

Efficiency of the Household Compost bin as a Waste Management Technique in Sri Lanka (A Case Study in Gampaha Municipal Council Area)

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Abstract— The quantity of waste adding to the mainstream can be simply reduced by home composting. During the year 2007, the Central Environmental Authority, Sri Lanka has introduced compost bins to encourage the home composting and also they launched pilot projects in selected Local Authorities. This research was focused on the understanding of the effectiveness of the household composting bins as a waste management technique for household garbage.

In this research, 70 household samples were selected randomly among the 4 Grama Niladhari Divisions in Gampaha Municipal Council Area and a questionnaire survey was carried out to understand the attitudes of the community towards the home composting and to identify the problems associate with the use of compost bin. During the survey to analyze the compost parameters, two compost samples were collected from the top and the bottom of the compost bin. The color, odor and texture of the compost samples were tested visually and the pH was measured by using a calibrated pH meter. Moisture content and the bulk densities were measured by oven dry method. Sieve test procedure was used to measure the particle size variation. Finally the collected data was analyzed statistically by using Minitab 14.

According the results of the questionnaire survey, it showed the most widely used waste type was kitchen waste which is about 97% and about 66% of the compost bin owners add waste to their compost bin once a day. Also the finding stated that the most abundant problems associate with the use of compost bin was leachate problems (19%), unpleasant smell (13%) and worm problems (10%). The questionnaire survey indicated that the wastes disposed to the waste collection services were reduced 69% after introducing this technology among the people.

Also the research findings revealed that there were no significant differences between the initial stage and the composting stage with respect to pH (Paired t test, P value=0.78), moisture content (Paired t test, P value=0.26), compact bulk densities (Wilcoxon Signed Rank test, P value=0.26) and loose densities (Wilcoxon Signed Rank test, P value=0.22) parameters. This was indicated that the efficiency of the compost bin was low on the basis of composting theories.

Index Term-- compost bin, leachate, waste, moisture content

I. INTRODUCTION

Home Composting is not a new technology and it has been practiced for many years around the world, as a simple and low cost method to manage household organic waste. In Sri Lanka, different set-ups of household composting units can be found and it has been more popularized in some areas. Home composting is now being encouraged as a means of reducing the organic waste being discarded and sent to the landfills. In Sri Lanka, organic fraction of Municipal Solid Waste (MSW) contributes 70 - 90% of total waste stream in many municipalities (Database of Municipal Solid Waste in Sri Lanka, 2005). These organic substances are bulky to handle and contributes for numerous liquid and gaseous emissions that deteriorate dumpsite environments. A good home composting programs can significantly reduce the quantity of organic waste adding to the mainstream and subsequent emissions upon final disposal. Valuable products (compost) are produced through this process while reducing the costs incurred for collection, transportation and final disposal at dumpsite.

Community participation has been a vital component in most successful integrated solid waste management programs. Home composting encourages the community involvement on waste management activities and it facilitates easy transferring of source separation concepts to the people. Home based composting compared to the compost produced from mixed waste is of high quality as the waste does not get contaminated with hazardous materials. The separated inorganic materials need less effort for cleaning before recycling. Therefore, household composting has been identified as an option to enhance the economic conditions of urban poor people through home-gardening and selling of compost and/or recyclables (Mamo etal, 2008).

There are various technical options available as household level composting systems that vary from simple pit /heap methods to complex bin or rotating drum designs. Traditional composting methods (pit, heap, Jeewakotu) have been common practices in many rural/sub-urban areas with different kinds of organic matters. Most urban dwellers prefer bin composting system due to its convenience and as it has less impact an aestheticism with their very limited space.

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Fig. 1. Traditional composting methods (Jeewakotu)

The Central Environmental Authority has introduced composting bins and launched pilot projects in selected Local Authorities during the years 2007. The project launched in Gampaha municipal limits, started on 14th July 2007 and the programs are handling and coordinating by Gampaha Municipal Council (“Parisara Puwath”, Central Environmental Authority, 2008). Funding and monitoring is given by the Central Environmental Authority and Waste Management Authority in Gampaha District.

