


Application of the Analytic Hierarchy Process (AHP) to Select the Disposal Method for Diaper and Other Absorbent Hygiene Products (AHPs) Waste in Zimbabwean Cities: A Public Health Red Flag

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Abstract

The management of soiled diapers and other absorbent hygienic products (AHPs) constitutes a critical and growing public health challenge in Zimbabwean cities. Current disposal practices are predominantly informal and unsanitary, leading to environmental contamination and severe health risks. This study applied the multi-criteria decision-making framework of the Analytical Hierarchy Process (AHP) to systematically evaluate and rank nine waste disposal methods, including: Land filling, Open Space Dumping, Controlled Incineration, Uncontrolled Incineration/Burning, Burying, Composting, Recycling, Anaerobic Digesting, and Toilets/Latrine. The evaluation was based on four weighted criteria: Public health impact, Environmental sustainability, Economic Feasibility, and Social Acceptability, as well as fourteen sub-criteria, as determined by expert stakeholder surveys. Recycling and Anaerobic Digestion were identified as the most optimal disposal methods, achieving the highest global priority scores of 28.7% and 19.7%, respectively. Environmental impact was determined to be the most critical decision criterion with a priority weight of 0.45, significantly outweighing public health impact (0.36), social acceptability (0.14), and economic feasibility (0.05). Burying, latrine disposal, and uncontrolled open space dumping were ranked as the least favorable options due to their high long-term public health and environmental risks. The study concludes that recycling, despite its cost, is the most viable method to immediately mitigate the public health “red flag” posed by AHP waste in the Zimbabwean

urban context. Urgent policy intervention and investment are required to formalize and implement structured, high-temperature waste treatment systems for this hazardous waste stream.

Keywords

Diaper Disposal, Developing World Cities, Public Health, Environmental Impact, Analytical Hierarchy Process (AHP), Absorbent Hygiene Products (AHPs)

1. Introduction

Disposable diapers have become a ubiquitous product in modern society, offering convenience and hygiene benefits. They have brought about much-needed convenience to mothers in taking care of their children, especially when they are traveling. White *et al.* [1] noted that, however, their disposal presents a complex challenge, particularly in developing world cities where waste management infrastructure is often inadequate and levels of technology to aid waste management are generally at their infancy stage. Some recent technologies that can be used for AHPs waste management are documented in Khoo *et al.* [2]. To support this notion, Mudau *et al.* [3] posited that, in developing countries, the use of disposable diapers is steadily increasing, posing a significant challenge in the management of the associated waste since these countries lack the expertise and financial resources that can help in the adoption of state-of-the-art technologies to deal with solid waste. Zhang *et al.* [4] reiterate that, while most Municipal Solid Waste (MSW) and sewage are collected, reused, and recycled in industrialized countries, collection and adequate disposal are not yet a reality for most developing countries, not to mention well-designed municipal treatment facilities. Controlled disposal of diapers and sanitary pads, also known as Absorbent Hygiene Products (AHPs), has over the years proved to be a daunting task for city authorities in Zimbabwe among other developing nations, as these are non-biodegradable, which makes them seen everywhere in public places as shown in Figure 1.



Figure 1. Dumped absorbent hygiene products in Schenck *et al.* [5].

