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Environmental and Health Impacts of Improper Menstrual Waste Disposal: A Data-Driven Survey and Development of Computer Vision-Based Sorting Solutions in Katsina State, Dutsinma Local Government Area

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ABSTRACT

This paper presents a survey on the improper disposal of menstrual waste. Improper menstrual waste disposal practices, such as throwing away sanitary pads, can have a devastating effect on the environment. Sanitary pads often contain non-biodegradable materials, including dioxins and furans. These materials can pollute the ecosystem and remain in the environment for centuries (500-800 years). This study investigates the attitudes and practices regarding menstrual waste disposal in our community through a survey approach. Both health personnel and non-health personnel were surveyed using a set of questions. this aim is to identify common disposal methods, assess knowledge gaps on safe disposal, and explore their views on health and environmental impacts. By comparing the perspectives of health personnel, who have a stronger understanding of hygiene practices, we aim to gain a comprehensive understanding of the issue provide valuable insight into the scope of the problem, and inform the decision to effectively develop an automated waste sorting system using computer vision models as well as to inform the development of targeted interventions for promoting proper menstrual hygiene management practices. The result of the study shows that most participants understand the importance of proper waste management. However, a lack of public waste disposal facilities hinders responsible practices. The study further emphasizes the need for government and other stakeholders to provide these facilities. finally, the research recommends the development of an automated waste sorting management system in order to reduce health issues, minimizing pollution and limiting exposure to harmful substances, and promote a safer and more sustainable environment.

Keywords: Menstrual waste, Improper disposal, Survey, Public health, Environment, Health personnel, Non-health personnel, Sanitary pads.

1.0 Introduction

Menstrual hygiene management (MHM) plays a essential role in women's physical and mental well-being. Proper MHM practices, including using clean menstrual products and disposing of them correctly, are essential for preventing infection, ensuring participation in daily activities, and promoting dignity and confidence(Elledge et al., 2018). Effective disposal of sanitary napkins remains a challenge for menstruators and requires the development of appropriate practices (Kumar Nepal et al., 2021). However, improper disposal of menstrual waste, particularly disposable products like pads and tampons, presents a significant challenge to environment and public health (Brancoli et al., 2020). When not disposed of properly, these products can contaminate water sources with harmful bacteria and chemicals, increasing the risk of waterborne disease (Siddiqua et al., 2022). Additionally, they can block sanitation systems and take hundreds of years to decompose in landfills, harming wildlife and polluting ecosystems (Longe & Balogun, 2010).

A World Bank study highlights the issue of municipal solid waste (MSW) generation in Africa. The study shows that urban areas currently produce around 0.76 million tons of MSW daily, equivalent to 2.7 million cubic meters. These figures are projected to rise significantly by 2025, reaching an estimated 1.8 million tons or 5.2 million cubic meters of waste per day. In developing countries, collection of waste poses a significant public health threat. This unmanaged waste can lead to the spread of diseases, including deadly waterborne illnesses like cholera and dysentery. (Ukaogo et al., 2020). In Nigeria, the challenge of managing menstrual waste is not an exception where it become a critical issue this is because it ends up in incinerators, landfills, drains, waterways, and rivers and many of these non-biodegradable compounds contaminate ecosystems and remain in the environment for 500 to 800 years (Management et al., 2022). Furthermore, another study by Rita highlights that, burning sanitary products containing plastic which releases dangerous toxic compounds such as dioxin into the environment. The use of dioxin, even at low levels, can occupy the body's fat tissue and it can link to various health problems, including certain cancers such as cervical and ovarian (Parthasarathy et al., 2022). Improper disposal of sanitary pads creates a serious threat: increased sanitary waste and hygiene problems as highlighted by the World Health Organization (WHO). This study addresses the

significant environmental and public health impacts of improper menstrual waste disposal, including landfill waste, microplastic pollution. It aims to make an informed decision in the development of an automated waste sorting system using computer vision models. The findings will promote better menstrual hygiene management and guide policy decisions for improved disposal facilities and education.

2.0 LITERATURE REVIEW

Menstrual hygiene management (MHM) is important for women's health and well-being (Elledge et al., 2018). However, the improper disposal of menstrual waste, especially disposable products, presents a substantial risk to both public health and the environment. (Amasuomo & Baird, 2016).

