

Improper solid waste disposal and the risk of urban flooding: impact and management strategies

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Abstract

Purpose – Across the world, inefficient waste management systems and rapid urbanization have caused the accumulation of waste in drainage channels. Hence, this study addressed the problem of improper solid waste disposal (ISWD) habits of people in urban environments, and its impact on urban flooding. The specific objectives were to examine the impact of ISWD; resident's awareness level; types of solid waste disposed of; and mitigating strategies.

Design/methodology/approach – Survey and observational were used, with questionnaire and pictures as data collection instruments. Stratified sampling techniques was used to sample of 212 residents in the study area. While percentages, bar and pie charts, and Pearson's Product Moment Correlation (PPMC) were the tools used for data analysis.

Findings – Findings revealed that awareness level of residents on the contribution of ISWD to urban flooding is below 50%; 48% and 37% of residents' dispose of mostly plastic and cellophanes/nylons respectively; while others accounted for 15%. Findings also showed a high impact of ISWD on urban flooding. Strategies such as proper solid waste management, construction of better drainage channels, and environmental sanitation amongst others were suggested as strategies for mitigating the impact of ISWD on urban flooding.

Research limitations/implications – Participants may have given desirable responses instead of truthful ones. Secondly, survey research often collect data at surface level, rather than in-depth information, these could affect the reliability of the results.

Practical implications – The findings have raised a red alarm to urban authorities/governments, on the implications of irresponsible solid waste disposal. It will also highlight the cost of human negligence in waste management to public sectors and experts.

Originality/value – The authors' declare that this study is an original research that addresses a devastating environmental problem 'flooding in urban environments'.

Keywords Improper, Solid waste, Disposal, Awareness, Urban environment, Flooding, Impact and strategies

Paper type Research article

Introduction

Urban flooding and indiscriminate solid waste disposal across major cities and towns, especially in developing countries, seem to have become a recurring problem to the environment. With the vast amount of waste generated every day, especially in densely populated places, the lack of adequate facilities in managing solid waste has left major cities and towns vulnerable to serious consequences from solid waste disposal. The frequency has increased steadily over the years and this has led to serious environmental problems, accounting for so many fatalities globally. The Centre for Research on the Epidemiology of

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Conflicts of interest: The authors' declare, that there is no conflict of interest in the study.



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Disasters (CRED) reported 432 disastrous events worldwide from 2001 to 2020, this includes flooding occurrences. Environmental problems has caused over 10,000 deaths, displaced more than 100 million people, and accounted for over \$252 billion losses in economic and financial terms (CRED, 2021). In Nigeria, the year 2022 witnessed some of the worst and most devastating floods in history, accompanied with so many loss of lives, properties, and farmlands. The financial damages caused by the floods were estimated to be around \$9.12 billion. Thirty-four (34) out of the thirty-six (36) states were flooded; while about 64% of families were affected, and 40% of urban areas were submerged in floods (National Bureau of Statistics, 2022).

Flooding occurs mainly as a result of excessive rainfall that exceeds the normal capacity of water which the soil in a given environment can absorb. Although flooding is caused by meteorological and hydrological factors, it may also be connected with human activities, especially indiscriminate disposal of solid waste (ISWD) on open land/spaces, drainage channels/systems, streams/rivers, and streets (Dubey, Agarwai, Yadav, Goswami, & Ravat 2024). While the number of flood occurrences have become higher, more frequent, and more disastrous globally, urban communities seems to have received a larger chunk of their impact, especially in developing countries, which in most cases are ill-prepared for flood disasters (Hassan, 2025). This setback, caused by the ripple effects of urban flooding, postulates negative indices for sustainable development of urban environments, therefore, the causes of urban floods need to be investigated.

The prevalence of flooding, especially in urban towns and cities, may not be unconnected to various factors such as population explosion, lack of flood management plans in urban towns, blocked drainage channels, building on natural drainage ways, rise in sea levels, breakdown of hydroelectric dams, and clogged drainage channels as a result of indiscriminate waste disposal (Amato & Togo, 2021; Abass, 2020). Other factors such as age, gender, and self-concept could also be responsible for indiscriminate solid waste disposal (Bechel, Asor, Ojong, Betlang, & Ironbar, 2024). According to Yoshioka, Era, and Sasaki (2021), urban centers always experience rapid population growth, with little or no commensurate plan for solid waste management or expanded drainage infrastructure. In most cases the existing drainage systems are ill-equipped and not able to handle floods when the rainfall is heavy. Beside, these issues, many developing countries have only few private firms involved in the business of waste management.

