ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES IN NIGER STATE, NIGERIA

BY

ABDULSALAM, Abdulmajeed Bidemi
M.Tech/SSTE/2018/8723

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

NOVEMBER, 2022

ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES IN NIGER STATE, NIGERIA

BY

ABDULSALAM, Abdulmajeed Bidemi

M.Tech/SSTE/2018/8723

THESIS SUBMITTED TO POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGYMINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREEOF MASTER OF TECHNOLOGY IN INDUSTRIAL AND TECNOLOGY EDUCTION

NOVEMBER, 2022

ABSTRACT

The study assessed the informal E-waste recycling and refurbishing activities in Niger State, Nigeria. Seven research questions guided the study while seven null hypotheses were formulated and tested at 0.05 level of significance. Relevant literatures were reviewed in line with the objective of the study. The study adopted a mixed research design. The targeted population for the study was 428 respondents. True Non-probability sampling techniques, snowball and convenient sampling techniques were used to draw 40 Refurbishers, 40 Recyclers, 30 collectors and 68 Environmental Protection Agency (NISEPA) staff, 49 National Environmental Standard and Regulations Enforcement Agency (NESREA) staff, and 11 Federal Ministry of Environment (FME) staff in Minna metropolis. Structured questionnaire titled "Assessment of Informal E-waste Recycling and Refurbishing Activities" and structured interviews questions were used for data collection. The instrument was validated by three experts, One from Niger State Environmental Protection Agency, and other two from Department of Industrial and Technology Education, Federal University of Technology, Minna. Cronbach Alpha was used to ascertain the extent of the internal consistency of the instrument and a reliability coefficient of 0.82 was obtained for the entire instrument. Data collected was analyzed using statistical package for social science (SPSS version 21). Mean and standard deviation were used to answer the research questions, while One-way Analysis of Variance (ANOVA) was used to test the hypotheses at 0.05 level of significance. Post-hoc (Tukey Honesty Significant Difference, HSD) was used to test the difference for the rejected hypotheses at ($p<0.05$). The research question one shows that the mean of all the items were within 4.28 – 4.46 which is an indication that the activities are actively carried out in the study area while hypothesis one shows the analysis of f-ratio (1.584) and a significance criterion (sig) of 0.196 which is greater than p-value of 0.05. The study revealed among others that, E-waste are dismantled and disassembled to remove the valuable materials and the non valuable materials are disposed improperly and burnt within the environment. There is lack of proper awareness of health hazards associating with E-waste equipment amongst the stakeholders involved. Also, techniques in handling and improving recycling and refurbishing e-waste are not adequately aware of. The study recommended among others, that enlightment and sensitization programme on the activities of e-wastes should be organized for e-waste collectors, recyclers and refurbishers; Regulatory Agency should ensure regular orientation and skill acquisition programme for the personnel involved in informal E-waste sector on proper handling method, awareness of health hazards and techniques for improving recycling and refurbishing of e-waste. Government should also ensure that the personnel involved in informal e-waste sectors are registered with the Regulatory Agency to ensure proper monitoring of their activities in the State. Also the creation of public education and effective awareness to the community needs to be facilitated to help enhance proper handling method and reduce the effect of health hazards on public health and environments in Niger State Nigeria.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Electronic waste (e-waste) has become a growing concern in today's environment, particularly in developing nations such as Nigeria, which has given rise to a new environmental challenge and health problems. However, proper recycling and refurbishing of this waste conserve natural resources and avoid water and air pollution. Electronics waste is the trash generated from surplus, obsolete, broken and damage electronic and electrical devices which contain various harmful, toxic and hazardous chemicals and materials that are released into the environment if not properly disposed. E-Waste is define as an electrical and electronic equipment, including all its components, which has stopped working or suffered from functional defects during its production (Abdelbasir *et al*., 2018; Kumar *et al.,* 2017).These include electrical and electronic scrap of several equipment such as cell phones, videocassette recorders, scanners, faxes, printers, tablets, Digital Video Disc (DVD) players, microwaves, x-ray machines, and some scientific equipment which contains both valuables and hazardous materials (Abdelbasir *et al*., 2018).

E-waste contain valuable materials, including copper, precious metals (gold, silver, palladium), and other recyclable materials (such as, ferrous metals, plastics, rubbers, etc.). Effective recycling is of great economic value and can offset the consumption of natural resources. Therefore, efficient treatment and recycling of e-waste is critical for countries to balance the environmental and economic impacts of e-waste (Chen*et al.*, 2019). E-waste also contains hazardous components or materials, for example, lead, mercury and brominated flame retardants. Inappropriate treatment will lead to emission of pollutants to the air, water and/or soil, posing great risk for environment and the

public health. Feltham-King and Macleod (2020) described Public health as the “science and art of controlling disease”, prolonging life and improving quality of life through proper efforts of organized and informed various choices of individual, communities, society, organizations, private and public. Therefore, E-waste is neededto beproperlycollected from the Residential areas, Business andgovernment areas.

E-waste collectionactivities are the method in whichEnd of Life (Eol) or obsolete equipment are collected from the users and business areas for proper disposal. There are various possible ways of organizing collection systems, In developed countries, e-waste collection is organized to be collected at a point, where consumers are obliged to hand in their obsolete and damaged devices Mihai*et al.*(2019), the extended producer responsibility plan takes care of the product manufactured by the manufacturers, the users of Electrical and Electronic Equipment’s (EEE) are meant to return the Eol equipment to the manufacturers, but in Nigeria and Niger State in particular the informal method of E-waste collection is still in operation. At the residential areas EEE are being used and at the end of their life cycle are discarded and collected by the scavengers and finally brought to small and medium-sized scrap metal yards, where they are manually dismantled, sorted, stored and sold to traders. Fractions without value are discarded or burned. This practice exposes the collectors to a lot of health hazard and causes environmental pollution. Collection of e-waste and its proper segregation is a challenging task and Niger State Environmental Protection Agency (NISEPA) is in charge of handling this great task, also individuals seeking for livelihood go about to pick End of life (Eol) gargets and other metallic objects from homes and environments. The e-waste collection and disposal activities in Niger State being organized by NISEPA pick up obsolete electrical and electronic products that are disposed from our streets and environment. The informal waste collectors (scavengers) also move round

Minna to pick the Eol gadgets with their pushcarts. Collection of E-waste is considered as a preceding stage to the recycling and refurbishment operation (Garlapati, 2016).

