






 Research Article

Effectiveness of 3Rs Waste Management Practice: Implications for Climate Change and Environmental Sustainability

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Abstract

The study examined the effectiveness of the 3Rs (Reduce, Recycle, and Reuse) waste management practice: Implications for climate change and environmental sustainability. A descriptive design (survey) was employed, while five research questions guided this research and were conducted in the University of Nigeria, Nsukka. Participants comprised all 333 undergraduate biology education students enrolled during the 2023/2024 academic session. All were purposively sampled to take part in the study as the population was deemed manageable. The questionnaire on Waste Management (QWM) served as a data collection tool. The questionnaire was duly validated by three professionals in science education and was trial tested on 20 students in the same institution, but different faculty, and yielded a reliability coefficient value of 0.81, using Cronbach's alpha. Descriptive statistics of percentage, mean, and standard deviation were used to answer the study's questions. The findings show that most practice waste management includes open dumping and burning composting, while the 3Rs were found to be rarely practiced in schools. The findings revealed that students are aware of the 3Rs approach to waste management. Among the prominent barriers identified were the school curriculum's silence on 3Rs, lack of incentives to attract students to bring their waste for recycling, and the distance between dumpsites and where the populace lives. Lastly, the enforcement of environmental sanitation day within the school, the dumpsite should be located at a reasonable distance, and the opening of more dumpsite/waste containers within the schools was encouraged. It was recommended that an awareness program or campaign should be organized to enlighten the populace on the importance of the 3R approach to waste management.

Keywords: 3Rs, Climate Change, Waste Management, Environmental Sustainability

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1. INTRODUCTION

Environmental challenges, particularly waste management, have escalated in recent years due to an increase in waste generation exacerbated by a global increase in consumption, rapid industrialization, population growth, and urbanization. According to the United Nations Environment Programme (UNEP) (2021), the exponential growth of global waste generation has become a major environmental concern, contributing to pollution, climate change, and depletion of natural resources. This increase in waste generation has led to a significant environmental burden, affecting ecosystems, biodiversity, and human health. In agreement, the World Bank (2016) reported that by 2050, waste is expected to increase by 70% globally, from 2.01 billion tons in 2016 to about 3.4 billion tons. Unfortunately, much of this waste may not be properly managed, ending up in landfills, oceans, and the natural environment, contributing to

pollution, ecosystem degradation, and greenhouse gas emissions. Onoja (2014) argued that the environment that provides human and other organisms with all the support for their survival is now threatened due to overexploitation and improper waste management.

The challenge has attracted the attention of many stakeholders: scientists, politicians, researchers, and even economists (Twumasi, 2017). As global communities struggle with the environmental impact of waste, there is a growing need for an alternative waste management solution that prioritizes sustainability, as opposed to conventional waste management practices (landfilling, incineration, and open dumping) that have proved inadequate in addressing severe environmental issues. Landfills release methane, a potent greenhouse gas, while incineration generates air pollutants. According to Ukala and Osuafor (2019), conventional waste management does not address the root cause of waste generation, instead focusing on managing the consequences of excessive consumption. Furthermore, Vivek et al. (2013) adduced that the main reasons for environmental degradation are inefficient waste management. In agreement, Ukala and Osuafor (2019) opined that developing countries globally are faced with the problem of improper and unhealthy waste management, which consequently pollutes the environment (air, water, and land) and poses a serious risk to public health.

Waste management involves the process of gathering, moving, processing, or getting rid of waste products. According to Kaur (2015), waste is any material that people no longer need and either plan to discard or have already discarded, for example, packaging materials, garden trash, used paint cans, vegetables, and metals, etc. It could be semi-solid, liquid, solid, or a container for gaseous materials. Improper waste management contaminates groundwater, rivers, and releases hazardous gases into the air, threatening the collective health and safety of the environment, and poses additional costs on the government (Debrah et al., 2021). According to Ifeoluwa (2019), the uncontrollable rate of increase in solid waste generation as a result of human daily and economic activities in Nigeria is devastating.

Studies show that high school students have little knowledge about waste management (Anitha, 2017), and their awareness of waste management in terms of its importance, knowledge, and practice is low (Molina & Catan, 2021). Also, Lad et al. (2020) found that students are eager to learn and proffer solutions to the problem of solid waste management. Furthermore, they found no significant difference in solid waste management at home among kids attending government and private schools. Anitha (2017), Twumasi (2017), and Sola and Sunny (2019) discovered no discernible variation in high school boys' and girls' awareness of domestic solid waste management. However, there isn't much of a difference, but Sola and Sunny (2019) explained that males are slightly more aware than females, while Anitha's (2017) and Twumasi's (2017) findings are in favour of females. These unsatisfactory findings and the fact that little or no studies have been carried out recently to explore the 3Rs (Reduce, Reuse, Recycle) approach as an alternative waste management practice created a research gap that this study intends to fill.