Zimbabwe is one country where diaper waste has become a menace. There is a relatively poor waste collection and disposal system in the country, and in most cases, waste is dumped in any open space available in Manyame [6]. Diapers are among the bulk of waste found at both legal and illegal dumpsites in low-class residential areas. As their consumption continues to increase in developing world regions due to rapid growth in human population and urbanization, the absence of efficiency in their disposal is likely to worsen the resultant public health and environmental challenges. Studies on diaper usage estimation are found in Nell *et al.* [7] and Thomas-Possee *et al.* [8]. The urban population in developing countries is growing at an alarming rate, which is a cause for concern for solid waste management in Voukkali [9]. Materials used to make these indispensable sanitary products are among several factors that make their disposal a difficult task, especially in developing world cities. Generally, a typical disposable diaper consists of wood pulp fluff, sodium polyacrylate (also referred to as SAP or absorbent gel), polyolefin nonwoven fabric, adhesives, polyolefin film, and synthetic rubber elastic strands, as described in Ntekpe *et al.* [10]. Studies on the AHPs materials are found in Khanyile *et al.* [11], Mirabella *et al.* [12], Tariq *et al.* [13], and Bachra *et al.* [14]. Among those materials used in making baby diapers, polypropylene plastic from petroleum, as noted in Siregar [15], has been cited by different authorities as the most difficult to dispose of, given that it is non-biodegradable. Disposal of diapers as well as other sanitary materials, is associated with quite a number of methods, as highlighted in the literature. Some of the methods commonly used in developing world cities to dispose of this kind of waste include uncontrolled incineration, burying in Schenck *et al.* [5], illegal open space dumping, throwing in toilets as in Schenck *et al.* [5] and White *et al.* [1], and landfilling, but more sophisticated and technologically based ones like recycling in Khoo *et al.* [2] and Itsubo *et al.* [16], and controlled incineration, are less common. This can be supported by findings from a related study by Mudau *et al.* [3], which states that there are various methods used by communities to dispose of waste in the category of Absorbent Hygiene Products (AHP), which include burning as in Schenck *et al.* [5], composting in Mutowo & Mzengi [17], Espinosa-Valdemar *et al.* [18] [19], and Colón *et al.* [20], recycling in Shah *et al.* [21], or reusing and illegal dumping of waste in undesignated areas. There are various methods used by communities to dispose of waste which include burning, burying, composting, recycling or reusing, and illegal dumping in Nyamayedenga & Tsvere [22] of waste in undesignated areas. Improper disposal of diapers together with other sanitary materials has serious environmental and public health issues, including the spread of infectious diseases, contamination of water sources, and air pollution. Studies on the environmental and health impact of AHPs are found in Ntekpe *et al.* [10], Makoś-Chelstowska *et al.* [23], White *et al.* [1], Płotka-Wasyłka *et al.* [24], Cordella *et al.* [25], Reese *et al.* [26], Mendoza *et al.* [27], and Weisbrod & Van Hoof [28]. Literature has well documented that landfilling, a commonly used waste disposal method in developing world cities, emits the most greenhouse gas (GHG) com-

pared to anaerobic digestion, thus contributing to the greenhouse effect and global warming, as noted in Zhang *et al.* [4]. Other authorities have established that diapers themselves have some health implications for babies. Thus, according to Jamwal *et al.* [29], diapers lead to the risk of diaper dermatitis, also called diaper rash, mostly affecting body parts in contact with it, such as buttocks, lower abdomen, genitalia, and upper thighs. City authorities in developing world cities blame improper disposal of diapers along natural waterways and storm drains as one of the main contributing factors toward poor drainage, which increases the chances of flooding, as these would have blocked the drainage system. Incorrect disposal of litter such as diapers, plastics, and sanitary pads clogs Harare's drainage system, particularly in the Central Business District (CBD), as noted in Manyame [6]. Furthermore, Hoang and Fogarassy [30] highlighted that inadequate municipal solid waste management (MSWM) has given rise to a range of unexpected consequences, including the contamination of oceans and drains, the occurrence of floods, and the transmission of infections through the breeding of vectors. In this vein, it can be noted that improper dumping of diapers together with other wastes in the same category is a key driver of some of the disaster risks facing the urban poor, mainly including slum dwellers and low-income residents, given their location in disaster-sensitive areas, inclusive of water channels, river banks, among others, as well as their marginalization by policing and service provision. Supporting this notion, Mlilo *et al.* [31] noted that refuse collection in Bulawayo, in general, and Cowdray Park suburb, in particular, has been unreliable; and these areas could go for months without municipality waste management services. Arriving at an optimal method of disposing of wastes such as diapers by Local Governments (LGs) running developing world cities is associated with complexity. There are several stakeholders who must be involved, and there are socioeconomic and also environmental factors to be taken into account. Put in other terms, the optimal disposal method should embrace all the elements of sustainability, thereby contributing toward achieving sustainable urban development in developing states, given their rapid urbanization. Through this optimal method, authorities must see to it that disaster risk reduction goals are met, considering that improper disposal of wastes is a key driver of some biological and hydrological disaster risks that have proven to be perennial in most third world cities, such as epidemics and flash floods due to blocked drainage systems. To address this issue, a comprehensive and sustainable approach is required to manage diaper waste. This study aims to develop an MCDM framework to identify the optimal diaper disposal method considering multiple criteria, including environmental impact, economic feasibility, social acceptability, and public health implications. Although there is rich literature regarding garbage disposal in developing world cities, there is still a grey area to be filled. Works involving the application of MCDM in informing better decision-making on the best garbage disposal methods are limited. This study is therefore aimed at contributing toward covering this gap while improving waste disposal, especially of non-biodegradable items such as AHPs, together with re-

