ASSESSMENT OF METAL STEEL WASTE MANAGEMENT PRACTICES IN AJAOKUTA STEEL COMPANY, KOGI STATE, NIGERIA

BY

OLORUNTOBA, Gabriel
MTech/SSTE/2018/8986

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA

AUGUST, 2023

ASSESSMENT OF METAL STEEL WASTE MANAGEMENT PRACTICES IN AJAOKUTA STEEL COMPANY, KOGI STATE, NIGERIA

BY

OLORUNTOBA, Gabriel
MTech/SSTE/2018/8986

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN METALWORK TECHNOLOGY EDUCATION

AUGUST, 2023

ABSTRACT

The study was designed to assess metal steel waste management practices in Ajaokuta Steel Company, Kogi State, Nigeria. Six research questions and four null hypotheses guided the study. A descriptive survey research design was adopted for the study. The study was conducted in Ajaokuta Steel Company, Kogi State, Nigeria. A total of 150 respondents comprising of 60 engineers, 50 technologists and 40 technicians in Ajaokuta steel company was used as total population for the study. A structured questionnaire titled: Metal Steel Waste Management Practices Questionnaire (MSWMP Q) was developed by the researcher and validated by three experts in the department of Industrial and Technology Education was used for data collection for the study. The internal consistency of the instrument was 0.97 through Cronbach Alpha formula. Mean and standard deviation were used to answer the research questions, out of 150 copies of the instrument administered to the respondents, 144 were returned given 96% returned rate. ANOVA was used to test the null hypotheses at 0.05 level of significance. The findings on the metal wastes collection practices with a grand mean ($\bar{x}$= 3.18) revealed that the respondents agreed with all the items as metal waste collection practices in ASCL. Findings on the metal waste recycling practices with a grand mean ($\bar{x}$= 3.08) also showed that the respondents agreed with all the items as metal waste recycling practices in ASCL. Findings on the metal waste disposal practices with a grand mean ($\bar{x}$= 2.28) revealed that the respondents disagreed with the majority of the items as metal waste disposal practices in ASCL. Findings on the metal waste reduction practices with a grand mean ($\bar{x}$= 3.54) revealed that the respondents agreed with all the items as metal waste reduction practices in ASCL. Findings on the constraints associated with metal waste management practices with a grand mean ($\bar{x}$= 2.81) showed that the respondents agreed with the majority of the items as constraints associated with metal waste management practices in ASCL. Findings on the ways of improving metal waste management practices with a grand mean ($\bar{x}$ = 3.76) showed that the respondents strongly agreed with all the items as ways of improving metal waste management practices in ASCL. Similarly, the grand standard deviations of various sections of the research questions were found to be 0.69, 0.71, 0.66, 0.71, 0.77 and 0.79 respectively. All less than 1.96 which further implies that the respondents were close to one another in their responses. Based on the findings, it was recommended among others that metal steel waste management practices should be utilize by Ajaokuta steel company in other to reduce wastes, health hazard and improve its profitability. Engineers, technologists and technicians should be retrained regularly on maintaining precision rules during production of components in other to reduce metal wastes. Furthermore, engineers, technologists and technicians should adopt new technological practices like the use of automated sensors, optical sorters and magnets and also apply innovative machining procedures during production of components in order to be more effective on the job.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Metals are substances or minerals that form naturally below the surface of the earth. They are natural compounds of the earth crust that are generally found in the form of metal ores, associated with one another and with many other elements. According to Anne (2019) metal is a substance with high electrical conductivity, luster, and malleability, which readily loses electrons to form positive ions (cations). Metals as chemical elements are solid, hard, strong, durable, shiny, good conductors of heat and electricity, and easy to work into various different shapes and forms such as thin sheets and wires. The production of these metals encapsulates all the processes involved in the conversion of a raw material, such as a metallic ore to a final form in which the metal can be used for some domestic, commercial or industrial purposes. Chris (2020) opined that to extract metals from the earth and turn them into all kinds of useful materials was one of the most important developments in human civilization, spawning tools, jewelry, engines, machines and giant static constructions like bridges and scrapers. Hence the discovery of iron ore which is the principal ingredients for all categories of metals led to the establishment of Ajaokuta Steel Company in Nigeria.

Ajaokuta Steel Company Limited (ASCL) is one of the foremost industrial projects conceived after the discovery of iron ore and commercial quantities in Nigeria in 1970. The steel company with a capacity to produce 1.3 million tonnes of steel per year was designed and built as an integrated iron and steel complex, based on the conventional Blast Furnace (BF) route for iron making and Basic Oxygen Furnace (BOF) for steel making. Molten iron is produced in BF in presence of coke and molten steel is produced in BOF in presence of oxygen (Sushovan, 2015). The first phase of ASCL was designed to produce 1.3 million tonnes (Mt) of liquid steel per annum with inbuilt facilities to expand to 2.6 Million tonnes of liquid steel per annum in the second phase and to 5.2 Million tonnes per annum in the third and final phase. ASCL as an integrated steel plant has primary unit which includes, the blast furnace, sintering plant, coal cool room, lime plant and bye-product. The primary unit produces liquid steel which **is** transported to the steel making shop, iron making shop and the rolling mills. The rolling mills includes, the billet mill, lime section mill, wire rod mill and medium section and structural mill. The billet mill produces billets which can be used in different rolling mills depending on the size and sometimes ASCL adjust their production line to fit a particular type of size. According to Corrosionpedia (2015) billets are used as raw materials or feedstock in extrusion, forging, rolling and other metal processing operations. The lime section mill produces lime section mass used in industries and wire rod mill also produces wire rod of different sizes that are used in building sector. The medium section and structural mill produce rail tracks and thus led to the waste.

Wastes are materials or substances which are disposed of or are intended to be disposed of or are required to be disposed of because it's unwanted or useless and disposal is any operation that may lead to resource reclamation, recovery, recycling, direct re-use or alternative uses (Abhishek and Awasthi, 2017). There are different kind of waste, either liquid or solid waste. Liquid wastes are wastes in liquid form, such wastes include domestic washing, chemicals, oils, manufacturing industries and other sources while Solid waste could be domestic, commercial and industrial wastes such as plastics, woods, rubbers, bottles, cans, broken glasses, papers, and scrap metals. However, the focus of this study is on the metal steel waste.

Metal steel waste is one of the solid generating wastes produced in steel production industries. The effects of metal steel wastes if not properly managed, can affects human health, socio-economic conditions, coastal and marine environment, greenhouse gases (GHGs) may accumulate in earth's atmosphere as a result of human activities in the steel production industries and as well as during combustion of metal steel wastes**.** According to Mukuldev (2018) these wastes in steel production industries have a huge amount that need to be utilized by different methods and ways because industrialization, modernization and progress, all of these did take a toll on the health of our nation. Therefore, proper metal steel wastes management practices are crucial in steel production industries.

Wastes management are the practice or act of managing, handling or controlling wastes. Demirbas (2011) describes waste management as a process by which wastes are gathered, transported and processed before disposal of any remaining residues. Wastes management involves all activities and actions required to manage wastes from its inception to its final disposal which includes amongst other things, collection, transportation, treatment and disposal of waste together with monitoring and regulation (Mukuldev, 2018). In metal steel industries, many wastes are generated from the making of iron by removing oxygen and other impurities from iron ore and when iron is combined with carbon and small amounts of other elements it becomes steel. Hence one of the ways of ensuring that the environments is free from all these wastes is to adopt effective collection practices.

Collection practices of metal waste is one of the processes of waste management. It is the transfer of solid waste from the point of use and disposal to the point of treatment or landfill. Waste collection in a normal conventional steel company according to Dennis (2011) refers to the collection of the solid wastes (metal wastes) from the generators for disposal by the waste disposal agents. This also includes the collection of recyclable materials that are technically not wastes, because they can still be re-use or converted to other products. Environmental Protection Agency (EPA) (2020) argued that the metal wastes could be collected for further processing through recycling process.

Recycling practices involved the act of processing used or abandoned materials for use in creating new products. Dennis (2011) defines recycling as the process of adding value to the waste to make it economically useful. The need to recycle metal waste is clear, because allowing metal waste to end up in landfills poses risk, since metal contain toxic chemicals like mercury that could poison the nearby soil and the ground water. But the recycled metal can be used to manufacture new metal products which is considerably less expensive than mining for ore to obtain new metals. According to Rupali *et al.* (2015) recycling of solid waste materials saves natural resources, energy, reduces waste, air and water pollutants and reduce greenhouse gas emissions. Chattered Institute of Purchasing and Supply (CIPS) (2007) reported that a key development in the metal waste management is focus on preventing the production of waste through waste minimization and the re-use of waste materials through recycling. Hence, unused and unrecyclable metal wastes are disposed off through effective adoption of disposal practices.

Disposal practice is the activities of removing, discarding, recycling or destroying of unwanted materials called waste that is produced from domestic usage or industrial products. The right methods for waste disposal ensure lesser pollution and hazards for the environment. Vergara and Tchobanoglous (2012) reported that proper planning and control is required in other to prevent the negative impact of waste on the environment. As a result, Ghiani *et al.* (2014) added that, a proper organization of solid waste (metal waste) management has become an important task needed to safeguard the environment. The resultant effect of improper metal steel waste disposal is the accumulation of large waste volumes in and around various machine and tool shop, power and equipment repair shop, foundry shop, forge and fabrication shop, pattern making shop and various unconventional disposal sites**.** These problems could be avoided if proper metal waste reduction practices are put in place.

Reduction practice is one of the ways of controlling waste generation. This is done through policy implementation, improved product design, redesign packaging to eliminate excess material while maintaining strength and material reusable. However, Conserve Energy Future (CEF) (2021) viewed waste reduction practices to entails limiting the amount of waste that is generated thereby helping to eliminate the production of persistent and harmful wastes effectively supporting efforts that promote a society that is sustainable. Thus, waste reduction practices involve a change of industrial patterns that relate to production and consumption as well as redesigning products to eliminate the generation of waste. Erich (2018) opined that in every manufacturing plant, waste is generated and it is important that practices to reduce the generation of waste be established. The failure of metal waste reduction practices may be due to some constraints associated with metal wastes management practices.

The term constraint connotes hinderances. Constraints in the context of this study refers to the challenges associated with metal wastes management practices which ranges from poor management planning, insufficient tools and equipment to manage waste, inadequate knowledge of proper attitude for collection, recycling and disposal of metal wastes and inefficient policy for safety, health and environmental management of metal wastes among others. According to Kumar (2017) the major problems affecting metal wastes (solid waste) management are unscientific treatment, improper collection of waste, and ethical problems. This in turn leads to hazards like environmental degradation, water pollution, soil pollution, and air pollution. However, Gazali (2015) suggested numbers of ways by which these constraints could be overcome in a typical metal steel industry. These measures if properly adhere to, may improve metal wastes management in ASCL. These measures include: adherence to Government policy instruments that controls metal wastes, the use of relevant facilities to control metal wastes and absolute compliance with the existing environmental laws that guides metal wastes management among other measures. These measures will not only improve metal wastes management but may also protect metal steel personnel such as the engineers, technologists and the technicians against any form of hazard in the work place.

The technicians are Ordinary National Diploma (OND) holders. The technologists are Higher National Diploma (HND) holders in any technological fields. While the engineers are people who are COREN registered having obtained a degree in bachelor of engineering (B.Eng.) or bachelor of Technology (B.Tech.) or Higher National Diploma (HND) in any engineering fields. According to Collins English dictionary (2012) an engineer is a person trained in any branch of the profession of engineering. The engineers, technologists and technicians are the users and major steel workers in any metal steel industries. The activities of these steelworkers often generate waste which poses risks to people and the environment, especially if stored or disposed carelessly. These therefore, suggest the need for an assessment of metal wastes management practices.

Assessment is an act of judging or assessing a person or situation. Merriam-Webster Dictionary (2013) defines assessment as the act of making judgement about something or somebody. Assessment in the context of this study is to provide usable data on metal wastes and how these wastes generated during production are being managed. In Africa, Nigeria to be specific, production and consumption of metal is very high but metal wastes management practices are apparently poor. It is in the light of the above that this study is set to assess metal steel wastes management practices in Ajaokuta steel company, Kogi State, Nigeria.

1.2 Statement of the Research Problem

Metals are usually very strong, durable and highly resistant to every day wear and tear. As such, they have been used since ancient times for a lot of things. Even today, with the advances in technology, the importance of metal has broadened greatly. Metals like iron and steel among others are the main materials used in construction of buildings, bridges, manufacturing of automobiles, machinery, military ammunitions, electronics, production of medicine equipment, jewelry and decorative products among other uses (Eleke, 2007). These have created a huge opportunity for many countries to generate revenue. Nigeria, at one time, generated huge percentage of its national income from metal production. Ajaokuta Steel Company did not only generate auspicious revenue to develop the economy of the country but also created wealth and job opportunities for her citizens.

The use of metal is increasing rapidly, leading to rapidly growing metal waste volumes. The gathering, transferring, processing, recycling, disposal and monitoring of metal waste are an important economic activity that can provide income for informal enterprises operating in Nigeria especially in Ajaokuta Steel Company, Kogi State. Though, they are also associated with severe environmental and health hazards (Gazali, 2015). This give rise to why metal waste needs to be assessed appropriately.

However, despite the numerous importance of metals, metal waste management is apparently poor and little or no attention has been given to the impact of metal waste activities on human and general livelihood of the communities which poses very dangerous signal to the existence of people working or living around ASCL in Kogi State. The mismanagement of metal steel wastes has become a problem which is a big threat to human lives, aquatic existence and ecosystem. Some of the hazards of metal steel waste like dust and fumes irritate the eyes, skin and upper respiratory system and also causes lung fibrosis or lung cancer. The toxic chemical from metal causes skin burns and also pollute the environment. Muataz *et al.* (2017) reported that the increasing negative impacts of metal wastes have generated a growing public health concern about environmental pollution. As there are many injuries and long-term illnesses associated with working in dangerous scrap metal yards. For instance, Eleke (2007) lamented that several workers in the steel manufacturing industries that have experienced radiation accidents, caused by radioactive materials suffer from nausea diarrhea, loss of weight, premature aging and leukemia. The problem of this study therefore is put in a question form: what are the metal steel waste management practices in Ajaokuta Steel Company, Kogi State, Nigeria?

1.3 Aim and Objectives of the Study

The main aim of the study was to assess metal steel waste management practices in Ajaokuta Steel Company, Kogi State, Nigeria. Specifically, the study sought to achieve the following objectives:

1. Determine metal wastes collection practices in Ajaokuta steel company.
2. Find out metal wastes recycling practices in Ajaokuta steel company.
3. Determine metal wastes disposal practices in Ajaokuta steel company.
4. Find out metal wastes reduction practices in Ajaokuta steel company.
5. Identify the constraints associated with metal wastes management practices in Ajaokuta steel company.
6. Determine the ways of improving metal wastes management practices in Ajaokuta steel company.

1.4 Significance of the Study

The study will be of immense benefit to the engineers, the technologists, the technicians, the privately-owned steel plant, the State and Federal government, agencies of the government, and the society at large.

The result of the findings of this study will help the engineers, technologists and technicians to employ a better way of utilizing the available tools and facilities in managing metal wastes for higher productivity. This will be achieved through implementation of the findings and adopting the suggestions and the recommendations that was be made based on the findings of the study.

The privately-owned steel mills will also benefit from the study by studying the major findings and resuscitating their production system.

To the State and Federal Government, the findings of the research work will assist them in raising more awareness on the importance of metal waste management practices in steel industries, the economic value with other benefits associated with metal waste management such as saving energy, natural resources, reducing metal wastes, air and water pollutants and greenhouse gases. Also, highlighting the problems associated with improper management of metal wastes and ways of overcoming them which can result in a safe working environment and bring vibrant economic growth in the steel industries. The ministry of mines and steel will also benefit using the findings of this study to discover areas of improvement and areas of weakness in the provision of input facilities and tools for the implementation of metal waste management in the steel industries, especially ASCL.

In addition, general public will also benefit from the findings of the study, as the study revealed the impact of metal wastes to the environment and the strategies to be employed to prevent the menace on the society. Thereby providing a conducive environment for steel industries and business to thrive.

Lastly, the findings of the study will assist subsequent researchers with firsthand information to carry out similar or related study in other areas of wastes management in the steel industries.

1.5 Research Questions

The following research questions guided the study:

1. What are the metal wastes collection practices in Ajaokuta steel company?
2. What are the metal wastes recycling practices in Ajaokuta steel company?
3. What are the metal wastes disposal practices in Ajaokuta steel company?
4. What are the metal wastes reduction practices in Ajaokuta steel company?
5. What are the constraints associated with metal wastes management practices in Ajaokuta steel company?
6. What are the ways of improving metal wastes management practices in Ajaokuta steel company?

1.6 Scope of the Study

The study was on the assessment of metal steel wastes management practices in Ajaokuta Steel Company Limited. Specifically, the study was delimited to only metal waste management in ASCL with respect to metal wastes; collection practices, reduction practices, constraints associated with metal waste management practices in ASCL. However, other types of metal like aluminum, copper, bronze and brass were not covered in this study because metal and steel productions are the only activities of ASCL.

1.7 Hypotheses

The following null hypotheses were formulated and were tested at 0.05 level of significance:

$H0_1$: There is no significant difference in the mean response of the engineers, technologists and technicians on metal wastes collection practices in Ajaokuta steel company ($p<.05$).

$H0_2$: There is no significant difference in the mean response of the engineers, technologists and technicians on metal wastes recycling practices in Ajaokuta steel company ($p<.05$).

$H0_3$: There is no significant difference in the mean response of the engineers, technologists and technicians on metal wastes disposal practices in Ajaokuta steel company ($p<.05$).

$H0_4$: There is no significant difference in the mean response of the engineers, technologists and technicians on metal wastes reduction practices in Ajaokuta steel company ($p<.05$).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Framework of the Study

2.1.1 Theory of planned behaviour

The Theory of Planned Behaviour (TPB) as proposed in 1991, shows a model about how human action is guided. This is shown in figure 2.1

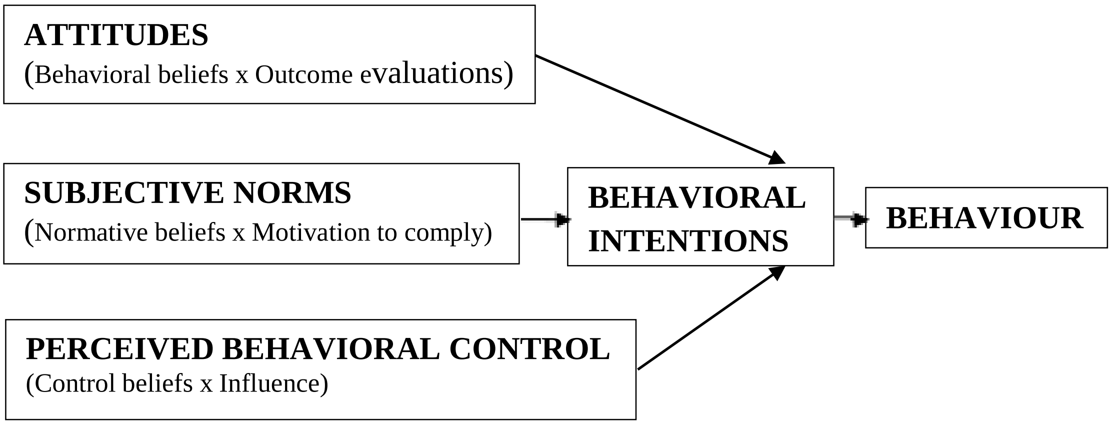

Figure 2.1: The Theory of Planned Behaviour (Ajzen, 1991).

According to the theory, human behaviour is guided by three kinds of considerations: beliefs about the likely consequences of the behaviour (behavioural beliefs), beliefs about the normative expectations of others (normative beliefs), and beliefs about the presence of factors that may facilitate or impede performance of the behaviour (control beliefs). In their respective summaries, behavioural beliefs produce a favourable or unfavourable attitude toward the behaviour, normative beliefs result in perceived social pressure or subjective norm, and control beliefs give rise to perceived behaviour control. The TPB can then be useful in designing ways to help people to adopt healthy behaviour in the work place.

TPB theory is based on the assumptions that individual behavioural intention is directly associated with their attitudes. The TPB views an individual's determination as influenced by attitude, social support and perceived behavioural control. Thus, it is best to examine human behaviour when decisions are voluntary and under an individual control. This theory therefore, is related to this study because peoples (engineers, technologists and technicians) behaviours are involved which need to be guided for proper metal waste management practices in ASCL. This theory is suitable for predicting the behaviours of the engineers, technologists and technicians in relation to metal waste management practices (Gamba and Oskamp, 1994).

2.1.2 Zero waste theory

Zero Waste Theory (ZWT) is another theory that is of value for metal wastes management. Zero waste is a whole system approach that aims at eliminating rather than managing waste, as well as encouraging waste diversion from landfill and incineration. It is a guiding design philosophy for eliminating waste at source and at all points down the supply chain. It shifts from the current one-way linear resource use and disposal culture to a 'closed-loop' circular system modelled on nature's successful strategies (Williams and Tony, 2010). Figure 2.2 describes the linear and cyclical resource flow of zero waste supply chain.

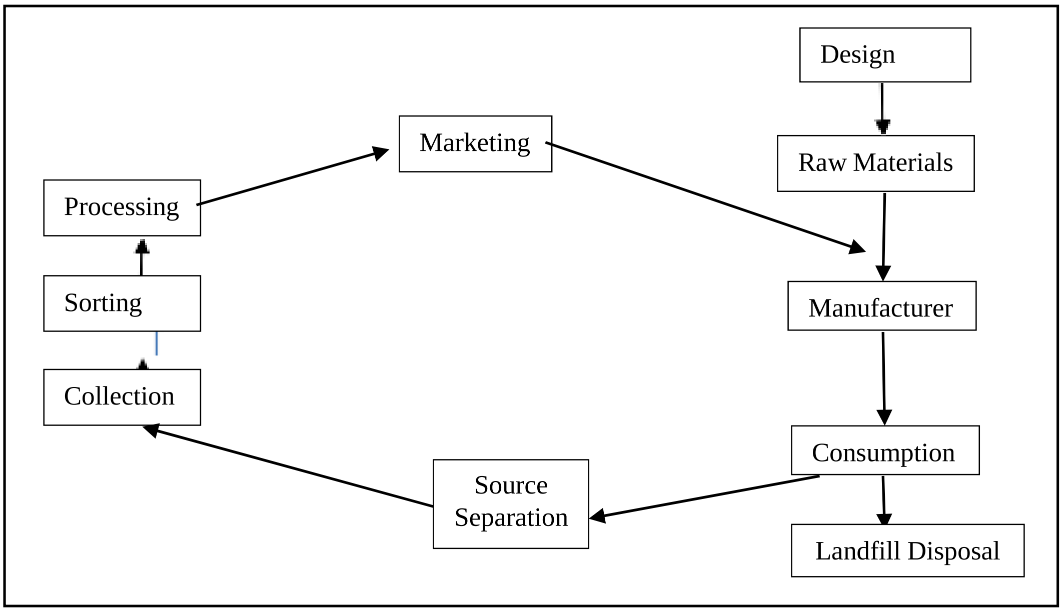

Figure 2.2: Linear and cyclical resource flows.
Source: www.waste-management-world.com

Activities in figure 2.2, show that targeting the whole system means striving for:

i. Zero waste of resources: energy, materials and human.

ii. Zero emissions: air, soil and water.

iii. Zero waste in activities: administration and production.

iv. Zero waste in product life: transportation, use, end of life and

v. Zero use of toxic: processes and products.

