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DISASTER WASTE CHALLENGES AND MANAGEMENT DURING AND POST FLOOD

Siti Salmiah Awang[a], Hasliza Abu Hassan[b*], Wan Farizatul Shima Wan Ahmad Fakuradzi[c]

[a] Institute of Aviation Medicine, Royal Malaysian AirForce, Subang Air Base, 40000, Shah Alam, Selangor, Malaysia
[b] Department of Clinical, Faculty of Medicine and Defence Health, National Defence University of Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia
[c] Department of Pre-Clinical, Faculty of Medicine and Defence Health, National Defence University of Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia

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ABSTRACT

Flood disaster potentially increases the infectious disease incidence rate from waterborne, vector-born, and zoonotic diseases due to a shortage of clean water, sanitation, and poor waste management. The occurrence of floods during the COVID-19 pandemic added an unprecedented layer of complexity to waste management in disaster-affected regions, as the pandemic already generated large amounts of medical waste. Therefore, any mismanagement of disaster waste can affect the response and long-term recovery in the affected area, resulting in severe environmental contamination and preventing the practice to reuse, recycle, or recovery in the waste stream. This article aims to understand the public health concerns, environmental impacts, and challenges associated with managing Malaysia's waste disposal in the context of the COVID-19 pandemic.

1.0 INTRODUCTION

The year 2021 witnessed a confluence of crises, as nations grappled not only with the far-reaching impact of the COVID-19 pandemic but also natural disasters, particularly devastating floods. According to National Security Council data, Pahang state recorded the highest number of flood victims in 2021, leading to the opening of numerous relief centres with strict protocols [1]. Floods often cause surface and groundwater contamination due to damages to sewage systems, in addition to environmental pollution due to waste management issues [2]. These impacts often pose ecological hazards, which can lead to a reduction in overall quality of life, as well as increases in casualties, morbidity and even premature death. While the COVID-19 pandemic was happening, the floods in 2021 resulted in the accumulation of additional wastes from food containers, water bottles, and personal protective items such as face masks, adding to the wastes already accumulated due to the flood. During the clean-up process, waste was a major problem for the local authorities and communities.

Moreover, powerful floodwater currents caused massive destruction to infrastructure, buildings, and crops. Deforestation practices elevated runoff volume, consequently triggering landslides, and mudslides because of the absence of natural vegetation that typically serves as a natural stabilizer for the soil structure. This erosion issue further compounded the problem by increasing sedimentation, leading to higher flood peaks, and inflicting greater damage to buildings and other structures. The flood generated a diverse range of wastes, encompassing concrete and demolition (C&D) debris, organic and food waste, materials suitable for recycling, electrical waste, and hazardous waste [2-3]. The composition of food waste posed additional challenges to waste reuse and recycling activities. In summary, the 2021 floods had extensive environment and public health impacts, exacerbating existing waste management challenges and limitations during the pandemic. Adopting efficient waste management strategies and disaster risk reduction measures is crucial to mitigating the effects of future floods and protecting affected communities.

*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my

The escalating waste and debris from the destruction of houses during floods can partly be attributed to unsustainable construction practices. This accumulation compounds preexisting issue of river and drainage blockages, worsening the floods' impact on the affected areas. Municipal councils play a pivotal role in managing flood-generated waste through collection and handling. Typically, collected waste is transported to transfer stations before final disposal in sanitary landfills. This process prevents further environmental contamination and health risks arising from improper disposal. Municipal councils must tackle the root causes of waste generation and promote sustainable practices like waste reduction, recycling, and eco-friendly construction to reduce flood impacts and ease the strain on waste management systems during disasters.

In Pahang, there is a noticeable absence of essential facilities such as Material Recovery Facilities (MRF) and Thermal Treatment Plants (TTP), as outlined in the 2002 "National Strategic Plan." Typically, the local population manages waste by depositing it at designated garbage collection sites within their respective villages, with a service provider responsible for collection. Alternative methods include burying trash in pits or disposing of waste along riverbanks. Local communities do not actively engage in source separation or recycling (reduce, reuse, and recycle) of domestic waste. Residential housing areas receive scheduled solid waste collection services through the service provider. During the 2021 flood, the District Council's waste management system experienced a breakdown, and the flood led to resident evacuation to relief centres [4]. A survey conducted by the Institute of Medical Research at flood evacuation centres in Gua Musang and Kuala Krai revealed inadequate waste handling during the Kelantan flood, impacting residents' health [5]. Another study by Mohd Radi et al. documented a rise in leptospirosis cases, attributed to increased interactions between humans and rodents in areas with significant garbage accumulation after the 2014 flood [6]. To address these issues, future strategies should prioritize prevention by improving the resilience and preparedness of states, local district councils, and communities in solid waste management, especially post-flood. Challenges include implementing swift measures to remove accumulated waste after floods, managing waste effectively at evacuation and relief centres, developing district councils' capacity and funding to adopt innovative waste management concepts, investing in technology to enhance practices, and strengthening capacity building while fostering community resilience in waste management [7].

