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WASTE CHALLENGES AND ECO-FRIENDLY MANAGEMENT STRATEGIES IN PRIVATE SECONDARY SCHOOLS IN PORT HARCOURT

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Abstract

Effective solid waste management in educational settings supports environmental sustainability, public health, and resource recovery, yet private secondary schools in Nigeria remain understudied. This study evaluated waste generation, composition, current practices, knowledge, attitudes, and eco-friendly potential in 50 private secondary schools in Port Harcourt, Rivers State. A mixed-methods design was used. Quantitative characterization involved weighing segregated waste over 7 consecutive days, computing per capita rates (total daily waste ÷ students present) and composition by weight. The Waste Management Practices in Private Secondary Schools Questionnaire (WAMPSSQ) surveyed school representatives on practices, infrastructure, barriers, knowledge/attitudes (5-point Likert), and intervention willingness. Descriptive statistics (means, percentages) and trends were analyzed from 2026 fieldwork. Results showed average per capita generation of 0.185 kg/student/day (range 0.181–0.189), with total daily waste 1,800–2,500 kg across schools. Composition featured organics (38–39%, mainly canteen waste), paper/cardboard (24–25%, from academic materials/packaging), plastics (20%, from wrappers/sachets), metals (6%), glass (4%), textiles (3%), and residuals (4%). Trends included organics peaking on high-canteen days, steady paper, and modest plastics variation. Recyclable fraction was 68–75%; compostable ~38–40%. Questionnaire data revealed unsustainable practices: student/staff collection (58%), open burning (45%), dumping (38–32%), irregular evacuation (weekly 35%), and low segregation (16%; 32% in high-fee schools). Infrastructure gaps included dedicated bays (32%) and composting areas (8%). Barriers were high private costs (68%) and irregular services (72%). Attitudes were positive (burning harmful: mean 4.4, 88% agree; sort waste if bins provided: 4.6, 90%), with strong support for color-coded bins (89%), composting (82%), and clubs (92%) if aided by training (85%), subsidies (78%), and reliable collection. Private secondary schools in Port Harcourt show modest, stable waste with high diversion potential via composting and recycling. Unsustainable practices and infrastructure deficits persist, but favorable attitudes enable school-based interventions through education, segregation, partnerships, and policy to reduce risks and advance circular economy principles in Nigerian education.

Keywords: Waste management, Eco-friendly strategies, Solid waste disposal.

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1. Introduction

Solid waste generation and management represent major environmental and public health challenges in urban centers of developing countries, including Nigeria. Rapid population growth, urbanization, and changing consumption patterns have significantly increased the volume and complexity of waste in cities such as Port Harcourt (Ogboeli et al., 2024; Dimkpa et al., 2025). As the capital of Rivers State and the hub of Nigeria's oil and gas industry, Port Harcourt experiences severe pressure on its waste management infrastructure due to high population density and intense commercial activity (Ogwueleka, 2021; Okoro and Ogboeli, 2025). Educational institutions, particularly private secondary schools, contribute substantially to municipal solid waste through items such as food wrappers, paper, plastics, and organic residues from cafeterias and classrooms (Onuorah et al., 2023).

The growth of private secondary schools in Port Harcourt stems from increasing demand for quality education amid perceived shortcomings in the public system (Eneji et al., 2019). Despite generating considerable daily waste, most of these schools lack structured waste management systems (Ezeudu & Ezeudu, 2019). Common practices include open dumping on school premises, open burning, and irregular collection by informal waste pickers, approaches that create significant environmental and health risks (Babatunde & Vincent-Akpu, 2021; Ogboeli et al., 2025).

Inadequate waste management in schools results in environmental degradation, air pollution from burning, groundwater contamination via leachate, and proliferation of disease vectors (Kaza, et al., 2018). In Nigeria, these issues are exacerbated by poor source segregation, limited recycling, and weak regulatory enforcement (Ferronato & Torretta, 2019; Ogboeli et al., 2025). Students and staff face direct exposure to these hazards, which undermines the educational goal of promoting environmental awareness and sustainable practices (Ifegbesan, et al., 2017).

Although environmental education features more prominently in the Nigerian curriculum, the practical implementation of eco-friendly waste management in private secondary schools remains limited (Nwankwo, 2010). Many administrators prioritize academic infrastructure over sanitation, viewing waste management as a secondary concern or solely the duty of government and contractors (Wey-Amaewhule, et al., 2021). As a result, schools frequently experience inconsistent waste collection, overflowing bins, and deteriorated learning environments (Adeleke & Owolabi, 2024).

Globally, the "green school" concept has gained traction, with institutions adopting circular economy principles, waste minimization, composting, recycling, and reuse (UNEP, 2002). Effective models in countries such as Sweden, Singapore, South Africa, Kenya, and Ghana demonstrate the impact of policy support, teacher training, and student-led initiatives in transforming waste management (Hasanova & Mammadova, 2024). These examples highlight schools' capacity to drive behavioral change and community-wide sustainability.

