

## Waste Management, Sustainability, and Circular Economy” Education for Engineering and Technology Disciplines – A case Study on the Need Assessment for Innovating a New Curriculum for the Engineering Technology Undergraduate Studies

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### Abstract

Sri Lanka is rapidly urbanizing and then solid waste generation is increasing due to increases in population, urbanization, industrialization, and change in consumption patterns. Currently, 7000 Metric Tons of solid waste were generated per day in the country. Nearly 60% of the total generation is from the Western Province. Each person produces around 0.4-1.0 kg of waste per day. As a long-term strategy, introducing waste management courses for Higher Education programs and capacity Building in the field of waste management can address waste management issues in the country. This study intended to identify the knowledge gap and requirements of waste management skills and knowledge of society. Furthermore, this study revealed that areas need to be strengthened to fulfill the industrial requirement and future potential employment opportunities related to waste management technologies. Finally, the outcomes of the study were used to develop a new course in UNIVOTEC for waste management and valorization.

**Keywords:** *Circular economy, Curriculum, Need assessment, Sustainability, Waste management*

### 1. Introduction

Increased population, urbanization, industrialization, and changing consumption patterns all contribute to increased solid waste generation and solid waste diversification in Sri Lanka. Over the years, waste collection and disposal have become major issues in Sri Lanka. People are more likely to live in cities as cities develop, so daily waste generation is increasing. As a result, more efforts must be made to address the waste disposal issue [1]. Increased solid waste management and related environmental issues are the most visible environmental issues in cities. Some researchers were revealed that many cities in the South Asian region are not able to manage it due to institutional, regulatory,

financial, technical, and public participation shortcomings [2]. Sri Lanka's per capita solid waste generation in the South Asian region is significantly higher than that of other major countries such as the Maldives, Pakistan, Bangladesh, Bhutan, Nepal, and Maldives [3]. Though the government and related institutions were implemented strategic plans and programs to control the waste issues that have not been successfully achieved considerable outcomes. Therefore, the introducing of capacity building related waste management through higher education programmes has identified as the long term strategies and intended to contribute to the country's ability to educate students who will go on to improve Sri Lanka's waste management

practices. Therefore, need analysis from relevant stakeholders is essential to identify the targeted groups (students), knowledge gap, labour market potential (industry's needs and employability), national and regional needs, and in-house resources (both physical and personnel. In this survey mainly focused to identify the gap of knowledge and skills among the undergraduate level for further development of curricula of the degree programs.

## **2. Literature Review**

Furthermore, inadequate waste disposal facilities can lead to contamination of surface and groundwater via leachate; soil contamination via direct waste contact or leachate; air pollution via waste burning; disease transmission via various vectors such as birds, insects, and rodents; and uncontrolled methane release via anaerobic waste decomposition. Municipal councils are currently required to pay Rs. 3,000/= per ton for separated garbage and Rs. 5,000/= per ton for mixed garbage as garbage collection expenditure for the private sector [4]. Because many local governments in Sri Lanka currently dispose of solid waste by open dumping in low-lying areas, the general public (the majority of who are from lower-income families) faces serious environmental and health issues. Most parts of the country lack the infrastructure and resources for waste collection and disposal, resulting in uncontrollable garbage scattering and dumping into the environment [5]. Many local governments pay little attention to this issue because of the financial difficulties they face as a result of the limited financial budgetary allocation they receive from the central government, which is more concerned with improving physical resources coming under their purview. Concern for SWM is low, and the amount of resources allocated is insufficient [6]. Sri

Lanka generates 7000 Metric Tons of solid waste per day, with the Western Province accounting for nearly 60% of the country's solid waste. Each person produces 0.4-1.0 kg of waste per day on average [4]. The local authorities collected approximately 3242 metric tons per day, with the western province collecting the most (1783 metric tons per day). The district with the highest population is Colombo, which collects 1284 metric tons of solid waste [7]. Most developing Asian countries, including Sri Lanka, have a high percentage (50-80%) of organic matter in their waste streams, which makes them unsuitable for incineration [8,10]. When solid wastes are incinerated, they are reduced to ash and potentially hazardous gases are released into the air, posing a risk to public health. When these wastes are disposed of in landfills, they contribute to the release of methane into the atmosphere and it has a higher Global Warming Potential (GWP) than CO<sub>2</sub> [9], [11]. Therefore, short term and long term strategic plans are needed to solve the potential hazards for the environmental and human impact from waste in Sri Lanka.