The system investigates and demonstrates the closed-loop philosophy's contribution to achieving zero waste by adopting a network approach, and using a combination of methods and tools, use of technology and design innovations and policy measures. It has a goal that is both pragmatic and visionary, to guide people to emulate sustainable natural circles, where all discarded materials become resources for others to use (Williams & Tony, 2010). Zero waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials as close to zero as possible, conserve and recover all resources and not burn bury them. Successful implementation of zero waste will eliminate all discharges to land, water, or air that may be threats to human, animal or plant health.

Williams and Curran (2013) further described zero waste system as a unifying concept for a range of measures aimed at eliminating waste and challenging old ways of thinking. The authors further envisaged that zero waste to landfill or incineration in Europe can be achieved over a 10–30-year timescale, which presently has developed a co-ordinated and concerted effort focused on waste prevention, minimization and reuse. It is important to recognise that zero waste is a target to be strived for, not an absolute, and it is possible that landfill may ultimately be the best option for a very small number of wastes. While the term zero waste is used widely and enthusiastically applauded as a positive, yet often deemed impossible goal, no definite definition of the term exists. Examination of the concept reveals significant and opposing differences between theoretical and practical interpretations. The practical implementation of zero waste bears little relation to the foundational elements of zero waste theory and serves more to reinforce the status quo of unsustainable waste production and facilitate the ‘throwaway society’ than working towards waste elimination (Young, 1991). Therefore, the theory that was used for this research work was based on the zero-waste theory because this theory guided the study on waste management control with the best practices.

2.2 Conceptual Framework of the Study

The conceptual framework of metal steel waste management practices is considered using the concept of assessment and it models in the metal wastes collection practices, metal wastes recycling practices, metal wastes disposal practices, metal wastes reduction practices which are waste management techniques for unmaking of wastes. Since they could result in the prevention of waste in the first place, the amount of waste which must be composted, recycled, landfilled, among others is reduced. The constraints associated with metal steel wastes management practices require thorough assessment and the health hazards caused by improper metal steel wastes management. Hence, the need for ways of improving metal steel waste management practices in steel industries. Therefore, the concept of assessment in waste management was reviewed below as a guide in achieving the aim and objectives for this study.

2.2.1 Concept of assessment

Assessment is a process by which information is gained relative to some known purpose or goal. In other words, assessment is a process of measuring performance. The Merriam-Webster Dictionary (2013) defines assessment as the act of making judgment about something or somebody. It is the systematic appraisal, collection, review and use of information about a particular programme in order to improve the system. Assessment is the process of observing and measuring learning (Slattery, 2013). Assessment is the educational practice of identifying, gathering and interpreting information about students' learning. According to Anyor *et al*. (2014) the central purpose of assessment is to provide usable data on student achievement and progress in order to monitor the flow of ongoing teaching and learning. Assessment is not only to provide usable data on student achievement alone but also in other areas like the steel industries, assessment can be used to provide usable data on the steel industries achievement and progress in order to monitor the steel production and how well the wastes generated during the production are well managed. Assessment standards are expected to provide quality assurance in the practice of evaluation. Obioma and Ajagun (2006) posited that standards often describe expectations of skills, knowledge competencies and behavior needed by steel engineers, Technologists and Technicians to perform at high levels. What is obvious across Nigeria today is a wanton proliferation of diverse assessment mechanisms, an indication of the half-hearted attention and lips service paid to the fundamental dogma of any programme or industrial assessment. The state of assessment practices in Nigeria only point to the unhealthy lack of guiding principles. If the core tenets of metal waste management must be followed there is an urgent need to revisit existing views of assessment in the Nigerian industrial system. Atsumbe and Raymond (2012) attested that there is lack of uniform standards in the implementation of assessment across several schools. This is not only affecting schools but also in the industrial settings most especially in the steel industries in Nigeria.

Assessment model: Atsumbe and Raymond (2012) said that the acceptable concept of assessment practice is for a classroom teacher to construct and implement his or her own assessment, and then make evaluative decisions based on the results. This is also applicable in the steel industries. The steel engineers could construct and implement their own assessment and then make evaluative decisions based on the results. Appropriate assessment models must take cognizance of the goals of the steel industries. A good assessment should ask what are the methods of recovery of metal waste, what are the effects of metal waste, what are the methods of metal waste reduction, and what are the problems associated with metal waste reduction. Suggesting an assessment framework at the end of the 32nd Annual Conference of the International Association for Educational Assessment (IAEA), officials of the Nigerian Educational Research and Development Council (NERDC) submitted that a carefully conceptualized National Assessment Framework (NAF) should contain:

1. Explicit statements about the purposes that the assessment will serve;
2. Descriptions of the substance and technical quality of the skills and knowledge, being assessed for classroom-based learning;
3. Clear descriptions of relationships between assessment information and decisions that could be taken;
4. Description of data collection method, including varieties of instruments and sources of data that should be used;
5. Internal consistency measures and procedures;
6. Descriptions of the method for data interpretation; and
7. Descriptions of the decisions that could be made including who will make the decisions and by what procedures. (Obioma & Ajagun, 2006).

This beautiful blueprint for national standards for assessment has suffered implementation challenges several years after, as confirmed by the Chief Executive of NERDC elsewhere (Obioma, 2008).

Nature of assessment: Assessment is tightly linked with the learning process. Similarly, it unites with the course of study and teaching. For keeping a check on students' progress and achievement course of study play a constant role. Also, the teacher and students work to achieve the outcomes of the course of study. Classroom review helps teachers to continuously detect students learning. It gives students a calculation of their improvement as a pupil or student. Provides close examination chance to students in the learning process. They help in the collection of regular response to students' learning. Also, how they respond to specific teaching approaches. It uses a variety of plans. The opinion has a deep impact on the self-respect of students. Also, it is dangerous for learning. Thus, the evaluation includes all those activities by teachers which help in reviewing students. Furthermore, this information used as a review and modifies teaching activity.

Functions of Assessment: Assessment performs many functions which are as follows:

1. Detecting Function**:** It detects all the activities during the elevation. From making plans to estimating the results all activities are closely watched. It also helps in improving performance and achieving desired results.

2. Making Decisions: They have to decide what must be done for improvement. All the decision related to assessment has to be taken by the teacher/instructor. It helps to focus on improvements.

3. Screening: The teacher/instructor must assess the probable incidence of the problem. They have to do this by using a simple yes or no. Assessment defines the problem while screening identifies and treats it.

4. Student's Placement in the Remedial Course: It means that if a student's evaluation is below average. In that case, remedial courses should be provided for them.

5. Instructional Planning: Instructional planning is a process for teachers. It helps the teacher to make a plan to target the course of study. Furthermore, it helps to address the diverse need of students.

6. Feedback/Response: This process helps to validate how student's marks are derived. It also identifies and prizes specific character in student's work. In addition, it guides students to make improvement in their work.

7. Inspiration: Inspiration or motivation is a very important tool. This tool provides information about the type of environment and tasks which helps in motivation.

Model of assessment: Assessment requires gathering of information and forming judgements about something/somebody in needs and the ability to meet those needs within any given set of circumstances. At times, this will also require one to consider the likely level of risk to that thing or the person involved where there are concerns about the circumstances the person is living within. It will also enable one to identify when something/person is at risk of poor outcomes. The followings are the process of assessment:

- Stage 1 - Information Gathering: The first part of any assessment is to gather information.
- Stage 2 - Identification and Analysis of Risk: When undertaking an analysis of the information gathered, the first thing to do is identify those factors which may cause one to be at risk or harm or at risk of poor outcomes.
- Stage 3 - Action Planning: After the risk analysis, the analysis must consider what needs to change if the level of risk is to be reduced and then provide a structure for the analysis.

- Stage 4 - Implementation and Review: The plan must outline what needs to change for a particular thing to be achieved.

Integrated assessment modelling: Integrated assessment modelling (IAM) or integrated modelling (IM) is a term used for a type of scientific modelling that tries to link main features of society and economy with the biosphere and atmosphere into one modelling framework. The goal of integrated assessment modelling is to accommodate informed policy-making, usually in the context of climate change (Wang *et al*., 2017) though also in other areas of human and social development. Hughes (2019) said while the detail and extent of integrated disciplines varies strongly per model, all climatic integrated assessment modelling includes economic processes as well as processes producing greenhouse gases. Other integrated assessment models also integrate other aspects of human development such as education, health, infrastructure, and governance (Hughes *et al.*, 2014).

These models are integrated because they span multiple academic disciplines, including economics and climate science and for more comprehensive models also energy systems**,** land-use change, agriculture, infrastructure, conflict, governance, technology, education, and health. The word assessment comes from the use of these models to provide information for answering policy questions. To quantify these integrated assessment studies, numerical models are used. Integrated assessment modelling does not provide predictions for the future but rather estimates what possible scenarios look like (Detlef, 2019).

There are different types of integrated assessment models. Firstly, models that quantify future developmental pathways or scenarios and provide detailed, sectoral information on the complex processes modelled. They are called process-based models. Secondly, there are models that aggregate the costs of climate change and climate change mitigation to find estimates of the total costs of climate change. A second classification makes a distinction between models that extrapolate verified patterns (via econometrics equations), or models that determine (globally) optimal economic solutions from the perspective of a social planner, assuming (partial) equilibrium of the economy (Lamperti *et al*., 2018).

2.2.2 Waste management

Modern day definitions of waste especially solid waste are converging on the important ingredients of the definition, for example sources of the material, characteristics and potential to cause harm to the environment. According to the World Health Organization Expert Committee in 1995, waste is an unwanted or discarded material that arise from man's activities. The Department of the Environment Transport and Regions (DETR) (2000) also defined waste as "any substance which constitute scrap material or an effluent or other unwanted surplus substance arising from the application of a process, or any substance which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled. Furthermore, the European Union Framework Directive on Waste (91/156/EEC) adopted the definition of waste as "any substance or object which the holder discards or intends to discard and which falls into one of the following categories:

- Production or consumption residue.
- Product whose date for appropriate use has expired.
- Contaminated or soiled materials.
- Substances that no longer perform satisfactorily" (Europa, 2006).

Generally, Waste creation by man is inevitable as far as the manipulation of the environment continues (Danbuzu, 2011). As a result of our daily activities to survive, we produce waste in millions of tons annually (Hammed, 2006). Waste is either an asset or liability depending upon our attitude to it. To some because of it menace, waste is more of a liability. However, the best and the most rewarding attitude to waste is to see it as an asset. With this kind of attitudes waste can be better planned for man's benefits. The principal sources of Solid Waste in an urban area according to Isirimah (2002) are: Municipal, (from street sweeping, sewage, waste from schools, markets and other institutions); Domestic, (garbage, rubbish and often large waste from homes); Commercial (from stores and offices); Industrial (from manufacturing plants); Mining, (from coal mining and strip mining) Construction and Demolition, (new construction sites, road repairs, renovation sites razing broken pavements) and Agriculture. Gobo and Ubong (2001) gave a detailed classification of solid wastes as follows:

• **Garbage;** these are putrescible waste from food, slaughterhouses, canning and freezing industries.

ii. **Rubbish**- non putrescible wastes, either combustible or non-combustible. Combustible wastes, either combustible or non-combustibles would include metals, glass, ceramics, stones, dirt, masonry and some chemicals.

iii. **Ashes -** residues (such as cinders and fly ash) of the combustion of solid fuels, for heating and cooking or the incineration of solid waste by municipal, industrial and apartment house incinerators.

iv. **Large wastes** from demolition and construction rubble, automobiles, furniture, refrigerators, and other home appliances, furniture, refrigerators, and other home appliances.

v. **Dead animals:** household pets, birds' rodents and zoo animals.

vi. **Hospital Waste:** anatomical and pathological wastes from hospitals.

vii. **Sewage treatment process solids:** screenings, settled solids and sludge.

viii. **Industrial solid waste:** chemicals, paints, and explosives.

ix. **Agricultural wastes:** farm animal manure and crop residues.

x. **Mining Waste:** tailings, slag heaps, culm piles at coat mines among others.

Waste management is the act or practice of managing, handling or controlling something. In the steel production industries, waste management is the way by which metal waste are been managed or controlled in order to keep the environment safe and further process the metal waste for other usage. Waste management is a problem susceptible to the application of classical engineering analysis and solution. Hence by extension of the most fundamental planning and management techniques, the problem can be solved in a manner which will protect man and improve his environment. All waste materials are economic assets. It is only when they are accidently or intentionally dispersed at lower concentrations into the air, soil or water that the essential management element or control is lost, and human may become exposed to their short- or long-term hazards. In solid waste management, solid waste such as power plant fly ash, acid sludge from by product plant, tar sludge, coke breeze, granulated B.F. slag, steel slag, calcined lime and dolomite dusts, steel scrap, among others are generated in huge quantities causing environmental degradation. Onu *et al.* (2001) sees waste management as the application of techniques that ensures the orderly execution of the functions of collecting, transfer, processing, treatment and disposal of wastes. Waste management, according to Wokekoro (2007) is a planned system of effectively controlling the production, storage, collection, transportation, processing and disposal or utilization of wastes, in a sanitary, aesthetically acceptable and economical manner. It includes all administrative, financial, legal and planning functions as well as the physical aspects of waste handling.

The solid waste management techniques are waste reduction, reuse and recycling. This is referred to as the 3R's of waste management. The most favored option being waste reduction (waste prevention and minimization). The least favored option is sending wastes to landfills. Solid wastes segregation technique which enables individuals to segregate wastes at the source of generation is also an important technique that should be developed in individuals in other to attain effective management of wastes in Nigeria. Solid waste disposal methods which are mostly preferred and considered as environmentally friendly in waste management business are incineration, composting, dumping in approved dumpsites and land filling. However, littering, open burning and open dumping of solid wastes which are practiced by many individuals are not environmentally friendly because they aid in the spreading of diseases and the pollution of the environment (Wokekoro, 2007).

Waste is introduced into the environment due to the day-to-day activities of humans. Waste management can also be referring to as many methods and processes of dealing with waste at every stage from generation and collection through to final disposal. Waste needs to be managed in order to prevent contact with humans or their immediate environment and moreover waste possesses economic value that can be reuse. Therefore, the main purpose of waste management is to isolate waste from humans, the environment and to reprocesses waste for the economic benefits, and consequently, safeguard individual, family, community health and increase in productivity. In addition, the aesthetic value of a better outlook and a clean physical environment is important for our emotional wellbeing. The waste we produce can be categorized as liquid waste or solid waste depending on its physical state. It can also be categorized as hazardous or non-hazardous waste. Hazardous wastes are not classified by their physical state (solid, liquid or gas) but by their properties and potential to cause harm. Hazardous wastes are defined as wastes that have one or more of the following properties. They may be:

- Corrosive (substances that cause damage on contact like acids)
- Ignitable (materials that can catch fire easily like benzene)
- Toxic (materials that can be poisonous to humans when inhaled or ingested, or come in Contact with skin or mucous membranes)
- Reactive (substances that can yield a harmful chemical if they react with other substances)
- Infectious (substances that are capable of causing or communicating infection).

Solid waste management can be classified into five main stages. These stages are also referred to as the “functional elements” of solid waste management. These are:

- Onsite handling, storage and processing
- Collection
- Transfer and transport
- Resource recovery and processing
- Disposal.

Onsite handling, storage and processing methods are undertaken at household level. This includes compacting waste by squashing it and changing its size and shape for easy handling. It also includes sorting the waste in order to separate the items that can be reused or recycled. For example, organic wastes should be separated out for composting as part of onsite handling. Bottles and cans can be reused.

Collection and transfer or transport activities are not common in rural areas because the waste is usually disposed of immediately onsite in a prepared waste disposal or composting pit. Ideally, waste management should go beyond pollution prevention and disease prevention for humans and should benefit society by providing economic gain for families and communities. The preferred approach for dealing with solid waste is integrated solid waste management (ISWM). ISWM means considering not only the appropriate disposal of solid waste but integrating this with other management options such as minimizing waste production, recycling, composting and other waste recovery options. The advantages of ISWM are that it considers all options and aims to manage waste in ways that are most effective in protecting human health and the environment. ISWM can also have many economic and social benefits for the society. According to Ogogome (2015) the primary objectives of effective solid waste management can be highlighted as follows:

(a). The elimination of health hazards in the community by removing all the physical, biological and chemical agents like bottles, vectors or diseases and toxic substances that are harmful to man in his environment.

(b). To protect the natural environment being polluted or damaged. This is achieved by discouragement of wastes being dumped indiscriminately on either land or river.

(c). To provide gainful employment for many young men who would have been jobless.

(d). Enhancement of regular supply of raw materials to industries through salvaging and recycling of materials of economic value from wastes. Effective solid waste management by adult citizens will entail reduction of wastes, segregation of wastes into degradable and non- degradable materials, reuse, composting and recycling of wastes. The dumping of wastes in the designated collection Centre’s is equally needed in order to maintain clean and healthy environment (Ogogome, 2015).

2.2.3 Composition and source of waste generation

Waste composition indicates the components of the waste stream given as a percentage of the mass or volume. The main constituents of solid wastes are similar throughout the world but the proportions vary widely from country to country and even within a city, because the variations are closely related to income level. Waste generated in developing countries contains a large percentage of organic materials, usually three times higher than that of industrialized countries. The waste is also denser and more humid, due to the prevalent consumption of fresh fruits and vegetables, as well as unpackaged food. First World residents consume more processed food and packaged in cans, bottles, jars and plastic containers than those in the developing world. As a result, waste generated in the former contains more packaging materials than in that of the latter. Higher volumes of wastes and a changing composition have a profound impact on waste management practices (Ogogome, 2015).

Urban solid waste is a heterogeneous material and its generation rate and composition vary from place to place and from season to season (Gidarakos *et al.*, 2006). The composition and volumes differ between high and low-income locations (United Nations Environmental Protection (UNEP), 2002). According to Ogwueleka (2009) solid waste is wetter, heavier and more corrosive in developing nations, making its management more difficult. Affluent communities contain large proportion of papers, polythene, plastic, glasses and metals. While the waste in low-income communities were predominantly organic in nature. According to the World Bank (2001), waste generation is greatly influenced by a country's development. the more economically prosperous a country is, the more waste it generates per capital but the factor that seem to bridge the gap between waste generation and it's resultant effect is the method or efficiency of waste management strategy adopted by such country (Titus & Anim, 2014) For instance, comparing the waste situation in developed countries like; Britain, United States of America, Canada where there exist much economic activities that generate more waste but with a corresponding well organized waste management system compared to the situation in developing countries like; Nigeria, Ghana and Cameroun with their steady increase in population and a corresponding increase in their rate of waste generation from industrial and human activities but without an efficient waste management system. Ogwueleka (2009) reported that the process of waste generation is common to all communities and often linked to urbanization process, especially when both the natural and the migratory net gains are relatively large. Thus, man's activities on domestic, commercial and industrial processes produce some undesirable effects, which are pollutant of all categories. Certain factors determined the rate and characteristic of waste generated. These include the level of economic activities, the pattern of consumption, income level, culture, population size and the level of economic development. However, personal income has been found to have the most significant effect on waste generation, this is due to its impact on individual consumption pattern. Also, the rate of solid waste generation per capital increase as the standards of living improves (Ogogome, 2015).

Neal and Schebul (1987) in a study reported that "without populations there would be no pollution and that pollution is the price of progress" that the spatial variation of socio - economic and demographic characteristic as well as the level of technological development of our environment influence waste generation. In as much as the generation of waste is inevitable, therefore the need to protect our environment becomes paramount.

Solid waste generation: Globally, Solid Waste generation has continued to increase in line with growth in other socio-economic parameters such as population, personal income and consumption patterns (Achankeng, 2003). In the last two decades, per capital waste generation in the developed economies has increased nearly threefold (African Development Bank (AFDB), 2002). According to the same study, waste generation in the developing nations is growing rapidly and may double in aggregate volume within this decade, driven largely by growth in population and improvements in living standards. If current trends persist, a fivefold increase in global Solid Waste generation is probable by the year 2025 (AfDB, 2002). Waste generation is drawing increasing attention as citizens observe that too much garbage is lying uncollected on the streets, for instance, an overview of some selected developing and developed countries figures reveal that the United States, Canada and United Kingdom (developed countries) in 2002 recorded 760kg, 640kg and 560kg per capital or per year respectively ; but the figures for developing countries like China, India and Nigeria in 2012 were approximated at 277kg, 237kg and 212kg per capita or per year respectively. Although, the developed countries having larger mass of waste, they have developed strong institutional framework to manage their wastes effectively. Generally, the more economically prosperous a country is, the more waste it generates per capital but the factor that seem to bridge the gap between waste generation and its resultant effect is the method or efficiency of waste management strategy adopted by such country. A typical example could be seen when comparing the waste situation in developed countries like; Britain, United States of America, Canada where there exist much economic activities that generate more waste but with a corresponding well organized waste management system compared to the situation in developing countries like; Nigeria, Ghana and Cameroun with their steady increase in population and a corresponding increase in their rate of waste generation from industrial and human activities but without an efficient waste management system. It is realized that the waste situation in developed countries is much better than that of the developing countries irrespective of the volume of waste they generate due to the waste management strategy they practice or employ (Achankeng, 2003).

