Risk Analysis of Waste Management Failure at Al-Hikmah Quran Islamic Boarding School in Bogor Using FMEA and AHP Methods

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ABSTRACT

The Bogor Al-Hikmah Qur'an Islamic Boarding School is a male-only Islamic boarding school with 160 active students, producing no less than 50 kg of waste per day. Waste management is still carried out traditionally, that is, collected and then burned. Waste management is an important part that needs attention at the Al-Hikmah Quran Islamic Boarding School, Bogor. Therefore, this final project research aims to analyze the factors that have the potential to pose a risk of failure in waste management at the Bogor Al-Hikmah Qur'an Islamic Boarding School, and provide the best alternative that can be used by the Bogor Al-Hikmah Qur'an Islamic Boarding School in managing rubbish. The data used in this study came from literature studies, interviews, and distributing questionnaires to the boarding school. In this study using the fishbone diagram method to identify risks, Failure Mode and Effect Analysis (FMEA) to determine the factors that can cause failure in waste management, and Analytical Hierarchy Process (AHP) to find the best alternative in waste management at the Qur'an Islamic Boarding School and Al-Hikmah Bogor. From the results of this study, it was obtained that the highest Risk Priority Number (RPN) value was 720 on the human factor with the sub factor that there were still many students who littered, and on the method factor with the sub factor there were no regulations for disposing of waste in its place, and alternative solutions for management waste at the Al-Hikmah Quran Islamic Boarding School in Bogor is to conduct training for boarding school residents with a weight of 0.38. The alternative strategy is one of the solutions to solve the problem of plastic waste from students' rooms with a weight of 0.51. With the training for boarding school residents, it is hoped that the plastic waste produced by the boarding school can be recycled so that it can be reused, and reduce the rate of disposal of plastic waste to landfills.

Key word: waste; fishbone diagram; RPN; FMEA; AHP.

INTRODUCTION

Almost all countries in the world are struggling with waste issues. Big cities in Indonesia on average produce tens of tons of waste every day. Waste, as defined in Law Number 18 of 2008 concerning Waste Management (UUPS), is defined as the residual product of daily human activities and natural processes. Based on data from the National Waste Management Information Source (SIPSN) regarding the results of waste management performance, 75.13% managed waste and 24.87% unmanaged waste. Bogor Al-Hikmah Qur'an Islamic Boarding School as an educational institution as well as a social community institution, is a male-only Islamic boarding school with 160 active students and has a fairly large garden, producing no less than 50 kg of waste per day. Waste management is still carried out in the traditional way, that is, it is collected and then burned. After conducting a preliminary study on the characteristics of the waste that often occurs in Islamic boarding schools is solid waste. The solid waste comes from canteens, parks, kitchens, student dormitories and teacher houses. Based on the results of the data collection carried out, the types of solid waste produced by the Bogor Al-Hikmah Qur'an Islamic Boarding School were obtained, namely: plastic, paper, metal, glass, and food.

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Figure 1. Garbage Burning at Al-Hikmah Qur'an Islamic Boarding School Bogor

Food waste dominated 65% of the total waste generated during that period or weighed 406.58 kg, where the kitchen was the biggest contributor to food waste, because every day it produces food scraps, vegetables and fruit peels. The second most waste is plastic waste as much as 27% with a weight of 169.802 kg. Furthermore paper waste with an amount of 5% weighing 34.42 kg, glass with an amount of 2% weighing 10.12, and metal with an amount of 1% weighing 4.67 Kg. Based on the results of the preliminary study, waste management is an important part that needs attention at Islamic boarding schools Qur'an Al-Hikmah Bogor, but in the management process it will not escape the risk of failure which must be considered. For this reason, a method is needed that can be used in analyzing factors that have the potential to pose a risk of failure in waste management at the Al-Hikmah Qur'an Islamic Boarding School, Bogor.

