International Journal of Environment and Climate Change

Volume 13, Issue 11, Page 2395-2400, 2023; Article no.IJECC.108625
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Bulking Agents on Physical, Chemical and Biological Properties of Latex Sludge Waste

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i113405

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/108625

Original Research Article

Received: 23/08/2023
Accepted: 01/11/2023
Published: 07/11/2023

ABSTRACT

Aim: Production of latex sludge waste biocompost by co composting with different bulking agents like sawdust, zeolite and cattle manure in various ratios and checking its feasibility in agriculture use.
Study Design: The experiment was conducted by completely randomized design with ten treatments and three replications
Place and Duration of Study: The experiment was conducted at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Kerala Agriculture University between November 2022- February 2022
Methods: The latex sludge waste collected from HLL, Trivandrum was used for the study. The

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latex sludge waste is mixed with different bulking agent like sawdust, zeolite and cattle manure in different ratios. Composting inoculum is used equally in all the treatments to fasten the composting process. The resultant composts were analysed for physical, chemical and biological properties.
Results: The compost prepared from latex sludge, zeolite, sawdust and cattle manure resulted higher values of major macro and micro nutrients and good physical properties compared to other treatments. A gradual decrease in C:N ratio and carbon dioxide emission was observed for a period of 120 days of composting in all the experiment. The results showed that the co-composting of latex sludge with sawdust, zeolite and cattle manure produces quality compost. All the ratios of the mixture of composts were found to be a better growth medium for crops compared to application of latex sludge alone
Conclusion: Composting of latex sludge is found to be one of the economic and environmentally viable option for the management of large quantity of latex sludge waste. The compost showed optimum physical, chemical and biological properties and can be utilize for crop production.

Keywords: Latex sludge compost; sawdust; zeolite; cattle manure.

1. INTRODUCTION

Soil is one of the integral components of agriculture, which serve as the primary source of nutrients for the growth of plants. The transfer of nutrients from soil to plants greatly augments the nutritional value of food, thereby rendering it healthier. Healthy soils play a fundamental role in ensuring food security and laying the foundation for a sustainable future. Soil is a dynamic living natural body that supports life on earth.

Rapid industrialization has led to the production of considerable amounts of waste both solid and liquid form from various industrial sectors such as sugar, pulp and paper, fruit and food processing, distilleries, dairies, tanneries, slaughterhouses, poultries, rubber industries etc. Huge amount of these waste is used for unscientific landfilling, this will again lead to the contamination of soil as well as water bodies. Considering rubber industries that manufacture products from rubber latex are gloves, health care products like Blood collection bags, Surgical sutures, Hydrocephalus shunts, tissue expanders, clothing etc. About 10% of the natural rubber harvested from rubber tree (*Hevea brasiliensis*) is used to make latex products including gloves [1]. Natural Rubber is used to make 50,000 consumer products including 400 medical devices [2]. Due to the great demand for latex products in the global market, the associated production processes have generated a massive industry and the processing of latex generates large volume of waste with high pollution potential known as latex sludge.

Over an extended period, numerous chemical and biological techniques have been implemented for the management of sludge, including landfilling, incineration, anaerobic digestion, and aerobic composting. Among these methods, composting emerges as the most viable alternative for sludge management, as it permits the repurposing of waste as soil conditioners or organic fertilizers on agricultural lands for food and feed crops. Composting has aroused as a dependable and reliable technique for disposing of latex sludge while minimizing the deleterious effects on the environment and soil, and the cost of the method of composting is relatively low compared to other techniques.

The characteristics of the latex sludge will vary depending on the type of treatment carried out in the industry [3]. Due to the excess amount of moisture in the latex sludge waste, it is mixed with bulking agents such as sawdust, zeolite and cattle manure etc to bring the final product with appropriate moisture and sponginess [4]. The approach that is being employed to recycle the nutrients in the latex sludge wastes is highly beneficial for the agriculture chain and ensures soil health.