2.2.4 Overview of waste management in developing countries

The challenges of waste management in developing countries continue to generate thoughts, interest and research (Ogbe, 2014). Waste disposal is an enormous concern in developing countries across the world, as poverty, population growth and high urbanization rates combine with in effectual and under-funded governments to prevent efficient management of wastes (United Nations Environmental Programme (UNEP), 2002). There are several factors that set waste management in developing countries apart from management in industrialized countries. First, the types of materials that compose the majority of the waste are different. In developing countries, there is a much higher proportion of organic, and considerably less plastics. The large amount of organic material makes the waste denser, with greater moisture and smaller particles size. A second difference is that technologies used in industrialized countries are often inappropriate for developing countries. Even garbage trucks are less effective because of the much heavier, wetter and more corrosive quality of their burden. Other technologies such as incinerator, are often far too expensive to be applied in poor nations. Thirds, developing countries cities are characterized by unplanned, haphazardly constructed, sprawling slums with narrow roads that are inaccessible to collection vehicles. Finally, there is often a much smaller stock of environmental and social capital in developing countries. People are unaware or uncaring of cradle-to-grave solid waste management needs, being more concerned with more immediate problems such as disease and hunger (Ogogome, 2015).

2.2.5 Solid waste management in Nigeria

Studies have been carried out on aspects of waste management in Nigeria. According to Adelagan (2004) who traced the history of environmental policy and legislation in Nigeria to the earliest days of colonial rule around the early 1900s and posits that the formative years of environmental legislation and management in Nigeria has all along been characterized by absence of clearly laid out objectives and strategies to achieve stated objectives efficiently. The author further contended that there are no clearly formulated policies in Nigeria aimed at coordinating and addressing the harmful consequences of industrial development on the environment. The study maintains further that where legislation exists in the country, their enforcement had often been carried out rather poorly. While it is agreed that existing environmental legislation in the country are poorly enforced, asserting that there is no body of legislation and policies, on which management of environmental concerns may be based, amounts to an over statement. This is because several other studies on the subject agree that inefficiencies in solid waste management in Nigeria cannot be blamed solely on absence of policy and effective legal frameworks (Walling *et al.*, 2004).

The study of Walling *et al*. (2004) further reviewed several governmental initiatives at effective and efficient management of solid waste in the country, such as FEPA and VISION 2010, and was concluded by Adelagan (2004) that the Federal government currently have very little control over environmental regulation throughout the country. The study maintains further that though Local Governments were intended to fund solid waste management, most have shirked this responsibility as a result of resource inadequacies and endemic corruption in the system. The study sums up the major drivers of the solid waste problem in Nigeria as poverty, population growth rate, rapid urbanization and under funding of state agencies. Also, Adama (2007) carried out a study on the structure and relationships between various state agencies saddled with waste management responsibility and highlights areas of successes and major barriers militating against their efforts at sustainable management of waste in the country. Some of these barriers include; poor structures for efficient management from the Federal through to the local government levels and operational difficulties in waste management in the country are also reflective of the general state of infrastructural and economic decay in Nigeria. In order to have an effective solution, a thorough cognizance of the overall economic position of the country must be ensured and Government must begin to adopt integrated waste management solutions that are private sector driven as they have greater potential for long term desirable environmental and economic improvements.

2.2.6 Steel scrap

Steel scrap are metal suitable for reprocessing. It is crucial to industry because it is recyclable. Steel making heavily depends on scrap as its raw material, next to iron ore in importance. Recyclability is what distinguishes steel scrap from waste. Ore is indispensable to making new steel; however, it is much cheaper and easier (both ecologically and energetically) to make steel from scrap, since even when recovered from scrap, steel does not lose any of its desirable characteristics. Moreover, steel recovery saves a great deal of energy (United State Environmental Protection Agency (USEPA), 2012). Steel recovery begins in the scrapyard, where most collected steel scrap ends up. There it is sorted, shredded or otherwise compacted in preparation for being melted into new steel at steelworks. Fortunately, the separation of steel scrap from nonferrous and nonmetallic scrap is technologically straightforward due to steel's magnetically susceptible properties. The process known as Basic Oxygen Steelmaking (BOS) utilizes roughly thirty percent steel scrap to fabricate new steel. The BOS method results in reduced presence of residual elements, for instance, Cu, Ni, and Mo. By contrast, Electric

Arc Furnace (EAF) steel relies on steel scrap hundred percent, with a resulting higher presence of residual elements, which are not reducible by applied oxygen and lime. Unlike the milder and more ductile BOS steels, EAF steels are substantially harder due to the presence of the said residual elements.

- **Heavy Melting Steel Scrap**, consisting of steel that is more than 6mm thick. Coming mostly from commercial sources, it includes scrap machinery and equipment as well as steel plates and beams.
- **Pressing Steel Scrap**, comprising steel of no more than 6mm thick, mostly from domestic sources, commonly including washing machines, dryers, refrigerators, steel sheets and roofing steel.
- **Scrap Vehicles**, with their interiors and wheels either in place or removed.
- **Cast Iron Scrap**, including machinery, engine blocks, bathtubs, gates, and pipes.

Recycling of scrap metals prevent air, water and soil pollution, saves energy and raw materials and reduce greenhouse gas emissions. Recycling also conserve space in landfill sites. Energy savings during the recycling of metals are 95% for aluminum, 85% for copper, 65% for lead and 60% for zinc (USEPA, 2012).

2.2.7 Waste management in Ajaokuta steel company limited

During the iron and steel making process, the impurities present in the raw materials like iron ore, limestone and coal are normally removed as slag. Further, the operations of air and water pollution control equipment generate dusts and sludge. Currently this volume of solid wastes generated in the Ajaokuta plants is relatively high at 600-800 kg per ton of steel as compared to 400-500 kg in developed countries. This is mainly due to higher impurity levels in the raw materials. The steel industry has been successfully converting these wastes into useful by-products for recycling or else for use as a raw material in other industries, but that is not the case in the Ajaokuta Plants. The limited use of steel slag from BOF and EAF in Indian steel plants (less than 30%, mainly used in sinter plant as lime substitute, and use of recovered metallic in steel making) remains a matter of concern. In contrast, in developed countries, the steel making slag is used as construction material ensuring 100% utilization. The main reason for the lower domestic slag utilization may be attributed to the presence of free lime, which makes it unfit for construction industry due to its hydration and expansion after aging. Reportedly steel slag (with less than 5% free lime and a maximum 5% expansion during steam testing) can be effectively used as a construction material. This can be achieved by weathering of slag, granulation by air or water. Steel slag can be effectively used as a material for construction, substituting other natural resources like aggregates and sand, first by developing a product standard for steel slag by the steel plants and later mandating its use in construction as has been done in case of fly ash. Steel slag after removal of metallic's can also be used as soil conditioner for conditioning acidic soils and to some extent in cement making. The use of slag generated in hot metal pretreatment and secondary metallurgy is another potential area of use to be studied by the industry. Rai (2006) said that the dusts and sludge collected from air and water pollution control equipment is extremely fine and is currently recycled through sinter making. However, in case of larger units, the recycling of large volumes of micro fine dusts is problematic, as it hinders the productivity of sinter plant. Many of our integrated steel plants elsewhere in the world have evolved innovative means of recycling dust and sludge and this need to be adopted by the Ajaokuta steel plant. Some of the practices followed are given below in Table 2.1.

Table 2.1: Global Best Practices in handling Sludge and Dust

Process dusts/sludge	Interim usage	Preferred usage
ESP dust from sinter/pellet plants	Recycle in sinter plant	Micro pellets
Flue dust from Blast furnaces	Sinter plant depending on alkali loading	Micro pellets
Dust from bag filters of coke ovens	Power plants	Micro pellets
Sludge from gas cleaning plant of blast furnaces	Disposed	Micro pellets after dewatering
Dust from secondary fume extraction system (ESP or ba g filter)	Sinter plant/BOF Converters	Micro pellets for use in sinter plant/briquettin g for use
Sludge from gas cleaning plant	Sinter plant/BOF Converters	Micro pellets for use in sinter plant/briquettin g for use in converters after dewatering
Mill scales from caster and Mills	Sinter plant, depending on oi l content	Briquetting for use in BOF Converters.

Steel plant operations also generate hazardous wastes and the relevant global best practices in effective management of this hazardous waste cover the following in Table 2.2.

Table 2.2: Global Best Practice in the Management of Hazardous Wastes

Area	Hazardous waste	Usage/Disposal
Coke ovens	Decanter sludge, BOD plant sludge, Tar sludge	Used in coke ovens
	Still bottoms	Incineration / Cement plant
Blast furnace	High zinc containing flue dust	Hazardous waste disposal or sale
Others	Acidic, alkaline sludge, sludge from water treatment,	Hazardous waste disposal
	Waste and used oils, electric wastes.	Sale to authorized agencies for recycling

It is to be noted that the management of dusts and sludge depends on the steel plant configuration and requires innovative solutions (Singhal, 2009). There is therefore a need for the Ajaokuta Plant to obtain the experience of successful recycling schemes from other steel plants.

2.2.8 History of steel development in Nigeria and Nigerian steel industry

In 1958, the idea to establish a government-owned Steel Company was conceived but the politics of location killed the idea. The idea re-emerged in the mid-sixties at the threshold of the Nigerian crisis. And In 1967, during the Nigerian civil war, the idea matured into a bilateral relationship between Nigeria and the former Union of Soviet Socialist Republics (USSR) and a team of Soviet experts was commissioned to conduct the feasibility study on setting up an integrated steel plant in Nigeria. In 1971 the Nigerian government signed a contract with the Techno-export Company of USSR for a detailed geological and geophysical exploration of Nigeria for the raw materials requirement of the Steel Industry. This contract was executed with the then Federal Ministry of Mines, Power and Steel. Abundance of raw materials especially iron ore, limestone and dolomite were confirmed (Obikwelu, 2005). On 14th April 1971, the Nigerian Government in a Decree No.19 established the Nigerian Steel Development Authority (NSDA) to identify, locate and procure locally available raw materials for the steel industry. By the middle seventies, NSDA re-established the availability of Iron ore and coal in Nigeria. In 1974 Tiaj Prom-Export (TPE) of USSR submitted a preliminary project report (PPR), rationalized in 1975 when the siting of the Company at Ajaokuta to utilize the Itakpe iron ore was agreed upon. In the same 1975 TPE was commissioned to prepare a detailed project report (DPR) which was submitted to the Nigerian Government in 1977. In 1978 DPR was examined, modified and finally accepted. The DPR specified in broad terms the general layout, the raw materials requirements and the tentative master schedule (Obikwelu, 2005).

The above account shows that DPR for the Ajaokuta Steel Company became a working document since 1978, a period of almost thirty-one (31) years now. At this stage the then Federal Ministry of Mines, Power and Steel and the Steel Companies negotiated to establish the Beneficiating plant at Itakpe near Okene, the site of iron ore deposit, to supply iron concentrates to the Steel Plants. In 1979 NSDA was replaced with the National Steel Council made up of the Mining and Exploration Division based in Kaduna and the Metallurgical Development Centre based in Jos. On 18th September, 1979, the Associated Ores Mining Company (AOMC) now the Nigerian Iron Ores Mining Company (NIOMC) was established by Decree No.60 in 1975/80 Development Plan, the Nigerian Government disclosed its intention to set up additional steel plants based on the Direct Reduction Route of producing iron to be sited in Ovwian –Aladja in order to utilize copious natural gas being flared in the various oil fields. The Nigerian Government also decided to establish three Rolling Mills, each of 210,000 tons annual capacity to be sited in Katsina, Oshogbo and Jos. In October, 1977, the contract for the construction of Delta Steel Company at Ovwian – Aladja, Warri was awarded to the German Consortium headed by Messrs. Delta Steel Company would consist of seven units integrated process-wise to produce 1 million tons of liquid steel per annum and a captive rolling mill with 320,000 tons rolling capacity. In 1982 precisely on 29th July, the fully completed Delta Steel Plant was commissioned and production started in the same year. In 1982 and 1983 the Rolling Mills at Jos, Katsina and Oshogbo were all commissioned and were expected to obtain their billets from Delta steel company Ovwian-Aladja in Warri (Obikwelu, 2005).

In 1987, in order to ensure that steel plants were not starved of raw materials Government established the Raw Materials Research and Development Council (RMRDC) by decree No.39 under the Federal Ministry of Science and Technology. RMRDC should amongst other things establish self- supporting small-scale projects on raw materials exploitation to expedite industrial development for maximum utilization of local raw materials deposits as inputs to the steel industries. The National Metallurgical Development Centre (NMDC) should undertake studies and projects on beneficiation of locally available raw materials, development of processes and products for the exploitation of these raw materials into pilot scale for commercialization. On the other hand, to ensure availability of junior and middle level personnel support for the Steel Industry, the Nigerian Government established the Metallurgical Training Institute (MTI) to be located at Onitsha to train this cadre of staff for the Steel Industry (Obikwelu, 2005).

Delta Steel Company, Ovwian-Aladja, Warri was based on the German DIN standard and consists of the following units operationally integrated: Beneficiating and pelletizing plant, Direct Reduction (DR) plant, made up of two modules, the Steel Melt shop, the continuous casting shop, the air separation plant, the foundry, the General Maintenance Shop with feeder units in various process departments. Light and heavy vehicle maintenance units were in this Maintenance Shop. The basic raw materials in tons required for the Delta Steel Company Operations were as follows in tones per annum: Iron Ore: $1.5x10^6$**,** Limestone: 130,000**,** Coke: 5000**,** Scrap: up to 160,000**,** Refractories: 16, 000. The Projected product mix was made up of Direct Reduced Iron (DRI), Billets (120x120) mm^2, ribbed bars, angles, strips and channels. Plate production in the Delta Steel Company would have enriched the product mix for other industrial applications. It is strange for Delta Steel Company Limited because it is not clear whether DSC as it is popularly known is alive or dead or dying in a country at the peak of her technological growth. These are the happenings in the Metallurgical industries especially the Steel Industry in Nigeria which were designed to produce 210,000 tons of rolled products based on (120x120) mm^2 billets from Delta Steel Company Ovwian-Aladja. And for Private Steel Companies, apart from Universal Steel, Ikeja, and Continental Iron and Steel Ikeja that produced liquid steel and billets, others (Mayor Engineering, Ikorodu; Mandarin Steel Company, Ilupeju; Sell Metal, Ikeja) produced billets (100x100) mm^2, (120x120) mm^2, (60x60) mm^2, pipes (only Mandarin Steel Company produced pipes), and rods of dimensions (12 mm, 16 mm, 40 mm) using billets, crop ends and scraps. Quantity of steel products from private steel companies is very small compared to the Steel products from operating Government Steel Companies (Obikwelu, 2005).

The Ajaokuta Steel Plant design was based on the blast furnace route to iron production with initial capacity of 1.3 million tons of liquid steel per annum with built in capacity for possible future expansion to 2.6 million tons per annum in the first phase and up to 5.2 million tons per annum in the second phase. By the initial costing, the first phase was estimated to cost 2.5 billion naira. The present phase of the company and the amount already sunk into the Ajaokuta Steel Project or Company are any body's guess. The Ajaokuta Steel Company, the engine of industrial emancipation of Nigeria consists of the following process units:

- Raw materials preparation unit (including the sintering plant)
- Coke-oven and by product plant
- Iron making unit
- Steel making unit
- Rolling mill
- General Auxiliary unit

Ajaokuta Steel Company was designed and specified in Russian System yet in 2003 an American based Company found its way in Ajaokuta to run the company with disastrous consequences. Blast furnace operational route requires continuous operation for at least 5 years, and this presupposes stock piles of raw materials was to support the period of production. Projected Ajaokuta blast furnace slag from the Blast Furnace was to be used in **r**oad surfacing, aggregate for concrete, fertilizer for farmers, rock wool raw materials, cement and others.

2.2.9 Historical background of Ajaokuta steel company limited

Ajaokuta Steel Company Limited (ASCL) popularly known as Ajaokuta Steel Mill is a steel mill in Nigeria, located in Ajaokuta, Kogi State, Nigeria. ASCL was built on 24,000 hectares (59,000 acres) site which started in 1979 as the largest steel mill in Nigeria, and the coke oven and by-products plant are larger than all the refineries in Nigeria combined. However, the project was mismanaged and remains unfinished forty years later. Three-quarters of the complex have been abandoned, and only the light mills have been put into operation for small-scale fabrication and the production of iron rods. The project was undertaken by the Soviet Union under a cooperation agreement with Nigeria. In 1967, Soviet experts recommended prospecting for iron ore in Nigeria, as the known deposits were of poor quality for steelmaking. ASCL was incorporated in 1979, and the steel mill reached 98% completion in 1994, with 40 of the 43 plants at the facility having been built. To supply the Ajaokuta Steel Mill with raw materials and connect it with the world market, a contract was awarded in 1987 for the construction of Nigeria's first standard gauge railway, from the iron mines at Itakpe to the steel mill at Ajaokuta and continuing to the Atlantic Ocean at Warri.

However, both projects have been mismanaged. The Ajaokuta Steel Mill was still incomplete forty years after construction began. After several failed attempts at privatization, the Nigerian government took back control in 2016. The Ajaokuta Steel Mill still had not produced a single sheet of steel by 2017. The light mills were finally put into operation in 2018 for small-scale fabrication and the production of iron rods. However, three-quarters of the plant have been abandoned, including the large-scale equipment and the internal railway. The Itakpe–Warri Rail-way fell into disrepair, and part of the track was vandalized. In 2016, the Nigerian government awarded contracts to the China Civil Engineering Construction Corporation (CCECC) and Julius Berger to repair and complete the railway. Test runs began in 2018, and the railway was expected to be completed by the end of 2019 and finally this has come to reality **(**Ejike, 2018).

2.2.10 Strategies for educating and raising awareness on solid waste management

In order to control the way solid wastes (metal waste) are handled by individuals and authorities concerned with solid waste (metal waste) management, there is the need to educate the citizens and raise awareness on the negative impacts of improper management of solid wastes. This is supported by Ribble Valley Borough Council (RVBC) (2009) which asserts that adopting a waste awareness and education strategy would clearly indicate commitment to raising public awareness on waste. It also considered that such a strategy would provide an ideal educational framework that will lead to consistency of information and identify more practical activities that can be undertaken by individuals and authorities concerned with wastes management. The strategies are discussed below:

i. Infusion of solid wastes management themes into academic curricula: The infusion of Solid wastes (metal waste) management themes for environmental sustainability into the academic curricula at all levels of education will contribute immensely to the citizens perception and attitudinal change towards waste management. Waste management themes can be infused into traditional subjects like science, social studies, Geography and English. Adekunle *et al.* (2012) noted that if citizens are mobilized at a tender age, by infusing solid waste (metal waste) management themes into their curricular, safe waste disposal of materials will become a natural habit as their hearts and minds will be captured early in life. This will promote a sense of responsibility and best practices of managing wastes.

ii. Establishment of environmental clubs and programmes: Establishment of environmental clubs and programmes on solid waste (metal waste) management in primary, secondary, tertiary institutions and even in the industries where solid waste (metal waste) are also produced will equally enhance proper management of wastes. Through this medium, knowledge and understanding of solid waste (metal waste) management will be developed, positive attitudes, values, care and concern for the environment will be attained. In the same vein, appropriate skills and competences needed for segregation, reduction, reuse, composting and recycling will be inculcated in the citizens that will enhance active participation of people in solid wastes management (Festus & Ogegbunam, 2012).

iii. Informal and non-formal education strategy: Individuals in the society that cannot be reached in the formal school system can be educated informally and non-formally. This could be achieved through the print and audio-visual media and the internet. Educating the people through these media will enhance better practices of solid wastes (metal waste) segregation, reduction, composting and recycling of solid wastes (Festus & Ogegbunam, 2012).

iv. Public awareness on solid waste management: The creation of awareness on the negative impact of improper management of solid wastes (metal waste) is of great importance in motivating individuals to participate in waste management. In order to increase household participation in recycling, Omran *et al.* (2007) state that the message of recycling as an appropriate waste management technique needs to be adequately communicated to the public. This will enable residents to change their habits, behaviour and traditions towards recycling for the better. The message can be created through various strategies. This could be carried out through advertisements in the newspapers, television, radio, billboards and the use of leaflet. Enlightenment campaigns, clean up campaigns are other avenues of creating awareness on waste management. Omran *et al.* (2007) observe that the integrated use of all media can increase public participation in recycling of solid wastes. The organization of workshops, seminars on environmental issues and solid waste management in particular can equally be employed.

v. Use of environmental educational materials: End-user Environmental Adult Educational materials like posters, fliers located at strategic locations in various parts will constantly keep the citizens informed about appropriate attitude and proper methods of handling the wastes they generate daily end-user environmental adult education materials as noted by Mbalisi (2009) are "materials which the target audience require no further interpretation to understand and assimilate the information". The use of local languages in the dissemination of information on how to manage wastes properly is paramount in the sustainable solid waste (metal waste) management so as to reach out to the citizens that do not understand English language. These materials therefore can be prepared in different languages so as to enable the target audience to comprehend the messages they convey. The activity based environmental education materials like curriculum guides, reference materials and policy documents can also be utilized. Mbalisi (2009) also noted that activity-based materials are those environmental adult education materials which require further interpretation before the target audience could understand and assimilate the information they contain. These materials can be used in schools, workshops, seminars, presentations and group discussions (Festus & Ogegbunam, 2012).

2.2.11 Sustainable metal waste (solid waste) management

Over the years, the problem associated with solid waste management is more acute in developing countries of the world than the developed world (Zerbock, 2003). Many Developing Countries are still struggling with solid waste collection and management (Wilson, 2007), and Nigeria is no exception. Solid Waste (Metal waste) is waste generated and discarded as useless or unwanted from activities in homes, institutions, public and commercial places, and industries, though it is also a resource for reuse, recycle, and recovery. According to Ogogome (2015) waste management is the collection, transportation, processing, treatment, recycling or disposal of waste materials to reduce their adverse effect on human's health or amenities. A sustainable solid waste (metal waste) management system encompasses a system that is environmentally, financially, and socially appropriate and acceptable, and meets the criteria of sustainable development, development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. Environmental sustainability requires that solid waste (metal waste) collection and disposal which imposes great burden on the environment and resources, be transformed into a closed-cycle system (closing the loop) restoring various natural cycles, thus preventing the loss of raw materials, energy, and nutrients. (Ogogome, 2015).

2.2.12 National environmental policy for metal waste management

The law on the management of wastes in Nigeria has emerged from basically focusing on environmental sanitation regulation and is in the process of transforming into a more comprehensive body legislation that addresses other environmental management issues. Before now, traditional system of environmental regulation has been in existence, whereby customary laws and practices peculiar to particular ethnic groups existed and were enforced. It has been rightly observed that "long before the advent of the colonial laws, each clan and village had different laws for the protection of the environment. Some of these unwritten laws are in the form of societal norms while others are in the form of adages". Thus, the village head or king and his council of chiefs evolved and enforced these unwritten policies and laws respectively. Their pronouncements, affected all sanitation issues including refuse collection and disposal. Great significance was placed upon public health, site location in terms of local, indigenous industries (e.g., iron welding), commercial (market places), residential (local and foreign residents) and religious (worship places) activities. Therefore, it would not be too far-fetched to state that the traditional Nigerian society was environmental conscious especially in use and conservation of local resources.