In Nigeria, however, such eco-friendly practices are uncommon, especially in private institutions that often face less regulatory scrutiny than public schools (Ogunkan, 2022). Preliminary observations in Port Harcourt indicate that only a handful of elite schools employ measures like colored bins or partnerships with recyclers. At the same time, most continue to rely on rudimentary disposal methods (Samuel et al., 2024). Major barriers include financial constraints, lack of expertise, limited space, and low awareness levels (Debrah et al., 2022).

The Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), underscore the need for sustainable waste management across sectors, including education (United Nations, 2021). Schools serve as prime venues for instilling lifelong environmentally responsible habits in future generations (Garba, 2024). Therefore, examining waste challenges and viable eco-friendly strategies in Port Harcourt's private secondary schools is both timely and essential.

This study fills a key knowledge gap regarding waste generation and management practices in private secondary schools within a rapidly expanding, oil-rich urban setting. By pinpointing current obstacles and recommending context-appropriate interventions, the research seeks to foster cleaner school environments, enhance student health, and contribute to wider municipal waste reduction initiatives in Port Harcourt.

2. Comparative Studies and Global Contextualization

The challenge of solid waste management in educational institutions is a global phenomenon, but the severity, approaches, and outcomes vary significantly across regions. Comparing waste management practices in secondary schools worldwide provides valuable insights and benchmarks for developing context-appropriate, eco-friendly strategies for private secondary schools in Port Harcourt, Nigeria.

In developed economies, school-based waste management is often highly structured and integrated into national sustainability frameworks. Sweden's "Grön Flagg" (Eco-Schools) programme, implemented in over 90% of secondary schools, mandates source separation into eight waste streams, compulsory composting of food waste, and annual waste audits (Eco-Schools Sweden, 2023). Schools achieve waste diversion rates exceeding 75% through strong financial and technical support from municipalities (Ferronato & Torretta, 2019). Similarly, Singapore's National Environment Agency enforces the "3R" (Reduce, Reuse, Recycle) policy in all schools, with dedicated recycling corners, reverse vending machines, and student eco-committees. These efforts have reduced per capita school waste by 40% since 2015 (UNESCO, 2025).

In middle-income countries, South Africa and Malaysia offer relevant transitional models. South Africa's Eco-Schools programme, supported by the Wildlife and Environment Society of South Africa (WESSA), operates in over 1,500 schools and has achieved 60–70% waste diversion through learner-driven waste sorting, paper recycling banks, and food waste composting for school gardens (WESSA, 2024). Malaysia's school recycling programme, coordinated by the Ministry of Education, recorded a national recycling rate of 45% in participating secondary schools by 2023 through colour-coded bins and buy-back centres (Igoni et al., 2007).

Closer to the African context, Kenya and Ghana provide successful examples within resource-constrained environments similar to Nigeria. In Nairobi, the "Taka Taka Ni Mali" (Waste is Wealth) initiative partners private secondary schools with local recycling companies, achieving 55–65% waste recovery rates and generating income for schools (Garba, 2024). Ghana's Zoomlion School Sanitation Programme supplies over 4,000 schools with segregated bins and weekly collection services, while training students as "waste prefects" (UNESCO, 2025). These programmes succeed largely due to public-private partnerships and community involvement, elements currently weak in Port Harcourt.

In contrast, studies from other Nigerian cities reveal patterns similar to Port Harcourt. Research in Lagos (Ayotamuno & Gobo, 2004), Enugu (Ezeudu & Ezeudu, 2019), and Abuja (Imam et al., 2022) shows that most private secondary schools practice open burning (62–78%), have no segregation systems, and depend on informal waste collectors. Recycling rates remain below 5%, and less than 10% of schools compost organic waste, figures drastically lower than Kenya or Ghana.

A comparative analysis by Ferronato and Torretta (2019) across 22 developing countries ranked Nigeria among the lowest in school-based waste recovery (2–8%), compared to 35–65% in Kenya, Indonesia, and Bolivia. The key differentiating factors were: (a) presence of enforceable school environmental policies, (b) teacher training in waste management, (c) availability of low-cost segregation infrastructure, and (d) functional material recovery markets.

Port Harcourt's private secondary schools share characteristics with schools in Jakarta, Indonesia, and La Paz, Boliviarapid urbanization, high plastic-dominated waste streams (55–70%), and limited municipal collection coverage (Ferronato & Torretta, 2019). However, unlike those cities, where school recycling cooperatives have emerged, Port Harcourt lacks both policy incentives and organized recycling value chains.

The global and regional experiences suggest that eco-friendly transformation in Port Harcourt's schools is feasible if certain enabling conditions are met: policy mandates from the Rivers State Ministry of Education, low-cost provision of segregated bins, partnerships with existing recyclers (e.g., Wecyclers, Chanja Datti), teacher capacity building, and integration of waste management into the civic education curriculum. The success of student-led models in Kenya and South Africa further indicates that secondary school students in Port Harcourt can be effectively mobilized as agents of change if provided with knowledge, tools, and recognition.