Recycling is the process of converting waste materials that cannolonger meet its intended purposes into new materials and objects. Recycling involves dismantling i.e. removal of different parts of e-waste containing valuable and dangerous substances. The recycling can be classified into two categories, which are: formal and informal recycling.

Formal recycling refers to the dismantling of obsolete electrical/electronics to retrieve valuable elements with modern technology to avoid exposure or emission of dangerous chemicals (Okorhi *et al.,* 2015). Electronic waste recycling begins with disassembly and fraction separation, steps that are especially important when considering the complex composition of Electrical/Electronic Equipment (EEE) (Sun *et al.*,2015). Printed wiring boards, computers, mobile phones and other ICT devices contain precious metals that may require separate treatment for better recovery results. There is also pre-processing and separation of metals fractions (iron, copper, and aluminum) that are sent to smelters for proper recycling. Various plastics are also separated, in some cases for reuse or recycling and other cases for incineration. According to United States International Trade Commission (USITC, 2013), separated plastics are commonly reused to manufacture nonelectronic goods such as outdoor furniture, wood composites, and toys. E-waste with highly toxic content, such as batteries or Cathode Ray Tube (CRT) monitors, may require unique and special handling outside the processing described as formal recycling. Thus, the separation and treatment of hazardous materials may be necessary before other materials are recovered. When recycled under proper conditions, hazardous materials and substances can be reused in a controlled state, avoiding the risk of environmental and health harm. However, Manual disassembly of E-waste results in

a higher percentage of precious metals recovered and a more pure output of commodity materials than if mechanically shredded.

Informal e-waste recycling on the other hand is typically characterized as being beyond the reach of official governance, unregulated, lacking structure, unregistered and illegalassociation practice in the society. Where technology and oversight are lacking, a number of problematic techniques are used to recover valuable materials; techniques that can result in the emission of large amounts of toxic organic pollutants and heavy metals, exposing the surrounding inhabitants and environment to harm (Liebmann, 2015). Such activities are referred to as informal recovery and its treatment activities are being driven by convenience and cost efficiency (Tanner*et al.*, 2015). Theis (2021) describes informal recycling as the processing of used electronic equipment by individuals under unregulated conditions where safety or human health and environmental concerns are often ignored. Informal recycling activities are carried out in recycling craft villages where metal, plastic and electronic scraps are processed (Tran & Salhofer, 2018). Recycling of Printed Circuit Board (PCB) involves not only the gold and copper recovery but also exportation (or dispose) of other electronic components (such as capacitors, transistors) mainly to China.

In many developing countries, including Nigeria, Ghana, India, and Bangladesh, plastics are burned and acid baths are used to recover valuable materials from waste devices. The resulting toxic residues are often dumped in surrounding soil or water systems (United States International Trade Commission, USITC, 2013).Informal recyclers tend to focus their recovery efforts on only the valuable materials that are easily extracted (usually copper and very limited amounts of gold), while other valuable and rare metals such as indium, palladium and ruthenium are lost due to the crude

methods used in recycling or extracting them(Zhang *et al.*, 2017).The collection of electronic waste in developing countries often takes place door-to-door and the value for reusable materials is well known. The manual disassembly performed in informal recycling sectors gives the advantage of a more complete separation of goods, resulting in recovered fractions that are more valuable (United States International Trade Commission ,USITC, 2013). The valuable extracted materials are generally used by the refurbishers for refurbishing purpose.

Refurbishing is the act of repairing and rebuilding of old and/or non-functioning electronic devices; turning them into second-hand and functioning equipment either by replacing or repairing defective components. It also involves performing cleaning and repair activities in defective products in order to make the second hand equipment appealing to the customers. The actual benefits to the consumer in the new-for-old exchange practice are notional once seen commercially (Ari, 2016). Refurbishinghas a significant contribution to play in the End–of-Life(EOL) management of ElectronicWaste (E-waste) (Pathak*et al.*, 2017). E-waste management consists of the effective and proper recovery of all reusable materials from WEEEand the safe disposal of the hazardous and toxic substances in them to prevent their contamination of the environment (Ilankoon *et al.*, 2018).There is therefore need for E-waste proper collection, disposal practices and techniques, awareness on health issues in recycling and refurbishing activities. Disposal practices and techniques are operations which include physico-chemical or biological treatment, incineration and deposition of E-waste in secured landfill or dump site.E-waste recycling and refurbishing processes (which may include combustion) are a source of environmental exposure to a mixture of compounds of known toxicity, such as lead, mercury, cadmium, chromium, polychlorinated biphenyls (PCBs), brominated flame retardants and polycyclic aromatic

hydrocarbons, as well as unintentional persistent contaminants, such as dioxins and furans, among others. These compounds results to pollution and also a risk to the environment and public health.The consequences of the current collection, disposal practices, recycling and refurbishing activities of e-waste in Nigeria particularly in Minna Niger State involves toxic materials being exposed that has adverse effects on personal, public health and environment which calls for assessment.

Assessment is used to describe the effort to aggregate findings from a series of evaluations in order to judge their quality and/or to assess the performance of the evaluators.Assessment is also the process of collecting facts about the happenings, characteristics and outcomes of a programme or issue in order to make judgment, improve the effectiveness of the program (Peersman, 2014).However, to sustain effectiveness of a programme the challenge needs to be addressed.

