

# Comparative Analysis of Solid Waste Management Practices towards Zero-Waste in Food and Beverage Companies in Nigeria

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## ABSTRACT

*This study evaluated and compared solid waste management practices towards zero-waste in food and beverage companies in Nigeria. The study focuses on examining solid waste management practices within these manufacturing sectors as part of their journey toward achieving a zero-waste economy. A descriptive survey design was used, with 125 employees each from Company A and Company B as the sample size. Data analysis was conducted using descriptive statistics and statistical tools like Anova and Kruskal-Wallis. The study found that a significant relationship existed between infrastructure, technological innovations, and investment to enhance zero-waste management. The hypothesis that there was no significant difference in awareness or between infrastructural and technological innovations and investment was rejected. Recommendations included waste segregation, clearly labelling bins for different waste types, establishing recycling programs, encouraging employee and community participation, and exploring alternatives to single-use plastics in packaging. The study concluded that there is a need for companies to prioritize waste segregation and invest in infrastructure to promote a zero-waste economy.*

*Keywords: beverage companies, Kruskal-Wallis, solid waste management practices, Nigeria and zero-waste economy.*

## INTRODUCTION

**M**anufacturing companies frequently generate or use a significant amount of industrial waste during their day-to-day operations; this waste needs to be carefully managed in order to prevent harm to humans and the environment. Manufacturing outfits are continuously faced with a variety of challenges related to waste management. Zero-waste goes beyond just removing waste by recycling, reusing, and reducing it. In order to cut waste, it focuses on limiting production and distribution networks. Zero-waste management, as defined Abayomi and Atinuke (2020), is the conser-

vation of all resources through responsible production, consumption and reuse as well as the recovery of all goods, packaging and materials without burning them or releasing them into the air, water, or land that could endanger human health or the environment (Jegade, 2014). *The Guardian* (6 March 2023) stated that Nigeria's federal government had been urged to outlaw single-use plastic by members of the Global Alliance for Incineration Alternatives (GAIA). The overall efforts to reduce, reuse, redesign and recycle waste materials are how zero-waste is visualized. The goal of zero-waste proclivities is to reduce waste by designing products that do not end up as waste, especially after just one use and to make better use of what humanity produces.

Zero-waste management is a sustainable approach that aims to remove residues and reuse cleared materials and natural resources. It involves the design and implementation of infrastructures for disposal, treatment, and recycling in manufacturing organizations. As environmental concerns continue to rise, eco trends are taking on more significance in the design and manufacturing sectors. These trends, including biophilic design and sustainable materials, are not only beneficial to the environment but can also save costs and increase wellbeing for individuals and businesses. The goal of the zero-waste economy is to produce products with as little waste as possible during the manufacturing process or throughout their entire life cycle. The United Nations Environment Program [UNEP] (2023) calls for the ethical production, use, and disposal of goods in a closed, circular system. Waste prevention is one of the tenets of zero-waste, which includes optimizing the use of materials, using efficient construction methods, and using efficient manufacturing methods. Zero-waste management has become a crucial component in sustainability and corporate social responsibility. Global urbanization facilitates the generation of waste, and inadequate waste management can have detrimental effects on the environment, public health, tourism, productivity, the economy, and flood damage. In 2016, the total amount of waste produced globally was over 2.01 billion tons (Adamu et al., 2020). Solid waste is divided into five categories: special waste (e-waste, medical waste, plastic waste, and construction waste), agricultural, municipal, industrial, and household waste (David et al., 2020). The main financial tools used by solid waste management systems are producer fees, waste tipping fees, product fees, disposal taxes, pollution charges, eco taxes, pollution taxes, and waste generation taxes (Zebnail, 2022). Zero-waste is a waste prevention approach that aims to drastically alter the distribution of raw materials throughout society, reducing waste through recycling, reusing, and reducing it. The European Union [EU] (2023) outlines steps for implementing a zero-waste economy, including design using regenerative materials and modular components, reuse and repair, recycling, and manufacturing.

## METHODS

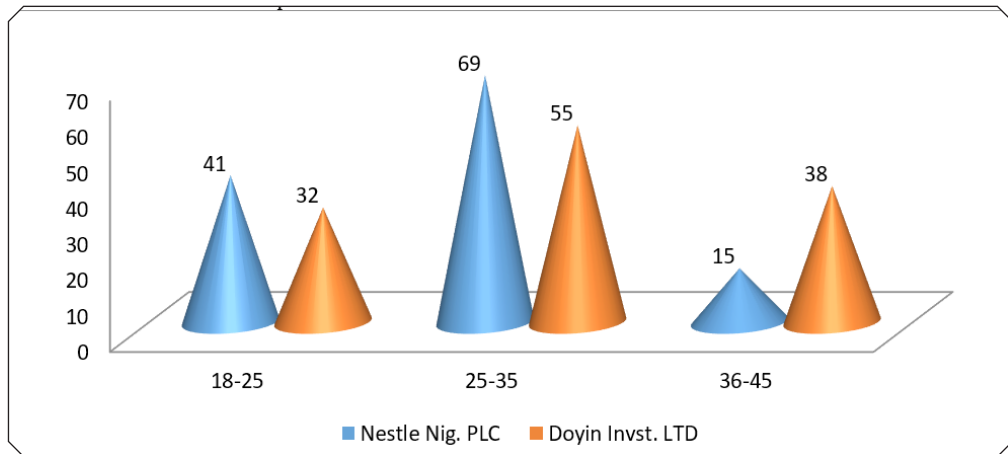
The research study employed structured questionnaires and purposive sampling to gather insights from knowledgeable individuals within the study area. Specifically, the survey focused on two prominent companies in the food and beverage sector: Company A (Nestle Nigeria PLC, Agbara, Ogun State) and Company B (Doyin Investment Ltd.). Company A, a notable food manufacturing and marketing entity listed on the Nigerian Stock Exchange, produces a diverse range of food products, including Maggi, Cerelac, Nutrend, Nan, Lactogen, and Golden Morn. On the other hand, Company B, formerly known as Consolidated Foods and Beverages, operates in food retail, food products, and industrial services, manufacturing items such as noodles, plastic Chinese balm, Maggi under its own label, and Dento MacLean. The study's primary focus was on examining solid waste management practices within these manufacturing sectors as part of their journey toward achieving a zero-waste economy. The case studies of Company A and Company B underscore the critical role of effective waste management in enhancing sustainability within the manufacturing industry (Ash et al., 2023). A few studies on solid waste management have taken zero-waste management practices into consideration, but most have focused on pollution resulting from waste and waste management in relation to food and beverage companies' waste generation and disposal practices (Zaman, 2015). To address gaps in current waste management practices, the initiative proposes implementing a unified model across the organizations. This model prioritizes sustainability by integrating best practices and aims to eliminate duplication, a significant source of waste, while also focusing beyond mere cost reduction on enhancing consumer satisfaction.