Mokuolu, Odunaike, Iji, and Aremu (2022) posited that presently, the world is experiencing an increase in urbanization as more than 50% of the world inhabitants is reported to be living in urban areas. It has also been estimated that with the current trend in urbanization, 66% of the world's people would be living in urban cities and towns by 2050 (Abubakar *et al.*, 2022). As more and more people strive to migrate to urban centers in search of better living, the governments/administrators of these urban centers are faced with the challenge of providing an environment that is free from the risk posed by floods (Mercado, Kawamura, & Amaguchi, 2020; Yoshioka *et al.*, 2021).

Equally disturbing is the fact that urban solid waste output is growing as a result of increasing urbanization. In spite of this increase in solid waste generated, Mokuolu *et al.*, (2022) claimed that only about 30% of solid waste is being collected by private waste collectors in developing countries. These practices increase pressure on drainage systems that are already overburdened, causing high frequency and severity of urban floods (Hassan, 2025). Therefore, the overlapping nature of improper solid waste disposal and its likely contribution to floods in urban areas is the major focus of this research.

Nigeria, Africa's most populous country with one of the biggest economies after South Africa, is besieged by floods annually (Nigeria Hydrological Agency Services, 2020). These floods are mostly experienced around the rainy/wet season, urban environments like Lagos, Ibadan, Calabar, Port-Harcourt, Warri, Abraka and many others receive the severity of these floods. As more floods are expected in the coming years, the number of people and urban areas susceptible to floods are also expected to increase, unless the causal factors are investigated

and preventive actions taken there might be no end to the problem of urban flooding. There seems to be a perceived lack of awareness among urban dwellers on the nexus between ISWD and urban flooding, therefore people don't understand the magnitude of the problem (Triakha, 2022). In addition, the job of solid waste management is seen by people as that of the downtrodden in the society. They seem to forget that everyone generates waste and therefore best practices in solid waste disposal should be the concern of everybody.

This study presuppose that the poor attitude of urban dwellers towards solid waste disposal may have contributed indiscriminate disposal of solid waste. Since solid waste are not biodegradable, they accumulate in drainage channels to cause a barrier in free flow of water when it rains. These scenarios have made urban environments vulnerable to incessant flooding (Mokuolu *et al.*, 2022; Durbey *et al.*, 2024). Therefore, the main objectives of this study were to examine residents level of awareness on impact of ISWD to urban floods; identify types of solid wastes generated in the area that can cause blockage of drains and flood; investigate the impact of improper solid waste disposal/management on urban flooding and proffer strategies to curb the problem. To achieve these objectives the following research questions and hypothesis were raised.

- RQ1. What is the awareness level among Abraka residents on the impact of improper solid waste disposal on urban floods?
- RQ2. What are the types of solid waste mostly disposed of by Abraka residents that can cause blockage of drainage channels and cause flooding?
- RQ3. What are the impacts of improper solid waste disposal (ISWD) on urban flooding in Abraka Metropolis?
- RQ4. What strategies can be adopted to mitigate the impact of improper waste disposal on urban flooding in Abraka Metropolis?
- Hypothesis.* There is no significant relationship between improper solid waste disposal (ISWD) and urban Flooding in Abraka Metropolis.

The dynamic-based synergistic model

The Dynamic-Based Synergistic Model, is a model which highlights the complexities, causal feedback, and nonlinearity inherent between systems and variables, (Wu & Huang, 2023). The system dynamics-based model optimize and analyze complex systems in a holistic manner. It is a model that can be used in understanding the behaviors of complex systems by using feedbacks, flow, and time. The model constitute a strong framework that can be used in managing systems that are interconnected such as solid waste disposal in urban areas and the sustainability of urban environments. Shao and Zhu (2022) applied the Systems Dynamic-Based Synergistic Model to evaluate the relationship between living ecological systems.

The key assumptions of the model posits that changes in one part of a system such as ISWD can have an effect on the other part of the system, say urban flooding over a period of time. Secondly, the model can be used by stakeholders (government and communities) for integrating solutions to environmental and ecological problems. Thirdly, the model presuppose that multiple models such as environmental (ISWD) and social (improper disposal habits) can become unified to present real life problems (urban flooding). The negative impacts of ISWD can put pressure on urban infrastructure, such as the drainage system. Therefore, the model as used in this study, suggest that there is a synergy between solid waste disposal practices and urban flooding in the environment. The researchers decided to adopt the model for explaining the ripple effect of ISWD on urban floods.

