学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　Kotte Hewa Praween Madusanka

学 位 論 文 題 名

Study of organic solid waste management in Sri Lanka using centralized composting and household scale anaerobic digestion
(施設堆肥化および家庭規模メタン発酵を用いたスリランカにおける有機性固形廃棄物管理に関する研究)

Solid waste management is a severe issue in Sri Lanka. Open dumping is often used for the waste management because of lacking financial and technological resources. The open dumping causes negative impacts such as greenhouse gas emissions, leachate generation under various climatic conditions and disease spread by facilitating breeding conditions for insects. As the solid waste generated in Sri Lanka contains a lot of readily degradable organics, biological treatments should be considered for better solid waste management. Among available methods centralized composting for collected waste, and household scale anaerobic digestion for uncollected waste can be identified as suitable methods. In this study, current situations of both two processes were studied, and possible future expansions of the two processes were investigated.

Chapter 1 included an introduction to this study. It contains background, the objectives, methodology and the organization of the study.

Chapter 2 studied prevailing centralized composting facilities for collected waste. By 2014, one-third of the total 335 local authorities operated centralized composting for collected waste. A questionnaire survey was carried out for 100 composting facilities via postal service. 37 replies were received within 1.5 months in 2014. According to the replies, 30 facilities used windrow composting. The field visits for 20 out of 30 windrow composting facilities were done for further clarifications regard to the composting processes. The main identified issue was the final compost was in low quality. This was because contaminated feedstock (because no source separation for waste collections) was used for composting, passive aerations during turning was limited for composting process due to compacted pile constructions and excessive moisture additions (lead to incomplete decomposition), duration of composting was decided by without monitoring the temperature, and maturation was inadequate as time durations for maturation was short. Monthly low compost selling compares to the input waste evidenced low-quality of the compost. To increase the quality of compost, allowing only source-separated waste as the feedstock and inclusion of monitoring the temperature, moisture, maturity into the composting process were required.

Chapter 3 focused on uses of household scale anaerobic digestion for uncollected waste. A questionnaire survey was conducted for 100 users in five provinces by visiting them. The study revealed that actual volume of the anaerobic digester, compared to required volume for input, were oversized. The users did not use all the potential waste for anaerobic digestion. The biogas was used only for cooking and sometimes led to being wasted when the biogas productions exceeded the demand. As the slurry often exposed to sunlight, it lost quality and quantity. Certain regular operations and maintenance works were missing such as monitoring pressure inside the digester, regular cleaning of H_2S filters. The cost assessment showed due to being the digesters over-sized and low use of outputs, the time taken to recover the cost was long. For better use of anaerobic digestion, the digester should

be sized appropriately for the amount of available input. The users should be instructed to feed all available waste, do the regular maintenance works. A reduction in the recovery period of cost could be realized by increasing gas production and demand. Also, taking measures to prevent the quality of the slurry and use slurry in correct ratios with chemical fertilizers contributes to the cost saving.

Chapter 4 focused future possible use of both centralized composting and household scale composting. Currently, two third of the local authorities used open dumping for the collected waste, which accounted around eighty-five percent of total waste collected per day. Based on the daily waste collection amounts and distance to transport the collected waste, the required number of composting facilities was calculated. For better quality compost, accepting only source-separated waste, adding bulking materials, pilling within adequately spaced area to provide passive aeration, temperature monitoring during compost, moisture addition considering requirements, enough maturation were included into the process flow. Sizing the composting facilities and calculating necessary equipments and workforce were done by referring. According to the study, 59 composting facilities were needed with five sizes 10, 20, 30, 80 and 140 ton/day in which 20 ton/day has the maximum demand. Implementation cost, utility cost, and maintenance cost show some economy of scale as a result of proper designing. Comparison of cost needed for implementation with main expenditures suggested some foreign financial assistance is needed. Years needed to recover the cost showed within the shorter period the cost can be covered if the demand is increased. To distribute the compost for farmers, co-selling of compost with chemical fertilizers was identified. On the other hand, anaerobic digestion for uncollected waste can be used for households with uncollected waste. Implementations were concerned for two type of households; households only and households with livestock which were accounted for ninety-three percent and seven percent of total households with uncollected waste. For both two groups, possible ways to increase biogas was concerned by assuming kitchen waste and human waste for the households, and livestock waste and kitchen waste for the household with livestock as the input. As the demand, cooking, lighting and power generation were considered. The sizing of the digesters was done according to the input amounts and accessories such as H_2S filters were placed in systems. Possible benefits were reduction of LP gas or wood in cooking, reduction of electricity for lighting and other purposes, and reductions in chemical fertilizers using slurry. Results showed for the first group both cooking and lighting were possible if kitchen waste from neighbors were allowed. For the second group, using only the livestock waste and kitchen waste cooking plus lighting can be done. In addition households with large livestock power generation using biogas also possible. Cost assessment showed the duration needed to recover the cost shorten as less as 10 years for all the cases in both groups under fifty percent of the subsidization for constructions.

Chapter 5 summarized the main findings of the study. For a reliable demand for organic fertilizers created by both two methods, promoting organic farming is essential. Advertising, conducting seminars can be used for promotions by describing the advantages of organic farming. The correct combination of organic fertilizers with chemical fertilizers should be informed to the farmers. Reduction in usage of chemical fertilizers benefits the country by reducing the annual cost for importing the chemical fertilizers.