Polluted environments are known to contribute to the spread of diseases, particularly waterborne illnesses like typhoid and cholera (Zhao et al. 2015). Environmental pollution can also cause non-communicable diseases (NCDs) like cancer asthma, and even birth defects in infants (Pandey et al., 2020). Gyabaah et al. (2024) evaluate the leachate from dumpsites, soil geotechnical properties, and their impact on water quality in Sunyani, Ghana. Using physicochemical analysis, the researchers found that leachate samples were heavily polluted with chlorides, BOD, ammonium ions, and cadmium. The water quality index (WQI) showed varying degrees of pollution, with some groundwater sources being heavily polluted. The geotechnical properties indicated high sand content, which could facilitate contaminant infiltration. The findings highlight the urgent need for dumpsite reclamation and public health education to mitigate environmental and health risks.

Ferreira et al. (2023) investigate groundwater quality around the Olusosun dumpsite in Lagos, Nigeria, analyzing monthly samples from 17 wells and boreholes during 2020. The study reveals significant contamination by heavy metals (e.g., lead, nickel, manganese, iron, chromium) and cations (e.g., calcium, magnesium, potassium), with groundwater quality declining during the wet season. Drinking water standards from the WHO and Nigerian government were frequently exceeded, highlighting the severe impact of the dumpsite on groundwater resources. The study emphasizes the need for remediation strategies to safeguard public health and water resource sustainability in Lagos.

Asomaku (2023) conducted a study to assess the quality of groundwater sourced from nearby abandoned landfills in an industrial city in Nigeria. The research analyzed nine groundwater samples for physicochemical and heavy metal parameters using water pollution indices such as Water Quality Index (WQI Pollution Load Index (PLI), Heavy Metal Evaluation Index (HEI), and Heavy Metal Pollution Index (HPI). Results indicated that while most heavy metals were within WHO limits, Nickel exceeded safe levels. The WQI classified groundwater quality from excellent to good, PLI and HEI indicated no to low pollution, and HPI varied from suitable to unsuitable for drinking. The study highlights the necessity for continuous monitoring and treatment of groundwater in such environments to ensure safety before use.

In their study (Siddiqua et al., 2022), investigated the environmental and health problems linked to landfills. While landfills are a common method for disposing of solid waste, they can contribute to air and water pollution. The study found that landfills emit harmful gases like carbon dioxide (CO2), hydrogen sulfide (H2S), methane (CH4), and nitrogen oxides (NOx). These emissions can pollute the surrounding air and contaminate groundwater. Additionally, the research suggests potential health risks associated with landfills, including respiratory problems and certain cancers, such as lung cancer.

(Parthasarathy et al., 2022), employed a survey distributed via social media to investigate menstrual practices. A total of 445 participants responded. The findings revealed that 40.4% were unaware of menstrual incinerators, while 59.6% were aware but only 17.8% actually used them. The research identified a diverse range of menstrual absorbents used by women, highlighting the role of availability in managing menstruation. Sanitary napkins were the most commonly used and disposed of, indicating the need for improved disposal mechanisms. Localized waste management solutions were proposed as a potentially better approach compared to widespread incinerator installation. However, the study recommends government intervention through the installation of incinerators in communities. Finally, the research suggests a focus on developing user-friendly and intelligent incinerators for future research.

In their study (Xu et al., 2022). titled "Environmental pollution, a hidden culprit for health issues" reviews the impact of environmental pollution on public health. The study highlights various pollutants such as heavy metals, air pollutants, and organic chemicals and their deleterious effects on human health, including respiratory, cardiovascular, endocrine, reproductive, and neurodevelopmental diseases. Historical public health emergencies caused by chemical pollution, such as the Great Smog of London and Minamata disease, are recalled to demonstrate the severe consequences of pollutant exposure. Epidemiological evidence links pollutants like endocrine-disrupting chemicals (EDCs) and particulate matters (PMs) to a variety of common diseases, emphasizing the urgent need for extensive studies to explore these cause-and-effect relationships. The paper concludes with a call for increased efforts in epidemiological and pathological research to better understand and mitigate the health risks associated with environmental pollution.

