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Assessment and design of solid waste disposal system in Rwanda polytechnic/ integrated polytechnic regional college, Huye campus

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Abstract

This research study is intended to assess the current/ existing solid waste management practices and collect information which will assist in preparing a required and proper solid waste collection project proposal in Rwanda Polytechnic/ Integrated Polytechnic Regional College/ Huye campus. The educational institutions represent the main components of sustainability promotion in our society and waste management is one of the challenges that educational institutions have to face in accomplishing sustainable goals and It is the reason why a survey study (non-experimental method) is conducted in RP/IPRC Huye campus from 01/10-31/01/2020 in which was very appropriate and as it is commonly used on other descriptive researches, the fact that, a longitudinal survey is used to collect data at more than one point or data collection period.

The population statistics of the campus from Human resources office and Directorate of academic services showed that by October 2020, 1340 students were registered and 170 permanent employees (Academic and supporting offices' staff). Based on findings of this research, it is revealed that the present system of Solid Waste Management in that College, is entirely relied on the poor management of solid waste collection, transportation and disposal and the efforts made by infrastructure and maintenance department and hired cleaners' company in Rwanda Polytechnic/ Integrated Polytechnic Regional College, Huye Campus to promote the situation in the campus are insufficient as it compared to the extent of the problem. The solid wastes generation rate in the campus is measured to be 0.308 kg/person/day. This made the estimate daily and annual total solid waste generation of the campus to be 489.5kg and 178'667.5kg respectively where the study was based on quantitative and qualitative approaches where the researcher was used a sample of 39 among 76 respondents (cleaners) selected from CROWN MULTISERVICES COMPANY using the convenience sampling technique from the total number of population. Interview, Observation, scheduled weight record by the researcher of solid waste was used. In this regard, some of Statistic Package for the Social Science analyses (SPSS) was used to conclude the results of the undertaken study. In fact, as consequence of our lifestyle, waste does not cease growing in quantity, complexity and even harmfulness, therefore, the best ways that used to tackle the aforementioned problems is an implementation of integrated solid waste management approach disposal design. The research study reveals that the best proposal method for solid waste final disposal is controlled landfill plant chosen by 87.2% of the respondents, Composting facility with 10.3 % mainly of respondent from agricultural and crop engineering department and incinerator/ burning chamber chosen especially for the cleaners who are working especially on the offices producing waste from unused papers with 2.6% of the respondents.

Keywords: Solid waste, Solid Waste Management, Solid waste final proposal.

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1. INTRODUCTION

Educational institutions such as universities can be considered as small communities that have significant impact on its surrounding. (Armijo de vega, C. Benitez, S. and Ramirez-Breto,M., 2003). Higher educational institutions are known as university cities assignable to their size and daily flow people. Inside them, there hospital, class rooms, restaurants, bank agents, offices, laboratories, workshop halls and places for events, for this reason, there is a wide diversity of waste produced and they have a critical role in sustainable development (Huge, J., Mac-Lean, C., Vargas, L., 2018).

Solid waste means anything that is either liquid nor gas and is discarded as unwanted resulting from day to day activities in the community. In other words, solid waste is defined as all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted by the person or organization that produces the wastes. It includes municipal garbage, industrial and commercial wastes, sewerage sludge, waste of agriculture and animal husbandry, demolition waste and mining residues.

Solid waste management is the collection, transport, disposal and treatment of waste materials. In today's polluted world, learning the collect method of handling the waste generated has become essential (Marello M. and Helwege A., 2014)

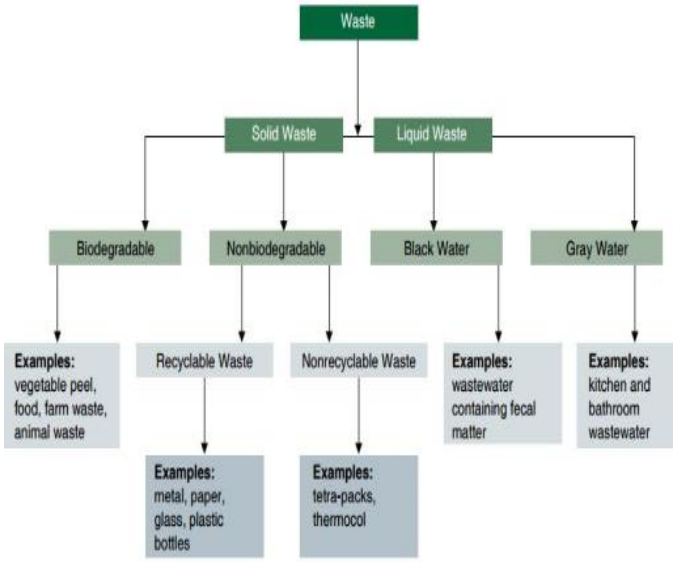

Figure 1.Type of Waste [Source: (The World Bank, 2012)]