lated policymaking under increasing waste generation associated with rapid urbanization in developing world cities.

2. Methodology

In this study, the methodology included gathering data associated with the disposal of diapers and sanitary pads in the developing world city of Bulawayo in Zimbabwe. There was triangulation of data collection tools, including questionnaire surveys for the AHP method, interviews and conversations, and a review of available literature. Site visits to locations including dumpsites and facilities, regulatory agencies such as the Bulawayo City Council (BCC), Environmental Management Agency officials (EMA), non-governmental organizations (NGOs), environmental pressure groups, and academics were made to support and supplement information gathered by the surveys. Interviews and conversations with health practitioners, environmental regulatory agencies, recycling industry experts, and PRO committees were conducted to obtain details of recent progress and development associated with AHPs management. These experts were selected purposively and conveniently. Available literature was also obtained and examined to compare AHPs waste management in Zimbabwean cities with that in other developing world cities and regions.

Analytical Hierarchy Process (AHP) Method

This study used the AHP to establish a model for selecting the most optimal disposal method for AHPs for local governments running developing world cities in the interest of protecting public health, disaster risk reduction, and sustainable urban development under the pressures of rapid urbanization. When the decision-making process is complex, the AHP method can be applied to rank available alternatives given some complex ranking criteria (Tawanda *et al.* [32]). The AHP method makes use of expert input from questionnaires, interviews, or any other way relevant input from experts can be collected in Saaty [33]. Weights of criteria, sub-criteria, and alternatives are computed using pairwise comparison matrices. The eigenvalue method (Saaty, 1996) has been widely used to evaluate weights in the AHP computations. Some AHP method equations are given by Equations (1), (2), and (3).

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

$$\omega_i = \sum (\omega_j) (\mu_j^i) \quad (3)$$

where in the maximum eigenvalue is given by λ_{\max} . CI is the consistency index, CR is the consistency ratio, and RI is the random index and this value is determined by (n) the number of alternatives. According to Saaty [33], the CR is considered to be consistent when ($CR \leq 0.1$); otherwise, the pairwise comparison is

not consistent and as a result the comparison computations or expert judgements have to be revisited. The overall alternative weights used for final ranking are given by ω_i where ω_j and μ_j^i are the relative weight and weight of the alternative respectively.

Several Absorbent Hygiene Products (AHPs) disposal methods were noted in the literature; these methods were classified as included or excluded in the research based on their applicability in developing world cities, considering factors such as the technology required, capital and disposal method maintenance costs, among others. **Table 1** summarises the disposal alternatives used in the AHP method hierarchy.

Table 1. Description of experts.