## **3. Methodology**

The student population was selected from the University of Vocational Technology as representing the higher educational institution, who are following the Bachelor of Technology in Manufacturing Technology (MAN), Mechatronic technology (MEC) and Food Process Technology (FPT) degree under the faculty of Industrial and Vocational Technology.

The sample was selected randomly 10 students of each batch from the final year (third year) by representing both weekday students group (unemployed) and weekend (employed in the industry) students group. Structured questionnaire was used to identify neediness of waste management

and sustainability knowledge as shown in the Table 1.

**Table 1 - Composition of the sample population**

Study program	(B1)		(B2)	
	Weekday Batch	Weekend Batch	Weekday Batch	Weekend Batch
B.Tech. Manufacturing Technology	10	05	10	03
B.Tech. Mechatronic technology	10	05	10	02
B.Tech. Food Process Technology	10	05	10	05
<b>Total</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>10</b>

Though the total population was 60 in the designed sample, only 25 numbers were responded to the questionnaire.

For finding the potential employment opportunities related to waste management, the employers, who were representing the different sectors were randomly selected 30 individuals and communicated with them. The brain storming sessions were used to gather information via online (zoom connectivity) due to the COVID pandemic crisis situation. Only 10 individuals were responded and the structured interview technique was used for the data collection. All the responses of the sample population were analysed using descriptive statistics.

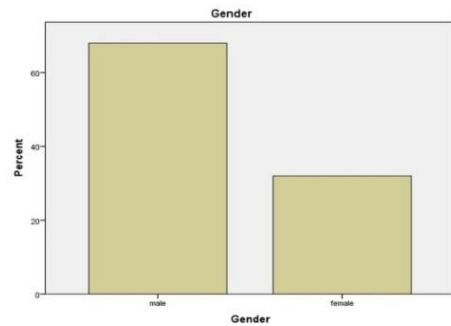
#### **4. Results and Discussion**

##### *4.1 Demographical analysis of the student population*

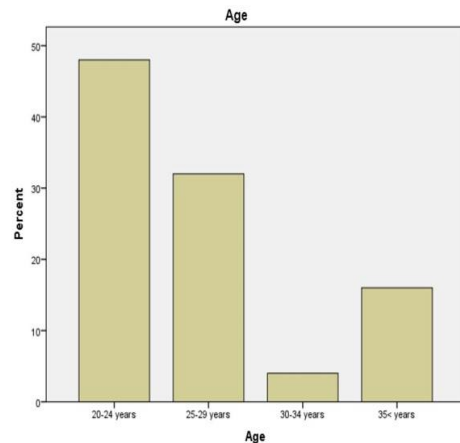
The background information of the responded student population was indicated in the figure number 1A to 1D.

30% of the sample was represented by female students and 45% of the sample was contained 20-24 year of age group, whereas less than 10% was included 30-34 years age

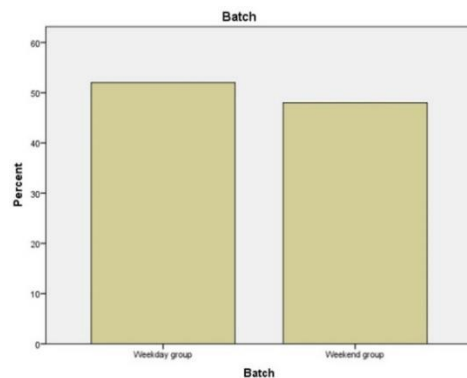
group. Both weekday and weekend group were represented around 50% and 40% of the students were included Food Process Degree program.