An effective waste management system includes one or more of the following options:

- Waste collection and transportation,
- Resource recovery through sorting and recycling (recovery of materials such as paper, glass, metals, etc. through separation.
- Resource recovery through waste processing (recovery of materials such compost or recovery of energy through biological, thermal or other processing).
- Waste transformation without recovery of resources (Reduction of volume, toxicity or other physical/ chemical properties of waste to make it suitable for final disposal. community (UWINEZA, 2012).

Poor management of solid and liquid waste from households or businesses can undermine endeavors of economic development and spread disease and discomfort. Priority shall be given to the minimization of waste and the

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enhancement of solid and liquid waste management in urban areas. Today, a wide array of technologies is available for waste collection, treatment and disposal. However, implementing activities shall be based on concepts and technologies to be evaluated within the integrated policy framework in terms of social acceptance and financial and technical feasibility. This approach is called the "waste hierarchy". It is a classification of waste management priorities in order of their impact and cost efficiency. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

Figure 2.Waste management Hierarch [Source: (Environmental Protection Agency, 2011)]

The activities associated with the management of solid wastes from the point of generation to final disposal can be grouped into six functional elements:

1) Waste generation,
2) Waste handling and sorting, storage and processing at the source,
3) Collection,
4) Sorting, processing and transformation,
5) Transfer and transport, and
6) Disposal (Schübeler Peter, Jurg Christen, Karl Wehrle., 1996).

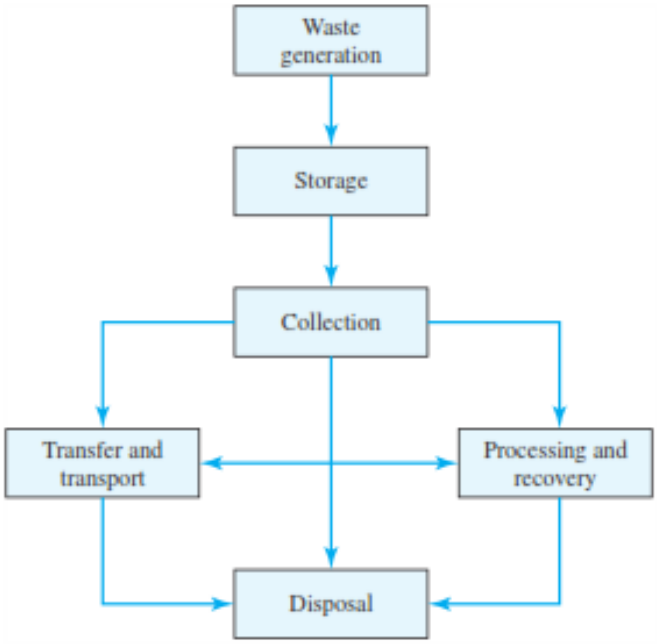

Figure 3.Elements of solid waste management system

Source:(Mackenzie L. Davis& Susan J. Masten, 2014)

In this study, an assessment for management and proposed integration approach disposal design of solid waste will be conducted at Rwanda polytechnic/ Integrated Polytechnic Regional College, Huye campus and this chapter introduces the general introduction of the study. It encompasses the background of the study, problem statement of the study, objectives of the study, research questions, hypotheses, scope of the study, significance of the study and logical frame work of the study. During this research study, the following will be performed:

Firstly, Functional elements of solid waste management system for of highlighted solid waste sources in that campus such as

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waste generation, waste handling and separation, storage and processing at the source, collection, transfer and transport, separation, processing and transformation and also their disposal will be analyzed. Secondary, Integrated approach to planning and design will be provided. Therefore, this thesis is intended to fill the current research gap related to the motive why the solid waste practice is inefficient and unorganized way in the school where dispose their waste improperly, context specific factors of the study area.

Objectives of the study

To study and assess existing solid waste management practices and collect information which will assist in preparing a required solid waste collection project proposal by Rwanda Polytechnic/ Integrated Polytechnic Regional College/ Huye campus

Main objectives of the study

The main objectives of the study are

- To assess the general situation of RP/IPRC HUYE's solid waste management and
- Design a solid waste disposal system construction and demolition waste.