The data collected from the study was meticulously presented using tables and charts, facilitating comprehensive analysis through descriptive statistics. Statistical tools such as ANOVA and Kruskal-Wallis tests were employed to discern patterns and variations in waste management practices among the sampled companies. The study utilized face-to-face questionnaires as the primary method for data collection, ensuring direct interaction between the researcher and respondents. All completed questionnaires were carefully collected and analyzed using rigorous statistical methods, including mean, standard deviation, ANOVA, and Kruskal-Wallis, to derive meaningful insights into the current state of solid waste management practices in the manufacturing sector.

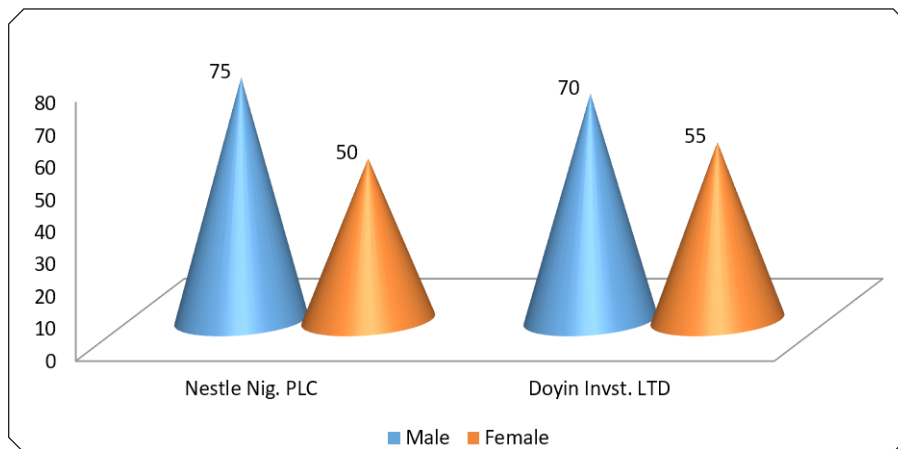
By integrating these findings and recommendations into existing knowledge on solid waste management, the study contributes valuable insights and proposes practical solutions aimed at enhancing sustainability practices within the manufacturing industry. This research not only identifies current gaps but also suggests how these gaps can be effectively addressed to achieve significant advancements in waste management strategies.

## Findings

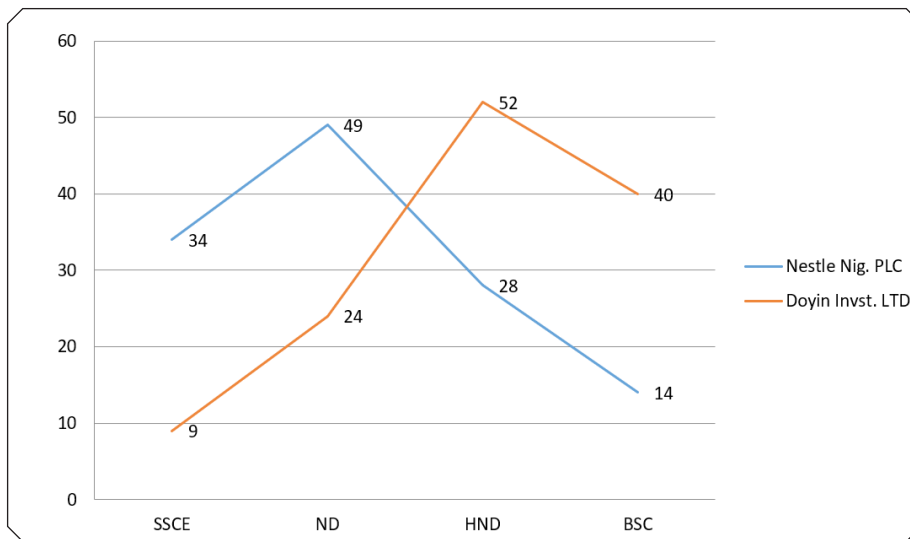
The results obtained are presented in the form of charts and tables and also discussed in this section.



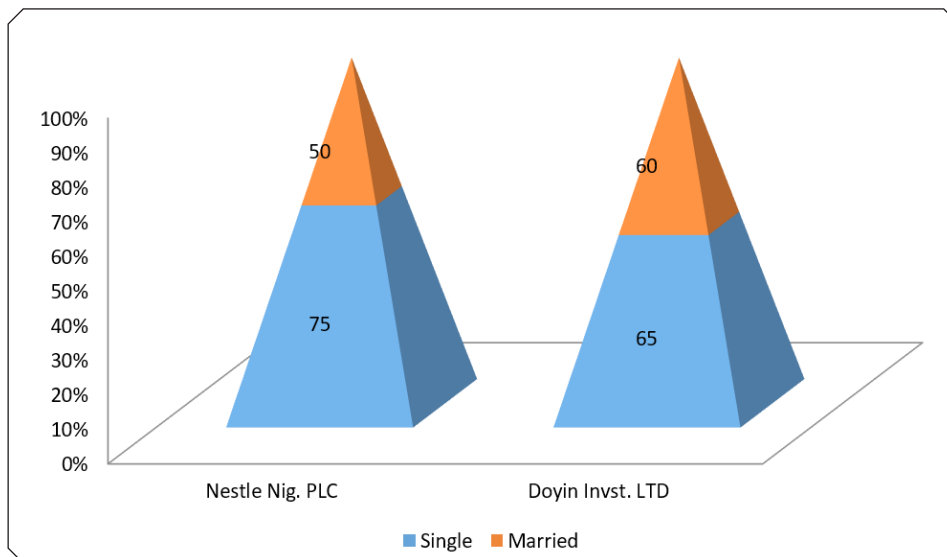
**Fig 3:** Age distribution of the respondents