| Categories of experts | Background | Number of experts involved | Contribution(s) |
|---------------------------------|--|----------------------------|--|
| Bulawayo City Council officials | Responsible for waste collection, disposal, and management | 4 | <ul style="list-style-type: none"> - Defining disposal alternatives - Relevant criteria establishment - Technical feasibility and economic viability of alternatives - Stakeholder engagement facilitation |
| EMA officials | Extensive knowledge of waste management systems, regulations, and local waste streams | 2 | <ul style="list-style-type: none"> - Selection of the best disposal methods - Scientific expertise on environmental impacts - Regulatory frameworks |
| NGOs officials | Field experience, community knowledge, understanding of local waste challenges, and expertise in sustainability and sanitation | 3 | <ul style="list-style-type: none"> - Selection of optimal disposal methods - Defining decision criteria |
| Environmental pressure groups | Specialised knowledge of AHPs' environmental impacts, and experience in waste monitoring and management issues | 2 | <ul style="list-style-type: none"> - Establishment of alternatives - Informing pairwise comparisons |
| Academics | Has expertise in environmental science, engineering, and life-cycle assessment | 4 | <ul style="list-style-type: none"> - Criteria establishment, disposal methods selection, and expert elicitation to assign weights to criteria |
| Health practitioners | Vast knowledge of biohazards, disease transmission, and safe waste management practices | 3 | <ul style="list-style-type: none"> - Judgments on criteria, assessing different disposal options, qualitative and quantitative weighting for criteria |
| Industrial experts | Vast hands-on experience in waste management infrastructure, regulatory frameworks, technological advancements, and the practicalities of implementation | 2 | <ul style="list-style-type: none"> - Criteria defining, evaluating disposal options, judgments for pairwise comparisons, input to sensitivity analysis |

The disposal methods were ranked based on several criteria not limited to environmental, economic, and public health factors. The impact of the ranking criteria was evaluated using a criterion-based sensitivity analysis.

3. Results

This section shows results from analyzed expert judgments and household opinions collected through surveys and interviews. The data covered diaper disposal methods, criteria, and sub-criteria used for the Analytical Hierarchical Process. The main goal was to determine the optimal method that can be used for diaper disposal by developing world cities.

Figure 2 shows the relative importance of criteria and sub-criteria used to determine the optimal disposal method local governments can prioritize in the long run. On the first level criteria, Environmental impact had the greatest relative importance (0.446) whilst on the second level criteria, Air-borne diseases had the highest relative importance followed by water pollution with (25.8% and 23.2%) respectively.

| Decision Hierarchy | | | | |
|----------------------------------|----------------------------------|----------------------------------|-------------|-----------|
| Level 0 | Level 1 | Level 2 | | Glb Prio. |
| Diaper Disposal Method Selection | Environmental Impact 0.44 | Green House Gas Emission | 0.09 | 4.4% |
| | | Air Pollution | 0.08 | 3.8% |
| | | Water Pollution | 0.52 | 23.2% |
| | | Soil Contamination | 0.25 | 11.5% |
| | | Land Filling Requirement | 0.03 | 1.7% |
| | Economic Feasibility 0.04 | Cost | 0.72 | 3.4% |
| | | Potential for Resource Recovery | 0.20 | 0.9% |
| | | Job Creation | 0.07 | 0.3% |
| | Social Acceptability 0.14 | Public Perception and Acceptance | 0.26 | 3.7% |
| | | Community Engagement | 0.32 | 4.7% |
| | | Ethical Considerations | 0.41 | 5.9% |
| | Public Health Impact 0.36 | Infectious Diseases | 0.06 | 2.2% |
| | | Vector-borne Diseases | 0.23 | 8.4% |
| | | Air-borne Diseases | 0.70 | 25.8% |
| | | | | |

Figure 2. Hierarchy showing the relative importance of criteria and sub-criteria.

Recycling was found to be the best diaper disposal method (28.7%), followed by anaerobic digestion (19.7%). The commonly utilized disposal method, that is, uncontrolled open space dumping, was ranked the least (2.7%), falling in the same category as other highly practiced methods, including latrine disposal (3.8%) and burying (4.6%), among others, as shown in **Figure 3**.

| Cat | | Priority | Rank |
|-----|---------------------------------|----------|------|
| 1 | Land filling | 8.6% | 5 |
| 2 | Uncontrolled Open Space Dumping | 2.7% | 9 |
| 3 | Controlled Incineration | 13.5% | 3 |
| 4 | Uncontrolled Incineration | 5.2% | 6 |
| 5 | Composting | 13.3% | 4 |
| 6 | Recycling | 28.7% | 1 |
| 7 | Anaerobic Digestion | 19.7% | 2 |
| 8 | Latrine Disposal | 3.8% | 8 |
| 9 | Burying | 4.6% | 7 |

Figure 3. Disposal methods ranking.