Specific objectives of the study

The specific objectives of the research are:

- Categorize the various types and describe the generation rate of household solid waste generated in the RP/ IPRC Huye.
- To examine the performance of the existing solid waste collection and disposal practices.
- To identify and locate where the problems are within the solid waste management.
- To use the research findings for designing an improved and sustaining solid waste management project proposal.

Scope of the study

In this research study, only solid waste management will be studied, except construction and demolition waste, where the concern includes four components such as household waste, agriculture and landscaping garbage and civil and construction workshops' organic waste.

2. METHODS

Study design

Study design is the strategy, the plan and structure of conducting a research and refers to the detailed plan laid down by a researcher that guides the execution of a research. This study research should use a case study as it is explained by research topic, but the researcher preferred to use a survey study (non-experimental method) conducted in RP/IPRC Huye campus from 01/10-30/01/2021 in which is very appropriate and as it is commonly used on other descriptive researches, the fact that, a longitudinal survey is used to collect data at more than one point or data collection period. This was meant to found a solution for the problem based on real evidences, it encompasses any measurement procedures that involve asking questions of respondents and it can take any form from short paper and pencil feedback form to an intensive one-on-one in-depth interview or questionnaire. It also involves the collection of information from members of

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a predefined finite population and the analysis of this information to illuminate some important issues.

Other information is also usually collected by means of observation schedules and interviews. Most survey research designs use samples of specified target population with a view for generalizing the results to the populations from which the sample were drawn. Surveys may be used to obtain descriptive information about a target population or to examine relationships between various factors and descriptive information in survey research design also enables to obtain the current information. It is also used in fact finding studies and helps to formulate certain principles and give solutions to the problems concerning society. Descriptive information in survey research focuses also on investigating the current status, practice, the problem of institutional arrangement and capacity and it involves collecting quantitative and qualitative information to describe the nature of the problem under study in its current status and in academic research, the use of the survey research design may range from small scale exploratory survey to stimulate hypothesis generation, to a large scale exploratory survey to obtain evidence in major policy making.

Usually, the starting point for a survey is the statement of the questions to be addressed by the investigation, followed by the conceptual framework. Next is the development of the instruments for data collection, followed by the data analysis and presentation of findings.

Figure 4. Typical Survey Research Cycle

Source: (Philip J. Runkel & Joseph E. McGrath, 1972)

Study setting

The questionnaire, observation and scheduled weight record of SW form for the cleaners in the college were developed dealing with the categorization of solid wastes and rationale of solid wastes disposal at RP/IPRC Huye.

Study population

RP/IPRC Huye is composed by many departments and many options means that all kind of wastes are generated. The study population was consisted by 76 cleaners from **FIFO COMPANY LTD** in which since January 2021 is by contract replaced by **CROWN MULTI-SERVICES COMPANY LTD**, all hired as private company by the institution for cleaning and any other services related on management of solid waste such as plastics, organics, wood residues (sawdust), metal scraps and glass and any others and from new company, 76 cleaners are selected to be part of the research.

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Sampling methodology

This involves the sample size determination and sampling method used by the researcher to reach the respondents. The adopted the multi-stage sampling procedures because all the known and recognized cleaners in RP/IPRC HUYE who served as respondents for the study were workers of hired private company. Therefore, the researcher purposively selecting the desired number of respondents from the employees of the hired private company.

Sample size

Cohen *et al* (2000) argue that a sample size is a way determined by the style of the research. In a survey study, there would be need for a representative sample of the population for generalizability of the study findings (Cohen L., Manion L. & Morrison K., 2000)

The target population was divided into strata commonly symbolized as departments and the respondents were selected for filling questionnaires based on purposive sampling method known as judgment, selective or subjective sampling and the result is summarized as follow:

	Departments	**Total number of Cleaners**	**Sample size (n)**
1	Electrical and electronics	10	5
2	Information technology	8	4
3	Civil engineering	11	6
4	Mechanical engineering	12	6
5	Hospitality	9	4
6	Agricultural and crop engineering	8	4
7	Irrigation engineering	6	3
8	Chemistry and physic laboratory	5	3
9	Veterinary technology	7	4
	Total	76	39

Table 1. Percentage from working departments for respondents.