They try to reduce the waste amount coming to the Municipal Council, improve household waste management and encourage recycling. For that they distributed about 2000 composting bins in 6 Grama Niladhari divisions in Gampaha Municipal Limits (Records from Gampaha Municipal Council). The bin design should facilitate the composting process with easy management practices. Therefore to get better results it is important to identify the effectiveness of compost bins as a solution for the household biodegradable garbage by considering the ideas of the owners of the compost bins and by analyzing the composition of the compost.



Fig. 2. Selected type of Compost Bin

Compost bin design should focus on;

- Easy transportation and installation
 - Drain the excess moisture (porous bottom pad)
 - Protect from external weather conditions, rain, winds
 - Retain the temperature inside
 - Easy adding of waste and removal of compost
 - Keeps away from the pest like rats, dogs crows etc.
 - Durability of the bin (material used, strength etc)
- (Technical guidelines on Solid waste management in Sri Lanka, 2005)

II. METHOD AND MATERIALS

A questionnaire survey was carried out in the study area to understand the attitudes of the community, towards the home composting and to identifying the problems associated with the compost bins. Two compost samples were collected from the top and the bottom of each compost bin for analyzes the compost parameters during the survey. The

color, odor and texture of the compost samples were tested visually and the pH was measured by using a calibrated pH meter. Moisture content and the bulk densities were measured by oven dry method and the sieve test procedure was used to measure the particle size variation. The parameters were compared with the standard composting qualities (Richard, 2007) and the results were explained statistically by using Minitab 14.

III. RESULTS AND DISCUSSION

This research was carried out to investigate the effectiveness of the compost bin as a waste management technique for household garbage and to identify the physical parameters of compost (color, odor, texture, pH, moisture, bulk density and particle size) and identify specific problems associated with the compost bins.

A. Questionnaire Survey

According to the survey done for determine the efficiency of the compost bin, it resulted that most compost bin owners use the compost bin in different ways. Therefore some of them are getting better results and some have problematic results. There are commonly used 6 types of household wastes, which are kitchen waste, tea waste, egg shells, wood ash, grass and leaves and dirty papers.

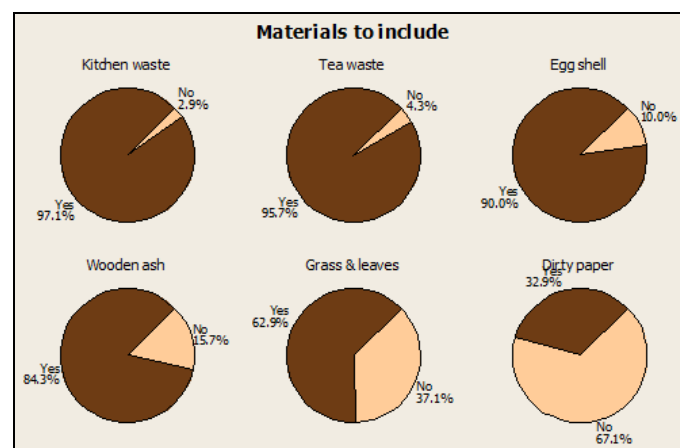


Fig. 3. Types of materials include in the compost bin

By considering the above charts it clearly represent that 97% compost bin owners dispose kitchen waste in to the compost bin. Most of the compost bin owners not include dirty papers to the compost bin. Dirty papers are a good way to obtain cellulose rapidly, rather than grass and leave. Therefore it helps to increase the C:N ratio at the beginning of the composting process, because readily available cellulose (carbon sources) is deficient in the top of the compost bin. By adding papers the readily available carbon amount can be increased and it helps to increase the microbial activities, because the cellulose like carbon sources act as a substrate for micro organisms.

Most compost bin owners use the compost bin once a day. Therefore number of hours during the day, the compost bin is closed. It may cause to poor aeration for the microbial activities. The 9th question is help to get an idea about the time period to obtain results from the compost bin.