**Fig 4:** Gender distribution of the respondents



**Fig 5:** *Educational qualification of the respondents*



**Fig 6:** *Marital status of the respondents*

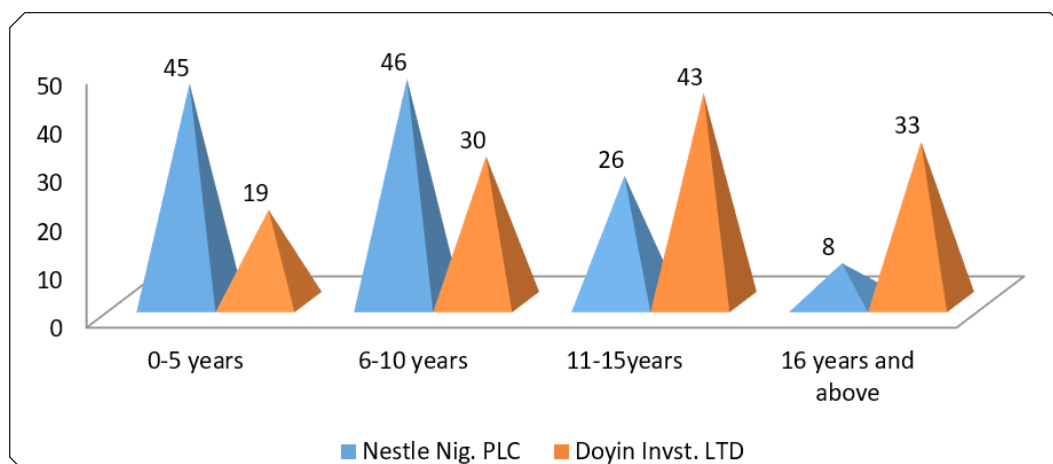


Fig 7: Length of service of respondents

Table 1: Percentage response of the respondents on level of awareness of zero-waste of economy among employees of company A and company B

|   | Statement  | Company A (%) |    |     |     | Company B (%) |      |    |    | Mean  | Std. Dev |
|---|--|---------------|----|-----|-----|---------------|------|----|----|-------|----------|
|   |  | SA            | A  | D   | SD  | SA            | A    | D  | SD |       |          |
| 1 | I am conversant with the zero-waste economy.   | 80            | 20 | 0   | 0   | 50            | 30   | 15 | 5  | 31.25 | 34.88    |
| 2 | Zero-waste refers to waste prevention as opposed to end-of-pipe waste management.        | 60            | 26 | 9.6 | 4.8 | 65            | 25   | 5  | 5  | 31.25 | 30.87    |
| 3 | I understand sustainable consumption and production pattern.                             | 50            | 30 | 5.6 | 15  | 70            | 20   | 5  | 5  | 31.25 | 29.69    |
| 4 | I support the societal shift towards circular economy.                                   | 50            | 40 | 9.6 | 0   | 60            | 30   | 10 | 0  | 31.25 | 29.25    |
| 5 | I am aware of the need to reshape resource supply chain.                                 | 45            | 40 | 9.6 | 5.6 | 40            | 35   | 15 | 10 | 31.25 | 20.49    |
| 6 | Open dumping and incineration is a serious environmental problem.                        | 70            | 20 | 10  | 0   | 60            | 30   | 10 | 0  | 31.25 | 33.25    |
| 7 | Reduction, reuse, recycling and recovery of waste enhances environmental sustainability. | 80            | 20 | 0   | 0   | 70            | 20.2 | 8  | 2  | 31.28 | 40.00    |

Source: Field Survey (2023)

Table 1 above presents the percentage responses from employees of Company A and Company B regarding their level of awareness of the zero-waste economy. The data shows that both Company A and Company B have moderate awareness of sustainable practices, supporting a circular economy. However, Company A has slightly lower awareness than Company B, possibly due to differences in corporate culture, training programs, or communication strategies. Both companies share a common belief in waste reduction, reuse, recycling, and recovery as crucial for environmental sustainability. This suggests that identifying areas of lower awareness could guide targeted training programs or communication strategies to foster a more comprehensive understanding of sustainable waste management practices. Practical recommendations include enhanced training programs, effective internal communication strategies, and monitoring and evaluation mechanisms to continuously improve practices and foster a culture of environmental stewardship. This aligns with Navarro and Vincenzo's (2019) study on waste management in developing countries. The study reveals varying awareness levels among Company A and Company B employees regarding the zero-waste economy concepts.

**Table 2: Percentage response of the respondents on zero-waste management practices embarked upon by company A and company B.**

|   | Statement  | Company A (%) |    |     |     | Company B (%) |      |     |     | Mean  | Std. Dev |
|---|--|---------------|----|-----|-----|---------------|------|-----|-----|-------|----------|
|   |  | SA            | A  | D   | SD  | SA            | A    | D   | SD  |       |          |
| 1 | Zero-waste initiatives foster promote sound waste management.                        | 71            | 20 | 8.8 | 0   | 60            | 30.4 | 9.6 | 0   | 31.25 | 33.95    |
| 2 | It minimizes and prevents excessive waste generation.                                | 80            | 20 | 0   | 0   | 69            | 19.2 | 8   | 4   | 31.25 | 39.48    |
| 3 | Zero-waste initiatives protect the environment and enhance biodiversity.             | 40            | 31 | 20  | 8.8 | 50            | 29.6 | 20  | 0   | 31.25 | 20.42    |
| 4 | It helps to reduce greenhouse gas emissions and combat anthropogenic global warming. | 60            | 30 | 9.6 | 0   | 50            | 40   | 8   | 1.6 | 31.25 | 29.21    |
| 5 | Zero-waste initiatives enhance food security.  | 69            | 31 | 0   | 0   | 60            | 29.6 | 5.6 | 4.8 | 31.25 | 34.19    |

*Source: Field survey (2023)*

**Table 3: Percentage response on infrastructural and technological innovations investments put in place to enhance zero-waste in company A and company B.**

