Application of Ergonomics in the Field of Waste Management (Case Study : Waste4Change)

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Abstract. . One of the serious environmental problems faced by the Indonesian people today is the waste problem. Waste separation is still an effective solution to facilitate the next waste handling process. In Indonesia, most of the work of waste sorting is done manually, causing work risks, one of which is related to ergonomics at work. Ergonomics is a work rule or norm that can bring comfort and productivity to work. Waste4Change is a social entrepreneurship that provides responsible waste management services. The aim of this research is to improve ergonomics and working methods in waste separation at Waste4Change. A combination of literature review and field studies is used as the research method. The results showed that waste separation by sitting for too long causes pain in the waist and back of workers. Additionally, the repetitive combination of sitting and standing movements when collecting waste for further separation is felt to be slow and inefficient. The solution to this problem is the provision of a sorting table made of stainless steel with a height of 100 cm, which is adjusted to the average height of waste sorting workers at Waste4Change. By using the sorting table method, the work of sorting waste is more effective and healthier for the bodies of the waste sorters.

Keywords: Solid waste, Waste Sorting, Work Posture, Ergonomics

1. Introduction

One of the serious environmental problems faced by the Indonesian people today, which is particularly significant, is the waste problem. There is still a significant amount of improperly disposed waste, which can have detrimental effects on the environment [1]. Indonesia is known for having a high annual waste volume. According to data from Sistem Informasi Pengelolaan Sampah Nasional (SIPSN) under the Ministry of Environment and Forestry of the Republic of Indonesia, the total amount of waste in Indonesia in 2021 was 24.4 million tons [2]. The most effective waste management approach currently employed is waste sorting based on its type, namely organic, inorganic, and residual waste. Each of these types requires different handling and treatment methods [3]. Sorting waste can be a challenging task for workers, as they need to adapt to various aspects of the job, including work processes, equipment, machinery, and the layout of the waste sorting site. This is a crucial factor as a comfortable work environment which can enhance productivity within any organisation [4].

One of the problems that often occurs among workers is work accidents. Several factors contribute to work accidents, including human factors, the work environment, equipment factors, and work methods [5]. Garbage sorting activities require a strong and comfortable working posture. To carry out waste sorting effectively, it is necessary to have a healthy body. Working in postures that contradict the body's natural conditions can cause discomfort and complaints among workers. If this continues, it can lead to physical symptoms [6]. Incorrect working postures combined with non-ergonomic environmental conditions, when sustained over time, can pose risks to the safety and health of workers [7]. In the context of ergonomics, it is essential to minimize or eliminate pain and complaints, such as work-related illnesses which can increase the burden of compensation for companies and reduce worker performance [8].

Other works that are similar to waste sorting are the activities of making 'batik' and breaking stones. According to Setyawati (2000), the fatigue level of 'batik' workers who use non-ergonomic work equipment is higher compared to workers who work with ergonomic work equipment [9]. Similarly, in the case of stone-breaking activities, many experts argue that more frequent but brief rest periods are better than long rest periods that occur infrequently [10].

Ergonomics is a systematic branch of science that utilizes information about human nature, abilities, and limitations in designing work systems so that people can live and work in those systems properly. The goal is to achieve desired outcomes through effective, safe, healthy, comfortable, and efficient work [11]. The term "ergonomics" originates from the Greek language, consisting of two words: "ergos," which means work, and "nomos," which means rule or law. Ergonomics establishes norms and rules within a work system [12]. The application of ergonomics is crucial in various settings, including schools, workplaces, and other locations, to ensure comfort and enhance productivity [13].

Effective waste management requires attention to ergonomic aspects. Ergonomic risks in waste management are closely related to body posture, repetitive movements, and excessive forceful movements [17]. The focus of this research is on the waste sorting method at Waste4Change, a social entrepreneurship that provides solutions to waste problems through behavior change and responsible management, with a mission to foster a responsible attitude towards waste in Indonesian society. Currently, the waste sorting process at Waste4Change's Material Recovery House (Rumah Pemulihan Material) still relies on manual sorting methods, although technological assistance has been introduced. Human operators are responsible for sorting the waste that arrives at the Rumah Pemulihan Material (RPM), and they place the sorted materials into designated containers based on their respective types.