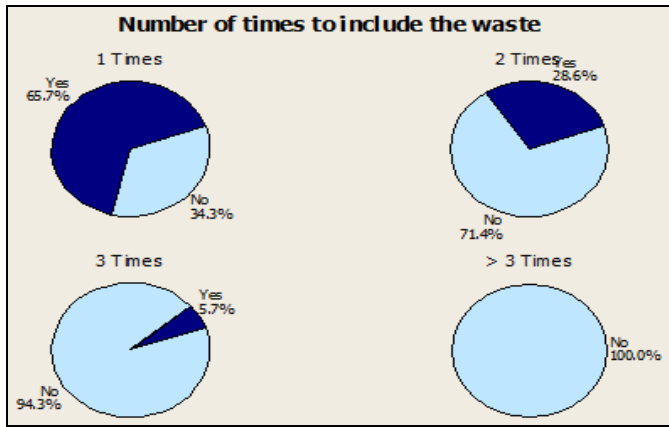


Fig. 4. Number of times to include wastes to the compost bin

Most people use the compost from the bin once a quarter year. If the compost bin maintain in a proper way we can get results within short time periods. The 12th question in the questionnaire paper is very important because it gives an image of the people to use the compost bin.

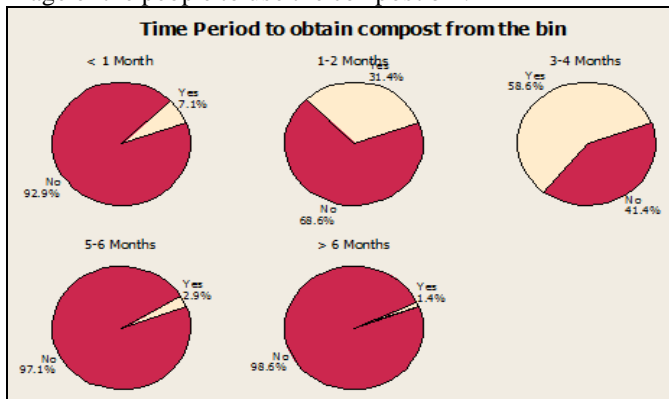


Fig. 5. Time period to obtain the compost from the compost bin

Most people use the compost bin to obtain the fertilizer for their home gardening. Few of them are considered the compost bin method is important to dispose the waste within a small area and others are considered it is as a healthy method for disposing the waste. Very few of them are considered that this waste disposing practice is a way to maintain a clean garden and an easy method.

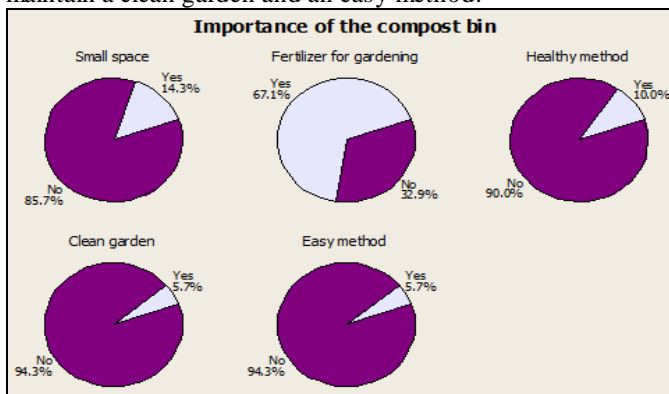


Fig. 6. Importance of the compost bin

Nearly 30% of the compost bin owners have problems associated with the compost bin. Most people are faced the leachate problem. They said during the rainy days this problem become very high. Also worms and unpleasant smell are another problems related with the compost bin. Also poor aeration is another reason for unpleasant odor by producing H₂S and NH₃ gases. About 13% of compost bin owners face worm and nematodes related problems. Meat,

fish refuses and dairy wastes are major sources to the growth of worms.

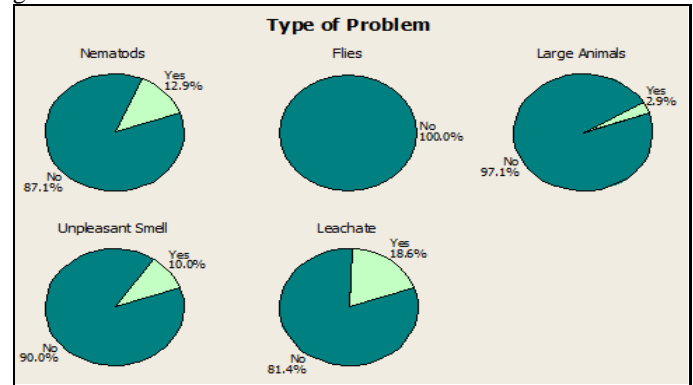


Fig. 7. Types of problems associated with the use of compost bin

According to the following charts it clearly shows that the amount of disposal waste becomes decrease after the use of the compost bin. Most people dispose the waste in to their garden before the use of compost bin. But now nearly 70% of the household waste amount disposes to the waste collection services can be decreased by using the compost bin. Therefore it says that the compost bin method is a very good waste disposing practice for household level.