Data collection procedures

To obtain sufficient and reliable information, the following data collection tools was employed.

a. Primary data

a.1. Questionnaire

This study was used a closed-ended type of questionnaire which was prepared in order to explore the SWM practices. This questionnaire was first prepared in the English version and translated in Kinyarwanda for easy reading and understanding. In fact, the researcher had decided to use this instrument because it was the most appropriate tool to obtain quantitatively as well as qualitative information relative to the other methods and it was easy for the researcher to construct the questions and analyze the responses.

a.2. Observation

The researcher has also used field observation as a major data collection method for this study. It was employed for assessing solid waste handling practices,

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illegal dumping, solid waste collection, the location of containers sitting and transportation systems. In each activity, photographs were taken during field observation. Thus, this technique was undertaken through personal observation in the field by preparing a checklist to generate data about the condition of the study area and also enable to assess the health threat and environmental problem of the study area.

The weight of solid mass was weighted and others are estimated. The scheduling period was chosen and the obtained data are fulfilled on the provided form and well considered for solid waste generation rate of the institution.

b. Secondary data

b.1. Document analysis

Furthermore, Secondary data was extracted from different sources including published and unpublished materials about solid waste management standard and other necessary information were employed, from sanitation administrative agency, solid waste and other institutional solid waste management system documentation such as annual reports, books, handouts, journals, magazines and online library.

b.2. Data analysis

The researcher analyzed and interpreted both quantitatively and qualitatively in accordance with the nature of the data that were given by respondents. In the qualitative method, data about the existing situation of the problem was organized, summarized and explained thematically for the comparison and analysis of attributes. The quantitative data was analyzed and interpreted by using different statistical techniques like descriptive and inferential statistics to compare, contrast and explain the personal the personal and existing practice of the samples. A Microsoft office in Excel 2013 was used for more statistical data entry and analysis SPSS version 21.0. The data was also analyzed using descriptive statistics such as frequencies, mean and standard deviations and displayed using tables and figures. Finally, conclusion and recommendation were formulated based on the findings.

3. RESULTS

This section mainly discusses with the analysis, interpretation and discussion of the obtained results from the sample survey through structured questionnaires, observation, scheduled weight record of SW form s and document analysis. A total of 39 structured questionnaires was distributed and the entire questionnaires which were distributed to the respondents were properly filled and returned. The generated SW are scheduled weighted on every Friday during 3 months on different workshops and areas of the institutions in order to estimate daily generation rate of SM by the researcher was not considered because it was under the generated rate estimated from interview forms, then, most of the data gathered were organized in tables and charts and followed by discussion. According to this paper objectives, this work report has been discussed enthusiastically by elaborating and answering the following research questions and also analyzed in the different statistical test measurement:

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- What are the various categories and how much household of solid waste generated in the RP/ IPRC Huye?
- What are the existing methods practiced in the collection and disposal of solid waste?
- What are the problems related to the solid waste management system?
- How an appropriate solid waste management and disposal systems should be improved, redesigned and sustained?

Bio-data of respondents

The general identification of the respondents known as bio-data, is presented by daily working department, gender, marital status, age range, educational level, working experience and obtained trainings related on solid waste management. Let first start on working department where the cleaners are performing their daily duties.

Departments		Frequency	%
	Electrical and electronics	5	12.8
	Information technology	4	10.3
	Civil engineering	6	15.4
	Mechanical engineering	6	15.4
	Hospitality	4	10.3
	Agricultural and crop engineering	4	10.3
	Veterinary technology	3	7.7
	Irrigation engineering	3	7.7
	Chemistry and physics laboratories	4	10.3
	Total	39	100.0

Table 2.Percentage from working departments for respondents

From purposive sampling method used for simple size performed according to the current cleaners accepted to work daily on assigned department. A total of 39 respondents are selected and all questionnaires are all distributed and returned, none is missed. The primary information presented in table 2 show also the frequency of respondents by departments. The next is gender preposition among the respondents

	Frequency	%	Valid %	Cumulative %
Male	12	30.8	30.8	30.8
Female	27	69.2	69.2	100.0
Total	39	100.0	100.0	

Table 3.Gender preposition

As presented above Table 3, 38.8 percent of the respondents were males while 69.2 percent were females, here it is revealed that solid waste management is occupation of female. Marital Status was an another feature described the respondents as presented below:

	Frequency	%	Valid %
Single	6	15.4	15.4
Married	31	79.5	79.5
Widow	2	5.1	5.1
Total	39	100.0	100.0

Table 4.Marital status

The study on primary information, revealed as shown on Table 4 above that 15.4 percent of respondents are single, 79.5 percent are married and 5.1 percent are widowers. The age range of respondents is also presented where the study revealed that all groups of people are employed especially who are under production where they show a lot of capacity of working.