Review of related literature

To establish available information/data on the research problem, a thorough literature review was carried out on related studies. For instance, [Wuyep, Musa, Bioltif, and Beka \(2024\)](#) established that awareness of the impact of improper solid waste disposal among urban dwellers is inadequate. While [Echendu \(2023\)](#) confirmed that improper solid waste disposal practices among urban residents in Nigeria have a nexus to recurrent floods. Flooding has a devastating and negative environmental impact in urban areas ([Pande & Makonye, 2023](#); [Mobosi, 2025](#)). Also, [Brian \(2021\)](#), identified unsuitable solid waste management as a contributor to urban flood risks. While, [Raphela, Manqele, and Erasmus \(2024\)](#) established that landfills of solid waste, endanger the surrounding environment to floods. These findings suggested that ISWD is a potential risk to urban floods. As observed by [Trikha \(2022\)](#) during a flood, solid waste assumes liquid state and subsequently act like water; this could cause substantial mobility of debris to block drainage channels. Likewise, [Echendu and Georgeou \(2021\)](#), and [Echendu \(2021\)](#) viewed ISWD as a barrier to the free flow of water in drainage channels.

[Ampofo \(2020\)](#) posited that strategies for mitigating the impact of floods across urban centers include, behavioral shift to best practices in solid waste disposal; public sensitization of urban dwellers on the impact of disposing of solid waste anywhere/anyhow; using residents to champion the practice of proper solid waste disposal; encouraging the business of private waste collectors, and recycling of solid waste. Previous research on the problem have investigated causes of floods in Ilorin, Mumbai and other urban environments around the world ([Hassan, 2025](#); [Mokuolu *et al.*, 2022](#); [Mobosi, 2025](#); [Durbey *et al.*, 2024](#)). Findings from these research showed that ISWD have negative impacts on health, water, environment and socio-economic life. A few have investigated how ISWD can exacerbate the risk of urban floods.

Similarly, it can be observed from the review that research on the impact of solid waste on urban flood risk and strategies in developing countries like Nigeria are scarce; available ones are inconsistent or outdated. Despite the danger that ISWD pose to urban flooding as demonstrated by prior literature, the review established an empirical gap on the problem, particularly in Abraka metropolis of Delta State, Nigeria. Therefore, in order to ascertain the impact of ISWD, and management strategies, the researchers deemed it necessary to carry out this investigation in Delta State or Abraka metropolis.

The study area.

The study area Abraka is a university town in Ethiope East Local Government Area of Delta State (see [Figure 1](#)). It is a residential and educational urban area. The presence of the first and oldest university in the state, government institutions, public schools, and the centrally located nature of Abraka have made it a major hub and center of attraction. Abraka is located at Lat. 05° 47'N and Long. 06°N, and drained by Rivers Ethiope and Ovwuwe ([Akinbode & Ugbohmeh, 2006](#)). It has a tropical rainforest and wet equatorial climate and records a total of 3,098mm of rainfall annually, experiencing heavy rainfall throughout the year, therefore prone to flooding. A relative humidity above 71% –80% further confirms the characteristic of a wet and rainy climate in the study area. ([Efe, 2006](#)). These climatic factors make the area susceptible to floods.

Materials and methods

The materials, methods and procedures applied in the study are shown in [Figure 2](#), a detailed flowchart showing the sequence methods of the study, and thereafter explained below the figure.

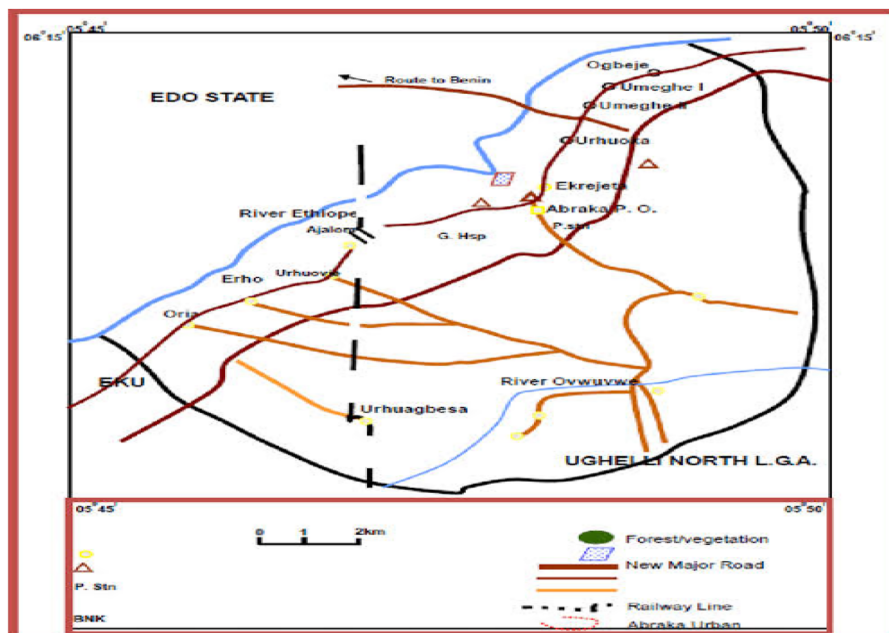


Figure 1. Map of Delta State, showing Abraka, the study area. **Source:** Ozabor and Obaro (2016)