The key sustainability challenge for Nigeria and Minna Niger State is to prevent informal e-waste recycling and refurbishing activities that can endanger human activities, health and environment without hampering the environment, public health and economically valuable trade of used EEE of good quality.In addition, since there is tendency of increase in volume of waste due to technology advancement, Canadian councils of Ministers of Environments (CCME, 1996), asserted that constant waste evaluation should be conducted at least once yearly. Whereas, the Federal Ministry of Environment (FME) in Nigeria was mandated by EIA Decree 86 of 1992 to conduct an environmental audit (Evaluation) every two to three years. The outcome from assessment will make allowance for the calculation of diversion rates, waste reduction, waste awareness, participation, techniques improvement and costs. Therefore,data gathered from the assessment process can be used in reviewing waste handling practices, awareness, policies and techniques for improvement. In that regards, it

therefore become necessary, assessing informal e-waste recycling and refurbishing activities in Niger State.

1.2 Statement of the Research Problem

The fast-growing surplus of e-waste and its menacein Nigeria has become a great issue. E-waste generation is on the increase in our environment.Recycling activities also generates varieties of harmful substances which pose threat to human health and environment.Renee (2018) found that inhaling toxic chemicals and direct contact with hazardous e-waste materials (even in some formal e-waste recycling settings) result in increases in spontaneous abortions, stillbirths, premature births, reduced birth weights, mutations, congenital malformations, abnormalthyroid function, increased lead levels in blood, decreased lung function, and neurobehavioral disturbances. Hence e-waste ought to be handled efficiently and adequately. The soil and surface water could be affected; going by the way e-waste is littered around the environment, and also the ways it's been recycle and refurbished pose threat to the public health.Niger State environmental protection agency (NISEPA) is saddled with the responsibility of managing e-waste. However, the agency collectsthe e-waste together with municipal solid waste (MSW) together without separation, disposed them in a dump site at kilometer 30 Maikunkele in Minna, Niger State.

E-waste handling practices such ascollection,recyclingand minimization according to Lu*et al*. (2015)are inadequate and inefficient, and hence pose a huge risk on human health and environment. Effort by the regulatory authorities seems to have little or no effect in the e-waste activities and management. E-waste regulation seems not to be adequately adhered to which might be due to ineffectiveenlightenment campaign and sensitization programme. This is obvious going by increase inthe amount of e-waste in our environment.Theprocessinvolved in e-waste recycling and refurbishingexpose

human and environments to hazardous chemical, hence this study is set out to assess the informal E-waste recycling and refurbishing activities in Niger State, Nigeria.

1.3 Aim and Objectives of the Study

The aim of this study is to assess the informal e-waste recycling and refurbishing activities in Niger State Nigeria, specifically, the study identified;

1. The activities in informal e-waste collection in Niger State, Nigeria.
2. The activities in informal e-waste recycling in Niger State, Nigeria.
3. The activities in informal e-waste refurbishing in Niger State, Nigeria.
4. Techniques for improving informal e-waste recycling in Niger State, Nigeria.
5. Techniques for improving informal e-waste refurbishing in Niger State, Nigeria.
6. Level of awareness on health hazards in informal e-waste recycling in Niger State, Nigeria.
7. Level of awareness on health hazards in informal e-waste refurbishing in Niger State, Nigeria.

1.4 Significance of the Study

The findings of this study is of great benefits to the E-waste collectors, recyclers, refurbishers, Environmental protection workers, the researchers, Electronic training institution, Electronic students, Niger State indigene, Niger State residenceand general public as a whole.

The findings of this study help to improve collector practices in the collection of electronic waste as the basic knowledge acquired from the study through public enlightenment and sensitization programme will equip them with the hazards involved. The need for keeping themselves safe through proper handling and disposal of e-waste while engaging in their practices.

The findings of this study also help the e-waste recyclers to improve on rudiment ways of dismantling electronic waste. The basic knowledge acquired from the study through enlightenment and sensitization programme will also equip them with the effects and hazards involved in improper handling of electronic waste.

Effective implementation of the findings is of great help and improves the working practices of electronic waste refurbisher. Knowledge acquires through public enlightenment and sensitization programme will give them the awareness about health and environmental risk involved in improper handling method of e-waste.

Proper implementation of the findings and the recommendations significantly improve safe working practice in Niger State among the Waste Management Agency as the management agency will adopt best practices methods in handling and disposing electronic waste to reduce the harmful effect on the public.

The researchers can use the result of this study and empirical bases for further research in other technical and vocational education options, engineering courses or industrial course conducting research relating to e-waste.

Electronic training institutions also benefit from the findings of the study through seminars. As the study will go a long way to provide the basic knowledge for training of electronic practitioners who are expected to acquire and apply the best standard and methods in handling and disposing e-waste.

Electronic students equally benefit from the findings of the study through workshops and seminars. As the study will be of great impact and go a long way to provide the basic knowledge for training of electronic students who are expected to acquire and apply the best standard and methods in handling and disposing e-waste.

The findings is of great benefits to the Niger State indigene as the findings will expose the dangers and the problems associated with electronic waste accumulation and the consequence of indiscriminate disposal.

The study also unveil to the residence on the danger associated with uncontrolled environment occupied with waste materials resulting from electronic waste activities.

Finally, the study is of benefit to the general public as the implementation of the recommendation of the study will help in improving electronic waste handling activities and also reduce the harmful effect on public health in Nigeria.

1.5 Scope of the Study

This study is limited to assessment of informal e-waste recycling and refurbishing in Niger State. The study captured e-waste issues relating to collections, recycling, refurbishing, and awareness level.The waste captured by the study are electrical and electronics scrap of several equipment such as cell phones, videocassette recorders, scanners, faxes, printers, tablets, Digital Video Disc (DVD) players, microwaves, x-ray machines, and some scientific equipment. The study does not cover the activities of formal recycling because the sector deals with advance technological and more sophisticated equipment, and which the sector is yet to be established in Niger State. Also, the study did not cover domestic solid waste due to the time and financial constraint.