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Age range	Frequency	%
19-30 years	26	66.7
31-50 years	11	28.2
51-60 years	2	5.1
Total	39	100.0

Table 5.Age range

The age range is represented on Table 5 where 66.7 percent is located between 19-18 years, 28.2 percent is on range of 31-50 years and 5.1 percent is situated between 51-60 years. It shows that the cleaners of the campus are active, should perform any duty related to their occupation because there were no under 18 years and over 60 years. Education level is also a bio-data and is examined during study as it is represented below:

Level of education	Frequency	%
Never attended school	2	5.1
Can read and write	7	17.9
Primary school	25	64.1
9 year basics education	1	2.6
Secondary school	2	5.1
University level	2	5.1
Total	39	100.0

Table 6. Levels of education

The primary data presented on Table 9 show that over 64 percent had primary school levels, 5.1 percent is never attended school and 17.9 percent of respondents didn't complete their primary schools while they are able of reading and writing but 10.2 percent is having secondary and university levels.

The study revealed that the most of employees have low levels of education is due to the high number of pupils who left the primary classes early for being employed on private companies as it mentioned by Rwanda education board on his annual report but fortunately, there were not anyone who is under 18 years among employees. The employer company should have at least one year of contract and skilled cleaners are mainly shifted by the company where it is gaining an offer. It is the reason why the quantitative results from working experience is very negligible and is presented below on the table 7:

Working experience	Frequency	%
Less than 6 months	4	10.3
12 months	10	25.6
24 months	16	41.0
Over 48 months	9	23.1
Total	39	100.0

Table 7.Working experience in solid waste

The study reveals that 10.3 percent is less than 6 months of working experience, 25.6 percent is about one year of working experience and more 64 percent is having more than 24 months of working experience and study concluded that all employees are experienced enough for conducting the assigned task of solid waste management on the campus. The last of bio-data features are working training obtained within the company or from any other environmental protection agency and how long the training is taken place. The results are presented below on the Table 8 and Table 9:

	Frequency	Percent	Valid Percent
Yes	35	89.7	89.7
No	4	10.3	10.3
Total	39	100.0	100.0

Table 8.Obtained training on solid waste management

The study revealed that 89.7 percent is obtained a short training on solid waste management while 10.3percent didn't. The table 9 results confirm that more 35.9 percent are received a briefing about solid

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waste management at the first day of his/her occupation.

	Frequency	%t
One day	14	35.9
One week	8	20.5
Two weeks	9	23.1
One month	1	2.6
More than one month	3	7.7
Never trained	4	10.3
Total	39	100.0

Table 9. Length period of obtained training for employees about solid waste management

Findings on types/ categories of solid waste generated per day on the working departments.

The research is conducted also for assessing the types/ categories/ classes of generated solid waste in the campus and the findings are presented in the Table 10 as follows:

	Frequency	%	Valid Percent	Cumulative Percent
Organic	33	84.6	84.6	84.6
Non-organic	6	15.4	15.4	100.0
Total	39	100.0	100.0	

Table 10.Types/ categories/ classes of solid waste generated in the campus

The study reveals that 84.6 percent of solid waste generated at the campus is biodegradable mainly formed by used papers, folders, garden waste, food left and any organic waste while 15.4 percent is non-biodegradable and is formed by metal scraps, empty used bottles and scraps from soil engineering laboratory listed on civil engineering department. The estimated amount of solid waste generated in the campus is also presented in Table 11 as follows:

	Frequency	%
1-20kg	36	92.3
21-40kg	2	5.1
41-60kg	1	2.6
Total	39	100.0

Table 11.The whole general amount of solid waste collected in the campus

Serial Number	Lowest estimated weight in Kg	Highest estimated weight in Kg.	Frequency	Average weight in Kg.	Total SW in Kg	Total population	Total SW generated in Kg. per day and per person
1	1	20	36	10.5	378	1586	**0.308**
2	21	40	2	30.5	61		
3	41	60	1	50.5	50.5		
Total	63	120	39	91.5	489.5		

Table 12.Total solid generated per day and per person in the campus

The table 12 above show that the estimated generated rate of solid waste per person and per day is 0.308 kg.