FMEA is the most helpful approach to achieve the goals mentioned above. Thus this study focuses on the FMEA method to analyze the risk of waste management failure at the Al-Hikmah Qur'an Islamic Boarding School, Bogor. The risk factors analyzed include methods, machines, people, materials, and the environment. Risk assessment is based on the severity, occurrence, and detection values to produce a Risk Priority Number (RPN), then from that value a risk evaluation is carried out so that the risks with the highest level can be identified for further action to be taken. To find the best alternative for waste management at Pondok Pesantren Al-Hikmah Qur'an Bogor, this research uses a decision support system. In this study using the Analytical Hierarchy Process (AHP) technique.

Waste processing systems using unused materials, such as plastic and other building materials, can be implemented using various innovative and environmentally friendly methods (Pinem HKWB et.al, 2022; Ulhasanah N et.al, 2021). The plastic is heated until it melts, then molded into new products such as plastic ore or ready-to-use plastic items. Recycled plastic can be mixed with other materials such as sand or cement to make durable bricks (Khiyana A et.al, 2024; Suci DP, Rakhmatulloh AR, 2024).

Used wooden pallets can be converted into furniture, such as tables, chairs and shelves. Used plastic bottles can be turned into home decorations such as flower pots, decorative lamps or wall hangings. Used construction materials such as concrete, wood, metal and glass are separated (Astarina NK et.al, 2023).

Crushing: Recyclable materials are crushed into smaller sizes. Organic waste such as food and plant waste can be processed into bioplastic which is more environmentally friendly than conventional plastic. Investment in efficient and environmentally friendly waste processing technology. By implementing these various methods, we can reduce the amount of waste that ends up in landfills, save natural resources, and reduce the environmental impact of plastic waste and building materials (Paikun P et.al, 2023; Asrudin A et.al, 2023)

RESEARCH METHODS

In this final project research, the background is the failure of waste management at the Al-Hikmah Qur'an Islamic Boarding School, Bogor. So that the roots of failure in waste management are sought by applying the causal diagram method (fishbone diagram). After getting the results from the fishbone diagram, the next step will be used to determine the most dominant risk factors by applying

the Failure Mode and Effect Analysis (FMEA) method. Then to achieve research objectives regarding alternative solutions in waste management at the Bogor Al-Hikmah Qur'an Islamic Boarding School, the Analytical Hierarchy Process (AHP) method is used. This study uses primary data in the form of interviews to obtain data on the factors that cause waste management failures that occur at Islamic Boarding School Qur'an Al-Hikmah Bogor, and distributing questionnaires to assess important factors in FMEA such as severity, occurrence, and detection as well as conducting pairwise comparisons.

RESULT AND DISCUSSION

This final project research was conducted at Al-Hikmah Qur'an Islamic Boarding School Bogor, located in Kramat Village RT.01/RW.04, Pabuaran Village, Kemang District, Bogor Regency, West Java 16310, Indonesia.

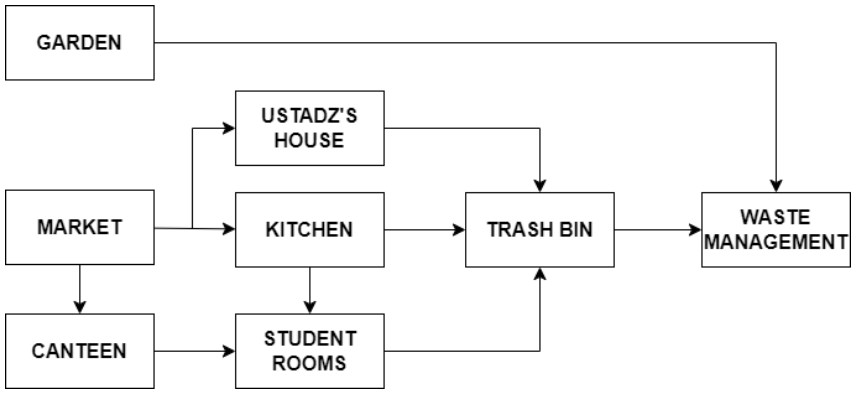

Figure 2. Waste Management Process in Existing Conditions

The conditions at the time of conducting the research were that the sources of Islamic boarding school waste were parks, canteens, ustadz houses, kitchens and students' rooms. All of the waste is transported and collected into one in a trash can, after which waste management is carried out, namely by burning it. But sometimes park cleaners will pick up trash that has a sale value, such as plastic bottles and cups and cardboard to be sold to collectors. In identifying the possibility of waste management failure at the Al-Hikmah Quran Bogor Islamic Boarding School, the results are poured into a fishbone diagram and grouped into several parts, namely: humans, machines, methods, materials, and the environment.