1.6 Research Questions

The following research questions guided the study;

1. What are the activities in informal e-waste collection in Niger State, Nigeria?
2. What are the activities in informal e-waste recycling in Niger State, Nigeria?
3. What are the activities in informal e-waste refurbishing in Niger State, Nigeria?
4. What are the techniques for improving informal e-waste recycling in Niger State, Nigeria?
5. What are the techniques for improving informal e-waste refurbishing in Niger State, Nigeria?
6. What is the level of awareness on health hazards in informal e-waste recycling in Niger State, Nigeria?
7. What is the level of awareness on health hazards in informal e-waste refurbishing in Niger State, Nigeria?

1.7 Hypotheses

The following null hypotheses were tested at 0.05 level of significant.

H_{01}: There is no significant difference in the mean responses of e-waste collectors, recycler, electronic refurbishers and regulatory agency on the activities in informal e-waste collection in Niger State, Nigeria.

H_{02}: There is no significant difference in the mean responses of e-waste recyclers, electronic refurbishers and regulatory agency on the activities in informal recycling of e-waste in Niger State, Nigeria.

H_{03}: There is no significant difference in the mean responses of e-wasterecyclers, electronic refurbishers and regulatory agencyon the activities in informal refurbishing of e-waste in Niger State, Nigeria.

H_{04}: There is no significant difference between the mean responses of e-waste recyclers, electronic refurbishers and regulatory agency on the techniques for improving informal e-waste recycling in Niger State, Nigeria.

H_{05}: There is no significant difference between the mean responses of e-wasterecyclers, electronic refurbishers and regulatory agency on the techniques for improving informal e-waste refurbishing in Niger State, Nigeria.

H_{06}: There is no significant difference in the mean responses of e-wasterecyclers, electronic refurbishersand regulatory agency on awareness level of health hazards in informal e-waste recycling in Niger State, Nigeria.

H_{07}: There is no significant difference in the mean responses of e-waste recyclers, electronic refurbishers and regulatory agency on awareness level of health hazards in informal e-waste refurbishing in Niger State, Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Theory of planned behavior (TPB)

The theory of planned behaviour(TPB)was propounded by Ajzen in 1991 and describes intention role in a behavior performance. TPB in its most simplified form explains behavioural intention as a function of three components: attitude, subjective norm and perceived behavioural control. In general terms, attitudes towards behavior show that individual evaluation of the action understudy from negative to positive. Subjective norm corresponds to thedegree of individual perception of the social desirability that theperson should perform that action. Perceived behavioural control includes both measures of self-efficacy and perceived control andindicates how well an individual feel that he or she can overcomethe obstacles, or taking advantage of the facilitators, when performing an action.

The theory assumes that intention is a good predictor of the behaviour itself, together with related past behaviors.Several variants of the TPB have been proposed according to the behaviour under study. In this study, besides the key components of the TPB, we also included socio-demographic and socio-economicvariables, the degree of awareness towards the problem, and thepersonal assessment of the environmental situation of Minna aspredictors of e-waste recycling. Based on this assumption, this study also assumes that most e-waste activities towards creation of waste are done intentionally. The extendedversion of the theory of planned behaviors in this context, are attitude towards e-waste recycling is shaped bythe beliefs that recycling is good for both the environment and forone's own and his family's health. Subjective norm indicates respondent's opinion on how other people, such as friends or family,think they should

behave. Perceived behavioural control is here affected by the presence of nearby recycling sites, by the belief thatrecycling e-waste is a time-consuming activity, or by the level oftrust towards government e-waste management and about individual control beliefs such as respondent's capacity to influence theother stakeholders. The model also added other two factors to thecore constructs of the TPB which are awareness of environmentaleffects of e-waste mismanagement and personal assessment ofenvironmental situation of the State. Socio-demographics (gender, age, income, education and region of residence) are alsolikely to play an important role in recycling behaviours.

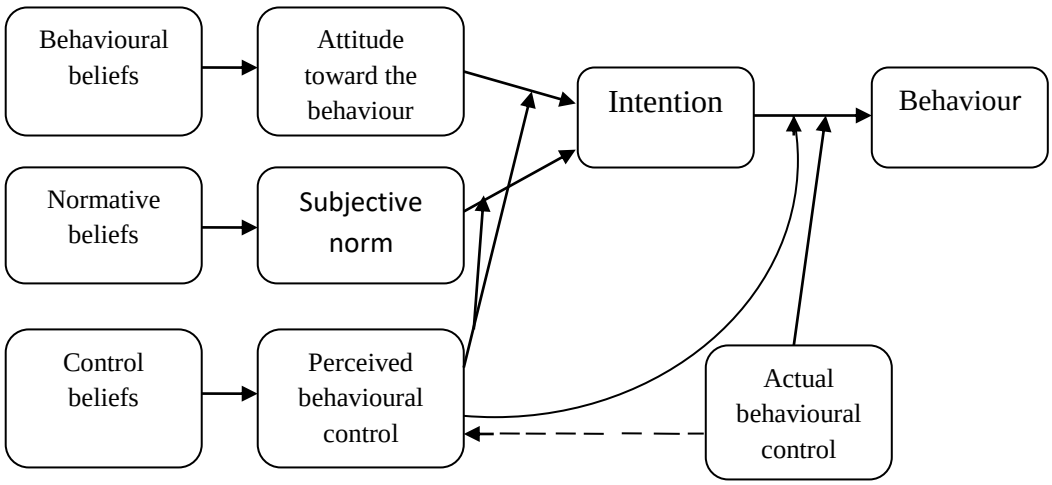

Figure 2.1: Theory of Planned Behaviour(TPB)
Source: Ajzen (1991)