In their study (Kumar Nepal et al., 2021), highlight a gap in addressing basic menstrual hygiene needs in Sherubtse College under the Royal University of Bhutan. The lack of appropriate disposal methods forces students to resort to potentially harmful "dumping" practices. The research team not only exposed the problem but also urged the college to address it. Additionally, they proposed solutions for sustainable sanitary waste management to ensure environmental protection. the research found that while the college lacks proper disposal systems, the female students themselves are knowledgeable about menstrual hygiene practices. This raises questions about the disconnect between student needs and the college's response. The study concludes by emphasizing the need for further research to understand the full environmental impact of improper sanitary napkin disposal.

(Nnennaya et al., 2021). In their study they investigated menstrual knowledge and hygiene practices among adolescent school girls in Taraba state. Notably, over 76% of the girls possessed knowledge about menstruation prior to their first period. However, only 69.7% demonstrated good overall menstrual knowledge, and 57.6% exhibited good menstrual hygiene management practices. These findings highlight the importance of equipping adolescent girls with the necessary knowledge and support to ensure proper menstrual hygiene management.

In their review, Morita et al. (2021) address the significant environmental hazards posed by dumpsites and non-sanitary landfills in Brazil, emphasizing their impact on soil and water quality. The study compiles data from 162 publications, identifying common contaminants such as coliforms, lead, and cadmium. It highlights that 74% of surface water samples, 70% of groundwater samples, and 24% of soil samples exceed Brazilian regulatory limits. The authors argue for stringent post-closure monitoring and interventions, recommending the implementation of comprehensive environmental assessments to mitigate these risks. The review underscores the urgent need for improved waste management practices in Brazil to protect public health and the environment.

Amano et al. (2020) investigate the impact of the Oti-Dompoase landfill site on the quality of nearby surface and groundwater in Kumasi, Ghana. The study analyzed water samples from 20 locations and found significant contamination, particularly with heavy metals such as cadmium, which exceeded WHO standards. The water quality index (WQI) indicated that a substantial portion of the water sources were unsuitable for drinking. The study highlights the severe health risks posed by landfill leachate and underscores the urgent need for improved waste management and remediation strategies to protect water resources and public health.

Boateng, Opoku, and Akoto (2019) assess heavy metal contamination in groundwater near the Oti landfill site in Kumasi, Ghana. The study reveals elevated levels of Pb, Fe, Cd, and Cr, exceeding WHO's acceptable limits. Pollution indices and health risk assessments indicate significant contamination, with some sites posing adverse health effects. Multivariate analysis suggests both lithogenic and anthropogenic sources of pollution. The study underscores the need for improved waste management practices to mitigate the impacts of leachate on groundwater quality and human health. These findings offer a benchmark for policymakers in similar environmental settings.

In the study of (Elledge et al., 2018) aimed to address a critical gap in sanitation efforts for low- and middle-income countries by focusing specifically on safe disposal of menstrual waste. Existing studies often overlook this aspect, leading to improper disposal with negative consequences for users. The findings highlight the need for further research to better understand menstrual waste management, including the types of waste generated, disposal behaviors, and the materials used in menstrual products. The study provides essential knowledge for developing effective waste management solutions that ensure health, safety, dignity, and mobility for women and girls.

In the work of (Ibrahim & Usman 2015) investigated sanitation issues in Kaita Local Government, Katsina State. They focused on understanding the types and sources of solid waste, and the potential environmental dangers linked to current disposal practices. They used statistical analysis and surveyed to gather data. Their findings revealed that most residents resorted to indiscriminate dumping due to a lack of proper public or private disposal facilities.

Majolagbe, Kasali, and Ghaniyu (2011) assess the groundwater quality near dumpsites in Ifo and Lagos, Nigeria, analyzing physicochemical parameters and heavy metals. Their findings reveal significant contamination, with Pb, Fe, and Cd levels in Lagos exceeding WHO standards. The groundwater in Lagos is moderately hard and acidic, requiring further treatment, while Ifo groundwater remains within acceptable limits. The study underscores the health risks posed by leachate from dumpsites and calls for regular monitoring and improved waste management practices to ensure safe drinking water. Akudo, Ozulu, and Chime (2010) conducted a study to assess groundwater quality around waste dumpsites in Warri, Nigeria. The research involved sampling groundwater from ten different boreholes near dumpsites, analyzing for physicochemical parameters and heavy metals. Results showed contamination with lead, cadmium, and nitrates exceeding WHO standards, indicating potential health risks. The study emphasizes the need for regular monitoring and remediation to ensure safe drinking water and minimize environmental impact. This research highlights significant pollution challenges and calls for improved waste management practices in the region.