|   | Statement  | Company A (%) |    |     |      | Company B (%) |      |     |      | Mean  | Std. Dev |
|---|--|---------------|----|-----|------|---------------|------|-----|------|-------|----------|
|   |  | SA            | A  | D   | SD   | SA            | A    | D   | SD   |       |          |
| 1 | We use modern techniques known as 5s techniques (sorting, straitening, scrubbing, standardized, sustain).  | 80            | 20 | 0   | 0    | 45            | 40   | 12  | 3    | 31.25 | 35.29    |
| 2 | There are provisions of standardized cleaning tools, for carrying out different operations of any waste materials such as brushes and packer                       | 50            | 28 | 20  | 2.4  | 60            | 25.6 | 9.6 | 4.8  | 31.25 | 25.97    |
| 3 | There is construction of waste transfer station, where all wastes collected are gathered and separated into different chambers                                     | 50            | 30 | 15  | 4    | 50            | 30.4 | 4.8 | 15.2 | 31.25 | 22.90    |
| 4 | We collaborate with suppliers to optimize packaging, transportation, and inventory management processes to reduce waste and promote efficient resource utilization | 47            | 26 | 22  | 5.6  | 50            | 40   | 9.6 | 0    | 31.25 | 24.15    |
| 5 | We invest in energy-efficient technologies and practices to reduce energy consumption and associated waste emissions in manufacturing facilities                   | 70            | 20 | 4.8 | 4.8  | 45            | 40   | 10  | 4.8  | 31.25 | 30.40    |
| 6 | We implement measures to conserve water through efficient usage, reuse, and recycling of water resources within manufacturing operations                           | 50            | 30 | 9.6 | 10.4 | 40            | 29.6 | 20  | 10.4 | 31.25 | 18.90    |
| 7 | We use regenerative materials and modular design techniques  | 44            | 35 | 18  | 2.4  | 60            | 29.6 | 10  | 0    | 31.25 | 26.32    |
| 8 | We us construction of ancient separation techniques SIEVE for separation of mixtures of waste from rework products   | 60            | 22 | 14  | 4    | 70            | 29.6 | 0   | 0    | 31.25 | 33.81    |
| 9 | We use construction of waste transfer disposal station where all the waste collected are sorted out for customers to purchase                                      | 65            | 20 | 9.6 | 5.6  | 55            | 34.4 | 8   | 2.4  | 31.25 | 29.97    |



|    | Statement   | Company A (%) |    |    |     | Company B (%) |    |    |     | Mean  | Std. Dev |
|----|---|---------------|----|----|-----|---------------|----|----|-----|-------|----------|
|    |   | SA            | A  | D  | SD  | SA            | A  | D  | SD  |       |          |
| 10 | We use of modern blending machine to regrind rework products generated from waste | 46            | 40 | 12 | 2.4 | 52            | 28 | 14 | 5.6 | 31.25 | 23.89    |

*STDEV (Standard Deviation). Source: Field Survey (2023)*

**Table 4: Percentage response of the respondents on the impacts of zero-waste initiative on company A and company B towards achieving a zero-waste economy**

|   | Statement   | Company A (%) |    |    |     | Company B (%) |      |     |     | Mean  | Std. dev |
|---|---|---------------|----|----|-----|---------------|------|-----|-----|-------|----------|
|   |   | SA            | A  | D  | SD  | SA            | A    | D   | SD  |       |          |
| 1 | There is insufficient provisions of standardized cleaning tools in the operational system             | 8             | 12 | 32 | 48  | 16            | 24   | 28  | 32  | 31.25 | 16.20    |
| 2 | There is shortage of manpower in some areas of high demand of goods                                   | 60            | 30 | 10 | 0   | 50            | 40.8 | 7.2 | 2.4 | 31.25 | 29.00    |
| 3 | There is consistence evacuating of vacuum cleaner technology system for collection of waste generated | 55            | 25 | 18 | 1.6 | 65            | 20   | 9.6 | 5.6 | 31.25 | 28.84    |
| 4 | There is difficulty in conveying generated waste collected from waste station                         | 52            | 28 | 15 | 4.8 | 46            | 40   | 12  | 2.4 | 31.25 | 23.96    |
| 5 | There is insufficient provision of personal protective equipment (PPE) used in waste segregation      | 4             | 12 | 32 | 52  | 8             | 16   | 32  | 44  | 31.25 | 22.00    |

*Source: Field survey (2023)*

**Table 5: Percentage response of the respondents on challenges facing company A and company B**

|   | Statement  | Company A (%) |    |    |    | Company B (%) |      |    |     | Mean  | Std. Dev |
|---|--|---------------|----|----|----|---------------|------|----|-----|-------|----------|
|   |  | SA            | A  | D  | SD | SA            | A    | D  | SD  |       |          |
| 1 | There is a provision of separation techniques know as SIEVE for separation of mixtures of waste and rework products  | 40            | 30 | 20 | 10 | 50            | 30.4 | 20 | 0   | 31.25 | 19.87    |
| 2 | There is a provision of air gun, for blowing of powder particles into a container to avoid wastage on the shop floor | 60            | 30 | 10 | 0  | 50            | 40   | 8  | 2.4 | 31.25 | 28.79    |

|   | Statement  | Company A (%) |    |     |     | Company B (%) |      |     |     | Mean  | Std. Dev. |
|---|--|---------------|----|-----|-----|---------------|------|-----|-----|-------|-----------|
|   |  | SA            | A  | D   | SD  | SA            | A    | D   | SD  |       |           |
| 3 | We implement strategies to minimize waste generation at all stages of our manufacturing process, including raw material sourcing, production processes and packaging.                | 70            | 30 | 0   | 0   | 60            | 30.4 | 5.6 | 4   | 31.25 | 34.73     |
| 3 | We implement strategies to minimize waste generation at all stages of our manufacturing process, including raw material sourcing, production processes and packaging.                | 55            | 26 | 17  | 2.4 | 65            | 20   | 10  | 4.8 | 31.25 | 28.82     |
| 4 | We design packaging that is reusable, recyclable, and made from sustainable materials. This includes exploring alternatives to single use plastics.                                  | 52            | 28 | 14  | 5.6 | 45            | 40   | 12  | 3.2 | 31.25 | 23.57     |
| 5 | We collaborate with Stakeholders partnering with local communities, NGOs, and government agencies to promote waste reduction and share best practices                                | 40            | 30 | 20  | 9.6 | 50            | 29.6 | 10  | 9.6 | 31.25 | 19.09     |
| 6 | We establishing robust recycling and composting programs to divert waste materials from landfills and promote the circular economy   | 80            | 20 | 0   | 0   | 50            | 29.6 | 14  | 5.6 | 31.25 | 34.89     |
| 7 | We adopt responsible product design and lifecycle thinking to minimize waste generation and environmental impact across the entire product lifecycle.                                | 60            | 25 | 10  | 4.8 | 65            | 25.6 | 4.8 | 4.8 | 31.25 | 30.79     |
| 8 | We are committed to educating and empowering employees to embrace zero water practices through training programs, workshops, engagement initiatives, and recognition/ reward systems | 50            | 30 | 4.8 | 15  | 70            | 20   | 4.8 | 4.8 | 31.25 | 30.03     |

|    | Statement   | Company A (%) |    |     |    | Company B (%) |      |    |      | Mean  | Std. Dev |
|----|---|---------------|----|-----|----|---------------|------|----|------|-------|----------|
|    |   | SA            | A  | D   | SD | SA            | A    | D  | SD   |       |          |
| 9  | Ongoing audits and reporting to track progress and ensure compliance with zero-waste goals. | 50            | 40 | 9.6 | 0  | 60            | 29.6 | 10 | 0    | 31.25 | 29.19    |
| 10 | We are committed to developing adaptable, flexible and resilient systems                    | 45            | 40 | 10  | 5  | 40            | 35.2 | 14 | 10.4 | 31.25 | 20.62    |
| 11 | We introduced stock control measures  | 70            | 20 | 10  | 0  | 60            | 29.6 | 10 | 0    | 31.25 | 33.20    |
| 12 | There is On-site sorting of waste   | 80            | 20 | 0   | 0  | 70            | 20   | 8  | 2.4  | 31.25 | 39.85    |