Sensitivity Analysis

Sensitivity analysis was conducted to enhance the multi-criteria decision-making process in line with the disposal of diapers in developing world cities.

According to AHP analysis, the sensitivity interval is known as the tolerance interval or acceptable range, which depicts the robustness of the ranking. In this context, the top-ranked alternative with the interval (28.7% – 2.9%, 28.7% + 2.6%) is considered robust as given in Figure 4.

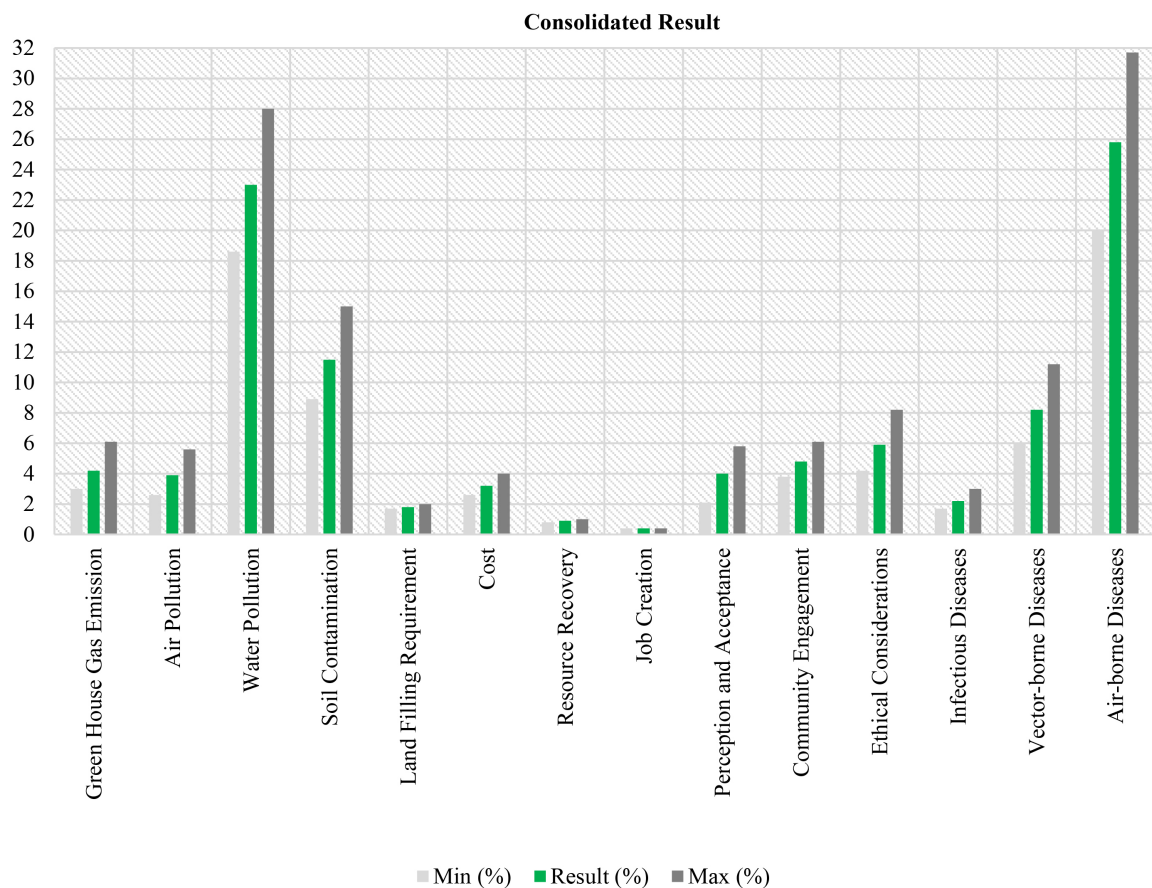
| Participant | Land Filling | Uncontrolled Open Space Dumping | Controlled Incineration | Uncontrolled Incineration | Composting | Recycling | Anaerobic Digestion | Latrine Disposal | Burying | CR_max |
|--------------|--------------|---------------------------------|-------------------------|---------------------------|------------|-----------|---------------------|------------------|---------|--------|
| Group result | 8.6% | 2.7% | 13.5% | 5.2% | 13.3% | 28.7% | 19.7% | 3.8% | 4.6% | 9.7% |
| (+) | 1.3% | 0.4% | 1.8% | 0.7% | 2.0% | 2.6% | 2.5% | 0.6% | 0.7% | n/a |
| (-) | 1.2% | 0.4% | 1.6% | 0.6% | 1.7% | 2.9% | 2.4% | 0.5% | 0.7% | n/a |