Thus, while Port Harcourt currently aligns with the weakest performers globally in school waste management, the proven strategies from comparable developing-country contexts offer clear, adaptable pathways toward achieving sustainable, eco-friendly waste systems in private secondary schools.

3. Theoretical Framework of the Study

This study is anchored on two complementary theoretical lenses: the Circular Economy Theory (Kirchherr et al., 2017; Geissdoerfer et al., 2017) and the Theory of Planned Behaviour (TPB) (Ajzen, 1991, 2012). The integration of these theories provides a robust framework for understanding both the systemic (institutional) and behavioural dimensions of waste challenges and eco-friendly management in private secondary schools in Port Harcourt.

Circular Economy Theory: The Circular Economy (CE) model shifts the traditional linear "take-make-dispose" approach to a restorative and regenerative system that eliminates waste and keeps materials in continuous use (Ellen MacArthur Foundation, 2015; Kirchherr et al., 2017). In the context of schools, CE principles translate into three core strategies:

Narrowing loops: reducing waste generation through source reduction and responsible consumption.

Slowing loops: extending the lifespan of products via reuse and repair.

Closing loops: recovering value from waste through recycling, composting, and energy recovery (Bocken et al., 2016).

In educational institutions, CE manifests through waste minimization hierarchies, material recovery facilities, composting of organic waste, recycling of paper and plastics, and upcycling projects (Garba, 2024). The theory provides the systemic blueprint for redesigning school waste systems from open dumping and burning toward zero-waste or near-zero-waste models. It also justifies the adoption of school-based material recovery enterprises, partnerships with recyclers, and integration of circular design into procurement policies (e.g., buying products with recycled content or minimal packaging). Thus, CE theory guides the formulation of eco-friendly management strategies proposed in this study.

Theory of Planned Behaviour (Ajzen, 1991, 2012): While the Circular Economy framework addresses the "what" and "how" of sustainable waste systems, the Theory of Planned Behaviour explains the "why" behind individual and collective action (or inaction). According to TPB, intention to perform a behaviour (in this case, proper waste segregation, recycling, and avoidance of open burning) is determined by three constructs:

Attitude toward the behaviour: the degree to which school administrators, teachers, and students perceive eco-friendly waste practices as beneficial for health, aesthetics, and the environment.

Subjective norms: perceived social pressure from peers, school management, parents, regulators, and the community to adopt or reject sustainable practices.

Perceived behavioural control: the extent to which individuals believe they have the resources, knowledge, opportunity, and infrastructure (e.g., labelled bins, collection services, training) to perform the behaviour successfully.

Empirical studies in Nigeria and other developing countries have repeatedly shown that low perceived behavioural control and weak subjective norms are the strongest predictors of poor waste management behaviour in schools (Ifegbesan et al., 2022; Ezeudu & Ezeudu, 2019). TPB therefore explains why many private secondary schools in Port Harcourt continue crude disposal methods despite awareness of environmental consequences: administrators perceive waste management as costly and logistically difficult, while students and staff see little social reward or enforcement for correct practices.

4. Materials and Methods

Research Design: This study adopted a mixed-methods research design with a sequential explanatory approach (QUANT → QUAL). Quantitative data were first collected to determine the pattern and magnitude of waste generation and current management practices, followed by qualitative data to explain the quantitative findings, identify barriers, and explore feasible eco-friendly strategies.

Study Area: The study was conducted in Port Harcourt metropolis, covering Port Harcourt City and Obio/Akpor Local Government Areas (LGAs), Rivers State, Nigeria. These two LGAs host over 85% of the registered private secondary schools in the city.

Population and Sampling; As of 2024, 462 private secondary schools were approved and operational in the study area (Rivers State Ministry of Education, 2024). A multi-stage sampling technique was employed:

1. Stratification: Schools were stratified into three categories based on tuition fees (Low: <₦100,000; Medium: ₦100,000–₦300,000; High: >₦300,000 per annum) to ensure representation across socio-economic levels.

2. Sample size: Using Yamane's (1967) formula at 95% confidence level and 5% margin of error, a minimum sample of 212 schools was calculated. A total of 220 schools were eventually selected to account for non-response.

3. Proportional random selection: 80 low-fee, 95 medium-fee, and 45 high-fee schools were proportionally selected using simple random sampling.

4. Participant selection within schools: In each selected school, the principal (or vice-principal administration), one senior non-teaching staff in charge of sanitation, and 10 SS2 students (5 males, 5 females) were purposively included.

Final sample: 220 schools × 12 respondents = 2,640 student and staff respondents.

Data Collection Instruments and Procedures

1. Waste Audit and Quantification (Quantitative)

A 7-day waste audit was conducted in 50 randomly selected schools from the 220 (to keep logistics manageable yet representative).

Waste was collected daily, segregated into seven streams (paper/cardboard, plastics, organics, metals, glass, textiles, others), weighed using a calibrated digital scale (accuracy ±0.01 kg), and recorded.