Source: Field survey (2023)

## TESTING OF HYPOTHESES

The endeavour to achieve a zero-waste economy has become an essential requirement for businesses globally, especially in the food and beverage production sector. In this comparative analysis, The study delves into the various facets of solid waste management practices among two prominent entities: Company A and Company B. The hypotheses were tested using Anova and Kruskal-Wallis. Details are demonstrated below.

**Table 6: Hypothetical test of the level of awareness of zero-waste among employees of Company A, and Company B using ANOVA**

| Summary  | Count | Sum    | Average  | Variance |
|----------|-------|--------|----------|----------|
| Row 1    | 8     | 250    | 31.25    | 1216.518 |
| Row 2    | 8     | 250    | 31.25    | 953.25   |
| Row 3    | 8     | 250    | 31.25    | 881.4107 |
| Row 4    | 8     | 250    | 31.25    | 855.4286 |
| Row 5    | 8     | 250    | 31.25    | 419.7679 |
| Row 6    | 8     | 250    | 31.25    | 1105.429 |
| Row 7    | 8     | 250.2  | 31.275   | 1599.648 |
| Column 1 | 7     | 543    | 77.57143 | 336.9524 |
| Column 2 | 7     | 244    | 34.85714 | 127.1429 |
| Column 3 | 7     | 56     | 8        | 33.66667 |
| Column 4 | 7     | 32     | 4.571429 | 49.95238 |
| Column 5 | 7     | 518.75 | 74.10714 | 187.872  |
| Column 6 | 7     | 237.7  | 33.95714 | 49.63369 |

| Summary  | Count | Sum   | Average  | Variance |
|----------|-------|-------|----------|----------|
| Column 7 | 7     | 85    | 12.14286 | 26.93452 |
| Column 8 | 7     | 33.75 | 4.821429 | 19.49405 |

| ANOVA               |          |    |          |          |          |          |
|---------------------|----------|----|----------|----------|----------|----------|
| Source of variation | SS       | df | MS       | F        | P-value  | F crit   |
| Rows                | 0.004286 | 6  | 0.000714 | 6.01E-06 | 1        | 2.323994 |
| Columns             | 44230.27 | 7  | 6318.61  | 53.1839  | 7.67E-19 | 2.23707  |
| Error               | 4989.887 | 42 | 118.8068 |          |          |          |
| Total               | 49220.16 | 55 |          |          |          |          |

Source: Authors' computation

**Table 7: Hypothetical test to examine zero-waste management practices among company A and company B using Kruskal-Wallis**

| Summary  |       |     |         |          |
|----------|-------|-----|---------|----------|
| Groups   | Count | Sum | Average | Variance |
| Column 1 | 5     | 400 | 80      | 360.5    |
| Column 2 | 5     | 166 | 33.2    | 56.2     |
| Column 3 | 5     | 48  | 9.6     | 107.3    |
| Column 4 | 5     | 11  | 2.2     | 24.2     |
| Column 5 | 5     | 362 | 72.4    | 93.8     |
| Column 6 | 5     | 186 | 37.2    | 84.7     |
| Column 7 | 5     | 64  | 12.8    | 49.7     |
| Column 8 | 5     | 13  | 2.6     | 7.8      |

| ANOVA               |         |    |        |          |          |          |
|---------------------|---------|----|--------|----------|----------|----------|
| Source of variation | SS      | df | MS     | F        | P-value  | F crit   |
| Between groups      | 32914.7 | 7  | 4702.1 | 47.96838 | 3.47E-15 | 2.312741 |
| Within groups       | 3136.8  | 32 | 98.025 |          |          |          |
| Total               | 36051.5 | 39 |        |          |          |          |

Source: Authors' computation

**Table 8: Hypothetical test of infrastructural and technological innovations and investment to enhance zero-waste in Company A and Company B using Kruskal-Wallis test**

| Summary  |       |        |         |          |
|----------|-------|--------|---------|----------|
| Groups   | Count | Sum    | Average | Variance |
| Column 1 | 10    | 703    | 70.3    | 227.3444 |
| Column 2 | 10    | 338    | 33.8    | 75.28889 |
| Column 3 | 10    | 157    | 15.7    | 72.45556 |
| Column 4 | 10    | 52     | 5.2     | 12.17778 |
| Column 5 | 10    | 659.25 | 65.925  | 125.7785 |
| Column 6 | 10    | 409    | 40.9    | 46.76667 |
| Column 7 | 10    | 124    | 12.4    | 44.26667 |
| Column 8 | 10    | 57.75  | 5.775   | 37.83958 |

| ANOVA               |            |    |          |          |          |          |
|---------------------|------------|----|----------|----------|----------|----------|
| Source of variation | SS         | df | MS       | F        | P-value  | F crit   |
| Between groups      | 47515.8625 | 7  | 6787.98  | 84.59622 | 3.64E-32 | 2.139656 |
| Within groups       | 5777.2625  | 72 | 80.23976 |          |          |          |
| Total               | 53293.125  | 79 |          |          |          |          |