Findings on existing methods practiced in the collection and disposal of solid waste in the campus

The solid waste collection in the campus is a cleaners' duty and is the first responsibility indicated on company contract with the campus. The methods used during solid waste collection is presented in Table 13 below:

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	Frequency	%	Valid Percent	Cumulative Percent
Yes	15	38.5	38.5	38.5
No	24	61.5	61.5	100.0
Total	39	100.0	100.0	

Table 13.Solid waste separation in the campus

The study reveals that 61.5 percent of the respondents are storing separately solid waste generated on their respective departments of the campus while 38.5 of them are not aware. During that assessment, the respondents asked the types of solid waste materials storage mainly used and their responses are presented below in the Table 14:

	Frequency	%	Valid %	Cumulative %
Bag	24	61.5	61.5	61.5
Basket	2	5.1	5.1	66.7
Plastic bins	6	15.4	15.4	82.1
Nearest pit	7	17.9	17.9	100.0
Total	39	100.0	100.0	

Table 14.Types of storage materials of solid waste generated on the campus

The study revealed that the solid waste generated on the campus are stored on the bag as the majority stated where 61.5 percent while 5.1 percent are using baskets, 15.4 percent are using plastic bins and 17.9 percent are using nearest pit, in fact that the methods used in the storing are the same as the methods used during solid waste handling. The respondents are also asked if the storage materials are colored according to the types of solid waste in which is being stored and the results are displayed below in the Table 15:

	Frequency	%	Valid Percent	Cumulative Percent
Yes	7	17.9	17.9	17.9
No	32	82.1	82.1	100.0
Total	39	100.0	100.0	

Table 15.Labelling/ Coloring storage of solid waste containers by types generated in the campus

Majority of the respondents of 82.1 percent indicated that the storage materials are not colored according to the types of solid waste are storing where the mainly methods used are bags and it is the reason why the coloring is not possible and the percentage of skills related on separating the solid waste is low. The feature of methods practiced in disposal of solid waste is assessed and findings are that 100 percent affirm that there was not any efficient solid waste disposal facility available in the campus and the means used of disposal of the solid waste collected on their respective departments are presented in Table 16 below:

	Frequency	%	Valid %	Cumulative %
Throw it on open space	12	30.8	30.8	30.8
Burn it	23	59.0	59.0	89.7
Bury on any space	3	7.7	7.7	97.4
Private collectors enter in the campus and take it	1	2.6	2.6	100.0
Total	39	100.0	100.0	

Table 16.Current solid waste disposal methods practiced in the campus

The study reveals that, 59 percent of solid waste generated in the campus are burned on open space, 30.8 percent are thrown on

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open space, 7.7 percent are buried on any space while 2.6 percent from hospitality department stated that their solid waste are collected by private collectors in order to be transformed on animal feeding.

The problems related to the solid waste management findings

The problems related to the solid waste management in the campus are also assessed where 97.4 percent are familiar with the meaning of solid waste management meaning, 100 percent of the respondents affirm that there was not any institutional officer who should making supervision and control an illegal dumping of solid waste around the campus.

The 100 percent of the respondents said that there were not any signs indicating that anyone should not dump waste anywhere only in designated waste bins and only 1.0 percent emphasized that the solid wastes are not harmful for human being and environment if they are not treated in proper ways. Those impacts are presented in Table 17 below:

	Frequency	%	Valid %	Cumulative %
Suddenly illness	4	10.3	10.3	10.3
Damage of environment	3	7.7	7.7	17.9
Both	32	82.1	82.1	100.0
Total	39	100.0	100.0	

Table 17. The impacts on society of throwing anywhere solid waste

The 79.5 percent of respondents have ever seen any violator even out of the campus of environmental regulations regarding solid waste management penalized for his/her misconduct as represented on Table 18 below:

	Frequency	%	Valid %	Cumulative %
Yes	8	20.5	20.5	20.5
No	31	79.5	79.5	100.0
Total	39	100.0	100.0	

Table 18.Percentage of penalization for violators of environmental regulations on solid waste management

The effort made by the institution to provide efficient solid waste management service compared with other services like water supply, internet connection and electricity is assessed and the results are presented on Table 19 below:

	Frequency	%	Valid %	Cumulative %
Strong	3	7.7	7.7	7.7
Fair	15	38.5	38.5	46.2
Weak	2	5.1	5.1	51.3
Very weak	19	48.7	48.7	100.0
Total	39	100.0	100.0	

Table 19.The effort made by institution for providing efficient solid waste management service

The study reveals that over 53.8 percent of respondents said that the effort made by institution for providing efficient solid waste management service is weak and very weak while 38.5 percent is fair where the respondents affirm that instead of quit their job from carelessness of the campus of providing solid waste facilities, they will stay at work making effort at instructing their colleagues about solid waste management and doing their best in proper management.