Research design

Survey and observation research were adopted for the study, the researchers used both designs in order to complement each other. Survey was used to collect quantitative data on the attitude, knowledge, opinion, and habits of residents on the impact of solid waste disposal on flooding. While observation research provided insights into the actual impact of solid waste disposal habit on flooding.

Population

According to [City Facts \(2015\)](#) Abraka has a population of 79,963 as at 2025, with an annual population growth rate of 37.2 % annually, the researchers arrived at a population of 407,169 presently. However, evidence on the ground suggests that the population of the area could be more due to the high traffic flow experienced in Abraka, increase level of development, prevalence of residential land use, the presence of public schools/institutions, and commercial nature of the area.

Sample and sampling technique

A sample of two hundred and twelve (212) residents were selected using stratified sampling technique. The population was stratified into sub populations that are homogenous in nature, and then a number from each stratum was selected from five areas (Abraka PO-44; Ekrejeta-43; Urhouvie-43; Urhoka-42, and Ajalomi-40), this constitute the sample of 212 residents used for the study.

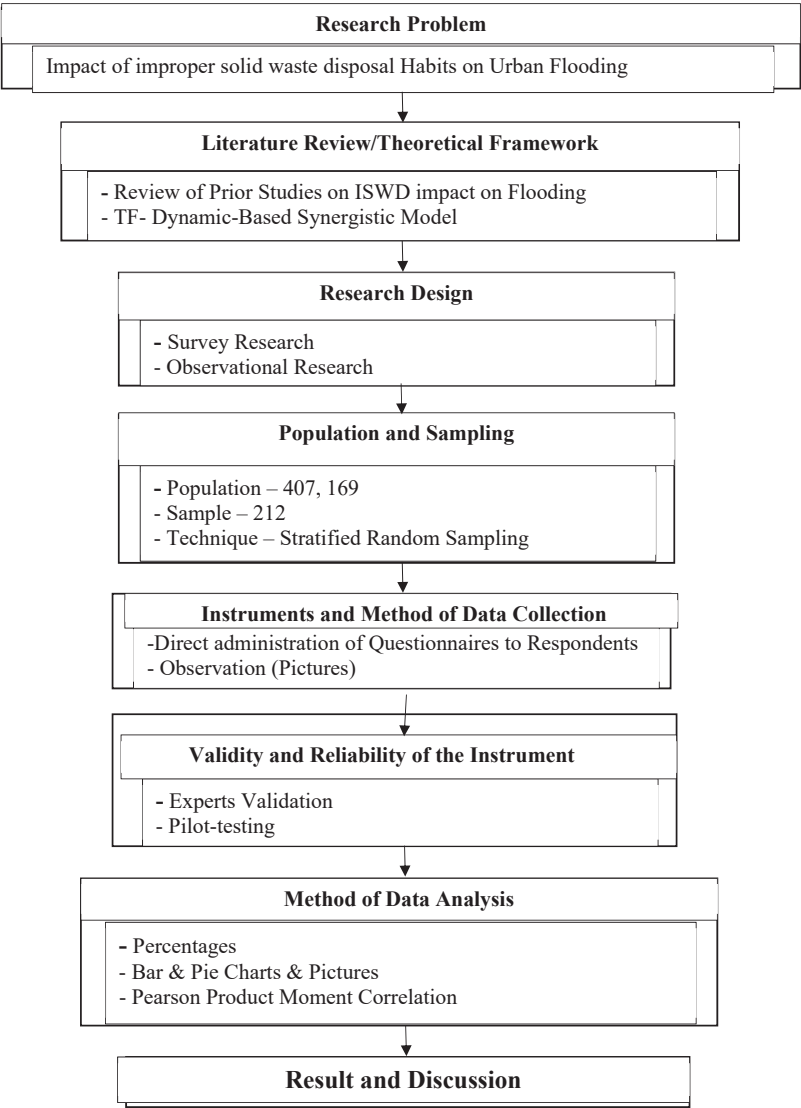


Figure 2. A methodology flow chart of the study

Data collection instruments

A well-structured questionnaire was diligently constructed by the researchers bearing the research questions and [Hypothesis](#) in mind (see [supplementary file](#)). The questionnaire was titled “*Improper Solid Waste Disposal Questionnaire (ISWDQ)*,” Similarly, the researchers made use of pictures as instruments of data collection, and they went round the area presented pictures on the nature of the problem (see [Figure 3](#)).