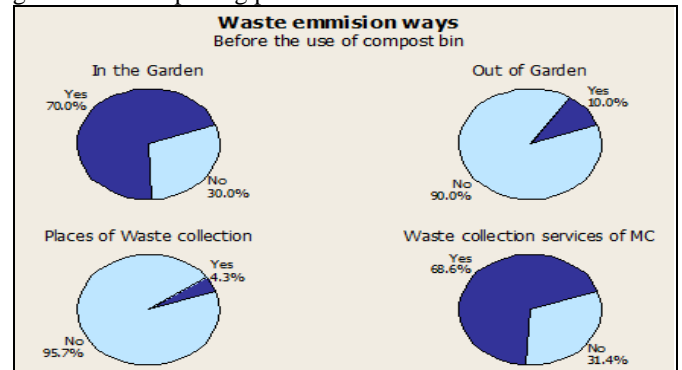


Fig. 8. Waste disposal methods before the use of compost bin

B. Analysis of the variation of Physical Parameters

1. Color

Different composting stages showed different color. Raw compost samples have light colors because of the partially degraded materials and partially matured compost has dark colors due to complete degradation. The raw compost samples (collected from top of the compost bin) have greenish yellow color and yellowish brown color. And the matured compost samples (collected from the bottom of the compost bin) have blackish brown and brownish black color.

2. Odor

Odor is come due to the microbial activities. Ammonia is the most common odor found in composting bin. Ammonia odors can be formed aerobically as well as anaerobically. Most raw compost has foul odor due to incomplete degradation. But the compost samples which are collected from the bottom of the bin mostly have H₂S and NH₃ mixed odor.

3. Texture

Texture is determined by the visual analysis. It is given an idea about maturity of the compost. Compost maturity infers a level of chemical stability reduces C:N ratio, uniform particle size, and organic fraction that resemble soil humic

substances. Most raw compost samples were wet, partially degraded or not consist particles with fibrous media. Matured compost consists of dry small particles. Most raw compost samples (collected from the top of the compost bin) are large fibrous lumpy texture and most mature compost samples (collected from the bottom of the compost bin) are tiny lumps with flowing particles texture. Mature compost samples which have free flowing particle texture, are relatively low in amount.

4. pH

During the initial stages of decomposition, organic acids are formed. The acidic conditions are favorable for growth of fungi and breakdown lignin and cellulose. The research findings revealed that the pH of the initial composting stage was 9.94 and pH of the composting stage was 10.04 and the following graph shows the variation of pH in two stages.

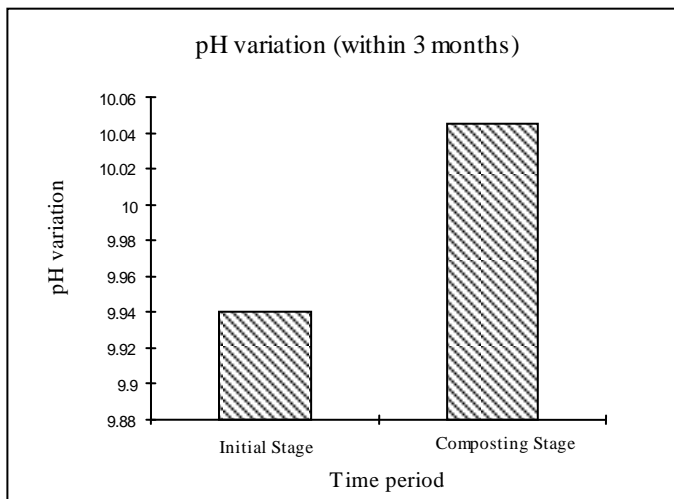


Fig. 9. Variation of pH

5. Moisture Content

Moisture content is an important physical parameter in the composting process. Because moisture supports the metabolic processes of the micro-organisms and it makes the media for chemical reactions. The research findings revealed that the moisture content of the initial stage was 54.10% and composting stage was 51.75%.