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Findings on appropriate solid waste management and disposal system designs proposal

In order to assess the kind of an appropriate solid waste management and disposal system designs proposal, the majority of respondents (69.2 percent) agreed that solid waste can be sometimes useful, 76.9 percent of the respondents are aware about reusing solid waste, 66.7 percent know the meaning of recycling, 82.1 percent know that separated solid waste at the source can be the best way of facilitating recycling and facilitating easy final disposal.

Composting is identified on one of the current method by which the garden wastes are dumped at any open area and make a compost. Here the majority of respondents (97.4%) agreed that the compost prepared form organic waste generated on campus can be used as organic fertilizer for crops production especially on agricultural and crop engineering department.

The final main aim of the research study was to suggest any kind of facility for final disposal of solid waste in order to manage them efficiently. The assessment is performed on it and the respondents gave their ideas and the results are displayed on Table 20 and Figure 5 below:

	Frequency	%	Valid %	Cumulative %
Controlled landfill plant	34	87.2	87.2	87.2
Incinerator/burning chamber	1	2.6	2.6	89.7
Composting waste facility	4	10.3	10.3	100.0
Total	39	100.0	100.0	

Table 20.Solid waste final disposal design proposal in RP/IPRC Huye

The research study reveals that the best proposal method for solid waste final disposal is controlled landfill plant chosen by 87.2% of the respondents, Composting facility with 10.3 % mainly of respondent from agricultural and crop engineering department and Incinerator/ burning chamber chosen especially for the cleaners who are working especially on the offices with 2.6% of the respondents.

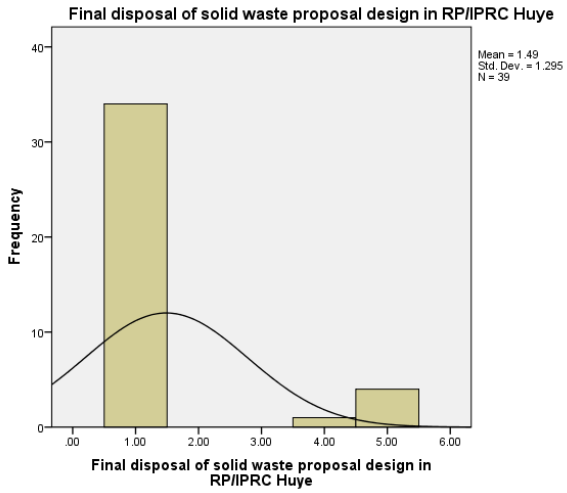

Figure 5. Histogram for final disposal of solid waste proposal design in RP/IPRC Huye

The figure 5 show histogram for final disposal of solid waste proposal design in R/P IPRC Huye explaining that the majority chose controlled landfill plant for solid waste disposal and treatment where Mean of 1.49, standard deviation of 1.295 calculated on total of 39 sample size/ respondents give the fact that the proposed method is highly needed. The respondents are asked the reason of choosing freely the method as displayed on above histogram and their answers are stated on Table 21 below:

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	Frequency	%	Valid %	Cumulative %
Sustainability	31	79.5	79.5	79.5
Not expensive	6	15.4	15.4	94.9
No other appropriate option	2	5.1	5.1	100.0
Total	39	100.0	100.0	

Table 21.The reason for solid waste final disposal proposal in RP/IPRC Huye

The study reveals that the first reason for selecting the method of solid waste final disposal proposal of controlled landfill plant is the sustainability selected by 79.5 percent of respondents while 17.9% of respondents stated that it is because cost where controlled landfill is not expensive and 2.6 % of the respondents affirmed that there was any other appropriate method rather than the majority selected. Therefore, other best ways that should be used to tackle the aforementioned problems are execution of sustainable solid waste management systems (reuse, recycle, composting and incineration) through awareness creation and training and implementation of integrated solid waste management approach disposal design.

Findings on improving, redesigning and sustaining the existing solid waste management systems

Basing on findings on improving, redesigning and sustaining the existing methods practiced on the campus in order to manage efficiently solid waste generated in the campus, the results are displayed on Table 22 below:

	Frequency	%	Valid %	Cumulative %t
Yes	2	5.1	5.1	5.1
No	37	94.9	94.9	100.0
Total	39	100.0	100.0	

Table 22. Suggestion of the respondent on improving, redesigning and sustaining the existing method of solid waste management in the campus

The study revealed that the majority (94.9%) refuse any improvement, redesign or sustaining the existing methods for solid waste management because they are not compiling to any regulations while they are source of suddenly illness and damage of environment.

The conclusion was to replace any assumed method in order to be replaced by the moderns of controlled landfill plant permitted by campus location area.