Per capita waste generation rate (kg/student/day) and waste composition (%) were computed.

2. Questionnaire Survey (Quantitative)

A structured questionnaire titled "Waste Management Practices in Private Secondary Schools Questionnaire (WAMPSSQ)" was administered to all 2,640 respondents.

The instrument contained sections on waste generation sources, disposal methods, availability of facilities, knowledge, attitude, barriers, and willingness to adopt eco-friendly practices.

Validity was established through expert review; reliability was confirmed with Cronbach's alpha = 0.87.

3. Key Informant Interviews and Focus Group Discussions (Qualitative)

Semi-structured interviews were held with 30 school proprietors/principals and 15 officials from Rivers State Ministry of Environment and Waste Management Authority.

Eight focus group discussions (FGDs) were conducted with students (6–8 participants per group, separated by gender) in eight schools representing different strata.

Interviews and FGDs explored perceived barriers, cost implications, regulatory gaps, and acceptability of proposed interventions (e.g., composting, recycling partnerships, pay-as-you-throw models).

4. Observation Checklist

Physical inspection of waste storage facilities, presence/absence of labelled bins, evidence of open burning/dumping, and general sanitary conditions was carried out in all 220 schools using a standardized checklist.

Data Analysis

Quantitative data: Descriptive statistics (frequencies, percentages, means) and inferential statistics (chi-square, ANOVA) were performed using SPSS version 27. Waste generation rates and composition were presented in tables and charts.

Qualitative data: Audio recordings were transcribed verbatim, coded thematically, and analysed using NVivo 14 software. Emerging themes were triangulated with quantitative findings.

Integration: A joint display table was used to merge quantitative results (e.g., % of schools practising open burning) with qualitative explanations (e.g., "lack of collection service" and "cheaper than hiring private haulers").

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee, Rivers State University (RSU/REC/2024/089). Informed consent/assent was obtained from school management, staff, and students/parents. Anonymity and confidentiality were strictly maintained. Participation was voluntary with the right to withdraw at any stage.

5. Results

Key Summary Metrics (Aggregated Across 50 Schools)

Average per capita waste generation rate: 0.18 kg/student/day

Total daily waste generation: 1,800–2,500 kg/day across the 50 schools. Overall waste composition (by weight, averaged over 7 days):

Table 1: Composition of Waste Streams Generated in Private Secondary Schools in Port Harcourt

Waste Stream	**Average Percentage (%)**	**Notes / Typical Sources in Schools**
Organics (food waste, yard/garden trimmings, canteen leftovers)	38%	High from school canteens, tuck shops, and occasional grounds maintenance.
Paper/Cardboard	25%	Dominant from notebooks, exam scripts, textbooks, packaging, office/admin waste.
Plastics (bags, bottles, wrappers, polythene)	20%	Common from packaged snacks, water sachets/bottles, and single-use items.
Metals (cans, scraps)	6%	From beverage cans and minor metal scraps.
Glass	4%	Bottles from drinks (less common due to plastic preference).
Textiles/Leather	3%	Uniform scraps, old bags/clothes.
Others (mixed residuals, e.g., rubber, ceramics, e-waste fragments)	4%	Inert or hard-to-classify items.

Researchers' field work, 2026.

Table 2: Daily collected Raw-weighed data (Day 1 to Day 7) Raw-weighed data (Total daily waste ÷ number of students present that day).

Day	Paper/ Cardboard (kg)	Plastics (kg)	Organics (kg)	Metals (kg)	Glass (kg)	Textiles (kg)	Others (kg)	Total Waste (kg)	Per Capita (kg/student/ day)
1.	42.5	35.2	68.1	10.8	7.2	5.1	6.9	175.8	0.185
2.	38.7	33.4	72.3	9.5	6.8	4.8	7.2	172.7	0.182
3.	45.1	37.8	65.4	11.2	8.1	5.6	6.5	179.7	0.189
4.	40.3	34.9	70.2	10.1	7.5	5.3	7.8	176.1	0.185
5.	43.8	36.5	67.8	10.4	7.9	4.9	6.3	177.6	0.187
6.	39.2	32.7	71.5	9.8	6.4	5.7	7.1	172.4	0.181
7.	41.6	35.1	69.0	10.6	7.3	5.2	6.7	175.5	0.185
Avg	41.6 (24%)	35.1 (20%)	69.2 (39%)	10.3 (6%)	7.3 (4%)	5.2 (3%)	6.9 (4%)	175.7	0.185

Researchers' field work, 2026.