Toxic chemicals are now a major threat, causing significant pollution problems worldwide (Vaughn, 2020). A study revealed that 78% of people residing close to landfill site reported substantial water and air pollution due to unpleasant odors, and 56% of those living near the landfill site expressed worries for their health in the future (Akmal & Jamil, 2021). Deep burial of waste presents a significant environmental risk. Non-biodegradable materials, such as plastics, may persist for long periods of time, potentially leading to environmental contamination (Poddar, 2023). Menstrual waste disposed of in rivers and streams may decompose into microplastics, posing a potential threat to aquatic ecosystems (Zahira et al., 2023). Menstrual pads can be categorized as hazardous waste causes more threat than municipal waste which can lead to a very serious health and environmental problems (Sommer et al., 2020).

this study aims to promote better MHM practices, advocate for improved waste management solutions, and contribute to a healthier and more sustainable future. It also identifies potential areas for further research, such as a deeper understanding of disposal behaviors and the need for development and implementation of effective waste sorting system management for menstrual products.

2.1 Application of Computer Vision in Waste Management

1. Automatic Waste Classification: Computer vision systems are used to automatically classify different types of waste. These systems use image acquisition devices like cameras to capture images of waste, which are then processed and compared against a database of labelled images to identify and classify the waste. (Briñez et al., 2015) implemented a system in Colombian high schools that classifies plastic bottles, cardboard boxes, and soda cans with an accuracy of over 70%.

2. Computer Vision for Waste Sorting and Recycling: Image processing techniques in computer vision are employed to sort and recycle waste materials efficiently. These systems identify and categorize different types of waste, improving the accuracy and speed of recycling operations. In their study (Zhang et al., 2021) they discuss a system that optimizes waste sorting processes, contributing to more efficient waste management and resource recovery.

3. Waste Collection and Segregation Using Convolutional Neural Networks (CNN): CNNs, a type of deep learning algorithm, that are used in conjunction with computer vision to enhance waste collection and segregation processes. These systems capture real-time images of waste, process them using image

processing libraries, and classify waste into different categories. (Sruthy et al., 2021) developed an automatic garbage collection system for water vessels that uses CNN to classify waste into biodegradable and non-biodegradable categories with over 90% accuracy.

4. Smart Waste Management Systems with AI and Computer Vision: AI-powered computer vision systems monitor waste levels in bins and sort waste materials. These systems use image recognition algorithms to automate the sorting process, reduce manual intervention, and increase sorting accuracy. (V et al. 2021) highlights a smart waste management system that uses cameras and image recognition to monitor and sort waste, supporting efficient waste collection and recycling practices.

3.0 METHODOLOGY

This section presents the research methodology. It outlines the planned approach for conducting the study, including the specific steps involved in each phase to achieve the research goals. The section is divided in to three main categories with subdivisions each, Data collection, Data analysis, and Result analysis.