Figure 3. Drainage channel (Gutter) littered with solid waste. Source: Researchers' observation fieldwork

Validity of the instrument

The questionnaire was duly validated by two experts, one in soil and environmental resources, in the Department of Geography and Regional Planning at the Delta State University Abraka. Then the second, an expert of environmental toxicology in the Department of Environmental Science, at the Southern Delta University, Ozoro both in Delta State, Nigeria. Their expertise were sought for, and they contributed immensely to drafting a final copy of the instrument. In a similar vein, a pilot-testing was carried out on the instrument to ascertain its reliability, the pilot test was done on 20 residents in Ukwuani Local Government Area which is outside the study area, and a PPMC reliability coefficient of 0.74 was established was a first and second administration. This result gave confidence to the researchers that the instrument can be relied upon for data collection for the study.

Data collection

The administration of instrument was carried out by the researcher's with the help of four undergraduates from the Department of Geography and Regional Planning, at the Delta State University, Abraka. The researchers and assistants administered the questionnaires on a one-on-one basis; with this pattern, 100% retrieval rate of the instrument was achieved. The researchers also took pictures of drains and flood conditions.

Data analysis

Data collected were collated, analyzed and computed manually using percentages and descriptive statistics such as bar charts and pie chart. The benchmark for judgment was set at 50%, any item with percentage below this benchmark is considered rejected, while any item

that records a percentage above 50% is considered as accepted. Pearson’s Product Moment Correlation Statistics (PPMC) was used to test the [Hypothesis](#) in the study.

Presentation of results

Observation

In [Figure 3](#) a picture of solid waste-filled drains and drainage channels littered with solid waste in the study area was presented.

In [Figure 3](#), the picture speaks volume as can be observed a wide drainage channel built and design to take water away from the metropolis to the River Ethiopie which drains the area has almost be submerged in solid waste. This type of scenarios were observed in major parts of the metropolis.

RQ1. What is the awareness level among Abraka residents on the contribution of Improper Solid Waste Disposal (ISWD) on urban floods?

As shown in [Figure 4](#), the level of awareness on how ISWD can contribute to high occurrence of floods in the study area, is below average. The chart reveal that all items on residents’ awareness on the impact of ISWD on urban flooding was below the average of 50%. While a whopping 89% of Abraka residents are involved in ISWD, apparently due to a lack of awareness on the impact on flooding.

Furthermore, the solid waste disposal pattern of respondents is illustrated in [Figure 5](#), the results showed that open dump sites, open sites, and drainage channels are the preferred places where respondents dispose of their solid wastes, with each recording 88%, 86%, and 82%, respectively. While 67% and 36% dump their solid waste on streets/roads and streams/rivers, respectively only 5% use the services of private waste collectors.

RQ2. What are the categories of solid wastes disposed of by Abraka residents that can cause blockage of drainage channels and cause flooding?

As seen in [Figure 6](#), the charts results indicates the different types of solid wastes disposed of by residents of the Abraka metropolis. From [Figure 6](#), it can be observed that the major types of solid waste disposed of by residents are plastics and cellophanes, and constitute materials that can form a major barrier to the free flow of drainage channels. Plastics such as PET bottles,

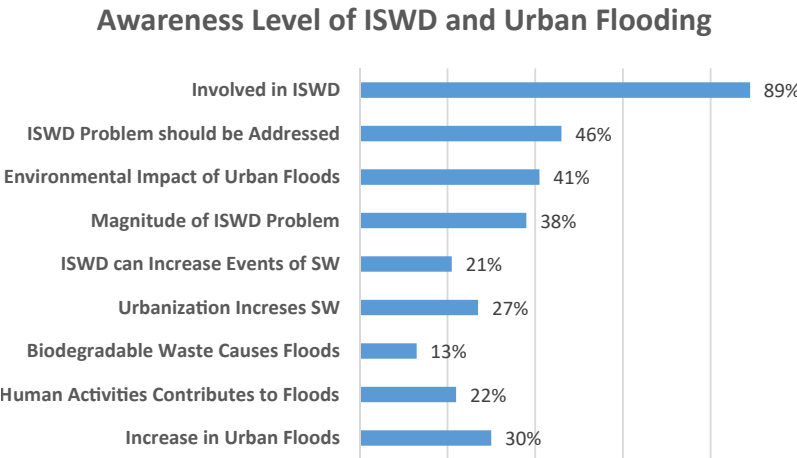


Figure 4. A bar chart showing results for residents awareness of ISWD impact on urban flooding. Source: Authors’ computations