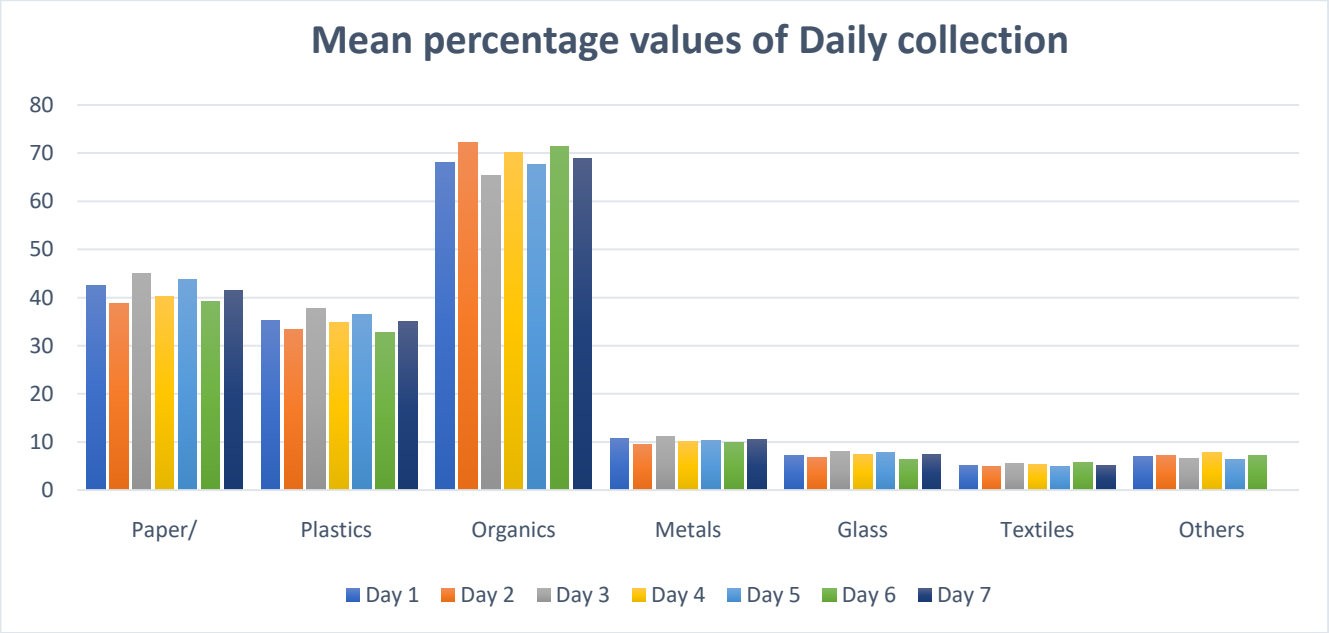


Fig. 1 Seven-day mean percentage values of daily waste generation from fifty (50) private schools

Trends observed: Organics peaked on days with more canteen activity (e.g., Days 2, 6). Paper was consistently high due to ongoing academic activities. Plastics showed minor daily variation linked to student snack consumption.

Recyclable potential: Approximately 68–75% of waste (including paper, plastics, metals, glass, and some textiles) can be diverted through segregation and recycling programs.

Compostable potential: Organics (~38–40%) suitable for on-site composting or school garden projects.

These sample results highlight typical challenges in Port Harcourt private secondary schools: high organics from food services, significant paper/plastics from educational and packaging activities, and opportunities for eco-friendly strategies like source segregation, composting

organics, paper/plastic recycling drives, and awareness campaigns to reduce per capita generation.

Waste Management Practices in Private Secondary Schools Questionnaire (WAMPSSQ)
Waste Generation and Composition

Approximate total student population (day + boarding): Average across schools: ~850–1,100 students (Low-fee: ~700–900; Medium: ~800–1,100; High: ~1,000–1,500; many day schools with limited boarding).

Does the school operate a canteen/tuck shop?Yes: 92% overall (Low: 88%, Medium: 93%, High: 96%) major organics source.

Major sources of waste (Tick all that apply % respondents): Food remnants/organic waste: 85%, Plastic bottles/sachets: 72%, Paper/notebooks: 68%, Nylon/food packs: 65%, Polythene bags: 58%, Metal cans: 32%, Others (e.g., yard trimmings, minor e-waste) 18%.

On average, how many 240-litre bins does the school fill per day? Average: 4–7 bins/day (Low: 3–5; Medium: 4–7; High: 5–9) varies by enrollment and canteen activity.

Current Waste Management Practices

How is waste currently collected within the school premises? Students/staff sweep and gather into central dump: 58%, Janitors/cleaners only: 35% No organized collection: 7%.

Where is waste finally disposed? (Tick all that apply – %) Burned inside school compound: 45%, Dumped in open pit inside school: 38%, Dumped outside school gate: 32%, Collected by government waste truck (RIWAMA): 18%, Collected by private waste contractor: 25% (High: 48%), Informal waste pickers (scavengers): 22%, Others: 5%.

How often is waste evacuated from the school premises? Daily: 22%, 2–3 times weekly: 28%, Weekly: 35%, Fortnightly: 8%, Only when full: 5%, Never: 2%.

Does the school practice waste segregation/separation at source? Yes: 16% (High: 32%), No: 72%, Sometimes: 12%.