*Figure 1A - Percentage distribution of responded student population as per gender*



*Figure 1B - Percentage distribution of age group of the population*



*Figure 1C - Percentage distribution of responded student population as weekday and weekend group*

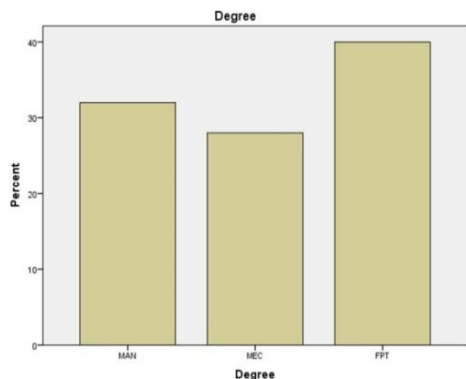


Figure 1D - Percentage distribution of responded student population as Degree programs

#### 4.2 Students perspective

Figure 2 shows that 36% of the population was indicated their good satisfaction about the existing curriculum contents but 45% of the sample was replied fair satisfactory level.

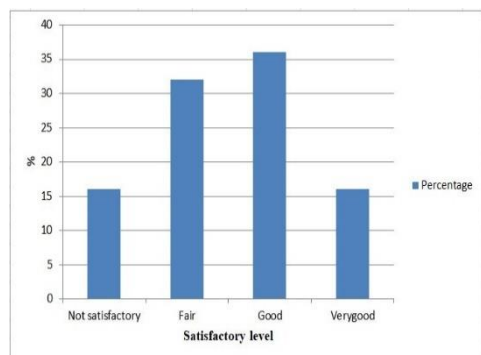


Figure 2- Satisfactory level of the contents in the existing curriculum

The Table 2, shows that 32% of the population was indicated that their definition about the waste management practices mean as "Waste" is everything that no longer has a use or purpose and needs to be disposed of, right.

The Figure 3 shows that 90% of the population was strongly agreed to the importance of the modules related to waste management to the curriculum.

Table 2 - Knowledge about the definition of waste management among the student population

Definition	Freq.	%	Cumulative freq.
Waste is any substance that is discarded after primary use, or is worthless, defective and of no use	4	16	16
Waste" is everything that no longer has a use or purpose and needs to be disposed of, right	8	32	48
Municipal by-product eliminated or discarded as no longer useful or required after the completion of the process	7	28	78
Waste is unwanted or un-useable material	3	12	88
Not included suitable definition	3	12	100

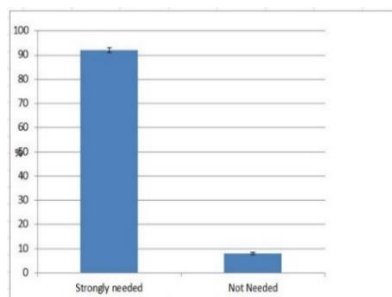


Figure 3 - Level of importance of the modules related to waste management in the degree program

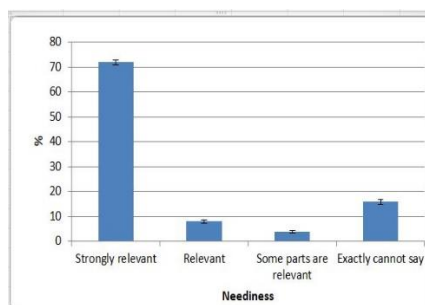


Figure 4 - Neediness of the content related to waste management for the degree

Furthermore, 70% of the students emphasized the importance of the module contents related to waste management technologies in the curriculum.

The Table 3 observed that the students were suggested to include some important topics to the existing curriculum

Table 3 - Suggested module contents of the curriculum relate with the waste management of the degree

• Methane production	• waste entrepreneurship
• The Present situation in Sri Lanka (waste - stat)	• field visit for solid waste management
• Classification of waste	• Regulations and conventions on waste
• Waste management	• Solid waste and Waste water management
• classification of waste	• Secure land fillings
• waste water from the food industry	• National and international regulations / environment regulations
• Food Safety	• Food Hygiene
• Environment management and cleaner production	• Product development
	• Food Engineering

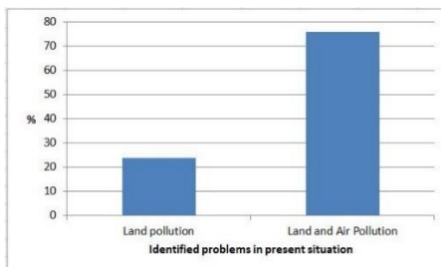


Figure 5 - Identified problems related to waste by the respondents

As per the Figure 5, more than 70% of the respondents were indicated both land and air polluted due to the current waste disposal activities.