2.1.2 Theory of reasoned action (TRA)

The theory of reasoned action according Fishbein Martin and Ajzen(1975) predicted that individuals deliberate on behaviour implications before carrying out a particular intention which is an important element in determining changes in behaviours. Also,with the addition of predictions of specific intentions and behaviour. The theory explains that behavior is not necessarilystrengthened by reward or discouraged by punishment. Rather, people form a conscious intention that is a “behavioral intention” to

act a certain way. The behavioral intention isdetermined by the beliefs that a specific behavior will yield a desired outcome, the value attributedto the outcome, the perception that a specific behavior will add to the outcome, the perceptionof the correctness of the behavior, and perceptions of the degree to which the specific behavior isexpected. Perhaps, people's intentions depend on their motivation to comply with whatthey believe is a desired action, what they feel is expected of them and "what they think they aresupposed to do". Dulany's theory of behavioral intention (BI) does not nullify the value of positive reinforcement,but emphasizes the role of people's beliefs which serves as determinant factor in the involvement of recyclers and refurbishers in Minna.

According to the TRA, an intention to act is a precursor to the behavior related to the sameact. In turn, attitude towards the behavior and social pressures (subjective norm) are determiningfactors of the intention to perform a certain action. Attitude is a personal factor which refers to aperson's evaluation of the behavior. Subjective norm is a social factor which refers to the "perceivedsocial pressure" to conform with a certain behavior, where social pressure is defined as the perceptions,beliefs, and judgments of other household members and community members related to recycling. Schwartz(1977)considered attitude and subjective norm asinculcated in the belief systems of a person. Whilesubjective norms are the construct where the "influence of relevant others" are expressed, attitude is a more personal construct, an expression of the "self". The assumption of this is study is that behavioral intentions of an individual in waste recycling are determined by the positive desirable outcomes, values and perception of the outcomes which sometimes driving by motivation.

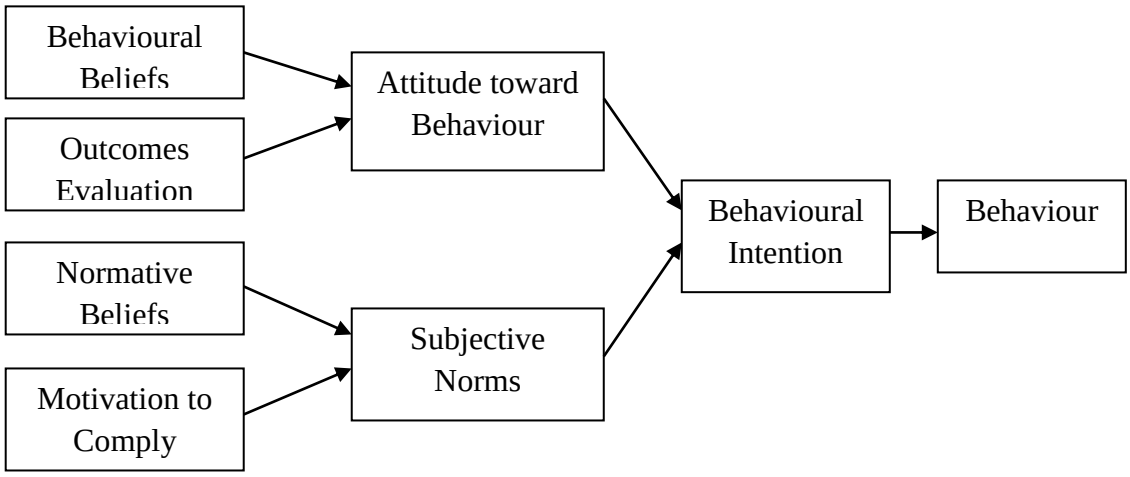

Figure 2.2: Theory of Reasoned Action (TRA)
Source: Fishbein and Ajzen(1975)

2.1.3 Health belief model

Health belief model was designed by Rosenstock (1966) in his model, he identified health belief model to be the first and valuable model in the promotion of health status. This model stated four constructs which include:

i. Evaluation of certain risk condition in related to statistical risk.

ii. Assessing the seriousness and consequences of a condition.

iii. Feel the impacts of certain condition such as awkwardness, side effects among others, and

iv. Perceived the implication of future interference.

All the constructs of this model were assumed to relate to motivation under susceptibility and fear of disease. In (1980) Becker reformed the model to include people's adaptability to sickness, and obey medical prescriptions, it further includes; disorder behaviours, screening and preventative of health. The main content of the model was the ability to adapt the desirable behaviours. The theory therefore related to this work because the study is intended to ensure there are proper awareness and regulations, and no accumulation of e-waste that can hinder better health and environmental living condition.