The Colonial period (1860-1960) witnessed greater impetus in the formal establishment of public health policies. The public health policies became a priority of the British Colonial Government (BCG) in its attempt to protect the health of its officers and troops from prevalent local diseases, specific environmental sanitation programmes were introduced and enforced by native Authorities (NA) such as control of mosquito breeding areas which were backed by law. The Public health ordinance of 1917 which initially applied only to Lagos township and later to the whole country was aimed at controlling identified problems.

The public health ordinance (cap. 125), 1958, LFN) was enacted in preparation to Nigerian's independence from British colonial rule concentrated mainly on environmentally related aspects of domestic waste disposal. This legislation was applicable in the country until 1990 when a national law exercise was conducted. The law contained provisions on controlling infectious diseases, slaughter of animals, night soil disposal (section 13, 14, 30, 34, 44, 45, 45, 47 and 49). The Criminal Code Act of 1958 also made provisions to prevent and control threats to public health through the visitation of the atmosphere. Offences in this respect resulted in imprisonment for six months or small fines. These laws were in force in Nigeria until the review of laws in 1990.

The role of colonial and post-colonial laws thus primarily focused on the management of domestic wastes, even though, one of priorities of the independent Nigeria State was the development of modern industries. The implication of the observation was that hardly any effort appears to have been to regulate the activities of emerging industries during the colonial and post-independence periods, particularly in terms of enacting legislations to manage waste. It must however be stated that in the 1980's, various Environmental Sanitation Edicts were essentially three-fold, namely: the provision of a legal framework and establishment of a body responsible for environmental sanitation maintenance; the prescription of miscellaneous offences and penalties relating to health and sanitation issues; and other incidental matters. Despite these laudable attempts at specifically regulating waste disposal activities, these laws fell short of their objective due to various factors which included lack of awareness by the populace, poor enforcement of laws, inter-ministerial or institutional inconsistencies, public apathy and lack of legal provisions.

2.2.13 Policy instrument

Environmental revolution has critically made the trend of control very complex by extending waste management issues beyond public health protection and national boundaries. It now extends into private and futuristic interests, international and political arena. In consonance to this, metal waste management industry has become one of the most controlled in the developed economics. Nevertheless, it is obviously not regulated in most developing economics including Nigeria leading to serious health and long-term environmental liabilities on the nation. Sadly, Nigeria today has no comprehensive policy framework on waste management and so has no nationally acceptable definition of waste (Osai, 2006). A framework of an enduring policy instrument likely to sustain Nigerian aspiration in waste management shall recognize the socio-economic structure of Nigeria, thus structuring responsibilities and jurisdiction in similar manner to minimize friction and improve business environment. This framework shall address the following:

- Imposing of physical, informative and financial duties on waste generator and importers or producers of special products.
- Technically adopting a stepwise approach that recognizes all technological options in lieu of waste hierarchy (integrated waste management). This shall ensure that environmental objectives are always balanced and also give room for transitional technology.
- Develop the concept of provision of service that will gradually shift from Government to waste generator.
- Transfer service delivery to private sector who will gradually assume the responsibility of cost recovery.
- Encourage development of national professional organization in waste management for establishment of code of conduct and best practices in the industry.
- Increase financial incentives to waste manager in terms of duty exemption, investment capital subsidy and tax holidays.
- Imposing of secondary raw material content in goods and subsidizing cost of energy generation from waste (Osai, 2006).

2.2.14 Current policy on domestic and industrial wastes disposal in Nigeria

In very recent times more concerted efforts have been made to address the wider issue of environmental protection, and particular the management of wastes in Nigeria through policy formulation and implementation as well as through legislation at Federal and State levels of governance. Some of these are briefly explained (Gazali, 2015).

2.2.15 National policy on environment, 1989

The policy was established in 1989, with the aim of achieving sustainable development of the Nigeria environment for the purpose of meeting the present and future development needs, the National Policy on Environment, 1989 is basically meant to:

- ❖ Securing a quality environment that is adequate for the health and well-being of all Nigerians;
- ❖ Conserving and using the environment and natural resources for present and future generations;
- ❖ Restoring, maintaining and enhancing ecosystem and ecological processes in other to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystem.
- ❖ Raising public awareness and promoting understanding of essential linkages between environment and development and encouraging individual and community participation in environmental improvement efforts.
- ❖ Cooperating with other countries, international organizations/agencies to achieve optimal use of trans-boundary environmental natural resources and effective prevention of abatement of trans-boundary environmental pollution.

The policy represents a deliberate attempt to integrate environmental issues in a holistic and systematic manner. One of the strategies outlined in the policy were towards establishing and strengthening legal, institutional, regulatory, research, monitoring evaluation, public information and other relevant mechanisms required is the Sanitation and Waste Management Strategy (SWMS). In this respect, the policy underscores the significance of appreciating the range of treatment, disposal and re-use options available for sanitary and industrial effluent, raw domestic wastes amongst others in the achievement of environmentally sound management of wastes. The need for environmental studies of industrial effluents as well as the variety of solid and liquid wastes generated in the various ecological zone of the country to prevent the spread of diseases and land, air and pollution is also recognized. The policy therefore advocates appropriate guidelines for waste collection and disposal, some of which include:

- ❖ Setting up and enforcement of standards for adequate sanitary facilities for the disposal of human and other solid wastes (metal waste) in dwellings, housing estates and public facilities in both urban and rural areas (Section 3.6 (d));
- ❖ Establishment of monitoring programmes including periodic surveillance of approved waste disposal sites and their surrounding and wastewater treatment systems (Section 3.6 (e));
- ❖ Establishment of safe limits for the location of water wells, boreholes and dams in the vicinity of major sanitary landfill sites (Section 3.6 (g));
- ❖ Establishment of an early warning system for the identification of potential waste disposal hazards (Section 3.6 (h));
- ❖ Regulation, registration and licensing of all major land-based waste disposal sites and system (Section 3.6 (i)); and public health criteria (Section 3.6 (v)).

The extent to which the current legal and institutional efforts have succeeded in achieving some or all the aims of these guidelines remains to be evaluated by all concerned (Gazali, 2015).

2.2.16 Federal environmental protection agency

Federal Environmental Protection Agency (FEPA) Act of 1988. FEPA was established by Decree 55 of December 30th, 1988. FEPA was vested with the statutory responsibility for overall protection of the environment. The FEPA decree covers all sectors that deal with environmental issues. The Decree contains penal provisions against offenders discharging hazardous substances in harmful quantities into the air, land and water. The decree requires FEPA to issue environmental guidelines and standards for the abatement and control of all forms of waste management. This guideline, the first ever of its type was launched in 1990. In 1991, FEPA established an inspectorate and enforcement department with divisions for standard regulation, chemical tracking and compliance monitoring waste management. All these were directed by exercising control and preventing hazards (Gazali, 2015).

2.2.17 The environmental impact assessment act

The environmental assessment Decree No 86 of 1992 is a compliment to the Federal Environmental Protection Act (FEPA) Decree in the important area of land utilization and sitting of industries. The principal goal of this enactment was stated under section 1 which is to ensure that possible negative impacts of development projects are predicted and addressed prior to any project take-off, while the second phase is to assess the principle of environmental audit or evaluation. This process was born out of an environmental audit report which complements the process of an environmental impact assessment. Based on the objectives of this Act, FEPA established an environmental impact assessment department in 1993. The department was saddled with the responsibilities of ensuring enforcement and compliance with provision of the act in every aspect of the nation’s environmental development in efforts. It is clear that this Act provides opportunity for enhancing sustainable development in Nigeria, but it is clear that uncontrolled industrial activities posed greater danger to the environment than any other activity. Nwufo (2010) reported that the problem of Nigeria is the problem of enforcement and implementation of the environmental laws.

2.2.18 The harmful waste (special criminal provision) act 1988

The Act was enacted with the specific object of prohibiting the carrying, depositing and dumping of hazardous wastes (metal waste) on any land, territorial waters and matters relating there to. Section 12 of the act is related to the offences constituted by doing any of the Act as stated in the act. The Act is sought to remove any immunity conferred by diplomatic immunities and privileges Act on any person for the purpose of criminal prosecution. However, it is important to note that despite its jurisdiction, it does not provide compensation to the victim of damage but only focuses on criminal prosecution of damage. For instance, Section 6 of the Act provides for a life imprisonment and in addition the forfeiture of any aircraft, vehicle or land connected with or involved with the violation. However, it was observed that there had never been a decided case of any person whether natural or artificial, prosecuted pursuant to the provision of this Act (Nwufo, 2010).

2.2.19 National environmental standards and regulations enforcement agency (NESREA) act, 2007

The National Environmental Standards and Regulations Enforcement Agency Act, 2007 repealed the Federal Environmental Protection Agency Act and create the National Environmental Standards and Regulations Enforcement Agency (NESREA). With the principal responsibility of protecting and developing the environment, its biodiversity, and conservation. NESREA is further charged to ensure the sustainable development of

Nigeria's natural resources, that is, its standards, regulations, rules, laws, policies and guidelines on water quality, environmental health and sanitation, which include pollution abatement. The agency is also charged to enforce compliance with environmental regulations on the important, exportation, production, distribution, storage, sale, use, handling and disposal of hazardous chemicals and waste generated in the none oil and gas industries. NESREA is not however empowered to regulate most environmental activities in the oil and gas sector**.** NESREA is also required to recognized every company that demonstrates and adopts the best environmental practices. One of the ways that such recognition will be conferred is by NESREA awarding to such a company the NESREA compliance mark flag award, which the compliant company can use to brand itself and its products. There are five kinds of NESREA compliance flag award; from the highest which is Green, to Blue, Yellow, Red and the lowest for non-compliance, which is red. In furtherance of the objectives of the NESREA Act, various environmental regulations were recently published in the government's official Gazette. Some of these regulations provide governance direction in some areas of human endeavor:

- Wetlands, Riverbanks, Lake Shores, Mountains and Hills
- Sanitation and Waste Control
- Mineral Resources
- Ozone Layer Protection
- Food, Beverages and Tobacco
- Textile, Wearing Apparel, Leather and Footwear
- Noise Standards and Control
- Chemicals, Pharmaceuticals, Soap and Detergent
- Telecommunication and Broadcasting
- Soil Erosion and Food Control

- Protection of the Endangered Species
- Coastal and Marine Area Protection
- Construction, Decommissioning and Demolition Activities
- Control of Vehicular Emissions from Petrol and Diesel Engines
- Electrical or Electronic Activities.

These Regulations further empower NESREA to strictly enforce the three “Rs”- Reuse, Recover and Recycle. Thus, all recyclable damaged and disused packaging materials like glass, plastics, wood, nylon, paper and metals must be recycled (Gazali, 2015).

2.3 Review of Related Empirical Studies.

Nwachukwu *et al.* (2010) carried out a study on the assessment of the integrated study for automobile wastes management and environmentally friendly mechanic villages in Imo River Basin, Nigeria. Analytical results of the study showed that heavy metal concentrations ($mgkg^{-1}$) were above background levels in the upper 100cm soil profiles of the Okigwe, the Orji and the Nekede mechanic villages in Imo River Basin. The study revealed that for proper waste management and environmentally friendly mechanic villages, mechanic villages should have emission testing facilities, concrete floor workshops, toilet facilities, tarred roads and drainage channeled to one or more three-phase storm water treatment facilities.

The study recommended the use of infiltration method in the sandy areas, and detention method in the shale areas. A combination of the two methods can be used in the transition zones of the basin. The infiltration method is not applicable at Okigwe due to the clay/silt content (47-64%) and presence of an underlying clay bed, despite the initially high infiltration rate (38.cm/h). weathered layer (0.74m) across Orji and Nekede, and (0-4m) at Okigwe was the most implicated in the soil pollution process. Other recommendations made include: extended producer responsibility (EPR) for used motor oil, the use of local phyto-remediation plants sensitive to Pb, Mn and Cu, installation of ground water monitoring wells, comprehensive waste management plan, standard guidelines for establishment of mechanic villages, code of practice, and continuous education for the mechanics.

This study reviewed is similar to the current study because they deal with waste management. They are also related in research design, place, method of data analysis, method of data collection; but not related in research questions and research objectives, and sampling technique.

Abechi *et al.* (2010) conducted a study on Evaluation of heavy metals in roadside soils of major streets in Jos's metropolis, Nigeria to assess the potential environmental impacts of automobile emission on the soil. The sampling locations were chosen to span a wide range of traffic density and to give a good geographical coverage in Jos's city. Seven sites were selected for study. The traffic density was determined by counting the number of motor vehicles passing the sampling sites over a period of twelve hours starting 6.00 a.m. to 6.00 p.m. each day for three days. Results indicated the decreasing order of the average total metal content for the studied metals: Fe > Zn > Mn > Pb > Cd. Except for Cd, all metals were lower than the levels of those reported in other studies. The absence of Co and Ni indicates no pollution due to these metals. Correlation analysis between metals and the traffic volume indicate significant positive correlation ($p < 0.05$) between Pb, Cd and Mn, and V.

The study further indicates that the metal pollution in the soil is mostly originated from vehicular emissions from motor vehicles. Therefore, this study provides a practical approach to monitor the level of these metals. The result of the study revealed the presence of all metals with exception of Co and Ni in the roadside soils. Hence, possible accumulation in the soil and transfer to plants growing along the edge of the highway could occur as a result of continual usage of the road by automobile.

It was concluded that this can also lead to accumulation of the metal in the tissues of organisms that feed on the plant and other plants growing along the highway which can also be transferred to other consumers in the food chain. There is a clear indication that the mechanics were not aware of the effects of uncoordinated disposal of automobile waste in their community an aspect which this study intend to cover. This study reviewed is similar to the current study because they deal with metals and it impact on the environment. They are also related in research design, method of data analysis, method of data collection; but not related in research questions and research objectives, and sampling technique.

Babayemi and Dauda (2009) carried out research on Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A case study of Nigeria. They noted that the quantity and generation rate of solid wastes in Nigeria have increased at an alarming rate over the years with lack of efficient and modern technology for the management of the wastes. The study makes use of extensive literature search, questionnaire, interview and personal observation to carry out the research. Questionnaires were administered, covering the major parts of Abeokuta. The results indicated large generation at high rate without a corresponding efficient technology to manage the wastes. Among the 201 respondents that answered the questionnaire in Abeokuta, 35.8% used waste collection services, 64.2% used other waste disposal options, 16.4% used both, 68.7% and 58.7% were aware of waste collection service and waste management regulations, respectively, while 28.4% separated their solid wastes at source.

The study recommended that there is the need to enlighten the populace on the wealth inherent in their organic, plastic and paper wastes. Solid waste management policies and enforcement of sanitation laws in various Nigerian states should be energized, and various environmental organizations and societies to do more until the dreamed clean environment in Nigeria becomes a reality. Efforts of environmental scientists in the country are highly solicited in researching into all possibilities of making sustainable solid waste management to stay in Nigeria. Government should reinforce waste collection and disposal systems in every state while strengthening and enforcing the appropriate laws. Priority should be given to waste management in other to prevent serious environmental disaster in Nigeria. This study reviewed is similar to the current study because they deal with solid waste. They are also related in research design, method of data analysis, method of data collection; but not related in research questions and research objectives, and sampling technique.

Ogogome (2015) conducted a study on the analysis of domestic solid waste management strategies in Tunga, Chanchaga local government area, Niger state, Nigeria. Five research questions and two null hypotheses guided the study. A descriptive survey research design was adopted for the study. The study was conducted in Tunga, Chanchaga local government area, Niger state, Nigeria. A total of 328 respondents consisting of 100 male households and 228 female households was used as a total population for the study. A structured questionnaire developed by the researcher and validated by three experts was used for the data collection for the study. The reliability coefficient of the instrument was found to be 0.87 using Cronbach Alpha method. Mean and standard deviation were the statistical tools used for analyzing research questions; while t-test statistics was used for testing the hypotheses formulated for the study at 0.05 level of significant.

The findings among others revealed that: the methods of waste management adopted in the study area do not conform to sustainable waste management practices. This implies that much attention has not been given to domestic solid waste management in the study area. Based on the findings it was recommended that public enlightenment and education on issues of waste management and a better public awareness strategy on the subject matter, increase in waste collection frequency and the adoption of composting as a method of waste management since majority of the domestic solid waste generated is organic in nature. The study reviewed is related to the present study because it's analysis of domestic solid waste management strategies in Tunga, Chanchaga local government area, Niger state, Nigeria while the present study is also designed to assess metal waste management practices in Ajaokuta steel company. The present study differs from the previous study in terms of population and area of the study. However, the use of a descriptive survey research design is common to both studies.

Efe (2010) examined the problem of waste disposal and management in Ughelli. A field survey was undertaken to determine the types, volume, effects and methods of managing solid waste in the Ughelli. The volume of waste was measured at dumpsites in the four existing quarters and from household bins. Appropriate waste characterization methods were employed in classifying the waste into various components on weekly basis. Eighty and twenty questionnaires were administered to household's heads and industries respectively and summarized with descriptive statistics. The findings revealed an increase in the volume of solid waste generated over the years with 15,540 Kg mean annual volume of solid waste generated in Ughelli at dumpsites, and 1104.7 Kg mean volume of solid waste generated per households that never arrives at dumpsites. The composition of solid waste generated and disposed in Ughelli were predominantly food items, bottles/cans and plastics, paper/carton and nylon of sachet water, which were mostly found in market places. The most widely adopted method of waste disposal is open dumping, land filling, dig and bury.

The study recommended that government should adopt an appropriate waste collection and disposal agency and more government approved dumpsites should be established in the area. The study reviewed and the current study is related, because they deal with assessment of waste management and disposal. The two studies used similar research design, instrument for data collection, method of determining reliability of the instrument, and the use of mean and standard deviation in answering the research questions, but differ in geographical location, scope of the study, population size and sampling technique.

Chukwunonye (2010) conducted a study on analysis of barriers and success factors Affecting the adoption of sustainable Management of municipal solid waste in Abuja, Nigeria. The objectives of the study are to survey literature on legislative and economic drivers of municipal solid waste in the UK, to survey existing literature on transfer of drivers from developed to developing socio-economic systems, and to prescribe changes to current institutional and legislative waste management frameworks, modelled after UK best practice, capable of driving performance at sustainable limits. The study adopted both quantitative and qualitative research design approaches, questionnaire survey and focus group interviews of stakeholders in municipal solid waste management as key methods for generation of data.

The study employed three separate questionnaire surveys in collecting data on the barriers and success factors that affect Municipal solid waste management in Abuja, the questionnaires were administered to three categories of respondents: households, businesses and policy makers in government agencies charged with waste management. A sample size of 1639 was used for the entire survey questionnaires. Data collected are analyzed using the Statistical Programme for Social Sciences, (SPSS) and Microsoft Excel software packages. Key statistical test carried out included the Analysis of Variance (ANOVA) and Chi-Square tests. The findings of the study indicate that between 65-70% of municipal solid waste samples from Abuja is biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. On the other hand, between 11%-30% of municipal solid waste samples from the City comprises mostly of non-degradable but recyclable materials such as glass, metals and cans, non-ferrous metals and waste electrical and electronic equipment.

Data analysis also reveals that the main barriers to sustainable municipal solid waste management in the City include low public awareness/education on municipal solid waste management, obsolete and insufficient equipment and funding limitations. Therefore, Fundamental shifts in current practices towards waste prevention; driven by a structured public education programme in municipal solid waste management is recommended, so as to bring about a more sustainable management regime. The study reviewed is related to the present study as they both focuses on Solid waste (metal waste) management. They differ in research design, instrument for data collection, and method of data analysis, geographical location, population, and sample size.

Abul (2010) carried out a study to examine the environmental and health effects of solid waste disposal at Mangwaneni dumpsite in Manzini, Swaziland. Three research questions and three null hypotheses guided the study. A case study design was adopted for the study. The study was conducted in Mangwaneni, Manzini city, Swaziland. A total of 78 respondents out of 121 households were surveyed educing self-administered questionnaires, a comparison between the nearby and far away residents were done, 39 households close to the dumpsites and 39 households far away from the dumpsite. Also, interview and a field observation were used. Descriptive statistics were used to analyze the data collected for the study. The findings show that both residents were affected by the location of the dumpsite closer to their settlements. It was also noted that the residents whose houses are less than 200 meters from the dumpsite are victims of malaria, chest pains, cholera, and diarrhea. While residents whose houses are more than 200 meters were also affected with the chest pain and bad smell from the dumpsite, but mainly when wind is blowing in their direction. Based on the findings it was recommended that dumpsites should be properly located and managed to minimize its effects on the environment. The government and municipalities should revise laws regarding the locations of dumpsites. The study reviewed is related to the present study because it's examined environmental and health effects of solid waste disposal at Mangwaneni dumpsite in Manzini, Swaziland while the present study is also designed to assess metal waste management practices in Ajaokuta steel company. They are also similar in instrument for data collection. But they are dissimilar in geographical location, population, and sample size technique.

Amalu and Ajake (2014) conducted a study on the Appraisal of solid waste management practices in Enugu city, Nigeria. Data for the study were collected through questionnaire survey, interviews, field inventory and participatory rural appraisal methods. A total of 250 respondents comprising of household heads and market owners were used as a total population for the study. The findings among others revealed that the techniques of waste management were inadequate with the use of a central waste collection method and pattern; and that the population of the study area produced much more waste than the waste dumpsites can accommodate. Based on the findings it was recommended that the employment of a door-to-door waste collection system and that government should ensure accessibility to homes by constructing roads across the city and a reduction of the waste levy on residents in the area.

The study reviewed is related to the present study because it's examined Appraisal of solid waste management practices in Enugu city, Nigeria while the present study is also designed to assess metal waste management practices in Ajaokuta steel company. They are also similar in instrument for data collection but they differ in geographical location, scope, population size, and sampling technique.

Ifegbesan (2010) carried out research to explore the understanding of waste management and practices in secondary schools in Ogun State, Nigeria, using a structured self-administered questionnaire. A total of 650 students were surveyed from six secondary schools in two of the four educational zones in the state. The findings revealed that secondary school students from the sampled zones were aware of waste problems in their school compounds, but possessed poor waste management practices. The study showed that propensity for waste management practices differ by sex, class and age of the students. Significant relationships were observed between student's ages, class and their level of awareness, knowledge and practices of waste management. The study therefore, recommends that, proper waste management practices should be encouraged in secondary schools and should form part of the curriculum of the school programme.