### 3.3 Identified activities existing waste accumulation

As per the respondent's feedback, the first five reasons were identified as contributing

factor for accumulating the waste at the existing level.

1. Transport
2. Over production
3. Inventory
4. Defects
5. Improper management

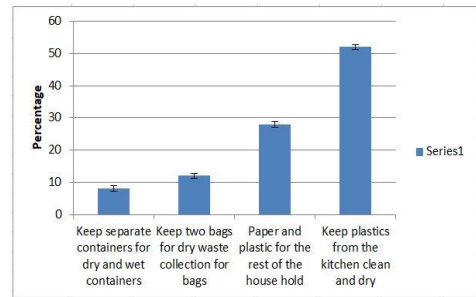


Figure 6 - Waste management practices at the home level

As per the Figure 6 shows, 52% of the population stated that their plastic waste is kept in the kitchen after cleaning and drying for reusable purposes. The majority population in household level was not followed the standard procedures, when separating the waste.

Fifty-six present of the respondents were expected more job opportunities related to the waste management practices (shown in Figure 7). 88% of the respondents were requested to allocate more fractions of the contents related to waste management to add more fractions.

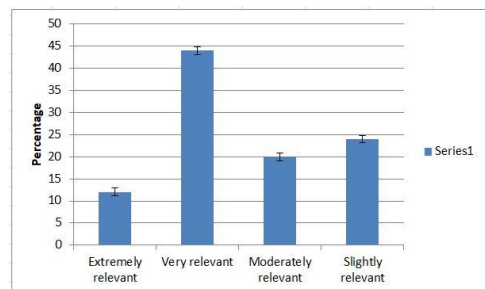


Figure 7 - Expectation of intended job opportunities related to waste management

#### 4.4 Prioritizing factors of the curriculum development

The Table 4 shows that when prioritizing the rank based on the requirements 60% is mentioned that they needed to fulfill the knowledge of the field of study. Secondly, 42% is emphasized that they needed to fulfill the capacity for applying knowledge in practice.

Table 4 - Requirements that have been considered as most important for the professional development of degree holders.

Criteria	Prioritizing level	
	No	%
Basic knowledge of the field of study/profession	1	60
Decision-making	2	28
Enhance Skill and knowledge development	2	28
Capacity for applying knowledge in practice	3	42
Capacity to adapt to new situations	4	35
Job creations and entrepreneurship	4	35
Job promotions	4	35
Critical and self-critical abilities	5	35
Own interest	9	28

#### 4.5 The knowledge gap, industrial requirement and self-motivation about the waste management

As per the responses for the knowledge gap, industrial requirement and self-motivation with regards to the waste management practices of the student population, this study revealed that all three factors were required to be fulfilled at future development of the curriculum. Their knowledge gap and requirement of waste management in the industries were identified as shown in Figure 8.

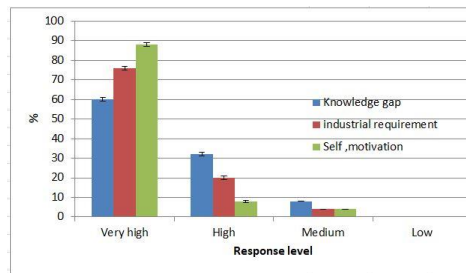


Figure 8 - knowledge gap, industrial requirement and self-motivation about the waste management

Table 5 shows that the summary of the employers, who have responded to the interview concerning the waste management, practices and their perspectives. 70% of the population represented in male employers. 80% of them were belonging to 36 to 45 years age group and more than 10 year experience. 50% of them were from agriculture sector organizations and followed well established waste disposal procedures. 60% of them were emphasized that more skillful and knowledgeable human resources are required for waste management activities in future.