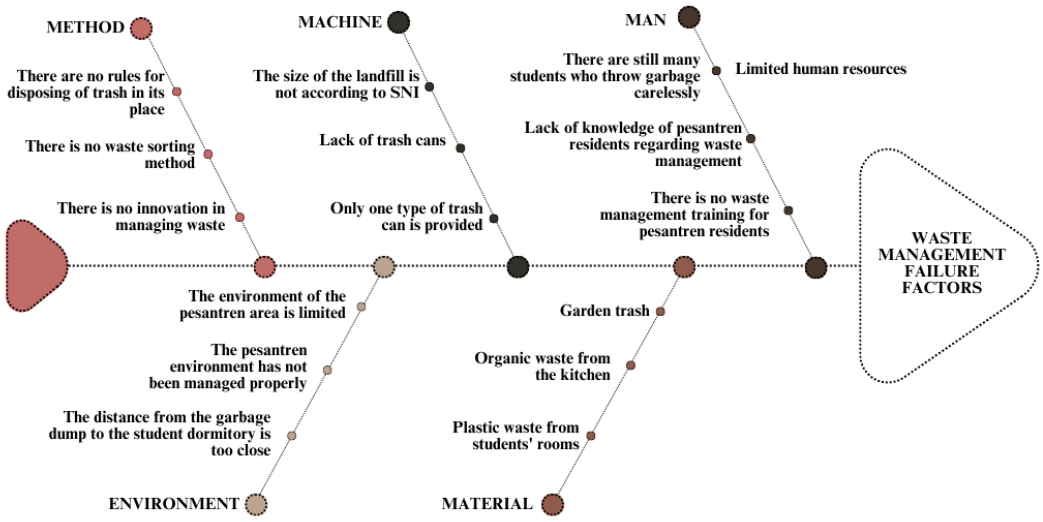

Figure 3. Identify with a fishbone diagram

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Based on the results of identifying the risk of failure in waste management at the Al-Hikmah Qur'an Islamic Boarding School in Bogor, questionnaires will then be distributed so that risk assessment and evaluation can be carried out using the Failure Mode Effect Analysis (FMEA) method.

Table 1. The risk level of waste management at the Koran Al-Hikmah Islamic Boarding School, Bogor

No	Factor	Sub-Factor	RPN value	Risk level	Action recommendations
1	Man	Limited human resources	504	*High*	Mitigation
2		There are still many students who throw garbage carelessly	720	*High-Very High*	Quick handling
3		Lack of knowledge of pesantren residents regarding waste management	432	*Moderate-High*	Mitigation
4		There is no waste management training for pesantren residents	448	*Moderate-High*	Mitigation
5	Machine	The size of the landfill is not according to SNI	432	*Moderate-High*	Mitigation
6		Lack of trash cans	576	*High*	Mitigation
7		Only one type of trash can is provided	512	*High*	Mitigation
8	Method	There are no rules for disposing of trash in its place	720	*High-Very High*	Quick handling
9		There is no waste sorting method	648	*High-Very High*	Quick handling
10		There is no innovation in managing waste	512	*High*	Mitigation
11	Material	Garden trash	216	*Low Moderate*	Accept
12		Organic waste from the kitchen	648	*High-Very High*	Quick handling
13		Plastic waste from students' rooms	576	*High*	Mitigation
14	Environment	The environment of the pesantren area is limited	648	*High-Very High*	Quick handling
15		The pesantren environment has not been managed properly	504	*High*	Mitigation

16	The distance from the garbage dump to the student dormitory is too close	432	*Moderate-High*		Mitigation

Based on the table above, it can be seen that there are several factors that can be categorized as very high risk, namely, there are still many students who litter, there are no regulations for disposing of waste in its place, there is no method of sorting waste, organic waste from the kitchen, and the environment of the Islamic boarding school area limited. These things require immediate preventive action so as not to cause a greater negative impact.