This study reviewed is similar to the current study because they deal with waste management and practices. They are also related in research design, method of data analysis, method of data collection; but not related in geographical location, population size, research questions and research objectives, and sampling technique.

Aondoakaa and Ishaya (2009) assessed people's perception of the impact of urban generated solid waste on the environment in Gboko, Benue State using 200 questionnaires which were administered to the inhabitants of the town. The major waste generated were household discarded materials and food remains while in the less developed areas, majority of the respondents expressed that most of the solid waste generated are from agricultural activities. They reported that most people in the study area have low knowledge of the impact of solid waste disposal on the environment and they feel they are not responsible for the management of the waste they generate. Their findings reveal that majority of the respondents that were aware that solid waste has an impact on the environment were educated.

The study recommended strong environmental campaign and an enactment of environmental laws in Gboko town. The study reviewed is related to the present study as they both focuses on assessing solid waste (metal waste) management. They are also similar in research design, and instrument for data collection. But they are dissimilar in geographical location, population, and sample size technique.

Afangideh, *et al.* (2012), examined the attitude of urban dwellers to waste disposal and management. One hundred and fifty copies of questionnaire were administered to residents in the area. Information such as the various classes of waste, frequency of waste disposal and methods of waste evacuation were obtained from the questionnaire. Finding revealed that family size has a great influence on waste disposal and generation which was evidence in the hypothesis with a calculated value of 7.32 greater than the critical value of 2.43 at 0.05 level of significance. Besides, environmental enlightenment has changed people’s attitude towards waste generation and management in the area. This was affirmed in the calculated f-value of 3.18 greater than critical t-value of 1.97 at 0.05 level of Significance. However, this result indicates that effective environmental enlightenment would help avert the attitude of urban dwellers to waste disposal and management in the area.

This study reviewed is similar to the current study because they deal with waste disposal and management practices. They are also related in research design, method of data analysis, method of data collection; But they are dissimilar in geographical location, population, and sample size technique.

Darma (2009), carried-out a study on the Task and Need Analysis of Metalwork Casting in Katsina State of Nigeria. Five research questions guided the study. The objectives of the study include; determine the future need of metal casting jobs in Katsina State, identifying programme content in metal casting for the Technical Colleges and Vocational Training Centres in Katsina State, determine skilled manpower need for the field of metalwork casting in Katsina State, and determine job opportunities that exist in the area of metal casting in Katsina State. Survey research design was adopted for the study. The study was carried out in Katsina State, Nigeria. The population of the study comprises of 379 personnel and 96 supervisors of metal casting industries in Katsina State. 100 sample respondents were chosen for the study using stratified random sampling technique. Structured questionnaire was used as data collection instrument. Simple percentage of mean and standard deviation were used to answer the research questions for the study.

The findings of the study among others show that: The personnel require skills in patternmaking, sand preparation, core-making and casting fettling; there is need for future personnel in casting industries in Katsina State; 98% of the respondents agreed that there is need for additional manpower in casting industries in Katsina State; and knowledge of computer literacy, and computer aided design and manufacturing is required by the personnel of the casting industries. The researcher made recommendations based on findings of the study. This study reviewed is similar to the current study because they deal with metalwork trade (steel production). They are also related in research design, method of data analysis, method of data collection; but not related in geographical location, research questions and research objectives, and sampling technique.

2.4 Summary of Literature Review

The planned behaviour and Zero waste theories were extensively reviewed. The principles behind these theories best explain the critical issues in metal steel waste management practices in Ajaokuta steel company, Kogi State, Nigeria and its problems. These theories were found to be the most relevant to the study; consequently, they are adopted for the study. The conceptual framework of metal wastes management is not left-out in the review as this section presents various concepts and theoretical frameworks on the subject of the study.

Similarly, it includes a review of literatures which provides suitable information for this study on the concept of assessment, waste and waste management, composition and source of waste generation, solid waste generation, overview of waste management in developing countries, Nigeria and ASCL, Steel Scrap, History of steel development and steel industries in Nigeria, Historical Background of ASCL sustainable waste management and strategies for educating awareness on solid waste (metal waste) management, national environmental policy for metal waste management, policy instrument, current policy on domestic and industrial wastes disposal in Nigeria, national policy on environmental, Federal environmental protection agency, the environmental impact assessment act, the harmful wastes act and also, the review explained the national environmental standards and regulations enforcement agency act.

In conclusion, many empirical studies found relevant to this study were reviewed; their similarities and dissimilarities to this study were spelt-out. However, none of them goes directly with the Assessment of metal steel waste management practices in Ajaokuta steel company, Kogi State, Nigeria and moreover, no empirical study on the Assessment of metal steel waste management practices in Ajaokuta steel company, Kogi State, Nigeria has been carried-out. Therefore, the research will greatly contribute to knowledge, and socio-economic development by creating more profit and reducing metal wastes in ASCL, other steel plants and the Country at large.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

A descriptive survey research design was adopted for this study. Ukwuije and Ubowu-Adutchay (2012), describes descriptive survey research design as a research design that employs the use of questionnaire for the collection of data from sample of a given population and make a generalization based on the data collected. It is also identified as a design which a group of people or items are studied by collecting data from few of them considered to be the sample or representatives of the entire group, and, draw-out conclusion or generalization on them, based on the data collected. The study involved the use of structured questionnaires developed from the review of related literature to assess metal steel waste management practices in Ajaokuta steel company, Kogi state, Nigeria. This design is therefore most suitable for the study.

3.2 Area of the Study.

The study was carried out in Ajaokuta Steel Company Limited (ASCL) in Kogi State, Nigeria. Kogi State has a total land area of 27,747Km^2. Kogi lies approximately along latitude 7^0N and 6^0E and is bordered by Nassarawa State to the northeast; Benue to the east; Enugu, Anambra, and Delta to the South; Edo, Ekiti and Kwara to the west; and Niger, FCT Abuja to the North (Idris, 2005). ASCL is popularly known as Ajaokuta Steel Mill in Kogi State, Nigeria. Mismanagement and inadequate utilization of metals steel waste by the engineers, technologists and technicians with resultant to loss of profits and human health condition necessitated the choice of ASCL as an area of study.

3.3 Population of the Study

The target population for this study was 150 respondents comprising of 60 engineers, 50 technologists and 40 technicians, all from ASCL, Kogi State, Nigeria. The Population of the study is highlighted in Table 3.1:

Table 3.1:
Population Distribution in the Area of Study

S/N	Respondents	Numbers
1.	Engineers	60
2.	Technologists	50
3.	Technicians	40
	Total	**150**

Source: Utility Department, ASCL (2021).

3.4 Sample and Sampling Technique.

Since the total population is of manageable size, no sampling technique was employed for the study, hence the entire population was utilized for the study.

3.5 Instrument for Data Collection.

The instrument that was used for data collection was a structured questionnaire titled: Metal Steel Waste Management Practices Questionnaire (MSWMPQ) (see Appendix A). This was divided into seven sections (A, B, C, D, E, F and G). Section A elicited personal information on the respondent. Section B contains 13 items on metal wastes collection practices in Ajaokuta steel company. Section C consists of 12 items on metal wastes recycling practices in Ajaokuta steel company. Section D contains 15 items on metal wastes disposal practices in Ajaokuta steel company. Section E contains 10 items on metal wastes reduction practices in Ajaokuta steel company. Section F contains 15 items which deals with the constraints associated with metal wastes management practices in Ajaokuta steel company. Section G consists of 15 items on ways of improving metal wastes management practices in Ajaokuta steel company, having a total of 80 questionnaire items. All sections of the research questions were structured on 4-point rating scale options of strongly agree (SA), agree (A), disagree (DA), and strongly disagree (SD) with 4 points rating Scale and assign numerical values of 4, 3, 2, and 1 were used.

3.6 Validation of the Instrument

To ensure the appropriateness of the Instrument, the instrument was content, and face validated by three experts in the Department of Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology Minna, Niger State. They were requested to ensured clarity and appropriateness of the items with regards to addressing the problem under study and the research questions under investigation, they made correction and suggestions. The instrument contained 80 items. See Appendix C validation certificate.

3.7 Reliability of the Instrument

The instrument was pilot tested using 8 engineers, 6 technologists and 6 technicians in Prism Steel Mills Limited, Ikirun, Osun State, Nigeria using split-half method. The choice of Prism Steel Mills Limited, Ikirun, Osun State for the pilot test exercise was because Prism Steel Mills Limited, Ikirun, Osun State, did not formed part of the study area. Cronbach Alpha method was used to test the reliability index of the instrument. Cronbach Alpha statistics was used to determine the reliability of the instrument because items are non-dichotomously scored. Statistical package for social sciences (SPSS) version 23 was used to compute the reliability coefficient for each of six clusters which formed the six research questions. Thus, the reliability coefficient of each section is as follows: section B = 0.78; section C = 0.89; section D = 0.93; section E= 0.78; section F = 0.78 and section G = 0.86 respectively. The overall reliability coefficient for the entire 80 items questionnaire was determined to be 0.97. The result indicated that the instrument was reliable, and it was therefore considered appropriate (see Appendix B).

3.8 Administration of the Instrument

The researcher personally visited Ajaokuta Steel Company Limited to administered the questionnaires. The questionnaires were administered to the respondents (engineers, technologists and technicians) with the help of three research assistants who were familiar with ASCL. The questionnaire was distributed and collected after two weeks. 100% of the questionnaires given to engineers and technologists were retrieved and analyzed. However, only 85% of the questionnaires given to technicians were retrieved and analyzed making 34 in number. See table below for distribution and returned rate of questionnaire.

Table 3.2: Distribution and Return rate of Questionnaire

S/N	Respondents	Number Distributed	Number Returned	% Returned
1.	Engineers	60	60	100
2.	Technologists	50	50	100
3.	Technicians	40	34	85
	Total	**150**	**144**	**96**

3.9 Method of Data Analysis

Statistical Package for Social Sciences (SPSS, version 23) was used for data analysis. Descriptive statistics of mean was used to answer the research questions. Standard deviation was used to determine the closeness of the mean scores. One way Analysis of variance (ANOVA) was used for testing the null hypotheses formulated for the study at 0.05 level of significance.

The standard deviation was used to decide the closeness or otherwise of the respondents from their mean responses. Therefore, any item with standard deviation of less than 1.96 was indicated that respondents were not too far from the mean or from one another in their responses; and any item having standard deviation equal/above the critical standard deviation were revealed that respondents were too far in their mean from their responses.

The decision on research questions were based on the resulting mean scores interpreted relative to the concept of the real lower and upper limit number as indicated in the Table 3.3; while the decision on the hypotheses formulated for the study was based on comparing the significant value with (p<.05) level of significant, that is where the significant value is less than (P<.05) it was rejected, while equal or greater than (p<.05) level of significant the hypotheses was accepted.

3.10 Decision Rule

Table 3.3 interpretation of four-point scale

S/N	Response Option	Rate	Real Limit	Remark
1.	Strongly Agree	4	3.50 - 4.00	Strongly Agreed
2.	Agree	3	2.50 - 3.49	Agreed
3.	Disagree	2	1.50 - 2.49	Disagreed
4.	Strongly Disagree	1	0.50 - 1.49	Strongly Disagreed

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Research Question 1

What are the metal wastes collection practices in Ajaokuta steel company?

The result of research question is presented in Table 4.1

Table 4.1: Mean and Standard Deviation of Respondent on the Metal Wastes Collection Practices in Ajaokuta Steel Company. N = 144

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Metal wastes are collected based on approved standard.	3.22	0.81	A
2.	Metal wastes collected are kept in the scrap yards.	3.72	0.47	SA
3.	Metal wastes bins are kept in a very strategic location.	3.65	0.62	SA
4.	Metal recycling equipment are used to collect metal wastes.	3.64	0.71	SA
5.	The collected metal wastes are sent out to mills or foundries.	3.04	0.65	A
6.	Metal wastes are collected at designated drop-offs.	2.93	0.62	A
7.	Metal wastes are collected by scrapers.	2.97	0.61	A
8.	Metal wastes are sorted out based on recyclable and non-recyclable materials.	3.19	0.74	A
9.	Metal wastes collected are melted in furnace for re-use.	3.29	0.75	A
10.	Re-melted waste metals are cast into ingots.	3.00	0.70	A
11.	Re-melted waste metals are stored in industrial flask for production of components.	3.06	0.87	A
12.	Metal wastes collected are squeezed/squashed for recycling.	3.11	0.59	A
13.	Metal wastes collected are broken down into tiny pieces for further processing.	2.59	0.87	A
	Grand Total Mean/SD	**3.18**	**0.69**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation;
SA = Strongly Agree; A = Agree

The analysis in Table 4.1 shows the means responses of the respondents on the thirteen (13) items posed to determine the metal waste collection practices in ASCL with a grand mean of 3.18. This implies that the respondents agreed with all the items as metal waste collection practices adopted in ASCL. The standard deviation of the items ranges from 0.47 - 0.87 which means that 13 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.2 Research Question 2

What are the metal wastes recycling practices in Ajaokuta steel company?

The result of research question is presented in Table 4.2

Table 4.2: Mean and Standard Deviation of Respondent on the Metal Wastes Recycling Practices in Ajaokuta Steel Company **N = 144**

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Metal wastes collected are sent to the scrap yards for recycling.	3.66	0.57	SA
2.	Metal wastes are sorted in an automated recycling operation.	2.94	0.72	A
3.	Magnets are used to aid the separation of metals from the mixed scrap metal stream.	3.04	0.58	A
4.	To allow further processing, metals are shredded.	3.00	0.57	A
5.	Scrap metals are melted in a large furnace and process for further use.	3.13	0.69	A
6.	Metal is taken to a specific furnace designed to melt a particular metal.	3.10	0.69	A
7.	Scrap metal purification is practiced to ensure the final product is of high quality and free of contaminants.	2.96	0.77	A
8.	Molten scrap metals are allowed to cool and solidify before forming into specific shapes.	3.04	0.81	A
9.	Solidified scrap metals after melting are transported to factories as raw material for the production of brand-new products.	3.02	0.77	A
10.	Eddy current separation is used to separate metals from a mixed stream of recyclable material.	2.97	0.73	A
11.	Metal sensors such as hydrometallurgy and pyrometallurgy are used for metal recycling.	2.97	0.83	A
12.	Wastes metals are redesigned into new products by recycling.	3.19	0.74	A
	Grand total Mean/SD	**3.08**	**0.71**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation;
SA = Strongly Agree; A = Agree

The analysis in Table 4.2 shows the means responses of the respondents on the twelve (12) items posed to determine the metal waste recycling practices in ASCL with a grand mean of 3.08. This implies that the respondents agreed with all the items as metal waste recycling practices adopted in ASCL. The standard deviation of the items ranges from 0.57 - 0.83 which means that 12 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.3 Research Question 3

What are the metal wastes disposal practices in Ajaokuta steel company?

The result of research question is presented in Table 4.3

Table 4.3: Mean and standard deviation of respondent on the metal wastes disposal practices in Ajaokuta steel company **N = 144**

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Incineration method is adopted.	2.46	0.76	D
2.	Plasma gasification method is practiced.	2.22	0.70	D
3.	Sanitary landfilling method is usually embarked upon.	2.02	0.46	D
4.	Waste compaction method is mostly adopted.	2.11	0.43	D
5.	Composting is one of metal wastes disposal practices.	2.16	0.63	D
6.	Chemical precipitation method is practiced.	2.15	0.57	D
7.	Chemical waste treatment and disposal is adopted.	2.06	0.58	D
8.	Electrochemical treatments are used.	2.13	0.41	D
9.	Direct disposal in rivers and drainages are used.	1.43	0.77	SD
10.	Membrane filtration method is adopted.	2.07	0.68	D
11.	Open dumping is practiced.	3.39	0.92	A
12.	Pyrolysis method is adopted.	2.59	0.69	A
13.	Reuse as backfill is practiced.	2.54	0.68	A
14.	Open burning and burying of metal wastes are practiced.	2.06	0.79	D
15.	Shredding method is always adopted.	2.85	0.87	A
	Grand Total Mean/SD	**2.28**	**0.66**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation;
A= Agree; D = Disagree; SD = Strongly Disagree

The analysis in Table 4.3 shows the means responses of the respondents on the fifteen (15) items posed to determine the metal waste disposal practices in ASCL with a grand mean of 2.28. This implies that the respondents disagreed with majority of the items as metal waste disposal practices not being adopted in ASCL. The standard deviation of the items ranges from 0.41 - 0.92 which means that 15 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.4 Research Question 4

What are the metal wastes reduction practices in Ajaokuta steel company?

The result of research question is presented in Table 4.4

Table 4.4: Mean and Standard Deviation of Respondent on the Metal Wastes Reduction Practices in Ajaokuta Steel Company N = 144

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Relevant machines are used for the right job to reduce wastage.	3.61	0.65	SA
2.	Application of innovative machining procedures during production of components reduces wastage.	3.75	0.56	SA
3.	Quality control department works to ensure reduction in metal wastage.	3.64	0.61	SA
4.	Maintaining precision rules during production of components reduces metal wastage.	3.60	0.75	SA
5.	Quality monitoring and supervision are given to machinist to avoid metal wastage.	3.61	0.76	SA
6.	The practice of zero waste approach is adopted.	3.36	0.98	A
7.	Avoid using outdated production machines that can cause metal wastage.	3.51	0.85	SA
8.	Production Engineers, Technologists and Technicians are constantly trained in waste reduction processes.	3.40	0.99	A
9.	Engineering components are given simple uncomplicated design to avoid wastage outlets in production.	3.47	0.78	A
10.	Design of special production machines that reduces wastages and scraps generation.	3.42	0.90	A
	Grand Total Mean/SD	**3.54**	**0.71**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation; SA = Strongly Agree; A = Agree

The analysis in Table 4.4 shows the means responses of the respondents on the ten (10) items posed to find out the metal waste reduction practices in ASCL with a grand mean of 3.54. This implies that the respondents agreed with all the items as metal waste reduction practices that should be adopted in ASCL. The standard deviation of the items ranges from 0.56 - 0.99 which means that 10 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.5 Research Question 5

What are the constraints associated with metal wastes management practices in Ajaokuta steel company?

The result of research question is presented in Table 4.5

Table 4.5: Mean and Standard Deviation of Respondent on the Constraints Associated with Metal Wastes Management Practices in Ajaokuta Steel Company N = 144

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Lack of proper management planning for metal wastes.	3.70	0.56	SA
2.	Lack of trained personnel to manage metal wastes.	2.47	0.69	D
3.	Lack of proper wastes assessment procedures for metal wastes.	2.45	0.74	D
4.	Lack of bulk storage for collection of metal wastes.	2.34	0.98	D
5.	Inadequate standard for metal wastes management practices.	2.36	0.93	D
6.	Lack of tools and equipment for managing metal wastes.	2.58	1.02	A
7.	Lack of financial resources for effective metal wastes management.	3.61	0.61	SA
8.	Irregularity of metal wastes collection.	2.84	0.62	A
9.	Lack of enforcement of measures on the part of agency responsible for metal wastes.	3.10	0.66	A
10.	Lack of documented procedures for identification of metal wastes discharges.	2.66	0.73	A
11.	Inadequate metal waste collection vehicles.	3.15	0.61	A
12.	Lack of efficient policy for safety, health and environmental management of metal wastes.	3.17	0.66	A
13.	Lack of landfill site to manage metal wastes.	1.91	1.04	SD
14.	Inadequate institutional setup for metal wastes management service.	2.84	0.91	A
15.	Inadequate knowledge on the environmental impacts of metal wastes.	2.97	0.84	A
	Grand Total Mean/SD	**2.81**	**0.77**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation; SA= Strongly Agree; A = Agree; D= Disagree; SD= Strongly Disagree

The analysis in Table 4.5 shows the means responses of the respondents on the fifteen (15) items posed to identify the constraints associated with metal waste management practices in ASCL with a grand mean of 2.81. This implies that the respondents agreed with the majority of the items as the constraints that are associated with metal waste management practices in ASCL. The standard deviation of the items ranges from 0.56 – 1.04 which means that 15 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.6 Research Question 6

What are the ways of improving metal wastes management practices in Ajaokuta steel company?

The result of research question is presented in Table 4.6

Table 4.6: Mean and Standard Deviation of Respondent on the Ways of Improving Metal Wastes Management Practices in Ajaokuta Steel Company N = 144

S/N	ITEMS	$\bar{x}$	SD	Remark
1.	Good Government policy instruments to control metal wastes.	3.80	0.51	SA
2.	The availability of relevant equipment/facilities control metal wastes.	3.79	0.74	SA
3.	Adequate funding of Ajaokuta steel company can help in metal wastes management.	3.86	0.99	SA
4.	Absolute compliance with the existing environmental laws that guides metal wastes management.	3.77	0.97	SA
5.	Regular training of the personnel on the current metal wastes management practices.	3.70	0.79	SA
6.	Metal wastes minimization practices should be carried out.	3.76	0.76	SA
7.	Regular metal wastes recycling.	3.65	0.98	SA
8.	Competent personnel to manage metal wastes.	3.75	0.72	SA
9.	Positive approach for long time planning and implementation.	3.79	0.87	SA
10.	Existence of environmental standards for metal wastes management.	3.70	0.58	SA
11.	Adopting new technological practices like the use of automated sensors, optical sorters and magnets of the developed countries.	3.81	0.84	SA
12.	The regulatory agencies ensuring quality control during production component is maintained by the industry.	3.73	0.82	SA
13.	Practicing metal wastes segregation at the source controls metal wastes generation.	3.72	0.88	SA
14.	Relevant metal wastes equipment used for the right job.	3.84	0.54	SA
15.	Good organizational practices give an effective metal wastes management.	3.81	0.51	SA
	Grand Total Mean/SD	**3.76**	**0.79**	

Note: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation; SA = Strongly Agree.

The analysis in Table 4.6 shows the means responses of the respondents on the fifteen (15) items posed to determine the ways of improving metal waste management practices in ASCL with a grand mean of 3.76. This implies that the respondents strongly agreed with all the items as a way of improving metal waste management practices in ASCL. The standard deviation of the items ranges from 0.33 – 0.58 which means that 15 items had their standard deviation less than 1.96 indicating that the respondents were close to one another in their responses.

4.7 Hypotheses 1

There is no significant difference in the mean responses of the engineers, technologists and technicians on metal waste collection practices in Ajaokuta steel company (P<.05). The result of the One-way ANOVA of mean scores of the respondents on the significant difference between the engineers, technologists and technicians on metal wastes collection practices in Table 4.7. Levenes test of homogeneity of variance for the data was .059 (See Appendix H, Page 113, for homogeneity of variance) therefore, the assumption of homogeneity was met, since the value is greater than the significant level of (P< .05), therefore, ANOVA can be used for analysis.