4. DISCUSSION

Rwanda Polytechnic/ Integrated Polytechnic Regional College, Huye (RP/ IPRC HUYE) is one of the public school by which proper provision of Solid Waste Management practice is still unsatisfactory and incomplete where illegal dumping of waste on open areas and ditches is considered as routine task of school administration, trainers and trainees. The first objective of the study was to find out the various categories/ types and generated rate of waste produced, the study stated that in RP/IPRC Huye revealed no more than 80% of solid waste are biodegradable where through composting, most of this organic waste can be converted into organic fertilizers to replace the inorganic fertilizers to save foreign exchange earnings. The organic fertilizers are far less expensive to

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produce than imported inorganic fertilizers and its application on the land for crop production is more environmentally friendly than the inorganic one and should be used in Agricultural engineering and crop production departments of the campus. The generated rate of solid waste in the campus is 0.308kg/person/day.

The study revealed that the transportation of solid waste in RP/IPRC Huye is performed manual, there were no any driven equipment facilitating any transportation of waste and the situation of solid waste management has been worsening due to carelessness of administrative enforcement of environmental regulations especially on infrastructures and this is cause the lack of public awareness and environmental ethics that result in uncontrolled solid waste disposal. The study revealed that different illegal dumping areas, turning into sources of contamination due to the incubation and proliferation of flies, mosquitoes and rodents, that in turn, are disease transmitters that affect the institution' users (Staff, students and visitors).

5. LIMITATIONS

In this research study, only solid wastes are studied except, except construction and demolition waste, where the concern includes following four components: household waste, agriculture and landscaping garbage and civil and construction workshops' organic waste.

There are the limitations that prevented the researcher from meeting its total expectations such as insufficient funds to enable the researcher covering the cost required for engineering tests like air quality, volatile solids caused by illegal incineration, etc. during conducting this research.

In spite of these limitations, the researcher hopes that they were not largely impair results of the study and the findings should be useful towards felling part of the apparent knowledge gap or at least form a foundation for further researches

6. CONCLUSION

The conclusion is based on findings. As the research has been conducted to assess the management practices of the current and proposing an appropriate disposal of solid waste where the investigation was addressed by employing questionnaires, field observation, scheduling weight mass of solid waste and reviewing/ analyzing documents written by different environmentalists. On the basis of quantitative and qualitative analysis of data, the findings of the study state that in general, the solid waste management practice in RP/IPRC HUYE is weak in terms of status, spatial coverage, solid waste management facilities and the disposal behavior is critical.

The proposed solid waste disposal design will be environmentally responsive and preserving healthcare of educational institution' users: Integrated waste management design is highly advocated in the report as the best approach to incorporate and handle the increasing volume. As an integrated waste management approach is needed, it will deal with the waste from segregation at source and collection to recovery and effective final disposal. The RP/IPRC Huye use landfill for waste disposal which is the least preferred method in ISWM approach. However, to fully incorporate the approach,

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it requires for proper environmental policies specifically on pollution and waste reduction to be enacted and implemented.

The concept of ISWM is beneficial for the institution and the surrounding because it primarily addresses on waste reduction, reuse and recycling resulting to a minimum amount of waste sent to dumpsites therefore reducing the effect of pollution from solid waste in the landfills. It is a must that RP/IPRC Huye provide gradually (according to the availability of financial means) an effective solid waste disposal method from open dumping to controlled dumping (with soil cover and controlled access), engineered landfill

As the study revealed that more than 88% of generated waste is from organic waste, there should be a need to explore the opportunities for the 3Rs (Reduce, Reuse and Recycle) in which composting should be the one of best way of solid waste management as the institution has agricultural and crop production departments, produced compost should be used on practical courses. The compost production will contribute socially (Clean, good health) and economically (reduce the cost of fertilizers).

Furthermore, waste need proper management and this can be done by segregating the waste at generating points into re-usable and non-reusable parts and utilizing the re-usable part into financially viable materials. Also, segregating the hazardous solid waste from the non-hazardous ones in order to ensure the safety of workers. This work-research had improved my knowledge about solid waste management and I will be part of the project implementation if my solid waste proposal design taken in consideration.

List of abbreviations

- **%:** Percent
- **3Rs**: Reuse, Reduce and Recycle
- **ISWM:** Integrated solid waste management
- **ISWM**: Integrated solid waste management
- **Kg**: Kilogram
- **Ltd**: Limited
- **RP/ IPRC:** Rwanda Polytechnic/ Integrated Polytechnic Regional College
- **SPSS:** Statistic Package for the Social Sciences
- **SWM**: Solid waste management

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