*Source: Authors' computation***Table 9: Hypothetical test on the impacts of the zero-waste management initiatives embarked upon by company A, and company B using Kruskal-Wallis**

| Summary  |       |     |         |          |
|----------|-------|-----|---------|----------|
| Groups   | Count | Sum | Average | Variance |
| Column 1 | 5     | 224 | 44.8    | 1175.2   |
| Column 2 | 5     | 133 | 26.6    | 116.8    |
| Column 3 | 5     | 135 | 27      | 153.5    |
| Column 4 | 5     | 133 | 26.6    | 1081.8   |
| Column 5 | 5     | 230 | 46      | 893.5    |
| Column 6 | 5     | 176 | 35.2    | 207.7    |
| Column 7 | 5     | 111 | 22.2    | 202.7    |
| Column 8 | 5     | 108 | 21.6    | 589.8    |

| ANOVA               |         |    |         |          |          |          |
|---------------------|---------|----|---------|----------|----------|----------|
| Source of variation | SS      | df | MS      | F        | P-value  | F crit   |
| Between groups      | 3265.5  | 7  | 466.5   | 0.844153 | 0.559618 | 2.312741 |
| Within groups       | 17684   | 32 | 552.625 |          |          |          |
| Total               | 20949.5 | 39 |         |          |          |          |

*Source: Authors' computation*

**Table 10: Hypothetical test on the challenges facing company A, and company B towards achieving a zero-waste economy using ANOVA**

| Summary  | Count | Sum    | Average  | Variance |
|----------|-------|--------|----------|----------|
| Row 1    | 8     | 250    | 31.25    | 394.7857 |
| Row 2    | 8     | 250    | 31.25    | 829.0714 |
| Row 3    | 8     | 250    | 31.25    | 1206.214 |
| Row 4    | 8     | 250    | 31.25    | 830.5    |
| Row 5    | 8     | 250    | 31.25    | 555.3571 |
| Row 6    | 8     | 250    | 31.25    | 364.5    |
| Row 7    | 8     | 250    | 31.25    | 1217.643 |
| Row 8    | 8     | 250    | 31.25    | 947.9286 |
| Row 9    | 8     | 250    | 31.25    | 901.9286 |
| Row 10   | 8     | 250    | 31.25    | 851.9286 |
| Row 11   | 8     | 250    | 31.25    | 425.125  |
| Row 12   | 8     | 250    | 31.25    | 1101.929 |
| Row 13   | 8     | 250    | 31.25    | 1587.929 |
| Column 1 | 13    | 940.25 | 72.32692 | 293.3894 |
| Column 2 | 13    | 460    | 35.38462 | 66.92308 |
| Column 3 | 13    | 158.5  | 12.19231 | 77.14744 |
| Column 4 | 13    | 66.25  | 5.096154 | 39.12019 |
| Column 5 | 13    | 918    | 70.61538 | 145.5897 |
| Column 6 | 13    | 475    | 36.53846 | 70.26923 |
| Column 7 | 13    | 167    | 12.84615 | 29.14103 |
| Column 8 | 13    | 65     | 5        | 17       |

| ANOVA               |          |     |          |          |          |          |
|---------------------|----------|-----|----------|----------|----------|----------|
| Source of Variation | SS       | df  | MS       | F        | P-value  | F crit   |
| Rows                | 0        | 12  | 0        | 0        | 1        | 1.869289 |
| Columns             | 69640.91 | 7   | 9948.702 | 94.29026 | 4.64E-37 | 2.120633 |
| Error               | 8862.962 | 84  | 105.5114 |          |          |          |
| Total               | 78503.88 | 103 |          |          |          |          |

*Source: Authors' computation*

## DISCUSSION

Figures 3 to 7 above illustrate the distribution of respondents according to age range, educational qualifications, marital status, and length of service. Both Company A and Company B are male-dominated, with 50% of respondents aged 25-35, and the majority of employees having secondary education as their highest level of education. Both companies have similar service experience, with 39.2% working between 0-5 years and 24.0% working 6-10 years, indicating that most members of staff have at least five years of experience.

Table 1 above presents the percentage responses from employees of Company A and Company B regarding their level of awareness of the zero-waste economy. The data shows that both Company A and Company B have moderate awareness of sustainable practices supporting a circular economy. However, Company A has slightly lower awareness than Company B, possibly due to differences in corporate culture, training programs, or communication strategies. Both companies share a common belief in waste reduction, reuse, recycling, and recovery as crucial for environmental sustainability. This suggests that identifying areas of lower awareness could guide targeted training programs or communication strategies to foster a more comprehensive understanding of sustainable waste management practices. Practical recommendations include enhanced training programs, effective internal communication strategies, and monitoring and evaluation mechanisms to continuously improve practices and foster a culture of environmental stewardship. This aligns with Navarro and Vincenzo (2019) on their study on waste management in developing countries.

Table 2 above presents the percentage responses from employees of Company A and Company B regarding the impacts of zero-waste management initiatives. Both companies agree that zero-waste initiatives promote sustainable waste management, environmental protection, biodiversity enhancement, greenhouse gas reduction, and food

security, with moderate standard deviations. Generally, employees perceive positive impacts from the zero-waste management initiatives undertaken by Company A and Company B, which aligns with David et al. (2020) in their study on public perception of solid waste management practices in Nigeria. However, there are differences in the level of agreement and understanding across various statements.

Table 3 above presents the percentage responses from employees of Company A and Company B regarding infrastructural and technological innovations aimed at enhancing zero-waste practices. Company A and Company B show moderate agreement on modern techniques, waste transfer stations, optimizing packaging, transportation, and inventory management processes. They also invest in energy-efficient technologies and conserve water through efficient usage, reuse, and recycling. The results support Neema and Zakaria's (2022) claim that waste is an intermediate step in the consumption process rather than an end-of-life issue. Company B and other companies use regenerative materials and modular design techniques, while SIEVE is used for waste mixture separation. Waste transfer disposal stations and modern blending machines are also used. Further analysis could explore these differences for a zero-waste economy.

Table 4 above presents employee responses from Company A and Company B regarding the impacts of zero-waste initiatives on their companies. Respondents expressed dissatisfaction with standardized cleaning tools, manpower shortages, inconsistent vacuum cleaner evacuation, difficulty in conveying waste, and lack of personal protective equipment in waste segregation, with Company B showing higher dissatisfaction. Company A respondents showed slightly higher dissatisfaction. These responses highlight several challenges faced by Company A and Company B in implementing zero-waste initiatives, in line with the study by Sherry (2023) on understanding the meaning of zero-waste usage, health and wellness, protection phases and systems, and waste management publication. Addressing these challenges is crucial for improving solid waste management practices and advancing towards a zero-waste economy in the food and beverages manufacturing sector.