Table 4.7: One way analysis of variance summary table showing the difference in the mean response of the engineers, technologists and technicians on metal wastes collection practices in Ajaokuta steel company

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Remark**
Between Groups	1557.005	2	778.502	22.526	.002	SD
Within Groups	4872.884	141	34.559			
Total	6429.889	143				

(P<0.05) SD = Significant different

Table 4.7 revealed that there were significant differences (P<0.05) in the mean ratings of the respondents (engineers, technologists and technicians) as regard the metal wastes collection practices. These data supported the hypothesis, $F (2, 141) = 22.526, p = .002$. The mean and standard deviation for the engineers were 3.47 and 0.24 respectively. Similarly, the mean and standard deviation for technologists were 2.90 and 0.71 (See Appendix H, Page113). In addition, the mean and standard deviation for technicians were 3.11 and 0.10 respectively. Hence, hypothesis one was rejected. This mean, there was significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes collection practices in Ajaokuta steel company. (Appendix H, Page 113, Post Hoc Turkeys HSD test) showed that there was no statistical difference between the responses of engineers and technicians $P = .092$; as well as engineers and technologists $P = .092$. However, there was significant difference in the mean response of technologists and technicians $P = .001$; on metal wastes collection practices. This could be as a result of the differences in the level of their training and experiences on metal wastes collection practices.

4.8 Hypotheses 2

There is no significant difference in the mean responses of the engineers, technologists and technicians as regards the metal wastes recycling practices in Ajaokuta steel company ($P<.05$).

The data for testing hypotheses two were presented in Table 4.8.

Table 4.8: One way analysis of variance summary table showing the difference in the mean response of the engineers, technologists and technicians on metal wastes recycling practices in Ajaokuta steel company.

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Remark**
Between Groups	830.548	2	415.274	11.061	.072	NS
Within Groups	5293.612	141	37.543			
Total	6124.160	143				

($P<0.05$) NS = No Significant

Table 4.8 revealed that there was no significant difference (P<0.05) in the mean ratings of the respondents (engineers, technologists and technicians) on metal wastes recycling practices. These data supported the hypothesis, F (2, 141) = 11.061, p = .072. The mean and standard deviation for engineers were 3.05 and 0.32 respectively. Similarly, the mean and standard deviation for technologists were 2.62 and 0.71 and the mean and standard deviation for technicians were 2.83 and 0.05 respectively (See Appendix I, Page 114). Hence, hypothesis two was retained. This means that, there was no significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes recycling practices in Ajaokuta steel company.

4.9 Hypotheses 3

There is no significant difference in the mean responses of the engineers, technologists and technicians on metal wastes disposal practices in Ajaokuta steel company.

The data for testing hypotheses two were presented in Table 4.9.

Table 4.9: One way analysis of variance summary table showing the difference in the mean response of the engineers, technologists and technicians on metal wastes disposal practices in Ajaokuta steel company

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Remark**
Between Groups	17.362	21	.827	1.402	.130	NS
Within Groups	71.944	122	.590			
Total	89.306	143				

(P<0.05) NS = No Significant

Table 4.9 revealed that there was no significant difference (P<0.05) in the mean ratings of the respondents (engineers, technologists and technicians) on metal wastes disposal practices. These data supported the hypothesis, F (2, 122) = 1.402, p = .130. The mean and standard deviation for engineers were 2.29 and 0.18 respectively. Similarly, the mean and standard deviation for technologists were 2.16 and 0.50 (See Appendix J, Page 115). In addition, the mean and standard deviation for technicians were 2.45 and 0.38 respectively. Hence, hypothesis three was retained. This means that, there was no significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes disposal practices in Ajaokuta steel company.

4.10 Hypotheses 4

There is no significant difference among the mean responses of the engineers, technologists and technicians as regards the metal wastes reduction practices in Ajaokuta steel company.

The result of the One-way ANOVA of mean scores of the respondents on the significant difference between the engineers, technologists and technicians on metal wastes reduction practices in Table 4.10. Levenes test of homogeneity of variance for the data was .082 (see appendix K, Page 116, for homogeneity of variance) therefore, the assumption of homogeneity was met, since the value is greater than the significant level of (P< .05), therefore, ANOVA can be used for analysis.

Table 4.10: One way analysis of variance summary table showing the difference in the mean response of the engineers, technologists and technicians on metal wastes reduction practices in Ajaokuta steel company

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	3235.831	2	1617.916	58.627	.045	SD
Within Groups	3891.169	141	27.597			
Total	7127.000	143				

(P<0.05) SD = Significant difference

Table 4.10 revealed that there was significant difference (P<0.05) in the mean ratings of the respondents. These data supported the hypothesis, F (2, 141) = .58.627, p = .045. The mean and standard deviation for engineers were 3.95 and 0.11; The mean and standard deviation for technologists were 2.90 and 0.79 respectively (See Appendix K, Page 116). In addition, the mean and standard deviation for technicians were 3.75 and 0.47. Hence, hypothesis four was rejected. This means that, there were significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes reduction practices in Ajaokuta steel company. (Appendix K, Page 116, Post Hoc Turkeys HSD test) showed that there was no statistical difference between the responses of technologists and technicians P = 0.200; as well as engineers and technologists P = 0.200. However, there was significant difference in the mean responses of engineers and technicians P = 0.001; on metal wastes reduction practices. This could be as a result of misconception or negligence on the part of the engineers and the technicians as regards the metal wastes reduction practices.

4.11 Findings of the Study

The following findings emerged from the study based on the research questions answered and the hypotheses tested.

1. The metal wastes collection practices in Ajaokuta steel company

The findings of the study on research question one relating to metal wastes collection practices revealed that the respondents strongly agreed to 3 items while the remaining 10 items were agreed. Some of the items strongly agreed were, keeping of metal wastes collected in the scrap yards; keeping of metal wastes bin in a very strategic location; using of metal recycling equipment to collect metal wastes, sending collected metal wastes out to mills or foundries among others.

2. The metal wastes recycling practices in Ajaokuta steel company

The findings of the study on research question two which pertains to metal wastes recycling practices revealed that the respondents strongly agreed to 1 item while the remaining 11 items were agreed. The sending of metal wastes collected to the scrap yards for recycling was strongly agreed to while other items agreed to were, redesigning of metal waste into new products by recycling, melting of scrap metals in a large furnace and process for further use and taking of metal to a specific furnace designed to melt particular metals among others.

3. The metal wastes disposal practices in Ajaokuta steel company

The findings of the study on research question three relating to metal wastes disposal practices showed that the respondents only agreed with 4 items while the remaining 11 items were disagreed. The items that were agreed include, shredding method is always adopted, reuse of backfill, adoption of the method of pyrolysis and open dumping as metal waste disposal practices. However, the items that were disagreed as method of disposal of metal waste not practiced in ASCL include, electrochemical treatments, plasma gasification method, chemical waste treatment and disposal and waste compaction method among others.

4. The metal wastes reduction practices in Ajaokuta steel company

The findings of the study on research question four which pertains to metal wastes reduction practices showed that the respondents strongly agreed with 6 items while the remaining 4 items were agreed to. Some of the items that were strongly agreed as practices that reduces metal waste include; the application of innovative machining procedures during production of components, the use of relevant machines for the right job, the regular training of the engineers, technologists and technicians in waste reduction processes and the practice of zero waste approach among others.

5. The constraints associated with metal wastes management practices in Ajaokuta steel Company

The findings of the study on research question five relating to constraints associated with metal waste management practices revealed that the respondents strongly agreed with 2 items and agreed with 8 items while 4 items were disagreed and 1 item were strongly disagreed. The strongly agreed items relating to constraint associated with metal wastes management practices were, deficiency in the proper planning of metal wastes management, lack of financial resources for effective metal wastes management practices, furthermore the respondents agreed that lack of efficient policy for safety, health and environmental management and inadequate metal waste collection vehicles among others were also constraints associated with metal wastes management practices. However, the items that were disagreed among others include; lack of trained personnel to manage metal wastes and lack of bulk storage for collection of metal wastes as they were not a constraint associated with metal wastes management practices in ASCL.

6. The ways of improving metal wastes management practices in Ajaokuta steel company

The findings of the study on research question six bothering on ways of improving metal wastes management practices revealed that the respondents strongly agreed with all the 15 items as ways by which metal wastes management practices can be improved in ASCL. Some of the items strongly agreed among others include; adequate funding, the availability of relevant equipment, the use of relevant metal wastes equipment for the right job, adopting new technological practices like the use of automated sensors, optical sorters and magnets and regular training of the personnel (engineers, technologists and technicians) on the current metal waste management practices among others.

7. The findings of the study on hypothesis one revealed that there was significant difference in the mean ratings of the responses of the three groups of respondents (60 engineers, 50 technologists and 34 technicians) as regards the metal waste collection practices in Ajaokuta steel company. Using Post Hoc test, the null hypothesis of no significant difference was therefore upheld for the two groups (engineers & technicians P = .092; engineers & technologists P = .092) but rejected (technologists & technicians P = .001). The implication of this is that the engineers/technician, and engineers/technol ogists did not differ significantly in their opinions. However, technologists/technicians differ significantly in their opinions on the 13 items.

8. The findings of the study on hypothesis two revealed that there was no significant difference in the mean ratings of the responses of the three groups of respondents (60 engineers, 50 technologists and 34 technicians) as regards the metal wastes recycling practices in Ajaokuta steel company. The null hypothesis of no significant difference was therefore upheld for the three groups on metal wastes recycling practices. The implication of this is that the engineers, technologists and technicians did not differ significantly in their opinions on the 12 items.

9. The findings of the study on hypothesis three revealed that there was no significant difference in the mean ratings of the responses of the three groups of respondents (60 engineers, 50 technologists and 34 technicians) as regards the metal wastes disposal practices in Ajaokuta steel company. The null hypothesis of no significant difference was therefore upheld for the three groups on metal wastes disposal practices. The implication of this is that the engineers, technologists and technicians did not differ significantly in their opinions on the 15 items.

10. The findings of the study on hypothesis four revealed that there was significant difference in the mean ratings of the responses of the three groups of respondents (60 engineers, 50 technologists and 34 technicians) as regards the metal wastes reduction practices in Ajaokuta steel company. Using Post Hoc test, the null hypothesis of no significant difference was therefore upheld for the two groups (technologists & technicians P = 0.200**;** engineers & technologists P = 0.200) but rejected (engineers & technicians P = 0.001). The implication of this is that the technologists/technicians, and engineers/technologists did not differ significantly in their opinions. However, engineers/technicians differ significantly in their opinions on the 10 items.

4.12 Discussion of Findings

The major findings of the study were discussed in the order of the research questions and hypotheses formulated for study.

The findings in Table 4.1 relating to research question one showed that the respondents agreed with all the 13 items adopted as metal wastes collection practices in ASCL. The findings revealed that metal wastes collected are kept in a scrap yard. This finding is in agreement with the views of Abhishek and Awasthi (2017) who asserted that, keeping of metal wastes collected in the scrap yards; keeping of metal wastes bin in a very strategic location were very important and play a vital role in metal wastes collection practices. This finding was further corroborated by EPA (2020) who noted that, sending collected metal wastes out to mills or foundries and sorting out of metal wastes based on recyclable and non-recyclable materials were legitimate metal wastes collection practices in ASCL as also supported by the author. This further revealed that trained engineers, technologist and technicians should have a deeper and wider scope of re-melting metal waste base on approve standard.

The findings on hypothesis one as contained in Table 4.7 revealed that there was significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal waste collection practices in Ajaokuta steel company. Using Post Hoc test, the null hypothesis of no significant difference was therefore upheld for the two groups (engineers and technicians P = .092; engineers and technologists P = .092) but rejected (technologists and technicians P = .001) The implication of this is that the technologists/technicians differ significantly in their opinions on the 13 items which could be as a result of their inability to work with precision tools or machine operations. However, engineers/techni cian, engineers/technologists did not differ significantly in their opinions. Generally, the findings of the study on hypothesis one was in line with the findings of Sushovan (2015) where it was found out that there is significance difference in the mean ratings of the responses of engineers, technologists and technicians. The findings of Sushovan (2015) gave credence to the findings of this study on hypothesis one as regards the metal waste collection practices in Ajaokuta steel company.

The findings in Table 4.2 relating to research question two showed that the respondents agreed with all the 12 items adopted as metal wastes recycling practices in ASCL. The findings revealed that metal waste collected are sent to the scrap yards for recycling. The finding is in agreement with the position of Chris (2020) who asserted that sending of metal wastes collected to the scrap yards for recycling was among important wastes recycling practices. Buttressing this assertion, Detlef (2019) pointed out that, solidifying of scrap metals after melting are transported to factories as raw material for the production of brand-new products, allowing of molten scrap metals to cool and solidify before forming into specific shapes, using of metal sensors such as hydrometallurgy and pyrometallurgy for metal recycling among others were paramount and play important role during metal wastes recycling practices as also agreed by the author.

The findings on hypothesis two as contained in Table 4.8 revealed that there was no significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal wastes recycling practices in Ajaokuta steel company. The null hypothesis of no significant difference was therefore upheld for the three groups on metal wastes recycling practices. The implication of this is that recycling practices plays an essential role in managing metal waste in ASCL. Generally, the findings of the study on hypothesis two was in conformity with the findings of Sushovan, (2015) where it was found out that there is no significance difference in the mean ratings of the responses of engineers, technologists and technicians. This is also inline with the work of Ogogome (2015) who asserted that the primary aim of waste recycling is to manage waste in ways that are most effective in protecting human and the environment. The findings of Ogogome (2015) gave credence to the findings of this study on hypothesis two as regards the metal waste recycling practices in ASCL.

The findings in Table 4.3 relating to research question three showed that the respondents agreed with 4 items. However, 11 items were disagreed by the respondents, these implies that there is inadequacy on metal was disposal practices. The finding is in agreement with the findings of Ejike (2018) who asserted that the irregularities in adopting shredding method, reusing of backfill practices among others were among the deficiency of metal wastes disposals practices. The findings however, does not corroborate with the findings of Erich (2018) who noted that, the adoption of chemical waste treatment and disposal, as well as the practice of chemical precipitation method, among others were not considered as deficiency in the practice of metal wastes disposal as further disagreed by the researcher. Although, the researcher further substantiated this claim by pointing to the fact that the use of direct disposal in rivers and drainages amount to negligence in metal wastes disposal practices as also supported by Gazali, (2015).

The findings on hypothesis three as contained in Table 4.9 revealed that there was no significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal wastes disposal practices in Ajaokuta steel company. The null hypothesis of no significant difference was therefore upheld for the three groups on metal wastes disposal practices. This implies that shredding method is always adopted in ASCL as collaboratively agreed by the respondents. Hence engineers, technologists and technicians did not differ significantly in their opinions on the items. Generally, the findings of the study on hypothesis three was in conformity with the findings of Ogbe (2014) where it was found out that there is no significance difference in the mean ratings of the responses of engineers, technologists and technicians. This finding was further supported by Mukuldev (2018) who asserted that wastes in steel industries have a huge amount that must be utilized by different methods to safeguard the health of our nation. The findings of Mukuldev (2018) gave credence to the findings of this study on hypothesis three as regards the metal waste disposal practices in Ajaokuta steel company.

The findings in Table 4.4 relating to research question four revealed that the respondents are strongly in agreement with 6 items and are also in agreement with the remaining 4 items which is indicative of the fact that the respondents are totally in support of the fact that, the application of innovative machining procedure during production of components, ensuring quality control of metal waste, the use of relevant machines for the right job and regular training for the engineers, technologists and technicians in waste reduction processes among others are good practices of metal wastes reduction. This finding is in agreement with the work of Hughes (2019) who asserted that using of relevant machines for the right job to reduce wastage and applicability of innovative machining procedures during production of components to reduce wastage shows that engineers, technologists and technicians plays vital role in ensuring reduction in metal wastage through quality control as strongly supported by the researcher. Buttressing this assertion, Kumar (2017) pointed out that, using of relevant machines for the right job to reduce wastage, applicability of innovative machining procedures during production of components to reduce wastage, as well as adopting the practice of zero waste approach among others were legitimate and paramount in reduction of metal wastes practices especially in ASCL.

The findings on hypothesis four as contained in Table 4.10 revealed that there was significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal wastes reduction practices in Ajaokuta steel company. Using Post Hoc test, the null hypothesis of no significant difference was therefore upheld for the two groups (technologists and technicians P = 0.200**;** engineers and technologists P = 0.200) but rejected (engineers and technicians P = 0.001). This implies that maintenance of precision rules was practiced by the technologists/technicians, and engineers/technologists, hence waste metal was eliminated during production of component. However, engineers/technicians differ significantly in their opinions on the 10 items, may be due to lack of quality monitoring and supervision on the part of the engineers and zero practice approach by the technicians. Generally, the findings of the study on hypothesis four were in consonance with the findings of Lamperti (2018) where it was found out that there is significance difference in the mean ratings of the responses of engineers, technologists and technicians. The findings of Lamperti (2018) gave credence to the findings of this study on hypothesis four as regards the metal waste reduction practices in Ajaokuta steel company.

The findings in Table 4.5 relating to research question five showed that the respondents are strongly in agreement with 2 items and also agreed with 8 items but disagreed with the remaining 5 items. The findings revealed that lack of proper management planning and financial resources for effective metal waste management were among the strong constraints that are associating with metal wastes management practices in ASCL. This outcome is consistent with the work of Lamperti, *et al.* (2018) who stressed that important theoretical foundation such as proper management planning for metal wastes and financial resources for effective metal wastes management needs to be imbibed in order to eliminate the constraints associated with metal wastes management. These implies that engineers, technologists and technicians may have limited tools and equipment in managing metal wastes due to deficiency in financial resources as submitted by the researcher. In the same vein, the findings of Muataz (2017) were also in conformity with the findings of the study but differs that lack of trained personnel to manage metal wastes, as well as lack of proper wastes assessment procedures for metal wastes among others did not correlate with constraints associated with metal wastes management practices as also supported by Mukuldev (2018) who noted that engineers, technologists and technicians must have acquire at least some basic training that is enough to manage and follow waste assessment procedures.

The findings in Table 4.6 relating to research question six showed that the respondents are strongly in agreement with all the 15 items as various ways by which metal wastes management practices can be improved in ASCL. Each of these strongly agreed items has a mean above 3.50, which is an indication that they are highly required so as to better improve metal waste management practices in ASCL. This finding is consistent with the assertion of Ogogome (2015) that, adequate funding with good Government policy instruments plays an important role in improving wastes management practices. The author further noted that, adopting new technological practices like the use of automated sensors consistently improve metal wastes management practices. Buttressing this assertion, Rupali *et al.* (2015) pointed out that, if the rate of positive approach for long time planning is being implemented, then the engineers, technologists and technicians need to improve on metal waste management practices to ensure quality control during production of components as also supported by the researcher.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings and discussions of the study, the following conclusions were made; It is evident from the study that metal steel waste management practices are important practices by which metal wastes are managed and reduced through effective adoption of metal waste collection practices, recycling practices, disposal practices and reduction practices as the engineers, technologists and technicians collaboratively agreed that it should be utilize by ASCL in other to reduce metal wastes, health hazard and improve its profitability. Furthermore, some metal waste management practices were adopted by ASCL. However, there is still need for improvement. Proper planning and adequate funding of metal waste management needs to be enhanced so as to achieve the objectives of metal waste management practice at high extent.

Interventions are needed on the part of the Government to provide good policy instruments that can enhanced easy control of metal wastes in Ajaokuta steel company.

The engineers, technologists and technicians require the use of relevant machines for the right job and proper application of innovative machining procedures during production of components to reduce metal wastage. As they are also constrained with inefficient policy for safety, health and environmental management of metal wastes based on their responses in the present study.

5.2 Recommendations

The following recommendations were made for implementation based on the findings of this study;

1. Metal steel waste management practices should be utilized by Ajaokuta steel company in other to reduce wastes, health hazard and improve its profitability. Furthermore, engineers, technologists and technicians should be retrained regularly through workshops and conferences on maintaining precision rules during production of components in other to reduce metal wastes.

2. Funding should be provided by the Federal Government in other to purchase new facilities/equipment in collecting and recycling of metal wastes in Ajaokuta steel company. Relevant metal wastes equipment should be used for the right job to avoid equipment damage and prevent wastage.

3. The engineers, technologists and technicians should adopt new technological practices like the use of automated sensors, optical sorters and magnets and also apply innovative machining procedures during production of components in order to be more effective on the job.

4. There should be efficient policy for safety, health and environmental management of metal wastes organize by the company based on the responses of the respondents in the present study as regard challenges associated with metal wastes collection practices.

5. The company should setup a regulatory agency to ensure quality control by following systematic process during production of component.

6. The engineers, technologists and technicians should not only keep metal wastes in the scrap yards but in a strategic location with the aim of recycling the collected wastes because of their economic value.

7. Assessment of non-ferrous metal waste management practices in Innoson Industrial Plastic Company in Enugu State, Nigeria.

8. Adequacy of modern workshop tools and equipment in metal waste management practices in Kogi State, Nigeria.

9. Assessment of precision instrument for effective metal waste management practices in Ajaokuta Steel Company.

10. Maintenance competency among technicians toward the use of modern equipment in metal steel waste management practices in Ajaokuta Company.

5.3 Contribution to Knowledge

The study has contributed to knowledge in metal waste management practices and other areas as follows:

1. The researcher developed current metal waste collection and recycling practices questionnaire which was used for data collection. This can be adopted by ASCL or any privately own steel plant as one of the best practices to management metal waste.
2. The work has come out with very practical solutions to metal waste recycling method among which is adoption of new technological practices like the use of automated sensors, optical sorters and magnets of the developed countries.

3. The study has contributed to the existing literature not only in the science and technology of metals but in waste management practices generally.

REFERENCES

Abechi, E. S., Okunola, O. J., Zubairu, S. M. J., Usman, A. A. & Apene, E. (2010). Evaluation of heavy metals in roadside soils of major streets in Jos metropolis, Nigeria, *Journal of Environmental Chemistry and Ecotoxicology, 2(6), 98-102.* Retrieved from http://www.academicjournals.org/jece.

Abhishek, K. & Awasthi, J. L. (2017). Management of electrical and electronic waste: A comparative evaluation of China and India. *Renewable and Sustainable Energy Reviews*-76, 434 447.