PATTERN OF SOLID WASTE DISPOSAL

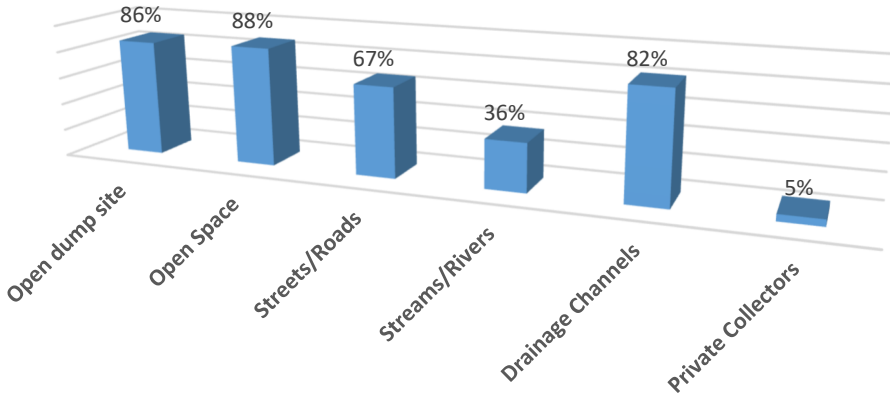


Figure 5. A bar chart showing pattern of solid waste of respondents. Source: Authors' computations

Types of Solid Wastes

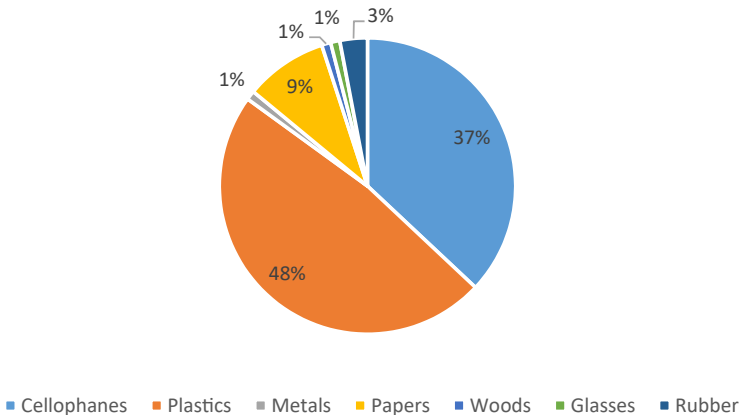


Figure 6. A pie chart showing types of solid waste disposed of by respondents. Source: Authors' computations

disposable plates. This waste accounted for about 48% of solid waste generated in the area. While glasses recorded the lowest at 1%.

RQ3. What are the impacts of improper solid waste disposal (ISWD) on urban flooding in Abraka Metropolis?

Data collected on impact of ISWD on urban flooding are presented in [Figure 7](#), it can be seen that findings all items recorded above the 50% average score. This establish that there is a significant impact of ISWD on urban flooding.

RQ4. What strategies can be used to mitigate the impact of improper waste disposal (ISWD) on urban flooding in Abraka Metropolis?

Impact of ISWD ON Urban Flooding

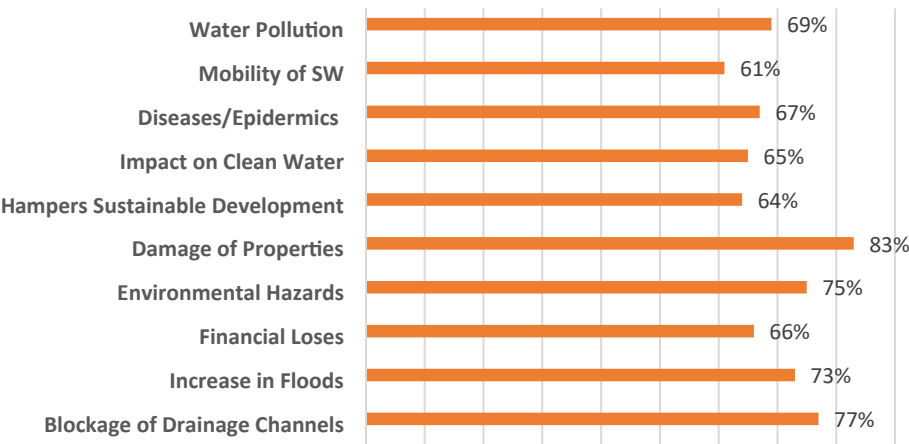


Figure 7. A bar chart showing impact of ISWD on urban flooding. Source: Authors' computations

Respondents take on strategies can be adopted by residents and government to mitigate the impact of ISWD on flooding in urban areas is presented in [Figure 8](#), the results showed that almost all items were accepted since they recorded more than 50%. With exception of involvement of residents 31%, the use of private waste collectors 46%, probably because they don't want to pay for such service.