2. MATERIALS AND METHODS

2.1 Production and Characterisation of Latex Sludge Compost

The latex sludge waste for conducting the experiment was procured from HLL, Trivandrum. In Kerala, HLL Lifecare Limited is one of the largest consumers of rubber in the form of latex for the manufacture of health care products like blood collection bags, surgical sutures, hydrocephalus shunts, tissue expanders etc. The latex sludge at this industry is a semi-solid byproduct that is produced following effluent treatment in the effluent treatment plant and presently treated as a waste material. The latex sludge compost was prepared by aerobic heap method mixed with bulking agents such as sawdust, cattle manure and zeolite in different proportions as per the ten different treatments. Moisture content of 50 to 60 per cent was maintained in the mixture by spraying water as it is one of the pre-requisites for uniform decomposition of organic wastes. To this mixture 5 per cent of microbial consortia (Composting inoculum) added uniformly in all treatments. The Composting inoculum for the experiment was collected from Department of Agricultural Microbiology, College of Agriculture, Vellayani. The composting heap is periodically turned once in ten days interval. In the study ten treatments were followed.

T_1: Latex Sludge Waste (LSW) + Sawdust (SD) (1:1)
T_2: Latex Sludge Waste (LSW) + Saw dust (SD) +Cattle Manure (CM) (1:1:1)
T_3: Latex Sludge Waste (LSW) + Zeolite (1:1)
T_4: Latex Sludge Waste (LSW) + Zeolite + Cattle Manure (CM) (1:1:1)
T_5: Latex Sludge Waste (LSW)+ Saw Dust (SD) (2:1)
T_6: Latex Sludge Waste (LSW) + Saw Dust (SD)+ Cattle Manure (CM) (2:1:1)
T_7: Latex Sludge Waste (LSW) +Zeolite (2:1)
T_8: Latex Sludge Waste (LSW) +Zeolite + Cattle manure (2:1:1)
T_9: Latex Sludge (LSW) + Zeolite + Saw dust (SD) + Cattle manure (CM) (2:1:1:1)
T_{10}: Latex Sludge Waste (LSW) alone

The period of composting was 120 days. The compost samples were collected from each heap is analysed for physical, chemical and biological properties.

2.2 Statistical Analysis

The production and characterization of latex sludge compost was done in completely randomized design (CRD). "F test is followed in ANOVA for testing the significance of treatments. CD was calculated. R-package grapesagri1 was used for data analysis" [5].

3. RESULTS AND DISCUSSION

3.1 Physical Properties of the Resultant Latex sludge Compost

The physical properties such as moisture content, water holding capacity and bulk density of latex sludge compost were analysed. The moisture content of resultant latex sludge compost varied between 21.12 to 36.62 per cent. The higher moisture content is present in T_9 prepared from Latex Sludge waste, Zeolite, Sawdust (SD) and Cattle manure (CM) in 2:1:1:1 ratio which might be due to the adsorption capacity of the materials used in the composting [6]. The water holding capacity of T_9 was found to be higher and which was on par with T_2 (Latex Sludge Waste (LSW) + Saw dust (SD) +Cattle Manure (CM) 1:1:1). The lowest bulk density of latex sludge compost was recorded for T_9 might be due to the presence of higher organic matter content in the compost. Bulk density is an important factor as it maintains influences the microbial development, activity and organic matter degradation [7]

3.2 Chemical Properties of the Resultant Latex Sludge Compost

The pH values of the latex sludge compost varied between 6.35 to 7.24. Initially the pH of the compost decreased due to the release of organic acids from the composting mixture later on maturation of compost it tends to increase and attains a neutral value [8]. The highest value of EC was found in T_{10} (Latex Sludge Waste (LSW) alone) is 2.97 ds m^{-1}. EC value of compost is an important parameter as it reflects the

Table 1. physical properties of resultant latex sludge compost

Treatments	Water holding capacity (%)	Bulk density (Mg m^{-3})	Moisture content (%)
T_1	73.85	0.63	29.61
T_2	84.70	0.41	35.50
T_3	72.15	0.71	24.71
T_4	79.65	0.45	33.43
T_5	70.29	0.71	27.81
T_6	82.23	0.44	34.62
T_7	70.53	0.73	22.58
T_8	77.26	0.48	32.63
T_9	85.70	0.36	36.62
T_{10}	67.44	0.82	21.12
SEm (±)	**0.405**	**0.023**	**1.414**
CD	**1.195**	**0.067**	**4.172**