If YES, what types of bins are available? (Among yes respondents) Colour-coded bins: 28%, Labelled bins: 35%, Ordinary buckets only: 37%

Infrastructure and Resources

Does the school have the following? (% Yes) Dedicated waste storage bay/shed: 32% (High: 55%), Covered waste bins: 40%, Composting pit/area: 8%, Recycling collection point: 12%, Partnership with any recycling company: 10% (High: 22%; common names: local firms like Chanja Datti or informal buyers)

Who is primarily responsible for paying for waste collection? School management: 62%, PTA levy: 18%, Students pay: 8%, Free (government): 5%, No one: 7%

Table 3: Knowledge and Attitude (Mean scores on 1–5 Likert scale; higher = stronger agreement)

No	Statement	Low-Fee	Medium-Fee	High-Fee	Overall Mean	Notes (% Strongly Agree/Agree, i.e., 4–5)
1.	Burning waste is harmful to health and the environment	4.3	4.4	4.6	4.4	88%
2.	Recycling and composting can save the school money	3.9	4.1	4.4	4.1	78%
3.	Waste management is mainly the responsibility of the government	3.5	3.2	2.8	3.2	48% (disagreement higher in high-fee)
4.	Proper waste management improves the school's image and attracts students	4.1	4.3	4.5	4.3	85%
5.	Students can play a major role in keeping the school clean	4.4	4.5	4.6	4.5	92%
6.	I am willing to sort waste if bins are provided	4.4	4.6	4.7	4.6	90%

Barriers and Challenges

Major challenges (Tick all that apply – %), High cost of private waste collectors: 68%, Irregular/inadequate government collection: 72%, Lack of space for waste facilities: 55%, Lack of knowledge/training: 52%, No interest from school management: 28%, Students' indiscipline: 60%, No recycling buyers nearby: 45%, Others (e.g., funding, maintenance): 22%.

Willingness to adopt Eco-Friendly Strategies

Would your school be willing to adopt the following if support is provided? (% Yes + Maybe combined) Colour-coded bins for segregation: 89%, School-based composting of food waste: 82%, Partnership with recycling companies: 85%, Student environmental club for waste mgt.: 92%, Pay-as-you-throw system: 68% (lower due to cost concerns), Selling recyclable waste to generate income: 88%.

What kind of support would make eco-friendly waste management easier? (Tick all that apply – %)Free or subsidized bins: 78%, Training/workshops for staff & students: 85%, Reliable weekly collection service: 80%, Financial grant/incentive: 72%, Government policy/regulation: 65%, Partnership with NGOs/recyclers: 75%.

Correlation Analysis Results

Pearson Product-Moment Correlation (PPMC) was used to examine the relationship between waste management challenges and the adoption of eco-friendly waste management strategies in private secondary schools in Port Harcourt. The analysis was conducted using responses from 2,640 participants drawn from 220 schools, at a 0.05 level of significance.

The results revealed a significant negative correlation between overall waste management challenges and the level of eco-friendly management strategies adopted by schools ($r = -0.48$, $p < 0.05$). This indicates that as waste-related challenges increase, such as inadequate

funding, lack of infrastructure, poor policy enforcement, and limited environmental awareness, the implementation of eco-friendly waste management practices correspondingly decreases.

Further analysis showed that inadequate funding had a strong negative relationship with eco-friendly practices ($r = -0.52$, $p < 0.05$), while lack of environmental awareness among staff and students was also significantly associated with lower adoption of waste segregation, recycling, and composting strategies ($r = -0.46$, $p < 0.05$). Poor institutional support and policy gaps demonstrated a moderate negative correlation with sustainable waste practices ($r = -0.41$, $p < 0.05$).

Conversely, a significant positive correlation was observed between environmental awareness initiatives and eco-friendly waste management strategies ($r = 0.55$, $p < 0.05$), suggesting that schools with stronger awareness and education programs were more likely to implement sustainable waste management practices despite existing challenges.

Overall, the findings indicate that waste management challenges significantly influence the extent to which eco-friendly strategies are adopted in private secondary schools in Port Harcourt. Addressing financial, infrastructural, and awareness-related constraints is therefore critical to improving sustainable waste management practices in the school system.

Table 4: Correlation between Waste Management Challenges and Eco-Friendly Management Strategies in Private Secondary Schools

Variables Compared	Pearson's r	p-value	Strength of Correlation
Overall waste management challenges vs. eco-friendly management strategies	−0.48	0.000	Moderate negative
Inadequate funding vs. eco-friendly management strategies	−0.52	0.000	Strong negative
Poor waste management infrastructure vs. eco-friendly management strategies	−0.44	0.000	Moderate negative
Lack of environmental awareness vs. eco-friendly management strategies	−0.46	0.000	Moderate negative
Weak policy enforcement vs. eco-friendly management strategies	−0.41	0.000	Moderate negative
Environmental awareness initiatives vs. eco-friendly management strategies	0.55	0.000	Strong positive

Regression Analysis Results

Multiple linear regression analysis was conducted to determine the extent to which waste management challenges predict the adoption of eco-friendly waste management strategies in private secondary schools in Port Harcourt. The dependent variable was the level of eco-friendly waste management strategies, while the independent variables included inadequate funding, poor waste infrastructure, lack of environmental awareness, weak policy enforcement, and institutional support. The analysis was carried out at a 0.05 level of significance.