2.2 Conceptual Framework

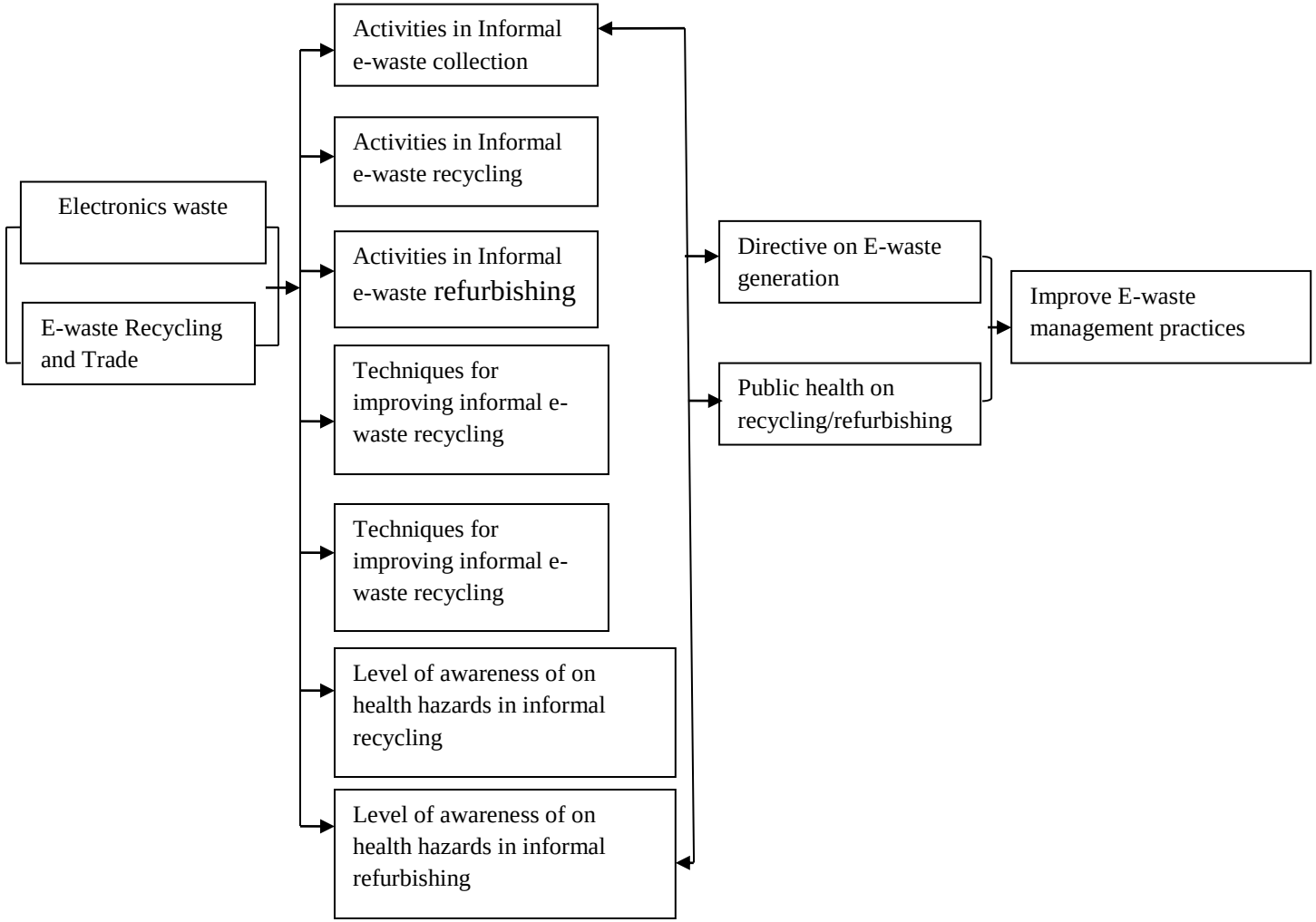

Figure 2.3: Schematic diagram on E-waste recycling by the researcher (2021)

2.2.1 Electronics waste(E-Waste)

E-waste is a combination of a broad and increasingly growing range of electronic devices such as large household devices (refrigerators, air conditioners) and mobile devices. Thus, e-waste has a plethora of definitions. Each definition depends on the interpretation of an electronic device's usefulness. The e-waste definitions converge to include characteristics such as discarded or unwanted electronic products regardless of their working state, electronic devices that are close to ending life, old devices that contains toxic and valuable materials, device that is subject to electric current or electromagnetic fields to work legitimately (Park *et al.*, 2017; Ceballos and Dong, 2016).

In 2014, the step initiative defined electrical and electronic equipment (EEE) as "any item from homes or businesses that contains circuits or electronic components and a power source or battery. Step also established that the term e-waste covers all types of electrical and electronic equipment and parts discarded by its owner as waste without the intention of re-use. It emphasizes the term "discarded" to distinguish between an item and product that can be reused from waste. E-waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use(United Nations University and Step Initiative, 2014). Furthermore, according to the Islam & Huda (2018), e-waste is a generic term comprising all electrical and electronic equipment (EEE) that have been disposed of by their original users and it includes everything from large household appliances, such as refrigerators, microwave, ovens, television sets and computers, to hand-held digital apparatuses such as cell phones and toys.

The main sources of e-waste are residue materials from the manufacture of electronic products; redundant electrical and electronic equipment discarded by repair shops, obsolete electrical and electronic equipment from various public and private organisations and obsolete electrical or electronic products from households (Yao*et al*., 2018).According to Lydall*et al*. (2017) waste from electrical and electronic equipment (WEEE) can originate from the following sources:

i. Large household appliances (refrigerators, stoves, etc.);
ii. Small household appliances (toasters, irons, etc.);
iii. IT and telecommunications equipment (desktop computers, laptops, cellular telephones, etc.);
iv. Consumer equipment (televisions, hi-fi's, musical instruments);
v. Lighting equipment (globes, electric lamps,;
vi. Electrical and electronic tools (including control boards and large-scale stationary industrial tools);
vii. Toys, leisure and sports equipment (video games, remove controlled toys);
viii. Medical devices (radiotherapy equipment, cardiology equipment, nuclear medicine equipment);
ix. Monitoring and control instruments (electronic control desks, screens), and
x. Automatic dispensers (vending machines, automatic teller machines).

From amongst all the sources of e-waste, the consumer and telecommunication equipments are the largest contributor to this waste, and to track the amount of e-waste generated worldwide, a good indicator would be the volume of computers sold (Dias*et al*., 2018). According to Nia (2014) less than 50000 telecommunication and consumerequipment valued at approximately $60 million were sold in 1975. However, in 2010, over 320 million personal computer, with a retail value of approximately $320

billion were sold while an estimation of approximately 2.1 billion personal computers were sold by the end of 2015(Govender, 2016). Factors that contribute to the progressive growth of e-waste are the rising consumption of electronic and electrical equipment (EEE) (Shevchenko*et al*., 2019). Echegaray (2016)also opined that the lifespan of electronic devices is getting shorter, and that this trend has a negative impact on the use of scarce resources. Table 2.1 lists a number of electronic products, their approximate mass and their estimated lifespan.