Hypothesis: There is no significant relationship between improper solid waste disposal (ISWD) and urban Flooding in Abraka Metropolis.

[Table 1](#), shows that the Pearson's Product Moment Correlation Coefficient (PPMCC) analysis of data on the relationship between ISWD and urban flooding. The PPMCC (r)

Strategies to Mitigate the Impact of ISWD on Urban Flooding

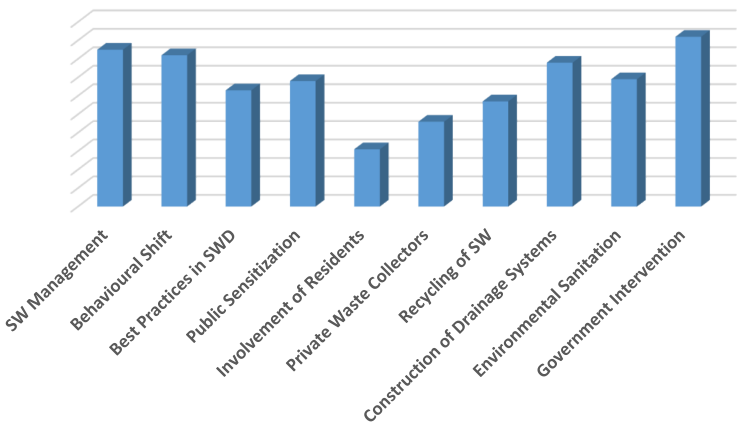


Figure 8. A bar chart on strategies to mitigate the impact of ISWD on urban flooding. Source: Authors' computations

Table 1. Pearson's Product Moment Correlation Coefficient (PPMCC) on the relationship between ISWD and urban flooding

Variables	N	R	Decision
ISWD	212	00.529	Strong relationship
Urban flooding	212		

Source(s): Researchers' computations

($r = 0.529$) indicated a strong relationship between both variables. Therefore, it can be concluded from the findings that there is a strong relationship between ISWD and urban flooding. Thus, the null hypothesis is therefore rejected and an alternate hypothesis "that there is a compelling relationship between ISWD and urban floods" is accepted in this study.

Discussion

The first finding revealed that the awareness level of respondents on the impact of ISWD on flooding in the area is below average; most respondents think that floods are natural occurrences and ISWD may not be a major factor. This lack of awareness may have reinforced indiscriminate waste disposal habits and have shown there is a need to create more awareness among residents on the impact of ISWD on flooding. Solid waste management awareness is key to mitigating the negative impact of indiscriminate solid waste disposal on floods. This is consistent with [Abass \(2020\)](#), [Brian \(2021\)](#), and [Echendu \(2021\)](#). These studies decried the rising cases of urban floods due to lack of awareness on indiscriminate solid waste disposal. Therefore, the findings from the study has confirmed that the lack of awareness on the impact of ISWD could contribute to urban flooding; hence, there is a need to create more awareness among residents.

Further finding from the study reported a high rate of solid waste generation such as non-biodegradable plastics and cellophanes. This brings to the front burner the prevalence and problem associated with the increasing rate of inappropriate disposal of plastics, cellophanes, metals, and other types of solid waste commonly dumped on drainage channels, roads, and open spaces amidst various waste disposal practices. Thus, plastics and cellophanes, are the highest generator of solid waste in the area, because they are used mainly by food vendors, staff, and students (who make up the bulk of the population), as well as other person especially during events such as birthday parties, other ceremonies, seminars, and the like. Other studies in this regard, such as ([Mokuolu et al., 2022](#); [Trikha, 2022](#); and [Mercado et al., 2020](#)) submitted similar findings. The research mentioned emphasized that the indiscriminate generation and disposal of solid wastes, especially plastics, metals, and cellophanes, in urban areas can be attributed to high flood risks in such places. There was no findings to the contrary on this problem.