Table 5 - Level of responding with regards to the waste management practices from employers

Variable	category	%
01 Gender	Male	70
	Female	30
02 Age group	26 -35 years	20
	36 -45 years	80
03 Type of the organization	Medium scale	20
	Large scale	80
04 Working experience in the organization	5 – 10 years	40
	More than 10 years	60
05 Sector	Agriculture	50
	Construction	10
	Health	10

	Live stock	20
	Services (vehicle)	10
<b>06</b> Position of the organization	Middle management	40
	Higher management	60
<b>07</b> Waste disposal procedures	Not established yet	10
	Established but not maintaining	40
	Well-established and maintaining	<b>50</b>
<b>08</b> Waste treatment procedures	Partially treated	40
	Follow treatment procedures	60
<b>09</b> Sustainability working environment	Yet to be planned	10
	Planning to implement	10
	The Implementation process going on	10
	Well-established and maintaining procedures	60
<b>10</b> Future forecasting related with waste management practices	Sustainability is essential part of the organization	20
	Needed more skills and knowledgeable human resources	60
	Awareness programs are needed	20

#### 4.7 Potential job markets related to waste management

According to employers, the following job categories are being created in the job market; already, Europe and some countries have declared these types of job opportunities.

Table 6 - Current job market (employability) for waste management

Job opportunities	
<ul style="list-style-type: none"> <li>Quality assurance (systems)</li> <li>Government legal &amp; regulation officers &amp; researchers</li> <li>SME – Bio- degradable packaging manufacturing</li> <li>SME – Fertilizer (bio extracts &amp; compost )</li> </ul>	<ul style="list-style-type: none"> <li>SME – Pesticide (bio extracts)</li> <li>SME – Sanitizers (ethanol)</li> <li>SME – Plastic (recycling)</li> <li>SME – Energy &amp; fertilizer (Methane &amp;compost)</li> <li>Waste treatment plant operation officers</li> <li>Waste management officer</li> <li>Management (Government &amp; other policy makers, certification bodies)</li> <li>Professional ( software, civil, mechanical engineers, scientists, technicians)</li> <li>Research and development persons</li> <li>Entrepreneurs ( To collect waste, Power generation from waste, waste management plants)</li> <li>Environment related experts</li> <li>Analysis-based employment ( chemical analyst)</li> <li>Consultants (Waste Management, for implementations of treatment plants/recycling plants)</li> <li>Civil Engineering services on waste recycling / treatments</li> <li>Chemical Engineering services on hazardous waste handling/ chemical analysis</li> <li>Quality assurance (systems)</li> <li>Environmental technologists</li> <li>Landfill engineers</li> <li>Sludge treatment technologist</li> <li>Water resources treatment process specialist</li> <li>Environment project managers/coordinators</li> <li>Front line employee – Drivers , Labourers</li> <li>Environmental consultant</li> <li>Recycling officer</li> <li>Quality manager</li> <li>Nature conservation officer</li> <li>Environmental health practitioner</li> <li>Waste management advisor</li> <li>Waste management and innovation assistant</li> <li>Environment assistant manager and executive</li> <li>Quality manager</li> <li>Process Engineer</li> <li>Digester operator, biogas plant operator</li> <li>Quality executive and assistant manager</li> <li>Production manager, executive and assistant manager</li> <li>Waste and recycling statically analyzer</li> <li>Waste management / Environment executive</li> </ul>

- Some jobs in the re-cycling plants as plastic re-cycling, and paper re-cycling
  - Supervisor environment control
  - Some industry recruit EHS (Environment, Health & safety) officers to maintain every EHS part.
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## 5. Conclusions and Recommendations

In this study revealed that following three main factors are needed to consider when developing the curriculum contents related to the waste management as prioritizing basic knowledge of the field of study/ profession, capacity for applying knowledge in practice and capacity to adapt to new situations, respectively.

Furthermore, when analysing job market 10 employment opportunities would be demanded or created in future related to waste management.

- Environment project managers/ coordinators
- Recycling officer
- Waste management advisor
- Waste/effluent treatment plant officer
- Waste management and innovation assistant
- Chemical/ System analyst
- Civil Engineering services on waste recycling / treatments
- Chemical Engineering services on hazardous waste handling/ chemical analysis
- Environmental technologists
- Landfill engineers

Finally, the overview of this survey is important to get industrial requirement of waste management technologies. The knowledge gap and technical requirement are clarified by the comments of the survey. Therefore, it can be identified following areas need to be strengthened to fulfill the industry requirement when restricting the curriculum, such as waste minimization, waste treatment technologies, waste

entrepreneurship, environmental sustainability, standard and regulations.

As vocationally oriented education system is practiced in the UNIVOTEC, the impact of the proposed course is highly effective to industries in the country. There more job-oriented course should be proposed to the requirement.

## Acknowledgement

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