Abul, S. (2010). Environmental and Health Impact of Solid Waste Disposal in Mangwaneni Dumpsite in Manzini: Swaziland. *Journal of Sustainable Development.*12(7), 64-78.

Achankeng, E. (2003). Globalization, Urbanization and Municipal Solid Waste Management in Africa. *Africa on a Global Stage*, 1-22.

Adama, O. (2007) *Governing from above: Solid waste management in Nigeria's new capital city of Abuja*. Ph.D. Thesis, Stockholm University, Sweden.

Adekunle, I.M., Oguns, O., Shekwolo, P.H., Igbukwwu, A.O.O. & Ogunkoya, O.O. (2012). *Assessment of Perception Impact on Value- Added Solid Waste Management Disposal in Developing Countries:* A Case Study of Port Harcourt City, Nigeria. http://www.interchopen.com/ download/ pdf35160> [April 20, 2012].

Adelagan, J. A. (2004). The history of environmental policy and pollution of water sources in Nigeria (1960-2004). *Department of Civil Engineering University of Ibadan, Nigeria*. Retrievedfromhttp://userpage.fuberlin.de/ffu/akumwelt/bc2004 /download/adelegan.pdf.

Afangideh, A.I., Kinuagbeye, U. & Atu, J.E. (2012). Attitude of urban Dwellers to Waste Disposal and Management in Calabar, Nigeria. *European journal of Sustainable Development.* 1, 22-34.

African Development Bank (2002). *Study on solid waste management options for Africa*. AFDB Sustainable Development and Poverty Reduction Unit, Abidjan, Cote d'Ivoire.

Ajzen, (1991). Theory of Planned Behavior-Cornerstone. Retrieved from https://cornerstone.lib.mnsu.edu

Amalu, T.E. & Ajake, A.O. (2014). Appraisal of Solid Waste Management Practices in Enugu City, Nigeria. *Journal of Environmental and Earth Science*, 4(1), 87-89.

Anne, H. H. (2019). The definition of metal. Retrieved and updated on 23rd September, 2019, from https://www.thoughtco.com

Anyor, J. W. & Abah, J. A. (2014). Mathematics curriculum change and assessment models: The quest for an integrated approach. *Benue Journal of Mathematics and Mathematics Education, 1*(3), 11-19.

Aondoakaa, S. C. & Ishaya, S. (2009). Assessment of People's Perception of the Impact of Urban Generated Solid Waste on the Environment in Gboko, Benue State. *Confluence Journal of Environmental Studies,* 4: 17-24.

Atsumbe, B. N. & Raymond, E. (2012). Problems of Implementing Continuous Assessment in Primary Schools in Nigeria. *Journal of Education and Practice,* 3(6), 71-76

Babayemi, J. O & Dauda, K. T. (2009). Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A case Study of Nigeria. *Journal of Applied Sciences & Environmental Management, Vol. 13, No. 3, Sept. 2009, pp. 83-88.*

Chattered Institute of Purchase and Supply (CIPS) (2007). How to develop a waste management and disposal strategy. Retrieved from www.cips.org/pdf.

Chris, W. (2020). The science of metals-Explain that stuff. Retrieved on 24th September,2020, from https://www.explainthatstuff.com/introduction -to-metals.html.

Chukwunonye, E. (2010). Analysis of barriers and success factors Affecting the adoption of sustainable Management of municipal solid waste in Abuja, Nigeria: A thesis submitted in fulfilment of the requirements of the University of Wolverhampton for the award of the degree of Doctor of Philosophy (PhD).

Collins English dictionary (2012). Engineer Definition and Meaning. Retrieved from https://www.dictionary.com

Conserve Energy Future (CEF) (2021). Benefits and Techniques of Waste Minimization. Retrieved from https://www.conserve-energy-future.com

Corrosionpedia, (2015). Definition of billets. Retrieved on 21st April, 2015 from https:/www. Corrosionpedia.com

Danbuzu, S.A.L. (2011). Composition and Spatial Distribution of Solid Waste Collection Point in Urban Katsina, Northern Nigeria. An M.sc Land Resource (Development). Research proposal submitted to the Department of Geography. B. U. K.

Darma, K. U. (2009). *Task and Need Survey of Metalwork Casting work in Katsina State, Nigeria.* Unpublished Msc. Thesis, Department of Career and Technical Education. University of Wisconsin-Stout, Menomoni Wi, USA.

Demirbas, A. (2011). Waste Management, waste resource facilities and waste conversion processes. *Energy Conversion & Management,52*(2), 1280-1287. https://doi.org/10.1016/j.enconman.2010.09.025.

Dennis, I. I. (2011). Status of Waste Management, Integrated Waste Management-Volume II, Sunil Kumar, Intech Open, DOI: 10.5772/20439. Available from: https://www.intechopen.com/chapters/18478

Department of the Environment Transport and Regions (2000). *A waste strategy for England and Wales*. DETR. London, UK.

Detlef, V. V. (2019). Integrated Assessment: Inaugural lecture: Back to the Future – PBL Netherlands Environmental Assessment Agency". Retrieved from https://www.pbl.nl. 2019-06-01.

Efe, S. I. (2010). Solid Waste Generation and Management in Ughelli, Delta State, Nigeria. *Journal of Environmental Management and Planning*, 3, 25-35.

Ejike, E. (2018). *Itakpe Train Service Begins Operation Today*. Leadership, p 8.

Eleke, F. N. (2007). Quality Control pollution and Environmental Management. A *paper* presented at the 2nd meeting of the National Council on Environment, APCU, Kano.

Environmental Protection Agency (2020). Recycling Basics. Retrieved on the 12th of November, 2020 from https://www.epa.gov

Erich, L. (2018). Effective ways to reduce manufacturing waste. Retrieved from https;//www.fishbowlinventory.com.

Europa (2006) *Framework Directive on Waste (91/156/EEC)* [online]. Retrieved on the 13th of October, 2020. http://eur-lex.europa.eu>.

Festus, M. O. & Ogegbunam A. (2012). Imperatives of Environmental Education and Awareness Creation to Solid Waste Management in Nigeria. *Educational Sciences. 3(2).*

Gamba, R., & Oskamp, S. (1994). Factors influencing community resident's participation in commingled curb side recycling programs. *Environment and Behaviour*, 26, 587 – 612.

Gazali, S. A. (2015). Evaluation of Automobile Waste Management and Disposal Strategy-In Federal Capital Territory, Abuja and Niger State, Nigeria.

Ghiani, G., Lagana, D., Manni, E., Musmanno, R., & Vigo, D. (2014). Operations research in solid waste management: A survey of strategic and tactical issues. *Computers & Operations Research*, *44*(4), 22-32. https://doi.org/10.1016/j.cor. 2013.10.006.

Gidarakos, E., Havas G. & Ntzamilis, P. (2006). Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete. Waste Mgt.

Gobo, A. E & Ubong, I. U. (2001). *Fundamentals of Environment Chemistry and Meteorology* Tom and Harry Publications Ltd, Port Harcourt, Nigeria. 11, 233 – 241.

Hammed, T. (2006). Overview of Solid Waste Management in Nigerian Communities. Cited in http://ezinearticles.com retrieved on 6th May 2011.

Hughes, B. (2019). International Futures: Building and Using Global Models. Elsevier Academic Press. ISBN 978-0128042717.

Hughes, B., Joshi, D., Moyer, J., Sisk, T. & Solorzano, J. (2014). Strengthening Governance Globally (PDF). Paradigm Press. ISBN 978-1-61205-561-9.

Idris A. (2005). Gov. Idris Okays N80m for Kogi Polytechnic. *Newsday*. Archived from the original on March 4, 2012. Retrieved 2020-05-18.

Ifegbesan, A. (2010). Exploring secondary school students" understanding and practices of waste management in Ogun State, Nigeria. *International Journal of Environmental and Science Education,* 5(2), 201-215.

Isirimah, N. O. (2002). Understanding the Nature, properties and sources of Wastes for Quality Environment. Tom and Harry Publications Port Harcourt Nigeria, 8,19 – 25.

Kumar, N. (2017). The Crisis of Waste Management in India- UNU Flores. Retrieved on 15th of November, 2017 from https://flores.unu.edu

Lamperti, F., Dosi, G., Napoletano, M., Roventini, A. & Sapio, A. (2018). Model". Ecological Economics. 150: 315–339.doi:10.1016/j.ecolecon.2018.03.023. ISSN 0921-8009.

Mbalisi, F. O. (2009). *Methods and materials for environmental adult education.* Unpublished manuscript. University of Port Harcourt. Models of Climate Change Economics. Singapore: Springer Singapore. doi:10.1007/978-981-10-3945-4.ISBN 9789811039430.

Merriam-Webster Dictionary (2013). *Assessment Definition*. Retrieved on 14th December, 2013, from http://www.merriam-webster.com/dictionary/assessment.

Muataz, A. Atieh, Yunji Viktor Kochkodan, (2017). *Metals in the environment: toxic metal removal; ID 4309198 https://doi.org/10.115512097/4309198.*

Mukuldev, K. (2018). Process Waste Generation and Utilization in Steel Industry. *International Journal of Industrial and Manufacturing Systems Engineering*. 3, (1), 1-5. doi: 10.11648/j.ijimse.20180301.11.

Neal, H. & Schebul, J. (1987). Solid Waste Management and the Environment: The mounting Garbage and Trash Crisis. Prentice Hall.

Nwachukwu, M. A., Huan, F. & Kennedy, A. (2010). Integrated study for automobile wastes management and environmentally friendly mechanic villages in the Imo River basin, Nigeria. *African Journal of Environmental Science and Technology* 4(4,), 234249. Retrieved from http://www.academicjournals.org/AJEST.

Nwufo, C. C. (2010). Legal Framework for the Regulation of waste in Nigeria. *An international Multi-Disciplinary Journal, Ethiopia Vol. 4 (2) Pp.* 491-501. Retrieved from www.afrrvjo,com/494.

Obikwelu, D.O.N. (2005). Materials in the Service of Man, Paper presented at the Nigerian Society of Engineers' Professional Meeting at Warri.

Obioma, G. & Ajagun, G. A. (2006). Establishing New Assessment Standards in the Context of Curriculum Change. A *paper presented* at the 32nd Annual Conference of the International Association for Educational Assessment (IAEA) held at the Grand Copthorne Hotel, Singapore, on May 21-26, 2006. 2-11.

Obioma, G. (2008). Continuous Assessment Practices of Primary and Junior Secondary School Teachers in Nigeria. Retrieved on 17th Decemeber, 2013, from http://iaea2008.cambridgeassessment.org.uk/ca/digitalAssets/164837_Obioma.pdf.

Ogbe, J. O. (2014). Analysis of Public and private Agents in Refuse Disposal Services in Urban Towns in Delta State, Nigeria. *European Journal of Business and Social Sciences*, 2, 1-10.

Ogogome, M. M. (2015). Analysis of domestic solid waste management strategies in Tunga, Chanchaga Local Government area, Niger State, Nigeria. A *thesis* submitted to the school of postgraduate studies, Ahmadu Bello University, Zaria Nigeria, in partial fulfillment of the requirements for the award of master of science degree in environmental management.

Ogwueleka T. C. (2009). Municipal Solid Waste Characteristics and Management in Nigeria. Iranian Journal of Health Science Engineering, 6:173-180

Omran, A., Mahmood, A., Aziz, A.H., and Robinson, G.M. (2007) Investigating Households Attitude towards Recycling of Solid Wastes in Malaysia. *International Journal of Research,* 3(2), 257-288.

Onu, B., Price, T., Surendran, S. & Ebie, S. (2001). Solid Waste Management: A Critique of Nigeria's Waste Management Policy. *International Journal of Knowledge, Culture and Change Management,* 11, 373-400.

Osai, R. M., (2006). Waste management Policy for 21st Century Nigerian (Concept, Contents and Constraint). *A presentation by of the National President Waste management society of Nigeria at 6st national council on environment meeting held at Katsina state secretariat, Katsina 13th – 17th November, 2006.*

Rai, G. D. (2006). Non-Conventional Energy Sources, 17th Edition, Khanna Publishers: New Dehl.

Ribble Valley Borough Council (2009). Waste awareness and education strategy. http://www.ribble valley.gov.ukWaste Education and Awareness Strategy 1 doc. April 10, 2020.

Rupali B., Vatsala, C., Bartik, P., & Upendra P. (2015). "Utilization of Mining and Industrial waste: A sustainable approach *Procedia Earth and Planetary Science* 11(2015) 242 – 246.

Singhal, K. K. (2009). "Energy efficiency in steel industry & Clean Development Mechanism," presented at the International Convention on Clean, Green, and Sustainable Technologies in Iron and Steelmaking, Bhubaneswar, India.

Slattery, W. (2013). Assessment. Retrieved on 14th December, 2013, from http://serc.carleton.edu/introgeo/assessment/index.html.

Sushovan, S. (2015). Solid Waste Management in Steel Industry-Challenges and Opportunities: World Academy of Science, Engineering and Technology. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering 9, 3, 2015.*

Titus, E. A. & Anim, O. A. (2014). Appraisal of Solid Waste Management Practices in Enugu City, Nigeria. *Journal of Environment and Earth Science,* 4, 97 – 105.

Ukwuije, R. P. I., & Obowu-Adutchay, V. (2012). *Introduction to Research Methods and Statistics in Education (3rd ed.),* Port Harcourt: Chadik Printing Press.

United Nations Environment Programme (2002). Contribution from Waste to Climate. Retrieved from *https://www.vitalgraphics.net/waste/html_file/42-43_climate*.

United State Environmental Protection Agency (USEPA) (2012). Benefits of recycling scrap metal. Retrieved from http://www.norstar.com.au/recycling/processing/benefits.aspaccessed12 October, 2012.

Vergara, S. E., & Tchobanoglous, G. (2012). Municipal Solid Waste and the Environment: A Global Perspective. *Environment and Resources*, *37*(37), 277-309. https://doi.org/10.1146/annurev-environ-050511-122532

Walling, E., Walston, A., Warren, E., Warshay, B. & Wilhelm, E. (2004) Municipal solid waste management in developing countries: Nigeria case study. *Department of Natural Resources, Connell University, USA* [online] [Retrieved 22 September, 2020. <http://www.dnr.cornell.edu.

Wang, Zheng; Wu, Jing; Liu, Changxin; Gu, Gaoxiang (2017). Integrated Assessment Models of Climate Change Economics. Singapore: Springer Singapore. doi:10.1007/978-981-10-3945-4. ISBN 9789811039430.

Williams, I. D. & Curran, T. (2013). Waste Management Research Group, School of Civil Engineering and the Environment, University of Southampton. Retrieved fromhttp://www.waste-management-world.com/articles/print/volume-11issue-4/Features/aiming-for-zero-waste.html. Retrieved 30th August, 2020.

Williams, I. D. & Tony, C. (2010). Aiming for zero waste. Retrieved on 2nd of August, 2020, from https://www.waste-managemnet-world.com

Wilson, D. C. (2007). Development drivers for waste management *Waste Management & Research* 25(3), 198-207.

Wokekoro, E. (2007). Solid Waste Management in the Construction Industry (A Case Study of Port Harcourt Metropolis). *Waste Management, Environmental Geotechnology and Global Sustainable Development*, 20, 1-11.

World Health Organization (1995). Expert Committee on Drug Dependence. Twenty – Ninth Report. Geneva, WHO, *Technical Report Series,* 856.

World Bank (2001). Philippines Environment Monitor 2001: Solid Waste. The World Report Paper, No.234/12.

Young, J. E. (1991). Discarding the Throw Away Society. World Watch Institute. Washington, DC.

Zerbock, O. (2003). Urban solid waste management: Waste reduction in developing nations. *School of Forest Resources & Environmental Science, Michigan Technological University, unpublished research paper, Michigan*.

APPENDIX A

SECTION A: INSTRUCTION AND PERSONAL DATA

Please kindly provide the most appropriate information by ticking (√) where applicable in each category. Your answers will be treated confidentially. Note that the following abbreviations and their full wordings as applicable to these questionnaires:

Key: SA - Strongly Agree 4

A - Agree 3

D - Disagree 2

SD - Strongly Disagree 1

Personal Data:

1 - Name of Department/Section ………………………….

2 - Designation:

(a) Engineers ( )

(b) Technologists ( )

(c) Technicians ( )

SECTION B: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on metal wastes collection practices in Ajaokuta steel company.

1. What are the metal wastes collection practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Metal wastes are collected based on approved standard.				
2.	Metal wastes collected are kept in the scrap yards.				
3.	Metal wastes bins are kept in a very strategic location.				
4.	Metal recycling equipment are used to collect metal wastes.				
5.	The collected metal wastes are sent out to mills or foundries.				
6.	Metal wastes are collected at designated drop-offs.				
7.	Metal wastes are collected by scrapers.				
8.	Metal wastes are sorted out based on recyclable and non-recyclable materials.				
9.	Metal wastes collected are melted in furnace for re-use.				
10.	Re-melted waste metals are cast into ingots.				
11.	Re-melted waste metals are stored in industrial flask for production of components.				

12.	Metal wastes collected are squeezed/squashed for recycling.				
13.	Metal wastes collected are broken down into tiny pieces for further processing.				

SECTION C: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on metal wastes recycling practices in Ajaokuta steel company.

2. What are the metal wastes recycling practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Metal wastes collected are sent to the scrap yards for recycling.				
2.	Metal wastes are sorted in an automated recycling operation.				
3.	Magnets and sensors are used to aid the separation of metals from the mixed scrap metal stream.				
4.	To allow further processing, metals is shredded.				
5.	Scrap metals are melted in a large furnace.				
6.	Metal is taken to a specific furnace designed to melt a particular metal.				
7.	Scrap metal purification is practiced to ensure the final product is of high quality and free of contaminants.				
8.	Molten scrap metals are allowed to cool and solidify before forming into specific shapes.				
9.	Solidified scrap metals after melting are transported to factories as raw material for the production of brand-new products.				
10.	Eddy current separation is used to separate metals from a mixed stream of recyclable material.				
11.	Metal sensors such as biotechnology, hydrometallurgy and pyrometallurgy are used in metal recycling.				
12.	Wastes metals are redesigned into new products by recycling.				

SECTION D: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on metal wastes disposal practices in Ajaokuta steel company.

3. What are the metal wastes disposal practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Incineration method				
2.	Plasma gasification method.				
3.	Sanitary landfilling method.				
4.	Waste compaction method.				

5.	Composting is one of metal wastes disposal practices.				
6.	Chemical precipitation method.				
7.	Chemical waste treatment and disposal.				
8.	Electrochemical treatments.				
9.	Disposal in Ocean or sea.				
10.	Membrane filtration.				
11.	Open dumping.				
12.	Pyrolysis method.				
13.	Reuse as backfill				
14.	Open burning and burying of metal waste.				
15.	Shredding method.				

SECTION E: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on metal wastes reduction practices in Ajaokuta steel company.

4. What are the metal wastes reduction practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Relevant machines are used for the right job to reduce wastage.				
2.	Application of innovative machining procedures during production of components reduces wastage.				
3.	Quality control department works to ensure reduction in metal wastage.				
4.	Maintaining precision rules during production of components reduces metal wastage.				
5.	Quality monitoring and supervision are given to machinist to avoid metal wastage.				
6.	The practice of zero waste approach reduces metal wastage.				
7.	Avoid using old outdated production machines that can cause metal wastage.				
8.	Production Engineers, Technologists and Technicians are constantly trained in wastage reduction processes.				
9.	Engineering components are given simple uncomplicated design to avoid wastage outlets in production.				
10.	Design of special production machines that reduces wastages and scraps generation.				

SECTION F: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on the constraints associated with metal wastes management practices in Ajaokuta steel company.

5. What are the constraints associated with metal wastes management practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Lack of proper management planning for metal wastes.				
2.	Lack of trained personnel to manage metal wastes.				
3.	Lack of proper wastes assessment procedures for metal wastes.				
4.	Lack of bulk storage for collection of metal wastes.				
5.	Inadequate standard for metal wastes management practices.				
6.	Lack of tools and equipment for managing metal wastes.				
7.	Lack of financial resources for effective metal wastes management.				
8.	Irregularity of metal wastes collection.				
9.	Lack of enforcement of measures on the part of agency responsible for metal wastes.				
10.	Lack of documented procedures for identification of metal wastes discharges.				
11.	Inadequate metal waste collection vehicles.				
12.	Lack of efficient policy for safety, health and environmental management of metal wastes.				
13.	Lack of landfill site to manage metal wastes.				
14.	Inadequate institutional setup for metal wastes management service.				
15.	Inadequate knowledge on the environmental impacts of metal wastes.				

SECTION G: Please read each statement carefully and respond by ticking (√) any appropriate option indicated as Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) against the options that best describe your opinion on the ways of improving metal wastes management practices in Ajaokuta steel company.

6. What are the ways of improving metal wastes management practices in Ajaokuta steel company?

S/N	ITEMS	SA	A	D	SD
1.	Good Government policy instruments to control metal wastes.				
2.	The availability of relevant equipment/facilities control metal wastes.				
3.	Adequate funding of Ajaokuta steel company can help in metal wastes management.				
4.	Absolute compliance with the existing environmental laws that guides metal wastes management.				
5.	Regular training of the personnel on the current metal wastes management practices.				
6.	Metal wastes minimization practices should be carried out.				
7.	Regular metal wastes recycling.				
8.	Competent personnel to manage metal wastes.				
9.	Positive approach for long time planning and implementation.				
10.	Existence of environmental standards for metal wastes management.				
11.	Adopting new technological practices like the use of automated sensors, optical sorters and magnets of the developed countries.				
12.	The regulatory agencies ensuring quality control during production component is maintained by the industry.				
13.	Practicing metal wastes segregation at the source controls metal wastes generation.				
14.	Relevant metal wastes equipment used for the right job.				
15.	Good organizational practices give an effective metal wastes management.				

APPENDIX B

REQUEST FOR VALIDATION OF RESEARCH INSTRUMENT

Department of Industrial and Technology Education,
Federal University of Technology Minna,
Niger State, Nigeria
Date…………………

……………………….

……………………….

Dear Prof./Dr.

REQUEST FOR VALIDATION OF RESERCH INSTRUMENT

I am M.Tech student in the Department of Industrial and Technology Education, Federal University of Technology Minna, Niger State. Currently conducting a research project titled: **ASSESSMET OF METAL STEEL WASTE MANAGEMENT PRACTICES IN AJAOKUTA STEEL COMPANY, KOGI STATE, NIGERIA**.

Attached is a draft copy of the questionnaire for the study. You are please requested to read the items for the purpose of identifying ambiguous, irrelevant and wrong statement(s) as well as ensuring total coverage of the variables of the topic. Space has been provided below for your comment and suggestions.

