.70
B (mg kg^{-1})	0.187	0.15	0.140	0.122	0.19
Cu (mg kg^{-1})	43.30	47.60	49.20	45.40	49.80
Fe (mg kg^{-1})	828.7	830.70	833.30	829.50	835.70
Cd (mg kg^{-1})	0.93	0.332	0.33	0.434	0.22
Cr (mg kg^{-1})	15.82	15.16	14.96	15.43	13.83
Pb (mg kg^{-1})	19.89	12.61	12.73	13.67	11.84
Ni (mg kg^{-1})	12.40	11.57	11.57	11.76	10.05

Note: LBC – Lake Biomass Compost; NCE-LBC – Neem Cake Enriched Lake Biomass Compost; SSPE-LBC – Single Super Phosphate Enriched Lake Biomass Compost; ME-LBC – Microbial consortium Enriched Lake Biomass Compost; MNSE-LBC – Microbial consortium + Neem cake + SSP Enriched Lake Biomass Compost

Since, lake biomass vast and abundant, also contains higher nutrients (N, K, Ca, Mg, S, P and micronutrients), it can be used to prepare compost. The compost can be enriched with different sources which enhances the soil nutrient availability in turn useful for the urban farmers to increase their crop productivity with the good organic nutrient source and reduces the hazards caused by the leftover lake biomass on the banks. The waste can be better utilized by preparing compost and it can be used as organic nutrient source. The urban famers are using different sources for compost preparation to sustain the soil fertility but sources are not producing the quantity of compost needed therefore, the biomass generated from the lakes is great and plentiful, includes better nutritional quantity (N, K, Ca, Mg, S, P and micronutrients) it may be used to prepare huge quantity needed.

Acknowledgment : The authors are thankful to the Department of Soil Science and Agricultural Chemistry and College of Agriculture, Bangalore, Karnataka, India and Indo-German project for supporting throughout the work.

References

AKANBI, W. B., TOGUN, A. O., OLANIRAN, O. A., AKINFASOYE, J. O. N. AND TAITU, F. M., 2007, Physico-chemical properties of egg plant (*Solanum melongena*) fruit in response to nitrogen fertilizer and fruit size. *Agric. J.*, **2** (1) : 365 - 369.

BHARGAVI, M. V., 2001, Bio remedial recycling of solid urban waste. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.

FARHAN, Z. S., MEGHASHRI, S. G., GAIND, S. AND NAIN, L., 2010, Exploration of composted cereal waste and poultry manure for soil restoration. *Bioresour. Technol.*, **101** (9) : 2996 - 3003

JACKSON, M. L., 1973, Soil chemical analysis. (Indian reprint, 1976). Prentice Hall of India, New Delhi, pp. : 498.

KAVITHA, R. AND SUBRAMANIAN, P., 2007, Effect of enriched municipal solid waste compost application on growth, plant nutrient uptake and yield of rice. *J. Agron.*, **6** (4) : 586 - 592.

LINDSAY, W. L. AND NORVELL, W. A., 1978, Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.,* **42** : 421 - 428.

MANNA, M. C., HAZRA, J. N., SINHA, N. B. AND GANGULY, T. K., 2000, Enrichment of compost by bio-inoculate and mineral treatments. *J. Indian Soc. Soil Sci.,* **45** (4) : 831 - 833.

MATHUR, B. S., SARKAR, A. K. AND MISHRA, B., 2016, Release of nitrogen and phosphorus from compost charged with rock phosphate. *J. Indian Soc. Soil Sci.,* **28** : 206 - 212.

NALUBEGA, M., VINNERAS, B., SUNDBERG, C. AND JONSSON, H., 2009, Treatment technologies for human faeces and urine. *Environ. Technol.*, **14** : 487 - 497.

PIPER, C. S., 1966, Soil and plant analysis, Hans publishers, Bombay, Monograph from the waits. Agriculture Research Institute, Univesity of Adelaid, **47** (111) : 197 - 200.

PLAZA, C., SENESI, N., BRUNETTI, G. AND MONDELLI, D., 2007, Evolution of the fulvic acid fractions during co-composting of olive oil mill wastewater sludge and tree cuttings. *Bioresour. Technol.*, **98** (10) : 1964 - 1971.

PREETHU, B. N., BHANU PRAKASH, U. H., SRINIVASAMURTHY, C. A. AND VASANTHI, B. G., 2007, Maturity indices as an index to evaluate the quality of compost of coffee waste blended with other organic wastes. Proc. *Int. Conf. Sustain*. Solid Waste Mangt, 5 - 7 Chennai, India. 270 - 275.

SADASHIVAM, S. AND MANICKAM, A., 1996, Biochemical methods. New age international (P) Ltd., Publishers, (Edn. 2), May.

SARANGTHEN, I. AND SINGH, S. J., 2005, Recycling of urban wastes as manures and their evaluation in French bean (*Phaseolus vulgaris*) In: Conference on Soil, Water and Environmental Quality Issue and Stratergies, pp. 296 - 312.

SUTHAR, S. AND SINGH, S., 2017, Feasibility of vermicomposting in biostabilization of sludge from a distillery industry. *Sci. Total Environ.*, **394** (2-3): 237 - 243.

SUPRAVA NATH., DEVAKUMAR, N., GANGADHAR ESHWAR RAO AND MURALI, K., 2023, Effect of different sources of organic manures on growth and yield of French bean

(*Phaseolus vulgaris* L.) *Mysore J. Agric. Sci.,* **57** (2) 403 - 415

UMAR, K. J., HASSAN, L. G., DANGOGGO, S. M. AND LADAN, M. J., 2007, Nutritional composition of water spinach (*Ipomoea aquatica* Frosk.) leaves. *J. Appl. Sci*., **7** (6) : 803 - 809.

VEENA, J. AND SATHISH, A., 2022, Characterization of organic manures incineratiom ash for physical and chemical properites to evaluate their efficicacy and yield of maize (*Zea mays* L.) *Mysore J. Agric. Sci.,* **56** (1) 389 - 400.

WALKLEY, A. AND BLACK, I. A., 1934, An examination of the method of determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.,* **37** : 29 - 38.