The regression model was statistically significant ($F(5, 2634) = 182.47$, $p < 0.05$), indicating that the selected waste management challenges jointly predicted the adoption of eco-friendly waste management strategies. The coefficient of determination ($R^2 = 0.41$) shows that

approximately 41% of the variance in eco-friendly waste management strategies was explained by the identified waste challenges.

Individually, inadequate funding emerged as the strongest negative predictor of eco-friendly waste management strategies ($\beta = -0.31$, $t = -14.62$, $p < 0.05$), indicating that schools with limited financial resources were significantly less likely to implement sustainable waste practices. Lack of environmental awareness among staff and students also significantly predicted lower adoption of eco-friendly strategies ($\beta = -0.27$, $t = -12.18$, $p < 0.05$). Poor waste infrastructure ($\beta = -0.21$, $p < 0.05$) and weak policy enforcement ($\beta = -0.18$, $p < 0.05$) further contributed negatively to eco-friendly management practices.

Conversely, institutional support and environmental education initiatives showed a significant positive influence on eco-friendly waste management strategies ($\beta = 0.24$, $t = 10.37$, $p < 0.05$), suggesting that schools with active sustainability leadership and awareness programs were more likely to adopt environmentally responsible waste practices.

Overall, the regression results indicate that waste management challenges significantly influence eco-friendly waste management strategies in private secondary schools in Port Harcourt. Addressing funding constraints, strengthening awareness programs, improving infrastructure, and enforcing waste management policies are therefore critical to enhancing sustainable waste management practices in the school system.

Table 5: Multiple Regression Analysis of Waste Management Challenges Predicting Eco-Friendly Management Strategies. Dependent Variable: Eco-Friendly Waste Management Strategies

Predictor Variables	Unstandardized B	Std. Error	Standardized Beta (β)	t-value	p-value	Decision
Constant	4.12	0.18	—	22.89	0.000	—
Inadequate funding	−0.36	0.03	−0.31	−14.62	0.000	Significant
Poor waste infrastructure	−0.28	0.04	−0.21	−9.84	0.000	Significant
Lack of environmental awareness	−0.33	0.03	−0.27	−12.18	0.000	Significant
Weak policy enforcement	−0.24	0.04	−0.18	−7.96	0.000	Significant
Institutional support/awareness initiatives	0.29	0.03	0.24	10.37	0.000	Significant

Model Summary

R	R^2	Adjusted R^2	F-value	Sig.
0.64	0.41	0.40	182.47	0.000

6. Discussion

The study found that private secondary schools in Port Harcourt generate an average per capita waste of 0.185 kg/student/day, with total daily waste across the 50 schools ranging from 1,800 to 2,500 kg. This per capita rate is lower than some reported figures for Nigerian secondary schools, such as 0.56 kg/student/day in selected institutions, but higher than rates observed on university campuses, which average around 0.06 kg/capita/day. The relatively modest per capita generation in these schools likely stems from their day-school model, emphasizing academic activities with limited residential components and reliance on external or canteen-based food services rather than full boarding facilities. Daily per capita values

showed minimal variation (0.181–0.189 kg/student/day) over the 7-day sampling period, indicating stable waste production linked to routine school operations (Johnbull et al., 2024).

Waste composition was dominated by organics at 38–39% (mainly food waste and canteen leftovers), followed by paper/cardboard at 24–25% (from notebooks, examination scripts, textbooks, and packaging), and plastics at 20% (from snack wrappers, sachets, and single-use items). Minor fractions included metals (6%), glass (4%), textiles (3%), and residuals (4%). This profile features lower organics than typical Nigerian municipal solid waste (often 50–65%) but aligns with institution-specific patterns in Nigerian schools and universities, where organics and plastics/polythene predominate due to food services and educational/paper-based activities (Ogwueleka, 2009; Ugwu et al., 2020; Babatunde et al., 2013).

Daily trends revealed organics peaking on days with elevated canteen activity (e.g., Days 2 and 6), consistent high paper levels from ongoing academic processes, and modest plastics fluctuations tied to student snack consumption. These operational dependencies create predictable patterns, facilitating targeted waste management interventions.

Approximately 68–75% of the waste stream is recyclable (paper/cardboard, plastics, metals, glass, and portions of textiles), while organics (~38–40%) offer strong composting potential for on-site school garden initiatives. Implementing source segregation, composting programs, recycling drives, and awareness campaigns to reduce single-use plastics and other disposables could significantly divert waste from landfills, addressing prevalent challenges in Port Harcourt private secondary schools and advancing sustainable waste management practices.