Table 5 above presents the percentage responses from employees of Company A and Company B regarding challenges they face in solid waste management practices. Both companies agree on SIEVE separation techniques for waste mixtures and rework products but differ in responses. Company A has higher agreement with an air gun for powder particle blowing, but Company B has a higher standard deviation. Both companies generally agree with the implementation of waste minimization strategies at all stages of the manufacturing process. The results align with a study by Ash et al. (2023) on waste management regulations enforcement leading the way to a healthy environment in Nigeria. The survey responses show moderate agreement between Company A and Company B on sustainable packaging design, waste reduction collaboration, recy-



cling and composting programs, responsible product design, employee education, ongoing audits, adaptable systems, stock control measures, and onsite waste sorting. However, there is a varying understanding the challenges facing solid waste management practices, requiring further analysis to understand their impact on achieving a zero-waste economy.

The awareness of zero-waste among employees of Company A and Company B was compared using ANOVA as shown in Table 6 above. The results showed a small p-value for awareness levels, indicating a significant difference, while a high p-value for companies indicated no significant difference. The null hypothesis was rejected for awareness levels, but for companies, the p-value was relatively high, suggesting no significant difference. The ANOVA results support the alternative hypothesis, suggesting a significant difference in awareness levels among employees across the two companies. This highlights the need for tailored strategies to enhance zero-waste awareness within each organization.

The Kruskal-Wallis Test was used to compare zero-waste management practices between Company A and Company B as shown in Table 7 above. The test was conducted using two hypotheses: no significant difference ( $H_0$ ) and significant difference ( $H_1$ ). The summary table analysis showed that there was a significant difference in zero-waste management practices between the two companies. The ANOVA results showed a low p-value ( $p < 0.05$ ), indicating strong evidence against the null hypothesis. The conclusion is that there is a significant difference in zero-waste management practices between Company A and Company B, indicating distinct approaches or levels of effectiveness in managing zero-waste. This test provides valuable insights into the comparative analysis of zero-waste management practices between companies, allowing researchers to determine significant differences.

The Kruskal-Wallis Test was also used to analyze the differences in infrastructural and technological innovations and investments aimed at enhancing zero-waste among Company A and Company B as shown in Table 8 above. The study tested two hypotheses and the summary table analysis showed a low p-value ( $p < 0.05$ ), indicating strong evidence against the null hypothesis. The results of the ANOVA Table showed a significant difference ( $p < 0.05$ ), indicating different levels or types of infrastructural and technological innovations and investments aimed at enhancing zero-waste. This suggests that these companies have different levels or types of infrastructural and technological innovations and investments, and these differences are statistically significant. The test provides valuable insights into the comparative analysis of infrastructural and technological innovations and investment among different companies, allowing researchers to determine significant differences.

The impact of zero-waste management initiatives on Company A and Company

B was evaluated using the Kruskal-Wallis Test as shown in Table 9 above. The study aimed to determine if there were significant differences in the observed impacts among these companies. The results showed that the null hypothesis (H<sub>0</sub>) was rejected, suggesting no significant impact. The alternative hypothesis (H<sub>1</sub>) was supported, suggesting a significant impact. The summary table analysis showed that the ANOVA table showed a high p-value ( $p > 0.05$ ), indicating insufficient evidence to reject the null hypothesis. The conclusion is that the zero-waste management initiatives did not have a significant impact on these companies, suggesting that they may not have produced significant differences in their outcomes or impacts.

The challenges faced by Company A and Company B in achieving a zero-waste economy were assessed using the ANOVA test as presented in Table 10 above. The results showed a significant difference in the challenges faced by these companies, suggesting that each company faces unique challenges in transitioning to a zero-waste economy. This suggests that tailored strategies and interventions may be required to overcome these challenges. The ANOVA test provides strong evidence against the null hypothesis, indicating that each company faces unique challenges in achieving a zero-waste economy.

## CONCLUSION

A zero-waste economy is a manufacturing philosophy that aims to minimize waste generation from production to the entire life cycle of a product. Companies A and B, predominantly male-oriented, acknowledge the importance of waste reduction, reuse, recycling, and recovery for environmental sustainability. They invest in modern techniques, energy-efficient technologies, and water conservation measures. However, they face challenges in implementing zero-waste initiatives, such as manpower shortages and inadequate equipment for waste segregation. ANOVA reveals a significant difference in awareness levels among employees, suggesting the need for tailored strategies.

The findings suggest several recommendations to address the identified gaps and enhance the transition towards a zero-waste economy within food and beverage companies. These include investing in improved waste segregation infrastructure and equipment, addressing manpower shortages and inadequate equipment, implementing communication campaigns and awareness programs, encouraging proactive participation in waste reduction efforts, establishing a comprehensive waste segregation system, forming partnerships with local recycling facilities, promoting awareness campaigns and engagement initiatives, and introducing composting programs for organic waste. A proper framework should be put in place to control the economic instruments of solid waste management systems, ensuring a structured and effective transition towards a zero-waste economy.

## R E F E R E N C E S

- Abayomi, O. & Atinuke, A. (2020). *Circular Economy: A Prototype for Sustainable Development in Nigeria*. Paper presented at The Tenth International Conference on Engaged Management Scholarship. Retrieved from <https://papers.ssrn.com>
- Ash, A., Omon, S. & Perneet, P. (2023). *Waste Management Regulations Enforcement Lead Way to Healthy Environment in Nigeria*. In Trends in Civil Engineering and its Architecture (pp. 2-9). UK: Lupine Establishers.
- Atiq, U.Z. (2017). *A Strategic Framework Towards Zero-waste Societies Based on Perceptions Surveys*. Built Environment, Curtin University, Bentley, Perth, WA6102, Australia. Retrieved from ResearchGate.
- Ching – Yan, W., Mei-Chih, H. & Fu-Chang, N. (2017). *Conducted a study on supporting a circular economy: insights from Taiwan's Plastic Waste Sector and Lessons for Developing Countries*. Sustain Prod Consum, 10, 228-238. <https://doi.org/10.1016/j.spc.2020.10.009>
- David O., Favour B. & Sunday, O. (2020). *Public Perception of Solid Waste Management Practices in Nigeria: Ogun State Experience*. Covenant University Ota, Nigeria. Retrieved from ResearchGate.
- Lowe, E. (2023). *Manufacturing a Circular Economy*. UK: MAKEUK (The Manufacturing Organization). Retrieved from [www.makeuk.org](http://www.makeuk.org)
- Yilmaz, E., Shuai, W. & Ibrahim, M. (2020). *Zero-waste Approaches for Cost-Effective Advance in Materials Science and Engineering Journal*, 1-5.
- EPA. (2018). *Yearbook of Environmental Protection Statistics Republic of China*. Environmental Protection Administration, Executive Yuan, Taiwan. Retrieved from <https://www.epa.gov.tw/>
- Yilmaz, E., Shuai, C., Weidong, S. & Ibrahim, C. (2020). *Zero-waste Approaches for Cost-Effective Treatment of Industrial Waste*. Turkey. Advances in Materials Science.
- Ishmaila, K., Umar, F., Maher, T. & Tereq, O. (2022). *Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South*. International Journal of Environmental Research and Public Health, 1-9.
- Ismaila, R., Khandoker, M., Umar, L., Faez, S., Maher, S., Sayed, M., Wadee, A. & Tareq, I. (2022). *Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South*. International Journal of Environmental Research and Public Health, 1-9.
- Jerome, S. (2022). *Taiwan's Chip Industry Steps Up with Zero-waste Manufacturing Centre*. Taiwan: Open GOV. Retrieved from [opengovasia.com](http://opengovasia.com).
- Mohammed, K. & Kasum, H. (2017). *Development of Performance Criteria for Sustainability Evaluation of Modular Construction Methods*. Journal of Cleaner Production, 142(4), 3592-3606.
- Navarro, F. & Vincenzo, T. (2019). *Waste Management in Developing Countries: A Review of Global Issues*. Int. J. Environ. Res. Public Health, 16(6).
- Neama, D. & Zakaria, E. (2022). *A systematic and Critical Review of Waste Management in Micro, Small and Medium-Sized Enterprises: Future Directions for Theory and Practices*. Environmental Science and Pollution Research, 3-10.

