Development of a waste management technology for pilot-scale production of an organic fertilizer from rural abattoir wastes

Synopsis Submitted for the Degree of Doctor of Philosophy (Engineering)

Jadavpur University

2022

By

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INDEX

1. INTRODUCTION

Over the decades food habit has changed worldwide and so has the type of waste generated from food producing industries: be it cultivation-derived or from livestock farms.

According to Agricultural and Processed Food Products Export Development Authority (APEDA) established by Government of India, there are 1176 formal slaughterhouses and 75 modern abattoirs. Approximately 35000 slaughterhouses in the country are unaccounted for improper and untreated disposal of waste, most of these are dated back to British period meaning they are very old and are still in primitive condition. Majority of these slaughterhouses are scattered in rural areas and they cater to the needs of urban consumers. Besides selling the edible parts of the slaughtered animals for meeting the needs of meat consuming industries, these abattoirs also provide raw materials to various other sectors like soap factories, tanneries, tallow and adhesive manufacturing industries, live-stock feed processing units and bone mills. Concurrently, the butchers are getting an alternative source of secondary income from the inedible parts (skin, fats, cartilages, bones, horns and hoovers). The only waste generated from these rural abattoirs which does not have any monetary importance to the owners are cattle blood and ruminal contents. Consequently, slaughterhouse owners are not concerned about the safe disposal of these wastes and are reluctant to invest in any non-profitable scientific and proper waste management technique.

Approximately only 45-50% of the slaughtered animal can be turned into edible products, about 40-45% of the animal is turned into by-products such as leather, soaps, tallow, and adhesives. However, the 15% is waste, primarily bovine blood and rumen digesta are discharged as solid waste and effluent without any treatment to the surroundings by most of all the rural slaughterhouses. The chemical oxygen demand (COD) of this typical discharged waste is between 4400-18000 mg/l. It is also being reported that the COD of slaughterhouse blood to be 375000 mg/l.

Animal waste to fertilizer conversion encourages use of organic fertilizer, which is potentially attractive for small farmers around the rural slaughterhouses who are competing with rapidly increasing demand for organic farm produce. Additionally, there is a valid possibility of

higher returns for both the slaughterhouse owners and farmers. A sustainable circular economy may be developed from this abattoir waste to organic fertilizer conversion strategy. Anaerobic digestion, composting, vermicomposting, pyrolysis and drying are the few alternative treatments that are used for fertilizer production. The process of mixing and drying of bovine blood and rumen digesta (3:1 ratio) to convert into a valorised product 'Bovine-Blood-Rumen-Digesta-Mixture' (BBRDM) as a fertilizer, it is reported that this abattoir waste converted fertilizer showed higher yield and productivity in vegetable crop cultivation.

2. AIM AND PURPOSE

Due to financial issues the slaughterhouse owners are reluctant to adapt the proper scientific and technical methods of disposing. As an environmentalist it is a food to thought to convert this waste into a profitable entity. To recycle this kind of waste, using a drying equipment will be a cost-effective technique to be implemented in these rural abattoirs. The drying in a properly designed dryer following a scientific method will convert the unhygienic waste to a safe and environment friendly organic fertilizer free from pathogens, heavy metals within permissible limit and unpleasant environment. Therefore, the evolution of acceptable processing technologies for abattoir waste is important. In the present study, the application of BBRDM (Bovine blood Rumen digesta Mixture) as a fertilizer and soil conditioner is being attempted. Developing a user friendly and less complicated drying equipment for these rural abattoirs will be easily accepted by the slaughterhouse owners and beneficial to the local farmers, as the waste made organic fertilizer will be way cheaper and effective than the market available fertilizers.

Therefore, objectives of this research work were:

1. To develop a low-cost recycling method for the welfare of both the slaughterhouse owners and environmental safety.
2. To design an equipment for enhancing the production system and commercialize the product for market interest and a profitable commodity in favour of the slaughterhouse owners and farmers.

3. THEORETICAL AND EXPERIMENTAL CONSIDERATIONS

Slaughterhouse wastes can be converted to beneficial products using different methods, which can easily interest the rural slaughterhouse owners to invest on those recycling technologies and on implementation will not only dispose the generated waste properly according to the environmental norms but also provide economic benefits in return.

Among the by-products recycled from abattoir waste, organic fertilizers are found to be quite popular among local famers surrounding these rural slaughterhouses. Organic fertilizers produced within the slaughterhouses are easily available to these farmers on cheaper rates as compared to the market price of existing fertilizers.

Drying treatment has been very popular in the fertilizer production for many years and is still in demand for mass scale production efficiency. This popularity is due to its moisture removal competence. In industrial processing of organic waste, the unit process of drying plays a major part, dryers that are most commonly preferred in the process, like drum, flash and spray dryers not only requires heavy equipment but, also demands a centralized slaughtering and collecting system for generated waste along with high operating cost [66]

BBRDM production methods, that were adopted previously are: tray drying, cook drying and sun drying. Conventionally, bovine blood and rumen digesta were mixed and then dried through the mentioned processes but few setbacks were observed in them and lead to a conclusion that a drying technique that has shorter drying time, lower requirement of energy and also capable of producing good quality product having longer shelf-life will be an efficient development.