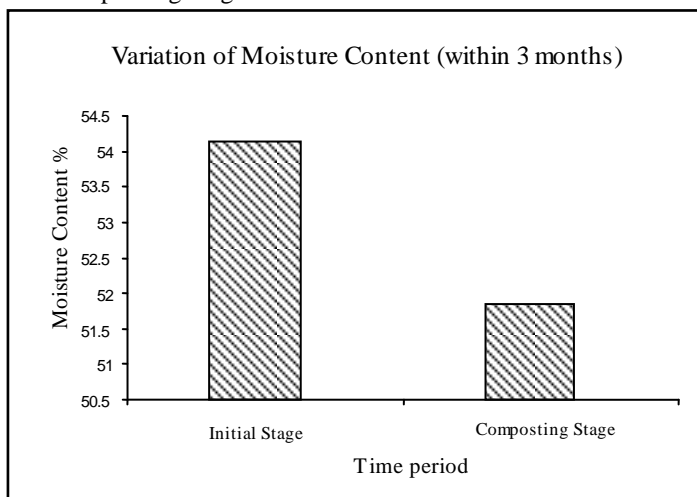


Fig. 10. Variation of Moisture Content

6. Bulk Density

Compact and loose bulk densities are another physical parameter in the compost. It is proportional to the porosity of the compost. Theoretically the samples from top layer of the compost bin have lower bulk densities compare with the bottom samples. The compact bulk densities of the initial stage and composting stage were 317.1 mg/ mL and 507.6 mg/ mL respectively and loose densities were varied 239.1 mg/ mL to 410.4 mg/ mL from the initial stage to composting stage.

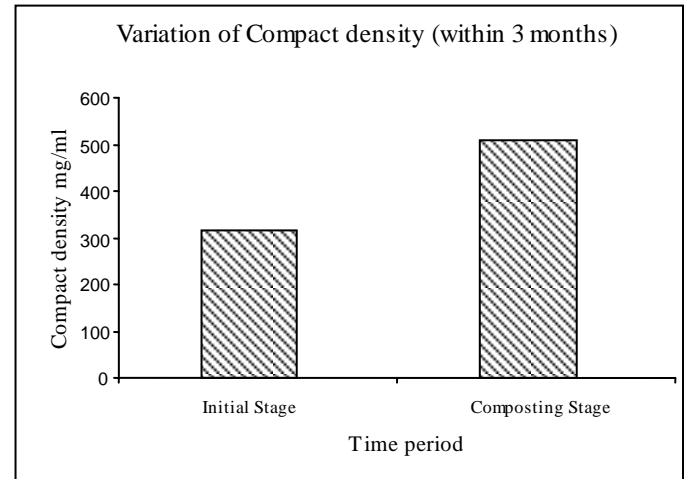


Fig. 11. Variation of Compact Density

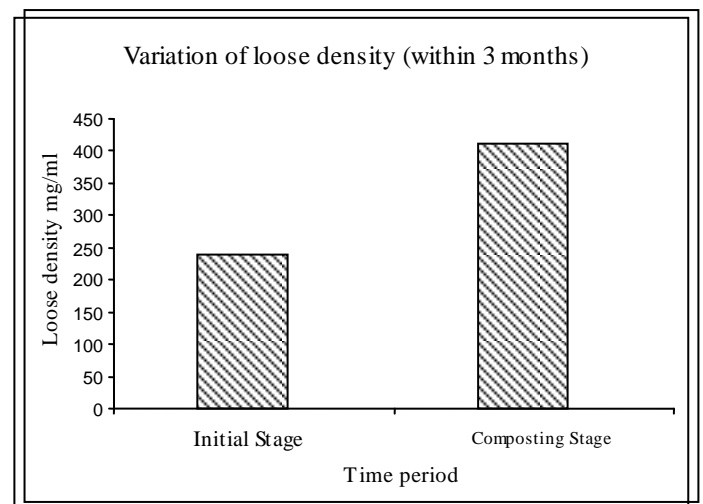


Fig. 12. Variation of Loose Density

7. Particle Size

Microbial activity generally occurs on the surface of the organic particles. Therefore, decreasing particle size effects of increasing surface area, encourage microbial activity and increase the rate of decomposition. On the other hand, when particles are too small and compact, air circulation through the pile is inhibited, decreased O₂ available within the pile and ultimately decreased the rate of microbial activity. The particle sizes vs. weight percentage relationships were indicated that the weight percentage of small particles was high in composting stage and weight percentage of large particles was high in initial stage.