Figure 4. Alternative sensitivity intervals.

Two of the fourteen sub-criteria (Table 2 and Figure 5) are robust, thus, job creation and resource recovery with acceptance ranges (0.3% ± 0.1%) and (0.9% – 0.2%, 0.9% + 0.3%) respectively. The remaining sub-criterion had overlapping tolerance intervals, implying that a slight change in input data will cause a major or minor change in the rankings of the alternatives.

Table 2. Absorbent Hygiene Products (AHPs) disposal methods.

| Disposal method | Source(s) | Included | Justification |
|-----------------------------------|--|----------|-----------------------------------|
| Land filling | Schenck <i>et al.</i> [5] and Khoo <i>et al.</i> [2] | Yes | Common in developing cities (CDC) |
| Open Space Dumping | Nyamayedenga and Tsvere [22], Schenck <i>et al.</i> [5], Ntekpe <i>et al.</i> [10] | Yes | CDC |
| Controlled Incineration | Khoo <i>et al.</i> [2] | Yes | CDC |
| Uncontrolled Incineration/Burning | Schenck <i>et al.</i> [5], White <i>et al.</i> [1], and Ntekpe <i>et al.</i> [10] | Yes | CDC |
| Burying | Schenck <i>et al.</i> [5], White <i>et al.</i> [1], and Ntekpe <i>et al.</i> [10] | Yes | CDC |
| Composting | Colón <i>et al.</i> [20], Mutowo and Mzengi [17], White <i>et al.</i> [1] | Yes | CDC |
| Recycling | Mutowo & Mzengi [17], Khoo <i>et al.</i> [2] | Yes | CDC |
| Anaerobic Digesting | Shah <i>et al.</i> [21], Mutowo & Mzengi [17] | Yes | CDC |
| Toilets/Latrine | Schenck <i>et al.</i> [5] and White <i>et al.</i> [1] | Yes | CDC |
| Dark fermentation | Shah <i>et al.</i> [21] | No | Limited research and application |
| Pyrolysis | Shah <i>et al.</i> [21] | No | Very costly |

**Figure 5.** Plots the sub-criteria sensitivity intervals.

The percentage-any critical criterion is Air-borne diseases; a change from 25.8% by absolute (-4.1%) will change the ranking between alternatives Controlled Incineration and Composting. The percentage-any critical performance measure is for alternative Composting under the criterion Water Pollution. A change from 19.2% by absolute 1.1% will change the ranking between Composting and Controlled Incineration (see **Table 3** and **Figure 6**).

Table 3. Sub-criteria sensitivity intervals.

| Sub-Criteria | Group Result (%) | (+ %) | (- %) |
|---------------------------------|------------------|-------|-------|
| Greenhouse Gas Emissions | 4.4 | 1.5 | 1.3 |
| Air Pollution | 3.8 | 1.5 | 1.2 |
| Water Pollution | 23.2 | 4.9 | 4.6 |
| Soil Contamination | 11.5 | 3.3 | 2.8 |
| Land Filling Requirements | 1.7 | 0.5 | 0.4 |
| Cost | 3.4 | 0.5 | 0.5 |
| Potential for Resource Recovery | 0.9 | 0.3 | 0.2 |
| Job Creation | 0.3 | 0.1 | 0.1 |
| Perception and Acceptance | 3.7 | 1.9 | 1.3 |
| Community Engagement | 4.7 | 2.5 | 1.8 |
| Ethical Considerations | 5.9 | 2.4 | 1.9 |
| Infectious Diseases | 2.2 | 0.7 | 0.6 |
| Vector-borne Diseases | 8.4 | 2.7 | 2.2 |
| Air-borne Diseases | 25.8 | 5.9 | 5.6 |