Thanks for your anticipated cooperation.

Yours sincerely,

OLORUNTOA, Gabriel
(MTech/SSTE/2018/8986)

APPENDIX C

VALIDATION CERTIFICATE

This is to certify that I validated the instrument on the research titled "**ASSESSMENT OF METAL STEEL WASTES MANAGEMENT PRACTICES IN AJAOKUTA STEEL COMPANY, KOGI STATE, NIGERIA**".

Validator's Name: DR. IBRAHIM YAKUBU UMAR

Institution/Establishment: F.U.T. MINNA

Department: INDUSTRIAL & TECHNOLOGY EDUCATION

Signature and Date: 15/07/2021

Validator's Name: Mohammed Abdulkadir PhD

Institution/Establishment: Federal University of Technology, Minna

Department: Industrial & Technology Education.

Signature and Date: 16/07/21

Validator's Name: Dr. E. Raymond

Institution/Establishment: F U T Minna

Department: I.T.E Dept

Signature and Date: 16/07/2021

APPENDIX D

Department of Industrial and Technology Education,

School of Science and Technology Education,

Federal University of Technology Minna,

Niger State, Nigeria.

Date……………………...

Dear Sir/Madam,

LETTER OF REQUEST TO RESPOND TO QUESTIONNAIRE

Questionnaires on Assessment of Metal Steel Waste Management Practices in Ajaokuta Steel Company, Kogi State, Nigeria.

Attached Questionnaire is designed to "**Assess Metal Steel Waste Management Practices in Ajaokuta Steel Company, Kogi State, Nigeria".** The questionnaire is specifically for Engineers, Technologists and Technicians.

Please it will be highly appreciated if you can supply the information needed by responding to the items in the questionnaire according to your understanding of the problems. All the information provided will be treated as confidential and used only for the purpose of this research work.

Thanks for your positive support.

Yours faithfully.

OLORUNTOBA, Gabriel
M.Tech/SSTE/2018/8986

APPENDIX E

DATA ON RESEARCH QUESTION 1 & 2

RQ. 1
Frequencies

Statistics

		Metal wastes are collected based on approved standard.	Metal wastes collected are kept in the scrap yards.	Metal wastes bins are kept in a very strategic location.	Metal recycling equipment are used to collect metal wastes.	The collected metal wastes are sent out to mills or foundries.	Metal wastes are collected at designated drop-offs.	Metal wastes are collected by scrapers.	Metal wastes are sorted out based on recyclable and non-recyclable recyclable materials.	Metal wastes collected are melted in furnace for re-use.	Re-melted waste metals are cast into ingots.	Re-melted waste metals are stored in industrial flask for production of components.	Metal wastes collected are squeezed/squashed for recycling.	Metal wastes collected are broken down into tiny pieces for further processing.
N	Valid	144	144	144	144	144	144	144	144	144	144	144	144	144
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		3.2222	3.7222	3.6528	3.6458	3.0417	2.9375	2.9792	3.1944	3.2986	3.0000	3.0694	3.1111	2.5972

Std. Error of Mean	.06788	.03996	.05245	.05951	.05476	.05235	.05165	.06176	.06317	.05913	.07286	.04939	.07263
Std. Deviation	.81459	.47958	.62935	.71418	.65713	.62823	.61982	.74117	.75799	.70957	.87429	.59262	.87161

RQ. 2

Statistics

		Metal wastes llected are ent to the ap yards for ecycling.	Metal wastes are sorted in an automated recycling operation.	Magnets are used to aid the separation of metals from the mixed scrap metal stream.	To allow further processing, metals are shredded.	Scrap metals are melted in a large furnace and process for further use.	Metal is taken to a specific furnace designed to melt a particular metal.	Scrap metal purification is practiced to ensure the final product is of high quality and free of contaminants.	Molten scrap metals are allowed to cool and solidify before forming into specific shapes.	Solidified scrap metals after melting are transported to factories as raw material for the production of brand-new products.	Eddy current separation is used to separate metals from a mixed stream of recyclable material.	Metal sensors such as hydrometallurgy and pyrometallurgy are used for metal recycling.	Wastes metals are redesigned into new products by recycling.
N	Valid	144	144	144	144	144	144	144	144	144	144	144	144

Missing	0	0	0	0	0	0	0	0	0	0	0	0
Mean	3.6667	2.9444	3.0417	3.0000	3.1319	3.1042	2.9653	3.0486	3.0208	2.9792	2.9792	3.1944
Std. Error of Mean	.04828	.06057	.04915	.04828	.05767	.05807	.06418	.06780	.06422	.06113	.06932	.06176
Std. Deviation	.57937	.72688	.58983	.57937	.69208	.69683	.77019	.81361	.77069	.73350	.83179	.74117

APPENDIX F

DATA ON RESEARCH QUESTION 3 & 4

RQ. 3

Statistics

		Incineration method is adopted.	Plasma gasification method is practiced.	Sanitary landfilling method is usually embarked upon.	Waste compaction method is mostly adopted.	Composting is one of metal wastes disposal practices.	Chemical precipitation method is practiced.	Chemical waste treatment and disposal is adopted.	Electrochemical treatments are used.	Direct disposal in rivers and drainages are used.	Membrane filtration method is adopted.	Open dumping is practiced.	Pyrolysis method is adopted.	Reuse as backfill is practiced.	Open burning and burying of metal wastes are practiced.	Shredding method is ays adopted.
N	Valid	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		2.4653	2.2222	2.0208	2.1181	2.1667	2.1597	2.0625	2.1319	1.4375	2.0764	3.3958	2.5903	2.5417	2.0625	2.8542
Median		2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000	2.0000	4.0000	3.0000	3.0000	2.0000	3.0000
Std. Deviation		.76564	.70408	.46513	.43447	.63686	.57529	.58200	.41386	.77296	.68019	.91773	.69376	.68831	.79525	.87681
Range		3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

RQ. 4

Statistics

		Relevant machines are used for the right job to reduce wastage.	Application of innovative machining procedures during production of components reduces wastage.	Quality control department works to ensure reduction in metal wastage.	Maintaining precision rules during production of components reduces metal wastage.	Quality monitoring and supervision are given to machinist to avoid metal wastage.	The practice of zero waste approach is adopted.	Avoid using outdated production machines that can cause metal wastage.	Production Engineers, Technologists and Technicians are constantly trained in waste reduction processes.	Engineering components are given simple uncomplicated design to avoid wastage outlets in production.	Design of special production machines that reduces wastages and scraps generation.
N	Valid	144	144	144	144	144	144	144	144	144	144
	Missing	0	0	0	0	0	0	0	0	0	0
Mean		3.6111	3.7500	3.6458	3.6042	3.6111	3.3681	3.5139	3.4097	3.4792	3.4236
Median		4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Std. Deviation		.65964	.56097	.61982	.75000	.76744	.98766	.85269	.99237	.78419	.90515
Range		2.00	2.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

APPENDIX G

DATA ON RESEARCH QUESTION 5 & 6

RQ.5

Statistics

		Lack of proper management planning for metal wastes.	Lack of trained personnel to manage metal wastes.	Lack of proper wastes assessment procedures for metal wastes.	Lack of bulk storage for collection of metal wastes.	Inadequate standard for metal wastes management practices.	Lack of tools and equipment for managing metal wastes.	Lack of financial resources for effective metal wastes management.	Irregularity of metal wastes collection.	Lack of enforcement of measures on the part of agency responsible for metal wastes.	Lack of documented procedures for identification of metal wastes discharges.	Inadequate metal waste collection vehicles.	Lack of efficient policy for safety, health and environmental management of metal wastes.	Lack of landfill site to manage metal wastes.	Inadequate institutional setup for metal wastes management service.	Inadequate knowledge on the environmental impacts of metal wastes.
N	Valid	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		3.7014	2.4792	2.4514	2.3403	2.3681	2.5833	3.6111	2.8472	3.1042	2.6667	3.1528	3.1736	1.9167	2.8472	2.9792
Std. Deviation		.56815	.69934	.74637	.98352	.93679	1.02759	.61577	.62935	.66605	.73855	.61813	.66195	1.04111	.91085	.84015

Variance	.323	.489	.557	.967	.878	1.056	.379	.396	.444	.545	.382	.438	1.084	.830	.706
Sum	533.00	357.00	353.00	337.00	341.00	372.00	520.00	410.00	447.00	384.00	454.00	457.00	276.00	410.00	429.00

RQ.6

Statistics

	Good Government policy instruments to control metal wastes.	The availability of relevant equipment/facilities control metal wastes.	Adequate funding of Ajaokuta steel company can help in metal wastes management.	Absolute compliance with the existing environmental laws that guides metal wastes management.	Regular training of the personnel on the current metal wastes management practices.	Metal wastes minimization practices should be carried out.	Regular metal wastes recycling.	Competent personnel to manage metal wastes.	Positive approach for long time planning and implementation.	Existence of environmental standards for metal wastes management.	Adopting new technological practices like the use of automated sensors, optical sorters and magnets of the developed countries.	The regulatory agencies ensuring quality control during production component is maintained by the industry.	Practicing metal wastes segregation at the source controls metal wastes generation.	Relevant metal wastes equipment used for the right job.	Good organizational practices give an effective metal wastes management.

N	Valid	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		3.8056	3.7986	3.8681	3.7778	3.7014	3.7639	3.6597	3.7500	3.7986	3.7083	3.8125	3.7361	3.7292	3.8472	3.8125
Std. Deviation		.51925	.43581	.33961	.50790	.45925	.54177	.55675	.52223	.40244	.58983	.39167	.52870	.50478	.54605	.39167
Variance		.270	.190	.115	.258	.211	.294	.310	.273	.162	.348	.153	.280	.255	.298	.153
Range		2.00	2.00	1.00	2.00	1.00	2.00	2.00	2.00	1.00	3.00	1.00	2.00	2.00	3.00	1.00
Sum		548.00	547.00	557.00	544.00	533.00	542.00	527.00	540.00	547.00	534.00	549.00	538.00	537.00	554.00	549.00

APPENDIX H

DATA ON hypotheses 1

Hypotheses 1

Descriptives

What are the metal wastes collection practices in Ajaokuta steel company

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
Engineers		60	3.47436	0.24942	.41861	44.3290	46.0043	41.00	50.00	
Technologists		50	2.90153	0.71166	1.30838	35.0907	40.3493	23.00	51.00	
Technicians		34	3.11312	0.10239	.22828	40.0061	40.9350	36.00	42.00	
Total		144	3.19016	0.51581	.55879	40.3677	42.5768	23.00	51.00	
Model	Fixed Effects			5.87873	.48989	40.5037	42.4407			
	Random Effects				2.40869	31.1085	51.8360			15.89433

Test of Homogeneity of Variances

What are the metal wastes collection practices in Ajaokuta steel company

Levene Statistic	df1	df2	Sig.
65.017	2	141	.059

ANOVA

What are the metal wastes collection practices in Ajaokuta steel company

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1557.005	2	778.502	22.526	.001
Within Groups	4872.884	141	34.559		
Total	6429.889	143			

Robust Tests of Equality of Means

What are the metal wastes collection practices in Ajaokuta steel company

	Statistic[a]	df1	df2	Sig.
Welch	52.268	2	84.555	.000
Brown-Forsythe	24.574	2	62.333	.000

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: What are the metal wastes collection practices in Ajaokuta steel company

	(I) **category of respondents**	(J) **category of respondents**	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Engineers	Technologists	7.44667*	1.12569	.000	4.7802	10.1131
		Technicians	4.69608*	1.26192	.001	1.7069	7.6852
	Technologists	Engineers	-7.44667*	1.12569	.000	-10.1131	-4.7802
		Technicians	-2.75059	1.30677	.092	-5.8460	.3448
	Technicians	Engineers	-4.69608*	1.26192	.601	-7.6852	-1.7069
		Technologists	2.75059	1.30677	.092	-.3448	5.8460
Scheffe	Engineers	Technologists	7.44667*	1.12569	.000	4.6617	10.2316
		Technicians	4.69608*	1.26192	.001	1.5741	7.8180
	Technologists	Engineers	-7.44667*	1.12569	.000	-10.2316	-4.6617
		Technicians	-2.75059	1.30677	.113	-5.9835	.4823
	Technicians	Engineers	-4.69608*	1.26192	.001	-7.8180	-1.5741
		Technologists	2.75059	1.30677	.113	-.4823	5.9835
LSD	Engineers	Technologists	7.44667*	1.12569	.000	5.2213	9.6721
		Technicians	4.69608*	1.26192	.000	2.2013	7.1908
	Technologists	Engineers	-7.44667*	1.12569	.000	-9.6721	-5.2213
		Technicians	-2.75059*	1.30677	.037	-5.3340	-.1672
	Technicians	Engineers	-4.69608*	1.26192	.000	-7.1908	-2.2013
		Technologists	2.75059*	1.30677	.037	.1672	5.3340
Hochberg	Engineers	Technologists	7.44667*	1.12569	.000	4.7277	10.1657
		Technicians	4.69608*	1.26192	.001	1.6480	7.7441
	Technologists	Engineers	-7.44667*	1.12569	.000	-10.1657	-4.7277
		Technicians	-2.75059	1.30677	.107	-5.9070	.4058
	Technicians	Engineers	-4.69608*	1.26192	.001	-7.7441	-1.6480
		Technologists	2.75059	1.30677	.107	-.4058	5.9070

*. The mean difference is significant at the 0.05 level.

APPENDIX I

DATA ON hypotheses 2

Hypotheses 2

Descriptive

What are the metal wastes recycling practices in Ajaokuta steel company

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
Engineers		60	3.05128	0.32809	.55064	38.5648	40.7685	25.00	47.00	
Technologists		50	2.62769	0.71240	1.30973	31.5280	36.7920	16.00	46.00	
Technicians		34	2.83031	0.05611	.12510	36.5396	37.0486	34.00	37.00	
Total		144	2.85203	0.50339	.54535	35.9984	38.1544	16.00	47.00	
Model	Fixed Effects			6.12726	.51061	36.0670	38.0858			
	Random Effects				1.75632	29.5195	44.6332			8.07021

Test of Homogeneity of Variances

What are the metal wastes recycling practices in Ajaokuta steel company

Levene Statistic	df1	df2	Sig.
32.356	2	141	.23

ANOVA

What are the metal wastes recycling practices in Ajaokuta steel company

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	830.548	2	415.274	11.061	.072
Within Groups	5293.612	141	37.543		
Total	6124.160	143			

Robust Tests of Equality of Means

What are the metal wastes recycling practices in Ajaokuta steel company

	Statistic[a]	df1	df2	Sig.
Welch	15.032	2	75.122	.000
Brown-Forsythe	12.395	2	68.146	.000

a. Asymptotically F distributed.

+ VG

APPENDIX J

DATA ON HYPOTHESES 3

Hypotheses 3: One way

Descriptives

What are the metal wastes disposal practices in Ajaokuta steel company

++			Statistic	Bootstrap[b] Bias	Std. Error	95% Confidence Interval Lower	Upper
Engineers	N		60	0	6	49	71
	Mean		2.29333	-.0008	.3539	33.7887	35.1841
	Std. Deviation		0.18255	-.12307	.72814	1.11241	3.99203
	Std. Error		.35351				
	95% Confidence Interval for Mean	Lower Bound	33.6926				
		Upper Bound	35.1074				
	Minimum		28.00				
	Maximum		47.00				
Technologists	N		50	0	6	39	62
	Mean		2.16800	-.0243	1.0945	30.3105	34.6907
	Std. Deviation		0.50829	-.06953	.58799	6.43371	8.68252
	Std. Error		1.07826				
	95% Confidence Interval for Mean	Lower Bound	30.3532				
		Upper Bound	34.6868				
	Minimum		22.00				
	Maximum		48.00				
Technicians	N		34	0	5	24	44
	Mean		2.45098	.0135	.9992	35.0000	38.9988
	Std. Deviation		0.38422	-.16501	.99873	3.27448	7.21118
	Std. Error		.98840				
	95% Confidence Interval for Mean	Lower Bound	34.7538				

			Upper Bound	38.7756				
		Minimum		33.00				
		Maximum		50.00				
Total		N		144	0	0	144	144
		Mean		34.3056	-.0106	.4756	33.3682	35.2500
		Std. Deviation		5.76495	.00088	.45350	4.85656	6.60504
		Std. Error		.48041				
		95% Confidence Interval for Mean	Lower Bound	33.3559				
			Upper Bound	35.2552				
		Minimum		22.00				
		Maximum		50.00				
Model	Fixed Effects	Std. Deviation		5.57794	-.04340	.41449	4.69527	6.32350
		Std. Error		.46483				
		95% Confidence Interval for Mean	Lower Bound	33.3866				
			Upper Bound	35.2245				
	Random Effects	Std. Error		1.16187				
		95% Confidence Interval for Mean	Lower Bound	29.3065				
			Upper Bound	39.3047				
		Between- Component Variance		3.24033				

b. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Test of Homogeneity of Variances

category of respondents

Levene Statistic	df1	df2	Sig.
13.778	21	122	.000

ANOVA

category of respondents

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.362	21	.827	1.402	.130
Within Groups	71.944	122	.590		
Tota+l	89.306	143			

Robust Tests of Equality of Means[b]

category of respondents

	Statistic[a]	df1	df2	Sig.
Welch	.	.	.	.
Brown-Forsythe	.	.	.	.

a. Asymptotically F distributed.

b. Robust tests of equality of means cannot be performed for **category of respondents** because at least one group has 0 variance.

APPENDIX K

DATA ON HYPOTHESES 4

Hypotheses 4

Descriptives

What are the metal wastes reduction practices in Ajaokuta steel company

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
Engineers		60	3.95333	0.112697	.14549	39.2422	39.8245	36.00	40.00	
Technologists		50	2.90000	0.790247	1.11758	26.7541	31.2459	15.00	40.00	
Technicians		34	3.75882	0.478709	.82098	35.9179	39.2585	24.00	40.00	
Total		144	3.54167	0.705969	.58831	34.2538	36.5796	15.00	40.00	
Model	Fixed Effects			0.525328	.43777	34.5512	36.2821			
	Random Effects				3.47578	20.4616	50.3717			33.97714

Test of Homogeneity of Variances

What are the metal wastes reduction practices in Ajaokuta steel company

Levene Statistic	df1	df2	Sig.
51.286	2	141	.082

ANOVA

What are the metal wastes reduction practices in Ajaokuta steel company

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3235.831	2	1617.916	58.627	.045
Within Groups	3891.169	141	27.597		
Total	7127.000	143			

Robust Tests of Equality of Means

What are the metal wastes reduction practices in Ajaokuta steel company

	Statistic[a]	df1	df2	Sig.
Welch	45.382	2	55.206	.000
Brown-Forsythe	54.834	2	80.592	.000

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: What are the metal wastes reduction practices in Ajaokuta steel company

	(I) category of respondents	(J) **category of respondents**	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Engineers	Technologists	10.53333*	1.00593	.000	8.1506	12.9161
		Technicians	1.94510	1.12766	.200	-.7260	4.6162
	Technologists	Engineers	-10.53333*	1.00593	.000	-12.9161	-8.1506
		Technicians	-8.58824*	1.16774	.000	-11.3543	-5.8222
	Technicians	Engineers	-1.94510	1.12766	.200	-4.6162	.7260
		Technologists	8.58824*	1.16774	.000	5.8222	11.3543
LSD	Engineers	Technologists	10.53333*	1.00593	.000	8.5447	12.5220
		Technicians	1.94510	1.12766	.087	-.2842	4.1744
	Technologists	Engineers	-10.53333*	1.00593	.000	-12.5220	-8.5447
		Technicians	-8.58824*	1.16774	.000	-10.8968	-6.2797
	Technicians	Engineers	-1.94510	1.12766	.087	-4.1744	.2842
		Technologists	8.58824*	1.16774	.000	6.2797	10.8968
Bonferroni	Engineers	Technologists	10.53333*	1.00593	.000	8.0961	12.9706
		Technicians	1.94510	1.12766	.260	-.7871	4.6773
	Technologists	Engineers	-10.53333*	1.00593	.000	-12.9706	-8.0961
		Technicians	-8.58824*	1.16774	.000	-11.4175	-5.7589
	Technicians	Engineers	-1.94510	1.12766	.260	-4.6773	.7871
		Technologists	8.58824*	1.16774	.000	5.7589	11.4175
Dunnett t (2-sided)[b]	Engineers	Technicians	1.94510	1.12766	.146	-.5559	4.4461
	Technologists	Technicians	-8.58824*	1.16774	.000	-11.1781	-5.9984

*. The mean difference is significant at the 0.05 level.

b. Dunnett t-tests treat one group as a **control and** compare all other groups against it.

Homogeneous Subsets

What are the metal wastes reduction practices in Ajaokuta steel company

	category of respondents	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a,b]	Technologists	50	29.0000	
	Technicians	34		37.5882
	Engineers	60		39.5333
	Sig.		1.000	.185
Tukey B[a,b]	Technologists	50	29.0000	
	Technicians	34		37.5882
	Engineers	60		39.5333
Duncan[a,b]	Technologists	50	29.0000	
	Technicians	34		37.5882
	Engineers	60		39.5333
	Sig.		1.000	.080

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 45.401.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

APPENDIX L

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA.

SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

Vice Chancellor:
PROF. ABDULLAHI BALA, FSSSN
B. Agric (ABU), M. Sc (Reading), Ph.D (London)

Head of Department:
DR. I. Y. UMAR, MTRCN, MTEPAN.
B. Tech, M.Tech (Minna), Ph.D (SWU-China)
E-mail: umaryakubu@futminna.edu.ng

P.M.B. 65, Minna
Telephone: +2348066059717
E-mail: ite@futminna.edu.ng
Website: www.futminna.edu.ng

Your Ref.

Our Ref.

Date: 8th November 2021

Ajaokuta Steel Company
Limited, Kogi State,
Nigeria

RECEIVED
23 NOV 2021
MANAGING DIRECTOR/CHIEF EXECUTIVE OFFICE
AJAOKUTA STEEL COMPANY LTD.

Sir/Ma,

TO WHOM IT MAY CONCERN

The bearer Olamitoba Gabriel with Registration Number M.Tech/SSTE/2015/5956 is A Master student of Industrial and Technology Education Department.

He is carrying out a research titled: Assessment of Metal Steel Waste Management Practices in Ajaokuta Steel Company, Kogi State, Nigeria.

He needs your assistance to enable him carry out his field work.

We will appreciate your anticipated co-operation.

Thank you.

Dr. R. Audu
Postgraduate Coordinator, ITE.