Table 2.1: Source of e-waste, their approximate mass and life span(Though the life span of the items depends on the usage)

Type of electronic item	**Mass** (kg)	**Estimated lifespan**(years)
Air conditioner	55	12
Cellular phone	0.1	2
Dish washer	50	10
Electric cooker	60	10
Electronic game consoles	3	5
Facsimile machine	3	5
Food mixer	1	5
Freezer	35	10
Hair-dryer	1	10
High-fidelity system	10	10
Electric Iron	1	10
Kettle	1	3
Microwave	15	7
Personal computer	25	3
Photocopier	60	8
Radio	2	10
Refrigerator	35	10
Telephone	1	5
Television	30	5
Toaster	1	5
Tumble dryer	35	10
Vacuum cleaner	10	10
Video recorder/DVD player	5	5
Washing machine	65	8

Source: (Govender, 2016;Gaidajis*et al.*,2010)

Table 2.1 indicates that electronic equipment has a finite lifespan and will eventually end up as e-waste, and the consequence of this relatively short product lifespan is the burgeoning quantity of e-waste that, if not neither recycled nor refurbished, poses a significant challenge to the environment (Gaidajis, *et al*., 2010). Electronic waste has

many toxic and hazardous elements/materials that are sources of environmental pollution and contamination of groundwater, surface water, air and soil,and also therisk from e-waste affects the entire ecosystem which is the major environmental health risk to wildlife and humans (Akram, *et al*., 2019). Therefore,this study seeks to assess the activities of informal recycling and refurbishing of e-waste in Niger State.

2.2.2 E-waste recycling and trade

The first electronic recycling system was implemented in Switzerland In 1991, beginning with the collection of used and obsolete refrigerators (Okorhi, *et al*., 2014). Over the years, all other electric and electronic devices were gradually added to the system. Legislation followed is: - The Waste Shipment Regulation (WSR) passed in 1993 and amended in 2007 was the first dedicated e-waste regulation. It emphasizes that no EU member state is allowed to export e-waste classified as hazardous to non-Organisation for Economic Cooperation & Development (OECD) countries. As number of e-waste components didn‘t fall under the WSR‘s definition of hazardous substance, these components continued to be exported to non-OECD countries under other provisions. In 2003 the EU has passed e-waste Directive / legislation for changing product designs and increasing recycling rates of discarded WEEE and Restriction of the use of certain hazardous substances (RoHS)(Tansel, 2017). The RoHS Directive addresses the beginning of the EEE life cycle by attempting to eliminate hazardous substances such as mercury, lead and fire retardants in domestically produced or imported electrical and electronic products. The WEEE Directive concentrates on the end-of-life stages of EEE. The Directive intends to encourage product designs that facilitate the recycling, refurbishing/repair, disassembly and reuse of WEEE by introducing the concept of Extended Producer Responsibility (EPR) (Fobbe *et al*., 2019). EPR deals with the financial responsibility for collecting and managing WEEE

in line with the Directive to the producers. Individual Producer Responsibility (IPR) applies for the management of new products put on the market. For historical waste, i.e. products put on the market before 13 August 2005, the financial responsibility is divided among producers in proportion to their market share of a specific type of equipment (WEEE Directive) (Paleari, 2015). The rationale behind producer responsibility is the 'polluter pays' principle, which intends to include the costs of disposal and treatment in a product's price, thus reflecting the product's environmental effects.

There are two established PROs (Producer Responsibility Organizations): Swiss economic association for the suppliers of information, communication and organizational technology, mainly handling electronic waste and Swiss foundation for waste management, mainly responsible for electrical appliances(Shamim *et al.*, 2015). In the 1990s, governments in European Union Countries, Japan and several states in United States set up e-waste recycling systems, but many countries do not have the capacity to deal with the sheer quantity of e-waste they generated annually or with its hazardous nature. In many cases, the cost of recycling e-waste exceeds the revenue recovered from materials especially in countries with strict environment regulations (Ilankoon *et al.*, 2018). Therefore, e-waste mostly ends up dumped in countries where environmental standards are low or nonexistent and working conditions are poor. Historically, Asian countries have been a popular dumping ground for e-waste, but as regulations have tightened in these countries over time, this trade has moved to other regions of the world, particularly West Africa (Shamim *et al.*, 2015). In West Africa, e-waste recycling sites are located in Lagos, Nigeria and Accra, Ghana (Orisakwe*et al.*, 2019). The e-waste is informally processed in many countries of the world, but a high-volume of informal e-waste recycling has been reported in China, Ghana, Nigeria, India,

Thailand, the Philippines, and Vietnam (Ibrahim, 2017). Demand for e-waste recycling in Asia begins to grow when scrap yards found they could extract valuable metals such as copper, iron, silicon, nickel and gold, during the recycling process. A mobile phone, for example, is 19% copper and 8% iron. Much of the informal e-waste recycling done in scrap yards and homes is done by children. The e-waste recycling in China is processed in the informal economy and constitutes a considerable amount of the gross national product (GNP) of the country (Shamim*et al*., 2015). Both the demand for recycled materials and the potential economic benefit are the main factors promoting the development of the disassembly (or recycling) industry for e-wastes (Shamim*et al*., 2015). Most of the literatures reported that informal waste recycling is carried out by poor, stranger and marginalized social groups who resort to scavenging and waste picking for income and survival (Khan, 2018).