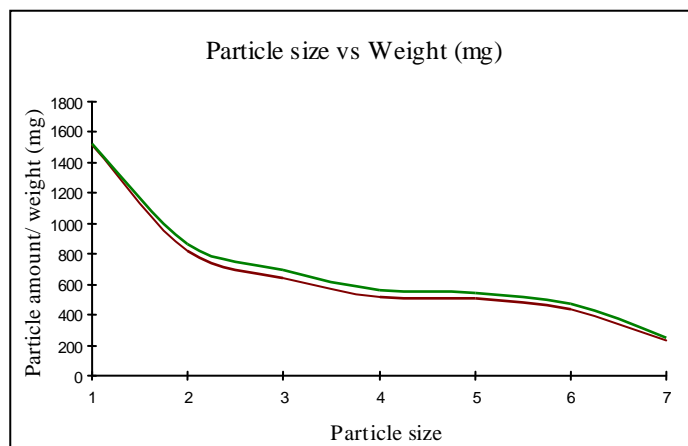


Fig. 13. Variation of Particle size in the composting stage and the initial stage

8. Micro Organisms in the Compost

In the process of composting, microorganisms break down organic matter and produce carbon dioxide, water, heat, and humus. Under optimal conditions, composting proceeds through three phases: Mesophilic, Thermophilic and Maturation phase. Different communities of microorganisms predominate during the various composting phases. At the initial decomposition state of the top of the compost bin, mesophilic microorganisms are remained and rapidly break down the soluble in to degradable compounds. The heat they produce increases the temperature inside the compost bin. In the beginning of the composting process, the following bacteria colony was observed by in the culture media of the compost samples which are collected from the top of the compost bin.

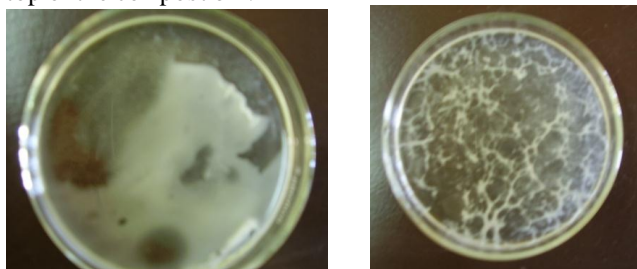


Fig. 14. Appearance of Culture media

IV. CONCLUSION

In the survey, the analysis of the questionnaire paper, it resulted some of the compost bin owners are not aware about the compost bin. Also they have not much knowledge about this technology. This research results showed that the unpleasant smell, producing leachate and also worms are the major practical problems that people has faced. Poor aeration inside the closed compost bin reduces efficiency of the production rate of compost.

Most compost bin owners say that they need awareness programs related with the maintaining of compost bin for gardening. The compost bin is an easy method for the disposal of household garbage and produced compost is largely use for growing vegetables.

According to the odor graph we can concluded that the compost samples are not completely degraded in the bottom of the compost bin because most compost samples collected in the bottom of the compost bin, shows H_2S and NH_3 mixed

odor. Therefore it resulted the compost bin is not 100% efficiently degrade the waste.

By considering the texture graph it says that most compost samples collected from the bottom of the compost bin are not completely degraded. Therefore the bin degradability is not completed. Large particles are remained in the final compost. This may happened by adding materials without sorting.

There are no significant different in moisture content with respect to the place of the compost bin (top and bottom). Therefore it can concluded that there are no significant different of bulk densities inside the compost bin, by considering the results of Minitab.

According to the results from microbial test it clearly shows that the bacteria are abundant in the top of the compost bin. The actinomycetes species are common in compost samples in the bottom of the compost bin.

According to the results gathered from the research it can be concluded that the proposed compost bin is not 100% efficient and redesigning should be needed for better results.

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ACKNOWLEDGEMENT

The author wishes to give her special thank to Dr. P.A.D.E. Kodithuwakku, Dr. P.I. Yapa, and other staff of the Soil Science Laboratory, Faculty of Agriculture, Sabaragamuwa University of Sri Lanka for giving their valuable guidance kind cooperation during her study period.

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