4. EXPERIMENTAL DESIGN FOR DRYER FABRICATION AND PERFORMANCE EVALUATION

As previously discussed, there is an immediate need for technical evolution in recycling process of abattoir waste leading to BBRDM production. For the performance evaluation of previously used BBRDM production methods and of the fabricated dryer few physical and chemical parameters were tested and few drying curves were plotted for better interpretation and understanding.

Parameters evaluated before processing of the waste were much higher than the permissible limits as prescribed in the environmental standards. Factors dominating the qualities of end product as an organic fertilizer were precisely and quantitatively measured for each batch of production. Extent of methane emission from the open waste dumping sites of slaughterhouse and the soil amended with BBRDM, an organic fertilizer converted from the same slaughterhouse waste was also one of the parameters that was measured.

The factors those were determined in order to evaluate the performance of new drying unit: (i) Consumption of energy was estimated in terms of drying time and energy utilized, (ii) Energy utilized for water removal was calculated on the basis of calorific value of fuel used for processing, (iii) Specific energy consumption was calculated on the basis of energy consumed in mega joules to remove one kilogram of water (MJ kg^{-1} of water). Two other parameters that were determined were: (a) Specific moisture extraction rate (SMER) and (b) Moisture extraction rate (MER).

These curves were plotted in this research work for assessment: (1) drying curve – a plot between moisture content(%wet basis) and time, (2) drying rate curve – It is a curve that is plotted for calculated drying rate and time, the rate can be calculated by derived formula using experimental drying time, (3) Krischer curve – This curve is independent of time which is plotted between the rate of drying and moisture content (% wet basis) and (4) Lastly, The curve of moisture removal plotted against drying time.

This valorisation of waste not only promotes a sustainable economy but also meets Sustainable Development Goal (SDG) 12 which is ‘Sustainable production and consumption’

5. EXPERIMENTAL RESULTS, INTERPRETATIONS AND DISCUSSION

The abattoir generates nearly about 400 kg of rumen content and 400 l of bovine blood as waste. Considering the amount of waste generated the recycling vessel was constructed of 0.61 m diameter and 0.71 m height so that it is able to handle at least close to 250 kg mass load in one run. Considering the equipment to be new and yet to be fully optimized the equipment was operated at its minimum load capacity that is 50% of total, 90kg. The operating load can be easily escalated according to the demand for processing and production.

Specifically, during preliminary runs for optimization and evaluation approximately 20kg of rumen content and 60kg of bovine blood was fed for all the batches under observation. The vessel carrying the mixture mass was further proceeded towards drying operation. The vessel was heated at 90-110 °C temperature until the dried product attained the required final moisture content. As from literature it was concluded that final product having less than 20 % moisture content are accepted for their increased shelf-life.

The recorded data and four plotted graphs exhibited similar trends to the curves presented for kinetics of experimental drying. Energy consumption and drying time, both the parameters for the fabricated recycling unit working on basic principles of drying are recorded to be low.

Other parameter that reflected potentially the environmental aspect, methane emission recorded from BBRDM amended agricultural soil, ranged between 0.01-0.15 $\mu\ g^{-1}\ h^{-1}$ which was 150 times lesser than that was recorded from soils of the dumping site, which ranged from 13.13-28.55 $\mu\ g^{-1}\ h^{-1}$ of slaughterhouses. The particle size of the end product was determined to be D_{70} indicating that 70 percent of the particles of end product retained on a mesh of 2 mm along with this the bulk density was noted to be 1190 ±7 kg m^3. Further final moisture content of the product was recorded to be 18.4 % and 15.6 % on dry and wet basis respectively.

6. SOCIO-ECONOMIC BENEFIT OF THE RESEARCH WORK

An economically feasible technology can be a solution to the waste disposal problems of rural abattoirs as well as an initiative towards developing a circular economy among abattoir owners and local farmers. Cost calculation for the installation and operation of the fabricated dryer was done along with the annual production cost of BBRDM. Operational costs include both one-time investments (non-recurring) as well as the expenses contracted for operation throughout the year (recurring). For an economically sustainable production the selling price of the recycled product was calculated by keeping a profit margin of 5% over production cost.

The proposed technology and the fabricated dryer therefore, enables slaughterhouse owners to recycle the slaughterhouse wastes in an easy and cost-effective way into an organic nitrogen fertilizer, the selling of which provides additional income to the abattoir owners. Such monetary benefit encourages them to reuse the wastes instead of dumping and landfilling. Furthermore, this effective recycling practice sustains cleaner production leading to cleaner and healthy surroundings for rural abattoirs

7. CONCLUSION

The findings and results of the research work solved two major issues (a) unhealthy environment around rural slaughterhouses and (b) unavailability of cheap, locally produced organic fertilizers for poor farmers.

8. FUTURE SCOPE

There is always a scope for improvement in a technology:

1. In the presented dryer the heating system involve consumption of either LPG or Diesel to create heat energy. This can be modified to electric heating by introducing electric heating belts supported by solar panels. Making this technology a completely green technology
2. Marketing of the presented product BBRDM, a nitrogen rich organic fertilizer by valorisation of slaughterhouse waste among local farmers. Raising awareness about the socio-economic benefits and environment improvement.

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(Signature of the Candidate with date)

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