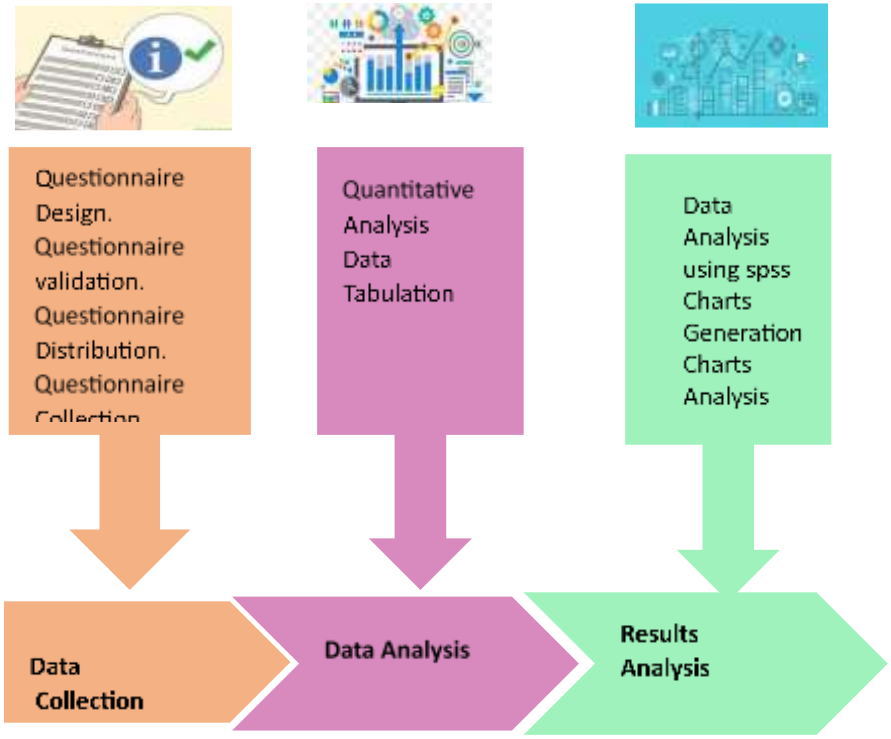

Figure 1: Research Framework

1. Data collection: the process followed in this stage are: Questionnaire design, Target population, Questionnaire validation, Questionnaire distribution, Questionnaire collection, and data preprocessing and preparations.

- Questionnaire design: The study employed a set of questionnaires designed to collect demographic data (age, gender, highest qualification, etc.) from both health personnel and non-health personnel. The questionnaire for non-health personnel consisted of dichotomous questions, while the questionnaire for health personnel included a mix of dichotomous and open-ended questions.

  - Dichotomous: yes/no it offers two answer choices.
  - Open-ended questions: allow respondents to answer in their own words

- Target Population: the target audiences for this study are health personnel and public individuals who are non-health personal.

- Questionnaire Validation: The questionnaire designed for health personnel underwent validation by health practitioners. The non-health personnel questionnaire was similarly validated by environmental experts.

- Questionnaire Distribution: both health and non-health personnel questionnaires were distributed through social media platforms including WhatsApp, Facebook, and Twitter.

- Questionnaire Collection A total of 109 participants completed the questionnaire. Among these respondents, 45 were health personnel and 64 were non-health personnel.

- Data preprocessing and preparations: principal components Analysis (PCA) was applied to improve visualization and also identify smaller set of factors that capture the most significant variation in the responses.

2. Data Analysis: Collected data was entered into data analysis software specifically SPSS for cleaning.

- Quantitative analysis: Given the quantitative nature of our data, descriptive statistics were employed to analyze the finding.

- Data tabulation: Participant demographics was summarized using frequency and percentage.

3. Results Analysis:

- Chart generation: Data visualization was performed using Google Sheets, with pie charts employed to represent the data.

- Chart Analysis: Following a comprehensive data analysis process, the study presents both charted findings and participant views and opinions.

4.0 RESULTS AND FINDINGS

The survey on improper disposal of menstrual waste was carryout to investigate the improper disposal of sanitary pads. Demographic data of the participants were tabulated and presented using frequencies and percentages. Participant responses and opinions were visually represented using pie charts. Additionally, selected open-ended responses from health personnel were highlighted.

Table 1: The demography of the study areas

Variable	Category	Frequency	Percentage
Age	15-18yrs	4	4
	19-22yrs	20	18
	23-26yrs	30	28
	27-30yrs	42	38
	31 above	13	12
	Male	57	52
Gender	Female	52	48
Highest Qualification	Secondary	11	10
	undergraduate	34	31
	graduate	54	50
	masters	10	9
Total		**109**	**100**

Table 1 details the demographic breakdown of participants, including age, gender, and highest educational attainment. The majority (66%) of respondents fell within the 23-30 years old. Regarding gender, there was a slight male majority, with 57 (52%) male respondents and 52 (48%) female respondents. Educational qualification demonstrated a dominance of graduates (54, 50%), followed by undergraduates (34, 31%), secondary school graduates (11, 10%), and lastly, those with a master's degree (10, 9%). Based on the observed distribution of educational backgrounds, it can be concluded that the majority of participants have likely received some level of education on environmental sanitation and hygiene