This review explored the impacts of floods on waste management challenges, their effects on public health and environment, while also examining the roles of agencies and the importance of community awareness in Malaysia. Research articles published between 2015 and 2024 were retrieved from databases such as Web of Science, SCOPUS, Google Scholar, and PubMed using keywords like "disaster waste management," "flood ," "challenges", "public health" and "Malaysia." The review emphasizes the need for comprehensive strategies to address critical waste management challenges during and after floods, aiming to enhance flood risk management, mitigate health risks, and build community resilience.

2.0 PUBLIC HEALTH AND WASTE MANAGEMENT DURING AND POST FLOOD

In the early aftermath of a disaster, such as a flood, dealing with waste disposal and accumulation challenges should be one of the immediate priorities. [It is crucial to have effective communication and coordination among various government agencies and organizations to ensure a well-organized response. This involves cooperation between federal, state, and local authorities, as well as the engagement of non-governmental organizations (NGOs) that can contribute to waste disposal and management activities. At the federal level, key agencies such as the National Security Council, Malaysia Armed Forces, Civil Defence, Fire and Rescue Department, and Department of Environment play a pivotal role in aiding and support during the disaster [8]. More localised actors including the State Secretary office, District Offices, Local District Councils, and local agencies, actively participate in the response efforts. It may also be necessary to involve private entities and neighbouring states, as disasters can have widespread impacts that require regional cooperation.] NGOs, such as Tzu Chi, can significantly contribute to providing additional assistance for waste disposal and management during the flood crisis, as observed in previous experiences [9].

To effectively handle flood waste, it's crucial to identify waste types and amounts before, during, and after the event*. Good logistical planning, including organizing lorries and water suppliers, and choosing suitable cleanup locations, is essential for efficient removal and disposal. Clear communication among agencies prevents duplicate efforts and enables the implementation of a standardized operating procedure. Post-event reviews identify areas for improvement, such as allocating infrastructure, improving logistics, and providing waste management training for relevant agencies and local district councils to better prepare for future disasters [10]. To reduce the spread of diseases like leptospirosis and other waterborne illnesses,

*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my

key measures include water chlorination, developing appropriate vaccines, promoting good hygiene practices, and conducting educational campaigns for individuals in flood-prone areas. Collaboration between the District Health Office and local municipal councils is crucial in engaging the public in hygiene awareness and promoting proper waste management practices. Leptospirosis is prevalent in Malaysia due to its humid and moist environment, abundant forest resources, and inadequate waste disposal practices [6, 11]. Raising awareness about the disease's sources and transmission modes, including the use of protective clothing during cleanup and rescue operations, can minimize infection risk. Improved rapid test kits at primary healthcare centres can reduce mortality rates by enabling early treatment after exposure to the infection [12].

Geographic Information System (GIS) is also a valuable tool for monitoring communicable diseases, as it visualizes and analyses epidemiological data. [12]. Spatial mapping of disease hotspots and clustering analysis for leptospirosis outbreaks enhance the visualization of areas requiring increased attention in environmental health management and services following flooding [12]. This approach reinforces preparedness for future events, facilitates the implementation of public health measures in flood-affected areas, improves waste management and hygiene practices at relocation centres, and educates the public about necessary safety measures [13].

A temporary storage site (TSS) is a crucial temporary area for managing waste and damaged materials during disasters [14]. It should be located close to the disaster areas but away from residential, infrastructure, business, rivers, canals, ponds, lakes, or drainage systems to prevent environmental contamination and potential health issues. The site selection should adhere to specific principles and guidelines, including categorization based on waste materials, access control, and flooring. The TSS should have designated sections for waste materials like mixed waste, recycled storage, furniture and wood debris, electrical and electronic waste, and hazardous waste. Access should be gated to ensure only authorized personnel and vehicles enter the site, reducing the risk of unauthorized dumping or hazardous materials mishandling. The TSS floor should be equipped with suitable materials to prevent leakage of sludge or liquid-based materials into the ground. Adhering to these principles and guidelines ensures the TSS can efficiently function as a secure and well-structured site for temporary waste storage and management during disaster recovery operations. [15]. Proper segregation and disposal of waste at the TSS minimize environmental consequences and ensure the safety and welfare of the affected community and surrounding areas.