Table 2. Characterization of resultant latex sludge compost

Treatments	pH	EC (dSm $^{-1}$)	Total organic carbon (%)	Total N (%)	Total P (%)	Total K (%)	Ca (%)	Mg (%)	S (%)	Fe (mg kg $^{-1}$)	Mn (mg kg $^{-1}$)	Zn (mg kg $^{-1}$)	Cu (mg kg $^{-1}$)	Pb (mg kg $^{-1}$)	Cd (µg kg $^{-1}$)	C:N ratio
T_1	6.79	1.80	21.38	1.18	0.52	0.16	2.91	1.43	0.39	1484.40	167.52	182.12	22.67	0.56	1.13	16.76
T_2	7.06	1.50	19.42	1.49	0.65	0.27	3.23	1.66	0.48	1773.90	178.69	256.06	30.54	0.12	0.27	13.03
T_3	7.23	1.60	21.33	1.25	0.59	0.18	2.08	1.64	0.44	1189.63	156.12	175.84	23.48	ND	0.57	17.05
T_4	7.24	2.10	18.43	1.45	0.78	0.36	3.23	1.97	0.57	1662.40	185.35	279.9	33.43	ND	ND	12.72
T_5	6.83	1.83	21.39	1.28	0.56	0.14	2.61	1.46	0.43	1480.50	166.91	201.34	22.39	0.18	1.27	18.28
T_6	7.12	1.90	21.02	1.56	0.71	0.31	3.59	1.66	0.51	1869.80	183.35	282.16	29.70	ND	0.03	13.47
T_7	7.17	1.70	20.71	1.16	0.55	0.14	2.35	1.46	0.41	1077.87	157.36	179.81	21.56	0.16	0.52	17.87
T_8	7.15	1.27	19.97	1.39	0.61	0.26	3.05	1.56	0.45	1532.60	179.44	253.34	33.09	0.05	0.78	14.37
T_9	7.13	1.90	20.57	1.66	0.96	0.42	3.91	1.95	0.61	1876.80	189.4	290.14	35.36	ND	ND	12.39
T_{10}	6.35	2.97	21.72	1.08	0.56	0.12	2.75	1.33	0.38	1062.63	141.76	156.84	21.38	1.5	1.39	20.05
SEm (±)	**0.011**	**0.151**	**0.246**	**0.021**	**0.012**	**0.011**	**0.019**	**0.019**	**0.006**	**22.457**	**1.965**	**1.626**	**0.744**	**0.001**	**0.004**	**0.020**
CD	**0.032**	**0.446**	**0.725**	**0.062**	**0.032**	**0.031**	**0.056**	**0.056**	**0.019**	**66.249**	**5.797**	**4.796**	**2.195**	**0.003**	**0.011**	**0.059**