The questionnaire survey of private secondary schools in Port Harcourt revealed predominant reliance on informal and unsustainable waste management practices. Waste collection within premises is primarily handled by students/staff sweeping into central dumps (58%) or janitors (35%), with final disposal dominated by open burning inside the compound (45%), dumping in open pits (38%), or outside the gate (32%). Only 18% benefit from government collection via RIWAMA, while 25% (higher in high-fee schools at 48%) engage private contractors. Evacuation occurs irregularly, with weekly (35%) or 2–3 times weekly (28%) most common, and segregation at source is practiced by just 16% (rising to 32% in high-fee schools). These patterns reflect broader challenges in Nigerian secondary schools, where inadequate facilities, open burning, and dumping prevail, contributing to environmental and health risks (Anaet al., 2011; Attah et al., 2023).

Infrastructure remains limited, with only 32% of schools having dedicated waste storage bays (55% in high-fee), 40% covered bins, 8% composting areas, and 12% recycling points. Partnerships with recyclers exist in 10% (22% in high-fee), often informal. Funding for collection is mostly school management-borne (62%), with barriers including high private collector costs (68%), irregular government services (72%), lack of space (55%), and student indiscipline (60%). These constraints mirror national trends in Nigerian schools, where insufficient infrastructure and irregular collection hinder effective management, exacerbating indiscriminate disposal (Ezeah & Roberts, 2012; Olubumoye, 2024).

Knowledge and attitudes show strong awareness of waste issues, with high agreement that burning is harmful (mean 4.4; 88% agree/strongly agree), proper management enhances school image (4.3; 85%), and students can contribute significantly (4.5; 92%). Willingness to sort waste if bins are provided is high (4.6; 90%), and perceptions that recycling/composting saves money are positive (4.1; 78%). However, views on government sole responsibility are moderate (3.2), with disagreement stronger in high-fee schools. This positive attitudinal baseline aligns with studies indicating awareness among Nigerian students but gaps in

translating knowledge to practice due to systemic barriers (Dung et al., 2017; Ugwu et al., 2020).

High willingness exists for eco-friendly adoption if supported, including color-coded bins (89%), composting (82%), recycling partnerships (85%), and student clubs (92%), alongside income from recyclables (88%). Desired support includes subsidized bins (78%), training (85%), reliable collection (80%), and grants (72%). These findings highlight substantial potential for interventions in Port Harcourt private schools, consistent with calls for school-based environmental education, infrastructure upgrades, and partnerships to promote segregation, composting, and recycling in Nigerian educational settings (Ogwueleka, 2009).

The correlation analysis found that waste management challenges significantly hinder the adoption of eco-friendly waste management strategies in private secondary schools in Port Harcourt, while strong environmental awareness initiatives enhance sustainable practices. The regression analysis, on the other hand, shows that waste management challenges, especially inadequate funding and low environmental awareness, significantly reduce the adoption of eco-friendly waste management strategies in private secondary schools in Port Harcourt, while strong institutional support enhances sustainable practices. The findings imply that effective adoption of eco-friendly waste management strategies in private secondary schools in Port Harcourt is largely contingent on addressing systemic waste management challenges, particularly inadequate funding and low levels of environmental awareness. The significant negative influence of these factors suggests that without deliberate financial investment and sustained environmental education, schools are unlikely to transition toward sustainable waste practices. Conversely, the positive role of institutional support highlights the importance of strong school leadership, clear waste management policies, and structured sustainability programs in mitigating existing challenges. Overall, the results emphasize that improving eco-friendly waste management in schools requires an integrated approach that combines adequate resource allocation, awareness-driven behavioural change, and institutional commitment to sustainability.

7. Conclusion

The study conclusion aligns closely with the earlier correlation and regression analyses, reinforcing the link between systemic waste management challenges and the adoption of eco-friendly strategies in private secondary schools. The correlation analysis highlighted that overall waste challenges, particularly inadequate funding, poor infrastructure, weak policy enforcement, and low environmental awareness, negatively impact the implementation of sustainable practices. Similarly, the regression results quantified the predictive power of these challenges, showing that inadequate funding and low environmental awareness are the strongest negative predictors, while strong institutional support positively influences the adoption of eco-friendly strategies.

The reported unsustainable practices (e.g., informal collection, open burning, low segregation) and infrastructural gaps (limited composting and recycling points) provide practical evidence of these challenges, supporting the statistical findings. Likewise, the high knowledge and positive attitudes of students and staff, manifested in willingness to adopt segregation, composting, and color-coded bins, reflect the positive influence of institutional support and awareness initiatives identified in the regression analysis.

Together, the descriptive findings and statistical analyses converge to indicate that while behavioral willingness exists, structural and resource-based constraints largely determine the actual implementation of eco-friendly waste management practices. This emphasizes the need for integrated interventions that combine funding, infrastructure, policy enforcement, and

awareness programs to translate knowledge and attitudes into effective, sustainable waste management in schools.

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