3.0 WASTE MANAGEMENT AT RELIEF AND EVACUATION CENTRES

Evacuation sites like schools, community centres, mosques, and religious centres face challenges in waste management due to the influx of evacuees. There is often no established procedure for collecting and segregating plastic bottles, polystyrene containers, and food waste, which can lead to the transmission of vector-borne and zoonotic diseases [14]. Assessing waste capacity, handling, recycling capabilities, and environmental risks is crucial for effective waste management. Adequate waste disposal areas and Standard Operating Procedures can be implemented to segregate food waste from recyclable items. This minimizes disease transmission and enhances waste management during disasters. Thermal plasma technologies are an efficient means of treating non-hazardous health-care waste and potentially infectious medical waste since they emit fewer harmful pollutants, are lower in size, and are designed to be portable [14]. These technologies can be deployed to treat innocuous waste in disaster situations, evacuation centres, and health facilities. An efficient and effective waste management system may be built by putting these methods and technologies into practice, which will lessen the impact of waste on the environment and public health both during and after flood occurrences.

Flood victims should receive education on waste separation and hygiene practices. Local authorities should implement scheduled waste collection, inspect construction works, approve construction licensing, and regulate solid waste management. They should also oversee the collection and disposal of waste in areas not covered by service providers. By integrating educational initiatives, scheduled waste collection, and proper regulation, local authorities can promote efficient waste management during and after flood events [16]. Studies have shown that self-efficiency, coping strategies, community spirit, and social support increase flood victim's resiliency, allowing them to adapt, survive, and recover from disaster [17]. This proactive approach can reduce the likelihood of health hazards and environmental pollution. In conclusion, incorporating education, waste collection, and proper regulation can help flood victims recover from disasters and reduce health hazards.

*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my

4.0 TRANSDISCIPLINARY APPROACH

The role of identification and engagement of a stakeholder network that includes local and national government and the private sector is vital within flood waste management [17]. The concept of public-private partnership as a multi-level social engagement is seen also as a useful tool to flood resilience and flood management [18]. It consists of in the case of Malaysia, several social, economic and environmental aspects of debris management. There are many participants in each flood management, including the Ministry of Water and Environment (KASA), the Ministry of Health (MOH), the Ministry of Works (KKR), Local Authorities (Regional and local councils), solid waste management contractors and providers of facilities and management – Solid Waste Corp (SWCorp) and Alam Flora, and even NGOs.
There are also protocols to observe on the management of waste materials above, which include a clear plan on what to do with waste materials after a disaster. A good waste management system depends on active stakeholder involvement, the review of laws, policies and regulations, adequate resources, upgrading facilities and equipment and new SOPs (Standard Operating Procedures), especially in any pandemics [19]. Flood management has faced challenges due to lack of cooperation and limited communication of inter-organization. One important barrier to Malaysia's flood management is the disparity in rules and laws among government entities [20].

People in communities actively participate in disaster waste management at all stages: response, recovery, preparedness, and mitigation[21]. Community behavioural interventions are effective in educating the population on specific domains, following strategies that target specific goals. Such communities tend to have efficient garbage management practices and produce lower quantities of waste during disasters due to their preparedness [22-23]. Collaboration with relevant local government institutions is important to solve waste management challenges, particularly in the collection of hazardous substances and flammable waste. Clear guidelines on proper waste sorting are essential, including managing waste from abandoned ships at TSS. Legislative measures should also be established to deter open burning of fields and indiscriminate waste dumping. Educating people on the physical handling of damaged property and encouraging proper disposal practices are crucial to protecting the environment. Heng et al concludes that an integrated framework focusing on smart waste tracking, gamified awareness education, and strict policies is essential for effective waste management in Malaysian cities to become resilient and sustainable [24]. Adopting a Zero Waste approach and efficiently managing disaster-generated waste can alleviate pressure on already strained waste management systems [25]. Local NGOs, such as 'ZERO WASTE MALAYSIA,' can play a vital role in nurturing a recycling culture by offering free educational modules to schoolchildren, partnering with other institutions, engaging in community surveillance activities, and monitoring waste disposal practices. Additionally, offering financial rewards for catching rodents can help control their population and mitigate disease transmission. Strategies such as public education, stakeholder collaboration, and recycling practices enhance community resilience in waste management, contributing to a cleaner, healthier environment.

4.0 CONCLUSION

Effective waste management during and after floods requires both structural and non-structural solutions, especially during pandemics. Evaluations of vulnerability and resilience raise public knowledge of post-disaster rehabilitation efforts and environmental consequences. Technical training, coordination with institutions, educational activities, and community documentation can improve waste management systems. A 3R procedure, including collection, separation, transportation, storage, treatment, recycling, and disposal, is crucial for reducing environmental and health impacts.

5.0 CONFLICT OF INTEREST

The authors declare no conflicts of interest.

6.0 AUTHORS CONTRIBUTION

Awang, S. S. (Methodology; Formal analysis; Data curation; Formal analysis; Investigation; Writing - original draft; Writing - review & editing)
Abu Hassan, H. (Methodology; Formal analysis; Writing - review & editing ; Resources;)

*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my

Wan Ahmad Fakuradzi, W. F. S. (Conceptualisation; Methodology; Software; Funding acquisition; Supervision)

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*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my

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*Corresponding Author | Abu Hassan, H. | hasliza@upnm.edu.my