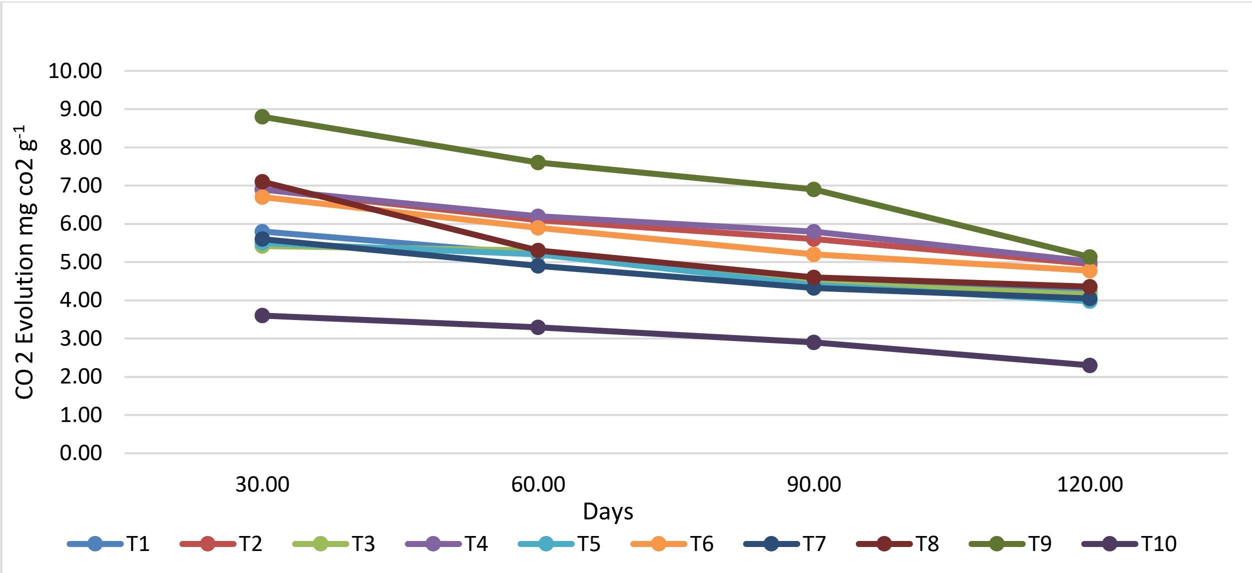

Fig. 1. Changes in CO_2 Evolution during composting over time

degree of salinity present in compost and also the phytotoxic effect of compost on plant growth [9]. EC of the latex sludge compost ranged from 2.97 dS m^{-1} to 1.27 dS m^{-1} which was below the recommended value as soil amendment.

The major macro and micro nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu) of the resultant latex sludge compost is given in table 2. During initial stages of composting the pile did not contain nitrates but later on composting continues the nitrate content increases as a result of nitrification of ammonium by nitrifying bacteria [10]. some amount of nitrogen may loss during composting through volatalization, denitrification, leaching and immobilization process [11]. The addition of organic matter such as sawdust for composting would also help to control the decomposition rate and promoting nitrogen retention within the compost [12]. The final compost contains higher concentration of nutrients and limited trace elements and heavy metal content conforms the compost quality produced from latex sludge mixed with bulking agents saw dust, zeolite and cattle manure as a growth medium [13].

3.3 Biological Properties of the Resultant Latex Sludge Compost

One of the important aspects of compost quality is compost stability and it is related to the extent to which the organic matter present in the mixture get stabilized throughout the process of composting. [14]. The quality and maturity of compost is analysed by various physical, chemical and biological parameters. The maturity of compost is monitored by C:N ratio, CO_2 evolution during composting, humic substances produced at the end of composting etc. [15]

A gradual decrease in C:N ratio was observed during 120 days of composting period in the study. At the end of composting a constant value has reached indicating the stabilization of compost. As the process of decomposition continued, the carbon content of the compostable material decreased over time primarily due to the losses of carbon in the form of carbon dioxide. Consequently, the N content per unit of material increased, leading to a decrease in the C:N ratio. The living microorganisms present in the compost mixture decomposes the organic matter and achieved maturity of compost [16]. Lower values of C:N ratios were observed in T_9 (12.39) and T_4 (12.72) indicates the maturity of compost. The C:N ratio of compost is given in table 2.

Carbon dioxide evolution can be utilized as a direct method to check the compost maturity as it reflects the microbial respiration and biological activity of the compost. The rate of CO_2 evolution decreases during composting indicates the stabilization of compost as a result of reduced metabolic activity in the compost [17]. The higher value of CO_2 evolution was observed in T_9 (5.13 mg CO_2 g^{-1}) and lower value in T_{10} (2.3 mg CO_2 g^{-1}) at 120th day of composting. During composting a gradual decrease of carbon dioxide was observed due to the stabilization of compost, which is shown in the fig (1) [18]. As the compounds undergo degradation, the medium experiences an increase in the concentration of more resilient compounds that are less easily utilized by microorganisms. Consequently, the microbial activity and the corresponding respiration exhibit a decline [19].

4. CONCLUSION

The co-composting of latex sludge with sawdust, zeolite and cattle manure provides high quality compost. The major macro and micro nutrients were found to be higher in T_9 (latex sludge compost prepared from latex sludge waste, zeolite, sawdust and cattle manure in 2:1:1:1 ratio) followed by T_6, T_2 and T_4. Composting of latex sludge waste is an economic and environment friendly method as it recycles the nutrients in latex sludge waste back into the agriculture system.

ACKNOWLEDGEMENTS

I extend my sincere thanks to Department of Soil Science and Agricultural Chemistry, Kerala Agricultural University for providing all facilities to carry out this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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