. **Figure 2: Improper disposal of solid waste in study areas**

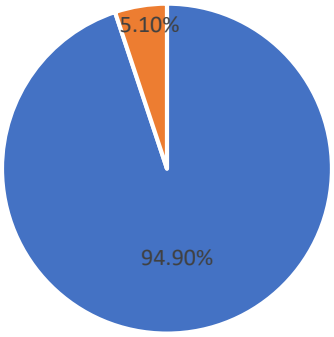

Figure 3: participant opinion on weather its critical or not critical issue

Fig. 3 shows that majority of respondents believe that improper menstrual waste disposal is a critical issue that require urgent attention. This suggests that most people who took this survey view improper menstrual waste disposal as a serious problem that needs to be addressed. According to (Manaf et al., 2009) Improper waste management poses a significant environmental threat as it can contaminate air, water, and soil.

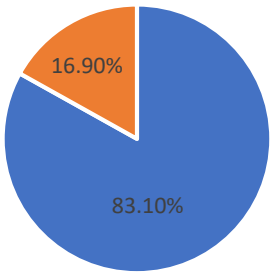

Figure 4: Participant response on sanitary pad end up in landfills

Given the sample size in Fig. 4, the results show that majority of respondents believe sanitary pads do typically end up in landfills. This means that they are aware that the waste ends up in landfills. According to (Osazee, 2021) Landfills represent designated physical facilities or locations where solid waste materials are deposited. The process of waste biodegradation within landfills produces landfill gas, and greenhouse gas (Thesis et al., 2012). Several researchers, policy makers, and stakeholders have advocated that landfills should be eliminated.

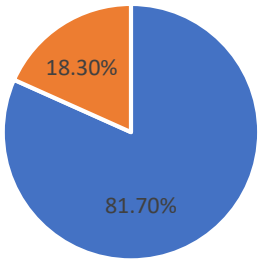

Figure 5: Participant response on sanitary pad end up in waterways

The majority of respondents 81.7% believe that sanitary pads often end up in waterways, while the minority 18.3% believe that they do not. This clearly shows that apart from landfills, sanitary pad ends up in waterways in most of our communities. waterways are increasingly becoming the end point for all sorts of waste including municipal solid waste, industrial waste, and hazardous waste (Immanuel, 2023).

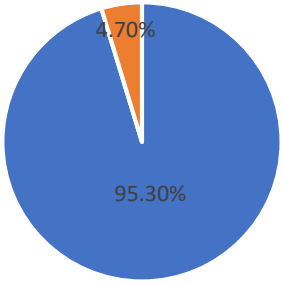

Figure 6: Participant response on sanitary pads contribute to environmental pollution

According to the survey, a vast majority of respondents believe sanitary pads contribute to environmental pollution. Waste disposal if not manage effectively can potentially leading to health hazards, environmental pollution, poverty damage, and economic losses (Gr et al., 2023). This suggests that people are aware of the environmental impact of sanitary pads. However, in their study (Triassi et al., 2015) stated why sanitary pads might be considered to have a negative impact on the environment:

1. Landfill waste: Sanitary pads typically are not biodegradable and could take hundreds of years to decompose in landfills.
2. Chemicals: They might contain chemicals such as furan and dioxin that could leach into groundwater if not disposed of properly.
3. Plastic: Many sanitary pads contain plastic components, which can also contribute to landfill waste and pollution.

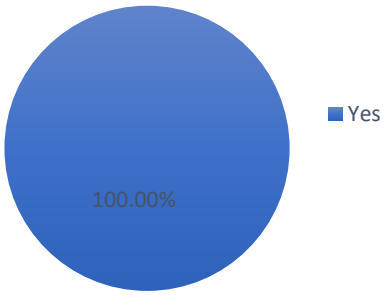

Figure 7: Participant response on sanitary pads weather it has negative health effects or not

According to the survey, all respondents (100%) agree that contaminated water from sanitary pads can have negative health effects. Dumping waste into our waterways is a serious threat. It devastates aquatic ecosystems and endangers human health through contaminated drinking water (Pandey et al., 2020). Contaminated water from sanitary pads could potentially cause negative health effects in a few ways**:** first, if sanitary pads come into contact with water that is not clean, they could harbor bacteria that can cause infections. Second**:** Some sanitary pads contain chemicals that could leach into water. These chemicals could potentially have negative health effects if ingested or absorbed through the skin. However, in their study (Amasuomo & Baird,

2016) highlighted the important note of how properly disposing of sanitary pads and maintaining good hygiene can help reduce the risk of contaminated water causing health problems.