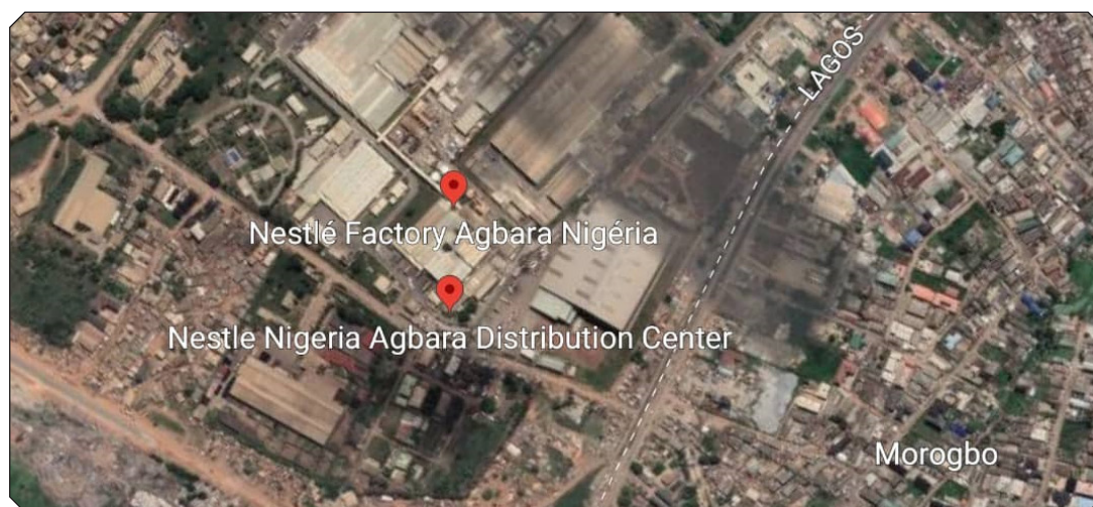
- Netalia, P., Jose, L., Duarte, R. & Janine, F. (2017). *Benefits, Challenges and Critical Factors of success for Zero-waste: A Systematic Literature Review*. *Waste Management*, 324-353.
- Piya, J. & Seeram, A. (2019). *Zero-waste Manufacturing: A Framework and Review of Technology, Research and Implementation Barriers for Enabling a Circular Economy Transition in Singapore*. *ScienceDirect*, 151, 104438.
- Selin, M. & Firat, H. (2023). *Environmental Sustainability in the OECD: The Power of Digitalisation, Green Innovation, Renewable Energy and Financial Development*. *Telecommunications Policy*, 47(6), 102568.
- Sezen, C. (2022). *Zero-waste Management Behavior: Conceptualization, Scale Development and Validation - A Case Study in Turkey*. Turkey. Retrieved from ResearchGate.
- Sherry, B. S. (2023). *Understanding the Meaning of Zero-waste. USA: Health and Wellness, Protection Phases and Systems, Waste Management Publication*. Retrieved from extension.msstate.edu.
- Temiloluwa, E., Adewunmi, I. & Ola, A. (2023). *Solid Waste Management Practices among Industries in Ota, Ogun State, Nigeria*. *International Journal of Environmental Quality*, 12-22.
- Ugreen. (2023). *Understanding Zero-waste Design: A Guide for Building Professionals*. Retrieved from ugreen.io.
- United Nations Environment Programme (UNEP; 2023). *Zero-waste Approach. International Zero-waste Day*. The United Nations.
- Wildad, N. & Hasmath, Y. (2022). *Household Solid Waste Management Practices and Perceptions among Residents in the East Coast of Malaysia*. *BMC Public Health*, 2-9.
- Wu, L., Subramanian, N., Abdul-Rahman, M.D., Liu, C. & Pawar K.S (2017). *Short-Term versus Long-Term Benefits: Balanced Sustainability Framework and Research Propositions*. *Sustainable Production and Consumption*, 18-30.
- Yen, T. (2019). *Zero-waste Lifestyle. Finland: Finland Tempere University of Applied Science*. Retrieved from ResearchGate.
- Zero-waste Scotland. (2019). *Circular Economy Skills Demand in Scottish Manufacturing*. Scotland: Open Access.
- Jegade, A. (2014). *Consumption and reuse as well as the recovery of all goods, packaging and materials without burning them or releasing them into the air, water, or land that could endanger human health or the environment*. *Environmental Sustainability Journal*, 10(2), 45-58.
- Adamu, T., Smith, J. & Lee, K. (2020). *Global waste production trends and implications for environmental sustainability*. *International Journal of Waste Management*, 15(4), 123-137.
- Zebnail, R. (2022). *Financial tools in solid waste management systems: An overview*. *Journal of Environmental Economics and Policy*, 18(3), 210-225.

## Appendices





**Fig. 1:** Aerial view of Company B (Source: google map, 2023)



**Fig. 2:** Aerial view of Company A Nigeria PLC (Source: google map, 2023)