To address these challenges, the concept of "Reduce, Reuse, and Recycle" (3Rs) has emerged as a fundamental strategy in environmental education and sustainable waste management. 3Rs focus on minimizing waste at its source, extending the lifecycle of products, and converting waste materials into new resources. The 3Rs concept originated in environmental policy discussions in the late 20th century, particularly after the 1970s, when environmental awareness increased dramatically, and global initiatives such as Earth Day and the establishment of environmental protection agencies took shape. It emphasizes the importance of minimizing waste by reducing the quantity of materials used, recycling whenever possible, and reusing items as much as possible. According to Debrah et al (2021), it is a sustainable waste management approach that has gained prominence in environmental and biology education. It encourages individuals and communities to minimize their environmental impact by following these three key principles (the principle of reducing, reusing, and recycling waste).

The United Nations Environmental Programme (2013) stated that reducing waste at its source is the most effective way to minimize environmental impact. This principle encourages individuals and industries to consume less, use resources efficiently, and avoid the production of unnecessary waste. Strategies to reduce waste include choosing durable products, minimizing packaging, and adopting more sustainable consumption patterns. The second principle, reuse, focuses on extending the life of products by finding new uses for them rather than discarding them after a single use. This can involve repairing, refurbishing, or repurposing items, thus reducing the demand for new products and conserving resources. Recycling entails conservation of raw materials and minimizing energy consumption by processing waste materials

into new products. While recycling is an important part of waste management, it is often considered less preferable than reducing and reusing because it requires energy and resources to process materials (Ifeoluwa, 2019).

Furthermore, when reduction and reuse are not possible, recycling provides a viable solution to divert waste from landfills and reduce environmental impact. The principles of the 3Rs are not only practical for waste management but also serve as foundational concepts in environmental education. Environmental education aims to foster awareness, knowledge, and behaviours that promote the preservation of the environment and the sustainable use of natural resources. The 3Rs are essential components of this education, as they instil values and practices that encourage responsible consumption and waste disposal (World Bank, 2018). Despite the growing awareness of the importance of the 3Rs, their implementation in educational settings remains limited. Many schools and universities either lack the resources or fail to prioritize the inclusion of sustainable waste management practices in their curricula.

In addition, societal habits of overconsumption and convenience-oriented disposal practices often undermine efforts to promote the 3Rs, particularly in Nigeria, with inadequate recycling infrastructure and low public awareness. Studies show that the practices of 3Rs in Nigeria are very poor and almost not practiced at all (Ogunleye & Uzoma, 2019; Ifeoluwa, 2019; Molina & Catan, 2021). Factors such as rapid urbanization, overpopulation, industrial revolution, perception of the people, failure of government and its agencies, poor government policies, lack of awareness, and rural-urban migration (Ezechi et al, 2017). According to Bakare (2016), Nigeria is one of the biggest producers of waste in Africa; of the 32 million metric tonnes of rubbish produced annually, only 20–30% are collected, and 70% are disposed of in hazardous locations, and of this amount, 2.5 million tonnes are plastic waste. More concerning is the Funmilayo (2023) report, which ranked Nigeria among the 30 nations with the worst waste management practices globally out of 180.

Without widespread implementation of the 3Rs in environmental education, students may not fully understand the significance of these practices in addressing the global waste crisis. Moreover, the absence of effective educational initiatives may hinder the ability of future generations to adopt sustainable behaviours and contribute to the solution. This research seeks to address these gaps by determining;

1. the most common waste management practice?
2. students' awareness of the 3Rs waste management practice?
3. the barriers to the effective adoption of 3Rs waste management practices among students?
4. how can institutions promote the adoption of the 3Rs waste management among students?

1.1. Theoretical Framework

The theory of Value-Belief-Norm (VBN), propounded by Stern (2000), guided the study. The theory focuses on the psychological factors that influence individuals' environmentally friendly actions. According to the VBN theory, people who appreciate the environment are more likely to have eco-friendly ideas and behaviours. Stern comes to the conclusion that people who have strong environmental values are more likely to develop favourable attitudes about the effects of their behaviour and to establish personal rules that encourage ecologically friendly behaviour. The theory is applicable to this study because it revealed that students with good perception and awareness about environmental sustainability have a good culture of proper WM and understand the consequences of poor disposal of waste.

2. METHODS

2.1. Research Design

The research deployed descriptive survey designs. A survey research design is one in which a group of people or items is studied by collecting and analysing data from only a part considered to be representative of the entire group. The design is appropriate because it gives a clearer understanding of the phenomenon and answers the research questions.