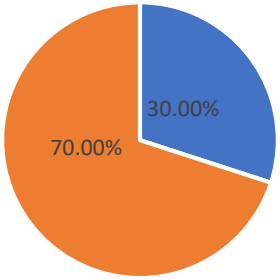

Figure 8: Participant response on weather there is sufficient number of waste disposal facilities or not

Fig. 8 underscores that around 70% of participants noted a deficiency in public waste facilities within their communities. This observation underscores the necessity for governmental and stakeholder intervention to bridge this gap and establish sufficient waste disposal infrastructure. Such infrastructure would facilitate the appropriate disposal of various waste materials, including menstrual hygiene products.

Why Sanitary pads is considered hazardous?

According to health personnel below are the reasons they stated:

1. Composed large amounts of plastic and other non-biodegradable materials can take centuries to decompose in landfills.

2. Potential for water contamination If not disposed of properly, sanitary pads can end up in waterways or come into contact with groundwater.

So, what can be done to minimize the environmental impact of sanitary pads?

1. Proper disposal: Always dispose of sanitary pads in designated bins and avoid flushing them down the toilet.

2. Look for biodegradable options: Some manufacturers offer sanitary pads made with biodegradable materials like bamboo or organic cotton.

3. Reusable menstrual products: Consider using menstrual cups or reusable pads, which can be a more sustainable alternative.

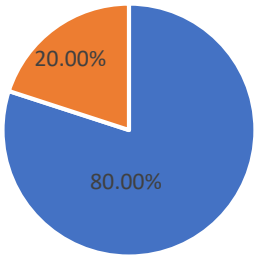

Figure 9: participant view to build automated waste management

Fig. 9 shows that the majority of participants (80%) are aware of the problems associated with improper waste management. This awareness presents a significant opportunity for researchers to develop automated waste management systems. By reducing health risks, minimizing pollution, and limiting exposure to harmful substances, such systems can contribute significantly to a safer and more sustainable environment. (Khudyakova & Lyaskovskaya, 2021) emphasize that handling hazardous waste materials manually is dangerous and detrimental to human health. Integrating AI into waste management practices can significantly enhance sustainability and improve overall waste management.

4. DISCUSSION AND CONCLUSION

This study investigated the environmental impact of improper menstrual waste disposal practices. A survey was conducted using two sets of questionnaires, namely a health personnel questionnaire and a non-health personnel questionnaire each containing 6-8 questions. Healthcare personnel, with their background knowledge, highlighted the severe negative health consequences of disposing of menstrual waste in landfills and waterways. The study through health personnel finds out that, using water contaminated with sanitary pads can harbor harmful bacteria like E. coli, Salmonella, and Shigella, leading to gastrointestinal illnesses with symptoms such as diarrhea, vomiting, cramps, and fever. However, this study revealed that the majority

of participants are aware of the critical issue of waste management, indicating knowledge of environmental sanitation and protection, but the lack of public waste disposal practices and facilities in their areas remains a significant barrier. This highlights the need for governmental and stakeholder intervention to address this gap. By providing adequate waste disposal infrastructure.

5.0 RECOMMENDATIONS

The findings of this study will be leveraged to develop an automated waste sorting system using advanced computer vision models. This system aims to minimize human contact with waste, significantly reducing health risks and improving workplace safety. By enhancing the efficiency and accuracy of waste sorting, the system will ensure proper recycling and disposal, reducing contamination and increasing material recovery rates. Additionally, this approach will help decrease environmental pollution by minimizing landfill waste and preventing soil and water contamination from hazardous substances, ultimately promoting sustainable waste management practices.

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