In addition, findings from the study revealed the impact of ISWD urban flood risks. The findings from the study (questionnaire) administered on respondents in this research underscored the impact of ISWD, as majority of the respondents realized that the solid waste they dump in drainage channels (popularly called gutters in Nigeria), open spaces, streams, and other places may have contributed to flooding in the area. The authors noted that at the initial stage, respondents were ignorant about the impact of ISWD on flooding, however, as they become more acquainted with the items in the questionnaire, their level of awareness on the impact of ISWD became enhanced. Findings are in congruence with the fact that solid waste indiscriminately disposed could be a common cause of drainage infrastructure blockage and increases the risk of flooding in the area. Nevertheless, they could be other factors apart from ISWD. Other impacts of ISWD could include environmental hazards, damage to lives and properties, good drinking water and health, water pollution, and hampering sustainable

development of the environment. Overall, this finding is in line with previous studies such as Hassan (2025), National Bureau of Statistics (2022), Echendu (2023), and Echendu and Georgeou (2021). The studies mentioned, reported similar impacts of ISWD on urban flooding. However, this study gave a deeper insight into the impact of ISWD on urban flooding in Abraka.

Further findings in this study, unveiled many strategies that could be used to mitigate the impact of ISWD on urban flooding. The strategies included proper solid waste management, recycling, and construction of bigger and wider drains, as well as behavioral shift among other mitigating strategies that could be adopted. This findings confirmed that a well-planned solid waste management strategy and recycling needs to be put in place by the authorities, to mitigate cases of more flooding in the area. Public sensitization at the grass roots, level, where selected residents from the area are made to champion the sensitization, can be good for proper solid waste disposal practice. A similar conclusion was reached by Ampofo (2020), though the findings from this study did not replicate the findings of those studies mentioned, they are an indication that the strategies suggested in this study can help in mitigating the impacts of ISWD on urban flooding. Therefore, the suggestions are crucial in solid waste management and should become ingrained in residents by the government, this could result in best solid waste disposal practices and ultimately, a reduction in cases of floods in urban areas.

The researchers discovered that the study's findings can also support the actualization of the Sustainable Development Goals (SDGs), because, the study can help in creating awareness and general behavioral changes towards ISWD especially as it impacts water resources, proper sanitation and urban flooding as posited by Atubi and Obiajulu-Anyia (2023).

Implications of the findings in the study

The results can be used as a blueprint by individuals' and urban authorities to create awareness on the risks that ISWD pose to humans in the aspect of floods in urban cities and towns. Secondly, the results bring to the fore the problem of solid waste generation from plastics and cellophanes in urban centers. Thirdly, private organizations can leverage the findings from this study, especially in the aspect of management strategies, and invest in urban waste collection and recycling. Finally, any government that wants to build sustainable cities devoid of floods could draw inspiration from the findings of the study by developing a blueprint for proper waste disposal and management in their domain.

Conclusions

Improper solid waste disposal is a significant contributor to urban flooding, this has been established in this study. Therefore, this research concluded that ISWD is a major cause of urban flooding since solid waste acts as a barrier to the free flow of water during rains, thereby leading to an increase in cases of floods in urban environments. The study reported below-average awareness levels of residents on the contribution of ISWD to urban flooding; this indicated residents' engagement in poor solid waste disposal practices. Similarly, the literature reviewed in this study, provided evidence that there is a connection between ISWD and urban flooding as acknowledged by the participants. Plastics, cellophanes, nylons, metals, and other solid waste were discovered to be types of solid waste mostly generated in the study area. Therefore, proper waste disposal should be encouraged, while recycling, sensitization programs by the government and behavioral shifts are required. Government authorities and residents should make efforts to improve solid waste collection to reduce the risk of urban flooding. In conclusion, the findings could pose further questions for research, such as will future generations understand the serious threat of ISWD to human health? Is the present generation ready to make drastic changes to ISWD habits, in order to preserve natural well-being? These questions are suggestions for new research in curbing the cruel attitude of humans towards the environment and the hazards associated with it such as flooding.

Practical research implications

The findings highlights the negative impact of indiscriminate solid waste disposal on urban flooding and how it can be curbed. In addition, government in urban areas should as a matter of policy take action in implementing an effective solid waste management system. There should be an aggressive campaign through public sensitization on best practices in solid waste disposal should be adopted by urban residents, while legislature to punish offenders enacted by the relevant government agencies. The use of private waste collectors should be encouraged by government in urban settlements, this seems like a viable option as long as people are made to pay for such service.

Informed consent statement

All the respondents and participants in this study provided informed consent.

Supplementary material

The supplementary material for this article can be found online.

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