2.2. Area of Study

The area of the study was the Nsukka Local Government Area of Enugu state, and was conducted at the University of Nigeria, Nsukka. The area was chosen for the study due to the high level of poor waste management obviously witnessed on the campus.

2.3. Population

The population of the study comprised 333 (84 male, 249 female) undergraduate Biology education students. All were purposively sampled to take part in the study as the population was deemed manageable.

2.4. Instrument

The researchers developed an instrument titled Questionnaire on Waste Management (QWM), which was utilized for data collection. QWM has two parts; part A contains participants' biodata, while part B of the instrument contains 13 items in sub-parts to address each of the research questions with a 4-point Likert scale that has scores of 4 to 1, with the exception of item 1.

The instruments were duly validated by three science education experts. They were given the purpose of the study and the research questions, along with the instrument, for face and content validation. Their corrections, suggestions, and recommendations helped to standardize the final draft of the instrument. The reliability coefficient value of 0.81 was observed using the Cronbach alpha technique. The choice of Cronbach's alpha was because the items were polytomously scored.

2.5. Procedure

To obtain data for the study, the researcher first obtained permission from the head of the department to be able to administer the instrument to the students. After obtaining the permission, a consent form was given to the students to fill out, indicating their willingness to participate in the study. The questionnaire was then administered by the researchers, with the help of two lecturers in the department who acted as research assistants during the study, and was retrieved from them on the spot to ensure a high return.

2.6. Data Analysis

Data obtained from the students were analysed using SPSS version 23. Hence, research question one was answered using percentages, while others were analysed using mean and standard deviation. The decision rule: question one was answered using a percentage, question two was based on a mean score of 10.00 and above being regarded as aware, otherwise not aware, while research questions three and four were based on a mean score of 2.5 and above as accepted, otherwise rejected.

3. RESULTS

Table 1. Descriptive Statistics of the Most Practiced Waste Management Strategy

S/N	Questionnaire Item	%
1	The most used waste management method	
	a. Open dumping	51.4
	b. Burying	12.8
	c. Burning Composting	19.2
	d. Landfilling	7.7
	e. Incineration	3.8
	f. Reduce, Reuse, and Recycle method (3R)	5.1

Table 1 shows that 51.4% of the students practice open dumping, followed by burning composting 19.2%, burying 12.8%, land filling 7.7%, 3Rs 5.1%, and incineration 3.8%, the least practiced. This implies that students mostly practice open dumping, followed by burning composting, then burying, landfilling, while only 3Rs and incineration represent the least practice in waste management.

Table 2. Descriptive Analysis of Student Awareness of the 3Rs Approach

	N	Mean	Std. Deviation
Awareness	246	13.6410	2.07004
Valid N (listwise)	246		

The result in Table 2 shows the student awareness mean score of 13.62 with a SD of 2.07, which is greater than the 10.0 mean benchmark for the study. The shows that students are aware of the 3Rs approach to waste management. The low SD value of 2.07 shows that students' awareness scores clustered around the mean scores, indicating that the majority of the students are aware.

Table 3. Descriptive Analysis of Barriers to Effective Practices of 3Rs among Students

S/N	Item on Challenges	Mean	SD	Remark
2	The school curriculum is silent on the 3Rs waste management strategy	3.51	.63	Accept
3	Lack of awareness of the need to adopt the 3Rs practice in waste management.	2.66	.69	Accept
4	No incentives to attract students to bring their waste for recycling	3.37	.58	Accept
5	The distance between dumpsites and where the populace lives	3.24	.68	Accept
6	Unavailability of the recycling machine	2.84	.60	Accept
	Grand mean	3.12		Accept

Table 3 shows the mean score of undergraduate students on the barriers to effective practices of 3Rs waste management in UNN. The mean rating of all the item statements was greater than the 2.50 benchmark for the study. Similarly, the items show a grand mean score of 3.12, which is also greater than the 2.50 mean score benchmark for the study, implying that students accept these items as barriers affecting the practices of 3Rs waste management.

Table 4. Descriptive Analysis on How Institutions Can Promote the Practice of 3Rs

S/N	Items on possible solutions	Mean	SD	Remark
7	providing more dumpsite/waste containers within the schools	3.15	.912	Accepted
8	Create more awareness on the importance of environmental education and personal hygiene	2.96	.945	Accepted
9	Incentives should be given to students who bring waste for recycling	3.16	.917	Accepted
10	Dumpsite should be located at a reasonable distance from the populace	3.21	.800	Accepted
11	More environmental concepts should be introduced into the curriculum	3.07	.679	Accepted
12	Enforcement of environmental sanitation day within the school	3.22	.762	Accepted
	Grand mean	3.13		Accept

Table 4 shows the mean score of students on how institutions can promote the practice of 3Rs in UNN. The mean rating of all the items was greater than the 2.50 benchmark for the study. The items show a grand mean score of 3.13, which is also greater than the 2.50 benchmark for the study, indicating that students accept these items as a way institutions could promote the practice of 3Rs as a sustainable waste management strategy in UNN.