After knowing the risks that occur in waste management at the Al-Hikmah Qur'an Islamic Boarding School in Bogor, a decision is made in determining alternative solutions using the AHP method. The next step that can be taken after creating a hierarchical structure and distributing AHP questionnaires to experts is to calculate the weighting of each hierarchical level, based on the pairwise comparison values given by the experts.

The first calculation is done at level 1 of the hierarchy, namely, criteria.

Table 2. Priority Results on Criteria

Criteria	**Weight**	***Consistency Ratio***	**Priority**
Man	0,22		4
Machine	0,09		5
Method	0,232	7,5%	1
Material	0,231		2
Environment	0,225		3

Based on the order of priority in the table above, the method criteria are the top priority with the highest weight of 0.232 with a consistency of 7.5%. This shows that the method can be a strategy to reduce the risk of waste management failure that occurs in Islamic boarding schools, because by using the right method waste management can be carried out effectively and efficiently.

Subsequent calculations are carried out at level 2 of the hierarchy, namely sub criteria.

Table 3. Recapitulation of Priority Weight on Sub Criteria

Criteria	**Sub Criteria**	**Weight**	***Consistency Ratio***	**Priority**
Material	Plastic waste from students' rooms	0,51	1,4%	1
Method	There is no innovation in managing waste	0,46	0,1%	2
Machine	Only one type of trash can is provided	0,42	1,4%	3
Environment	The distance from the garbage dump to the student dormitory is too close	0,42	8,9%	4

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Man	There are still many students who throw garbage carelessly	0,29	0,2%	5

Based on the table above, the first priority is the sub-criteria for plastic waste from students' rooms with a weight of 0.51 and a consistency of 1.4%. The problem of plastic waste from students' rooms is one of the causes of the failure of waste management at the Al-Hikmah Qur'an Islamic Boarding School in Bogor. The plastic waste sub-criteria from students' rooms is the main determinant in reducing the risk of waste management failure because the waste management that has been carried out so far at the Al-Hikmah Bogor Islamic Boarding School by burning including burning plastic waste from students' rooms can cause environmental and health pollution.

Subsequent calculations are carried out at level 3 of the hierarchy, namely alternatives.

Table 4. Priority Results on Alternatives

Criteria	*Consistency Ratio*	Weight	Priority
Training	6,2%	0,38	1
Make rules		0,23	3
Adding a trash can	6,2%	0,24	2
Create a waste management unit		0,14	4

Based on the order of priority in the table above, training alternatives are the top priority with the highest weight of 0.38 with a consistency of 6.2%.

CONCLUSION

Factors that have the potential to pose a risk of failure in waste management at the Al-Hikmah Qur'an Islamic Boarding School in Bogor, namely, humans, machines, methods, materials, and the environment. The results of risk analysis using the FMEA method obtained the highest Risk Priority Number (RPN) value of 720 on the human factor with the sub-factor there are still many students who litter, and on the method factor with the sub-factor there are no regulations for disposing of waste in its place. Then there is the second highest risk value of 648 on the method factor with the absence of a waste sorting method as a sub-factor, the materials factor with the organic waste sub-factor from the kitchen, and the environmental factor with the environment sub-factor in a limited boarding area.

The results of the analysis using the AHP method show that an alternative solution to waste management at the Al-Hikmah Qur'an Islamic Boarding School in Bogor is to conduct training for pesantren residents with a weight of 0.38. The alternative strategy is one of the solutions to solve the problem of plastic waste from students' rooms with a weight of 0.51. With the training for pesantren residents, it is hoped that the plastic waste produced by the pesantren can be recycled so that it can be reused, and reduce the rate of disposal of plastic waste to landfills.

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