The practice of waste sorting operators/workers sitting on the floor can lead to discomfort or physical complaints, increasing the risk of work-related illnesses [4]. This poses health issues for the workers, including back pain, hemorrhoids, muscle weakness, and other related problems. The objective of this research is to explore the solution implemented by Waste4Change for waste sorting to enhance ergonomics and improve work methods.

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2. Methods

This research used a combination method through literature studies and field studies to investigate the ergonomics in the waste sorting facility of Waste4Change, specifically at the waste sorting level. A literature study was conducted to gain insights into the problem being examined. It involved activities such as collecting library data, reading, note-taking, and analyzing research materials. The outcome of the literature study was a compilation of relevant references that contributed to formulating the research problem [14]. Subsequently, observations or field studies were conducted to identify the problems and various ergonomic risks faced by waste sorting operators at Waste4Change. The aim of this research was to mitigate ergonomic risks [4]. Field studies involve outdoor learning, where observation activities are carried out to uncover factual information and gather direct data from the field. Field studies can provide descriptions, explanations, predictions, innovations, and developments, making them a scientific method that employs an operational design to yield more accurate results [15].

The research involved the following steps:

a. Assessment of the current condition of waste sorting
b. Identification of ergonomic aspects form in Waste4Change waste sorting process as documented in Table 1
c. Documentation from observation in the field.

The collected data was then processed to achieve the following outcomes:

a. Determination of sorting table dimensions
b. Identification of the need for a sorting table

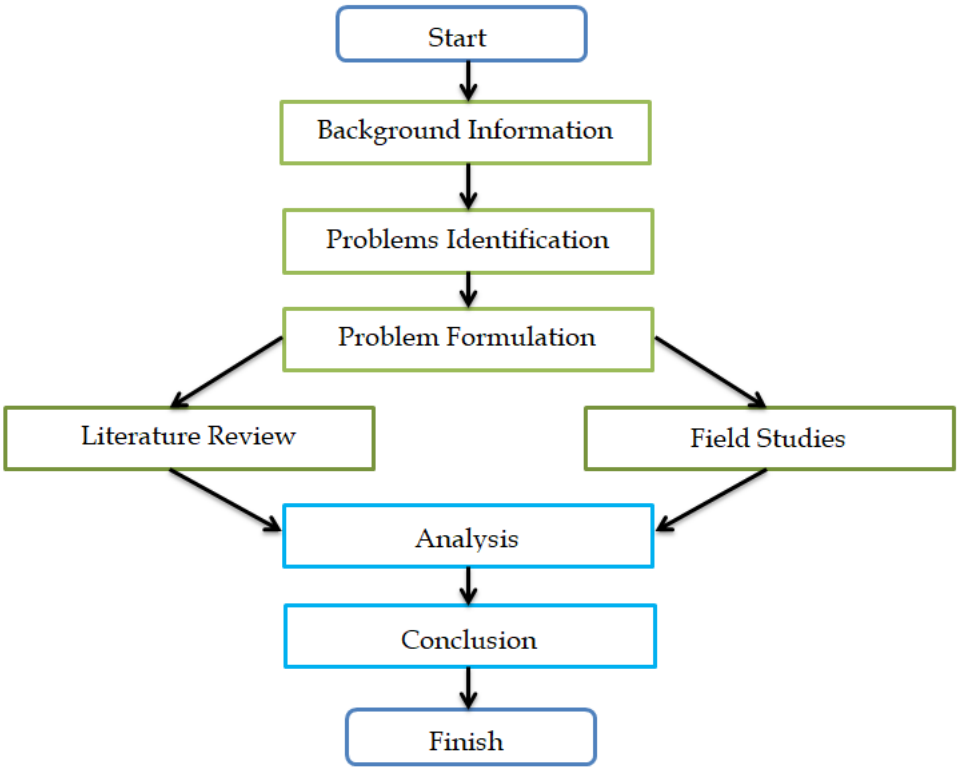
Subsequently, the data was analyzed to redesign the table, ensuring it meets ergonomic requirements and aligns with the average body posture of the operators

Table 1 Form Checklist Ergonomics at Waste4change (Waste4Change, 2023)