| Details | | Criterion: Air-borne Diseases - CR: 7% | | | | |
|--------------------------------|---------------------------------|--|------|------|------|--|
| Consolidated Priorities | | | | | | |
| Consistency Ratio CR: 7.0% | | | | | | |
| Cat | | Priority | Rank | (+) | (-) | |
| 1 | Land filling | 7.4% | 4 | 1.2% | 1.2% | |
| 2 | Uncontrolled Open Space Dumping | 2.4% | 8 | 0.5% | 0.3% | |
| 3 | Controlled Incineration | 13.1% | 3 | 1.3% | 1.3% | |
| 4 | Uncontrolled Incineration | 2.2% | 9 | 0.4% | 0.3% | |
| 5 | Composting | 7.2% | 5 | 1.0% | 0.7% | |
| 6 | Recycling | 35.9% | 1 | 2.2% | 2.8% | |
| 7 | Anaerobic Digestion | 24.0% | 2 | 2.5% | 2.1% | |
| 8 | Latrine Disposal | 3.0% | 7 | 0.5% | 0.5% | |
| 9 | Burying | 4.9% | 6 | 1.0% | 0.8% | |

| Details | | Criterion: Water Pollution - CR: 9.2% | | | | |
|--------------------------------|---------------------------------|---------------------------------------|------|------|------|--|
| Consolidated Priorities | | | | | | |
| Consistency Ratio CR: 9.2% | | | | | | |
| Cat | | Priority | Rank | (+) | (-) | |
| 1 | Land filling | 5.8% | 5 | 0.7% | 0.6% | |
| 2 | Uncontrolled Open Space Dumping | 1.5% | 9 | 0.1% | 0.1% | |
| 3 | Controlled Incineration | 15.3% | 4 | 1.8% | 1.4% | |
| 4 | Uncontrolled Incineration | 2.1% | 7 | 0.2% | 0.2% | |
| 5 | Composting | 19.2% | 3 | 2.4% | 2.1% | |
| 6 | Recycling | 25.0% | 1 | 3.2% | 3.2% | |
| 7 | Anaerobic Digestion | 24.5% | 2 | 3.1% | 3.3% | |
| 8 | Latrine Disposal | 2.1% | 8 | 0.3% | 0.3% | |
| 9 | Burying | 4.6% | 6 | 0.4% | 0.5% | |

Figure 6. Ranking of alternatives under the first and second influential sub-criteria.

4. Implications of the Findings

4.1. Implications for Local Governments and Policymakers

There are a multitude of positive implications for city authorities and policy makers associated with the study findings. To begin with, there is a need for consistency in waste collection; that is, the city authorities must strictly adhere to the garbage collection schedule. This will ensure that households do not develop their own unsustainable and environmentally unfriendly disposal methods (such as uncontrolled open space dumping, among others), posing a serious threat to public health. Secondly, garbage collection frequency must be guaranteed to prevent massive accumulation of waste within households' territories, which is one of the major factors behind the mushrooming of dumpsites everywhere, especially in low-class residential areas. Thirdly, public consultations in their operations are critical as they ensure active participation within the urban garbage collection and management cycle. Fourthly, city authorities should develop a system in which the frequency and quantity of waste collected per household are taken into account to ease the identification of those households who are most likely to be involved in home-based methods such as latrine dumping, uncontrolled incineration, and burying. Lastly but not least, local governments' (LVGs) garbage collection and management operations in developing world cities should undergo a paradigm shift. This paradigm shift involves fully embracing technologically based waste disposal methods (recycling, anaerobic digestion, among others), which the study considers as the best options.

4.2. Implications for the General Public (Urban Households)

Urban households should cooperate by ensuring that their garbage is at the right collection point on time to ease the collection task by local authorities as well as minimize garbage accumulation. In the same vein, they should desist from putting waste management into their own hands, which is one of the causal factors behind the sprouting of environmentally unfriendly garbage disposal methods such as those cited above.