4. DISCUSSION

The findings showed that open dumping was found to be the most commonly practiced waste management method among students. Secondly, the findings of the study revealed further that undergraduates, irrespective of gender, are aware of the importance of adopting the 3R waste management approach in UNN. The findings of this study are in agreement with the findings of Molina and Catan (2021), Lad et al. (2020), Sola and Sunny (2019), and Twumasi (2017), who also found that students have

high awareness of their role and responsibilities toward the environment. This could be due to an increase in global awareness of the need to ensure a sustainable environment, which the students, as a part of the global community, aligned themselves with. However, the finding differs from the findings of Anitha (2017) and Ukala and Osuafor (2018), who found that students have low awareness of environmental issues. The inconsistency in findings could be due to differences in the area of study, the population of study, and even the method adopted for the study. It could also be linked to sampling error in the study. As such, it would be hard to establish which findings are more reliable. Furthermore, the differences in findings could also be a result of behavioural change due to increased awareness of environmental issues.

Also, the findings revealed some challenges affecting the adoption of the 3Rs waste management approach, including but not limited to inadequate dumpsites in the area, lack of awareness on the importance of adopting 3Rs, and unavailability of recycling machines, among others. Similarly, the findings found some possible solutions to the challenges, including but not limited to: more dumpsite/waste containers should be provided, environmental education and awareness should be encouraged, and opening of more recycling centers, among others. These findings are in line with the findings of Funmilayo (2023) and Bakare (2016), who also found inadequate dumpsites and a lack of awareness on the importance of adopting 3R among students, as some of the challenges affecting the adoption of the 3R approach. The sync in these research findings reveals the generality of the educational challenges in Nigeria, and the desire to see the Nigerian government do better in terms of educational funding.

5. CONCLUSION

The Reduce, Reuse, and Recycle (3Rs) approach is a sustainable and effective waste management strategy that aligns with environmental education principles. By integrating the 3Rs into learning institutions, individuals can develop environmentally responsible behaviour that contributes to waste reduction, resource conservation, and pollution control. Although students are aware of the importance of adopting 3R waste management, the success of its implementation depends on increased awareness, infrastructure development, policy support, and community engagement. Through a collective effort, the 3Rs can play a significant role in achieving a cleaner and more sustainable environment, thereby reducing risk to lives and assuring a clean and healthy environment for present and future generations.

Note: An environmentally aware citizenry, along with a leadership with willpower, would ensure that wastes are properly managed, thereby reducing health risk and assuring a clean and healthy environment for present and future generations.

The findings of this study have educational implications for educational stakeholders, such as students, lecturers, and policymakers. For the students, it was recommended to have an improved awareness/campaign on 3Rs. Implying that when students gain a deeper understanding of environmental sustainability, it would lead to more responsible waste disposal habits in schools and communities. They would develop life skills, such as problem-solving, critical thinking, and practical skills related to waste management. They would also show a behavioural change, resulting in a long-term positive attitude towards environmental conservation.

For the teachers, they would be encouraged to incorporate 3Rs concepts into other subjects like Basic Science, Social Studies, or Civic Education, making the lessons more relevant and interdisciplinary. They would gain training or attend workshops to enhance their knowledge and delivery of environmental education and sustainable practices.

For the policy makers, especially regarding curriculum development, they would see the need to revise and strengthen environmental education components in the national curriculum to include practical aspects of the 3R principles. They would also see the need to formulate policies that promote waste segregation and install recycling infrastructure within schools (e.g., recycling bins, compost pits). They would also make resources available for environmental clubs, awareness programs, teacher training, and eco-friendly school infrastructure, as well as the need to implement monitoring systems to ensure effective implementation of 3R education at all levels.

6. RECOMMENDATIONS

Researchers make the following recommendations:

1. An awareness program or campaign should be organized by the government and other stakeholders to enlighten the populace on the importance of the 3R approach to waste management.
2. More environmental content should be included in the school curriculum.

Research Ethics. The ethics committee of the institution granted ethical approval (Ref. No. FE/SE/VII/4326) before the commencement of the study. The respondents were presented with an informed consent form to fill out and sign. Also, the authors adhered to the ethical standard specification of the World Medical Association, 2013. The study was consistent with national and international standards for conducting research with human subjects.

Data Availability Statement. All data can be obtained from the corresponding author on request.

Conflicts of Interest. The authors declare that they have no competing/conflict of interests.

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