No	Description	Available	Not Available
1	Anthropometry		
	1.a Worker height		
2	Variability		
	2.a Age		
	2.b Sex		
	2.c Body position		
	2.d Physical impairment		
No	Description	Available	Not Available
3	Lifting method		
	3.1 squat		
	3.2 stand		
	3.3 turn		
4	Work environment		
	4.1 air circulation		
	4.2 lighting		
	4.3 noise		
	4.4 vibration		
	4.5 smells		
5	Occupational Health and Safety (OHS)		
	5.1 Personal protective equipment		
	5.2 OHS box		
	5.3 Emergency number		

(Source: Author, 2023)

The research commences by providing a background of the problem, which is based on a literature review. Subsequently, the identification of problems and formulation of research objectives are conducted. Through a combination of literature studies and field studies, the research data is analyzed to derive conclusions aligned with the formulated objectives.



Picture 1. Research Flow Chart
(Source: Author, 2023)

3. Result And Discussion

3.1 About Waste4Change dan Waste Sorting Table Solutions

Waste4Change is a social entrepreneurship venture that focuses on responsible waste management. Waste4Change was established in November 2014 under the name PT Wasteforchange Alam Indonesia. Some of the services provided by Waste4Change that are relevant to this research are the Collect and Create services. The Collect service processes the collected waste responsibly and transforms it into recyclable materials. The Create service also processes the collected waste responsibly and converts it into recyclable materials. Both the Collect and Create services involve waste sorting activities. This research focuses on the waste sorting activity conducted at the Rumah Pemulihan Material, which is part of the Collect service, before further processing at the Create service.

The waste transported to the Rumah Pemulihan Material (RPM) still contains mixed items, requiring further sorting. In the early days of Waste4Change, the sorting was conducted while sitting on the floor. However, the sorting operators often experience discomfort in this sitting position, as prolonged sitting in an improper posture can lead to lower back pain and backaches. Additionally, the sorting operators must perform repetitive activities such as squatting and standing to retrieve unsorted waste, resulting in a slow and inefficient sorting process.

As a solution to this problem, Waste4Change conducts analysis and studies from various sources to determine an effective waste sorting method, which involves standing and utilizing a sorting table. Consequently, Waste4Change decided to develop a table-based sorting system. Initially, this sorting table was made from wood/bamboo and wooden planks. However, after further evaluation, it was found that these materials were prone to damage, resulting in a short lifespan for the sorting table. Despite the sorting table method being more effective and promoting healthier body posture for the operators, Waste4Change still implements a work regimen that includes standing for 2 hours followed by a 10–15-minute rest, then another 2 hours of work followed by a 1-hour rest period. Based on the results of the identification of ergonomic aspects in the Waste4Change waste sorting process, it can be seen in the **Table 2**.

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Table 2 Results of the Checklist Ergonomics at Waste4change (Waste4Change, 2023)

No	Description	Available	Not Available
1	Anthropometry		
	1.a Worker height	V	
2	Variability		
	2.a Age	V	
	2.b Sex	V	
	2.c Body position	V	
	2.d Physical impairment	V	
No	Description	Available	Not Available
3	Lifting method		
	3.1 squat	V	
	3.2 stand	V	
	3.3 turn	V	
4	Work environment		
	4.1 air circulation		V
	4.2 lighting		V
	4.3 noise	V	
	4.4 vibration		V
	4.5 smells		V
5	Occupational Health and Safety (OHS)		
	5.1 Personal protective equipment	V	
	5.2 OHS box	V	
	5.3 Emergency number	V	

(Source: Author, 2023)

3.2 The Development of Waste Sorting Table at Waste4Change

The waste sorting method at Waste4Change has undergone continuous development, starting from the initial squatting method to the implementation of the sorting table method. Further improvements were made by evaluating the materials used for the sorting table and exploring plans for future development, including adopting more modern methods with the assistance of technology. Here is a more detailed explanation of the evolution of the waste sorting table at Waste4Change.

1) The wooden sorting table

To alleviate back pain and discomfort caused by squatting while sorting waste, Waste4Change took the initiative to construct a wooden sorting table. The height of the wooden sorting table was determined based on the average height of the operators at Waste4Change. The research findings indicated that the optimal height for the sorting table during waste sorting activities was approximately 4 cm lower than the workers' elbow height [16]. The wooden base or sorting table had dimensions of approximately 120cm x 200cm. The introduction of sorting tables significantly improved the comfort of the operators, resulting in faster and more effective sorting. Complaints related to lower back pain and discomfort also decreased. However, the use of wood as the base material for the sorting table proved to be inefficient due to its susceptibility to weathering, especially considering that the waste being handled is primarily organic waste. The research findings also suggested that the preferred working height for sorting activities was slightly lower than the workers' elbow height, with a difference of approximately 4 cm.