4.3. Implications for Diaper Manufacturers and Academics

There is a need for collaboration between diaper manufacturers and the academic world in the design of diapers, especially the materials that should be used. Materials that bring convenience to both users and the waste management sector should be prioritized. Manufacturers should fund research aimed at developing user-friendly AHPs materials.

4.4. Implications for Health Practitioners

There is a need for health practitioners to guide the public, especially mothers, on the need for proper AHPs disposal since their careless dumping has serious public health-related consequences.

5. Discussion

This study used an MCDM approach, specifically the Analytic Hierarchy Process, to evaluate and select the most appropriate solid waste in the form of Absorbent Hygienic Products, focusing on disposal strategies for Zimbabwean cities.

Emphasis by experts on health and environmental factors at the expense of economic feasibility in the context of a developing world city, where issues to do with costs form a major barrier, is possibly a consequence of serious risks that are associated with improper disposal of these non-biodegradable wastes, emphasizing the dire need for responsible waste management practices. This underscores the need to minimize pollution, enhance waste management, and promote waste reuse for effective community-based diaper waste collection. Thus, environmental pollution from some current AHPs disposal methods has hazardous short-term and long-term effects on the life and health of citizens; hence, the criterion on health and environmental factors has more importance than the economic criterion. While economic feasibility ranked lower, it remains an important criterion in selecting the most sustainable solid waste disposal method, especially in developing nations with fragile economies.

Comparatively, our findings resonate with those from similar studies in South Africa, Kenya, Nigeria, and Pakistan, as reported by Slekiene *et al.* [34], Maluni [35], Ntekpe *et al.* [10], and Mujaba *et al.* [36], among others. Recycling was suggested to be the best diaper disposal method in the majority of studies on non-biodegradable waste disposal, such as AHPs, which are the focus of this study. These findings point to Environmental Impact as the most crucial factor in determining the best action for municipal solid waste management in Zimbabwean cities, particularly Bulawayo, and they can inform policy development and help guide future research on sustainable waste management practices in rapidly urbanizing developing world cities across the global village.

6. Limitations of the Study

The study's participants, who are experts from different fields related to the subject under investigation, were chosen through purposive sampling, focusing on the city of Bulawayo. Consequently, the insights obtained are closely linked to this city, limiting the generalizability of our conclusions across different regions or other socio-economic contexts. Furthermore, the assessment is based on current conditions and may not account for future changes in waste generation or technological advancements in waste management. This sampling approach, while beneficial for in-depth, context-specific understanding, may not reflect the full spectrum of experiences and behaviours present in varied settings. The study only utilized a single multi-criteria decision-making tool, the Analytical Hierarchical Process, to select the best disposal method for absorbent hygienic products (AHPs) in the developing world city of Bulawayo in Zimbabwe. Although the tool is versatile, the decision-making process could be enhanced by considering a hy-

brid multi-criteria approach where the technique can be combined with others such as TOPSIS, GIS, among others.

Future research should consider expanding the geographic scope of the study to include a wider range of urban settings, stakeholders, and communities, utilizing random sampling methods where feasible to enhance the representativeness of the findings. Also, the use of hybrid methods such as AHP-DEA applied to solve logistics problems in Sibanda *et al.* [37] and AHP-TOPSIS-SWARA applied in landfill selection by Mvembe *et al.* [38] should be considered.

7. Conclusion

The study aimed to determine the best waste disposal method for diapers among other AHPs for developing world cities, given the high fertility rates and rapid urbanization they are facing. The Analytical Hierarchical Process was used to rank the possible disposal methods (alternatives), among which recycling and anaerobic digestion were found to be the best and second best, respectively. Sensitivity analysis proved recycling to be the most robust disposal method. The study highlighted several implications for different relevant stakeholders.

Institutional Review Board Statement

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Informed Consent Statement

Not applicable.

Data Availability Statement

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Authorship Contribution Statement

All authors contributed equally.

Conflicts of Interest

The authors declare no conflict of interest.

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