2) Iron sorting table

The innovation in waste sorting using a sorting table has progressed, leading to the replacement of the wooden sorting table with a galvalume iron sorting table. The size of the iron sorting table is designed to accommodate the average height of the operator, following the Indonesian standard for height measurement. The iron material provides a sturdy and durable structure for the sorting table, as well as ease of cleaning (refer to Figure 2). This greatly facilitates the sorting process and post-work cleanup. However, due to the presence of wet organic waste among the collected and sorted waste, the iron table is prone to corrosion (refer to Figure 3). Additionally, the iron table is challenging to move due to its high density.

Figure 2. Iron table
(Source : Waste4Change, 2023)

Figure 3. Sorting with an iron table
(Source : Waste4Change, 2023)

3) Stainless Steel Sorting Table

Taking into account the material's strength and durability, Stainless Steel was chosen to replace the previous table material. The standard sizes used are 110cm x 190cm x 80cm, as shown in Figure 4. By using Stainless Steel, the sorting table has a lightweight structure, making it easy to assemble and move. It is also easier to clean and less prone to rusting. However, during the construction of this table, there were still some weak welding joints identified, requiring periodic maintenance. Despite these drawbacks, a sorting table made of stainless steel is considered the most ideal and effective option compared to tables made of wood or iron. Currently, Waste4Change continues to use stainless steel sorting tables for manual waste sorting operations.

Figure 4. Stainless Steel Table
(Source: Author, 2023)

4) Development of Sorting Method by Conveyor Machine

Currently, Waste4Change is developing more advanced waste sorting technologies, including conveyor machines. Additionally, they are also working on developing 'gibrik' machines, centric machines, chopping machines, and press machines, which will enhance the precision of the waste sorting process. The conveyor machines are utilized in the initial stage of waste sorting, accommodating the height requirements based on the average height of the operators (the average height of Indonesians). If the height of the conveyor machine exceeds the average height of the operators, Waste4Change provides a ladder to bridge the gap between the operators and the conveyor machine. The distance between the operator's arms and the waste moving on the conveyor remains within a suitable range, facilitating an easier, faster, more effective, and efficient sorting process, while also reducing the amount of residual waste that ends up in the Final Processing Site (TPA). However, the use of conveyor machines necessitates regular maintenance efforts due to their high maintenance requirements.

3.3. Benefit of the sorting table

Before using the sorting table, the waste sorting workers at Waste4Change stated that sorting waste while squatting or sitting on a small bench causes the waste to be scattered and difficult to reach because the body cannot move freely. After the sorting table was applied, it became easier for workers to manage waste, and the work was tidier and faster. Ergonomics felt in the worker's body when squatting caused pain in the back, legs, neck, hands, and buttocks. However, aching pain when working using a sorting table is only felt in the legs. Therefore, the leaders of Waste4Change have to take a break after 2 or 2 hours of work to relax the leg muscles that are tense from standing for a long time. The sorting table at Waste4Change helps the effectiveness and efficiency of the work of sorting waste, which in turn adds to the benefits of both the company and the work itself.

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4. Conclusion

Waste sorting activities at Waste4Change still rely on manual methods, but with significant developments over time. These developments include transitioning from the squatting method to the sorting table method and evaluating different materials for the sorting table. More recently, Waste4Change has incorporated modern methods and technology to enhance the waste sorting process. These advancements aim to address the discomfort experienced by workers and reduce the risk of occupational diseases. Waste4Change has discovered that the most effective solution for waste sorting operators is the implementation of a stainless steel sorting table, measuring 110cm x 190cm x 80cm, which is adjusted to the average height of the operators at Waste4Change. This stainless steel sorting table offers several advantages, including its lightweight structure, ease of assembly and mobility, ease of cleaning, and resistance to rust. The utilization of this sorting table has proven to be an effective approach in improving the waste sorting method and enhancing ergonomics in the workplace.

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