Refurbishment is an act of maintenance that involves replacing some worn out parts of equipment with new or used functional components to make it ready for further reuse. This significantly increases the service years of the computer, lessens the e-waste generation and maximizes the Information and Communication Technology use.When the simple repair of defective parts is not efficient enough the company resortstotheir refurbishmentprocess. A quality refurbishing aims atimproving the product's performance, extending their service life and bringing the mup to an acceptable quality level. Mostly, it is cheaper for expensive productsto be refurbished instead of replacingthe whole product by new one. Moreover, the returns are disassembledto separate items and modules whichare subject to anaccurate screening, inspection and testing process to replace or fix the outdated or damaged parts (Reike *et al*., 2018;Ari, 2016). Military and commercial aircraft are examples of expensive products which are refurbished, but surely the average of their remaining service life is shorter than the

service life of new ones(Levinson, 2016). Likewise, electronics sector, the automobile sector is one of the common sectors which implement the refurbishing process,especially for the expensive car's mechanism, such as gearboxes, clutch mechanismsetc.

2.2.3 Activities in informal e-waste collection

E-waste collection is the process of gathering obsolete e-waste products from end-users. This stage is crucial to establishing the e-waste recycling chain because it determines the amount of e-waste resources that are available for recovery.The collection of e-waste in the informal sector is done by informal collectors also known as scavengers who normally execute door-to-door collection and purchase obsolete e-waste from private individual, corporate and institutional consumers at relatively low prices and bring them to the scrap yard (Nduneseokwu *et al.,* 2017). Collectors sometimes travel long distances and also sift through waste bins, visit landfills and other waste dumping grounds for e-waste (Nduneseokwu *et al.,* 2017).

Yevuyibor, (2015);Grant and Oteng-Ababiov (2012) viewed that collection of e-waste is undertaken with the most rudimentary technologies like moving around with a pushcart, sacks and basic tools (hammer, wrench, screw driver). In several cases, collectors also engage in e-waste dismantling and metal recovery including the burning of cables and wires to liberate copper for sale (Nduneseokwu *et al.,* 2017). Currently, about 90% of e-waste in Ghana is collected by the informal sector (Khan, 2018). Nduneseokwu *et al*. (2017) in their socio-economic survey found that monthly incomes of e-waste collectors in both Accra (Ghana) and Lagos(Nigeria) were between US$70 and $140, refurbishers earned between US$190 to $250, and recyclers between US$175 to $ 285.

2.2.4 E-waste collection channels

E-waste collection channels in a country indicate the physical responsibilities for stakeholders under an Extended Producer Responsibility (EPR) mechanism. The collection stage is very important to the whole recycling system because it determines the amount of e-waste available for recovery. There are three main categories of collection channel which are organized by three main groups of stakeholders worldwide: producer, municipal collection and independent collector (Gutberlet, 2015). The examples of three collection channels are shown in Table 2.2.3:

Table 2.2: E-waste connection channel

By World Health Organization	Examples of collection options
Producer/Retailer	Trade-in/take-back by retailers Take-back from OEMs
Municipal collection	Curb side collection Drop-off events HHW collection bins
Independent collector	Non-profit volunteer Recycling company Profit-driven informal collector

Source: (Li 2013;Periodic Health Assessments (PHA) Consulting Associates, 2006)

i. Producer/retailer take-back allows the consumer to return the e-waste to retailers or directly to the manufacturer or distributor. Normally, retailer take-back schemes are arranged by relevant producers. Merely, retailers can promote their products by encouraging customers to return old products to get a discount on new purchases or cash back for the old item. Some retailer take-back schemes may depend upon the purchase of new electronic products and some may not, such as in Japan. Customers can return e-waste to retailers without buying new items and also stored the EEE (Nowakowski, 2017). The retailer and producer take-back schemes are aimed at different groups of end-users. For example, retailer take-back programs mainly target individual end-users (Business to

Consumer) (B2C) while the producer take-back programmes aim at groups (Business to Business) (B2B) and large quantities of EOL products from institutions (Gutberlet, 2015).

ii. Municipal collection is widely applied in many affluent societies such as the U.S., Canada, EU countries, and Australia. Municipal collection appears in various forms, including periodical collections such as kerbside pick-up/collection, drop-off events (Pirtilä, 2020) and collection bins to collect the household hazardous waste (HHW) component (Inglezakis, 2015). The detailed implementation of collection practices varies greatly in countries due to different WEEE management and legislative frameworks.

iii. Independent collection exists in both developed and developing countries, involving non-profit collection or profit driven collection operations of e-waste(Inglezakis, 2015). The non-profit collection activities are mostly organized by non-profit volunteers or Non-Government Organizations (NGOs) while many profit-driven collections are self-organized by informal individual collectors.

2.2.5 Activities in informal e-waste recycling

The informal e-waste recycling system comprised of a series of stakeholders, which have precise division of labour including WEEE collection, dismantling, and metals recovery. These informal stakeholders usually specialize and deal with one type of metal or recycling operation and then the e-waste items or components are passed on to other informal e-waste processors, which are spread over a wide geographical area (Gutberlet, 2015). After acquiring e-waste resources from households or institutions, informal collectors sell e-waste appliances to different downstream stakeholderswhich they either refurbished to be sold for reuse, resold to aformal sector(Orlins & Guan

2016). These collectors sort e-waste and decide which items ought to be dismantled or sold to second-hand markets (Arthaya& Nathania 2017). Many appliances are sold for reuse purposes after refurbishment in repair shops and a good quality component will be directly reused for a new product (Arthaya& Nathania 2017). E-waste that does not have a reuse value will be dismantled (by dismantlers). Recyclable materials such as plastic, glass and metal are sold to respective material traders. The residual e-waste and components such as wires and hard drivers are sold for further end-processing, such as extracting precious and non-precious metals by extractors (Ghosh, *et al*., 2016). During the latter stages of e-waste processing like dismantling, burning ash or leaching liquid for metal recovery which contain many toxic substances are often dumped into the environment such as in fields and rivers (by disposers)(Kaya, 2016).

Recyclers in Nigeria disassemble obsolete e-waste to recover metals, such as aluminium, copper and steel. While some recyclers are specialized on e-waste recycling, others engage in the recycling of various types of metal-containing wastes in parallel. Some recyclers also engage in the open incineration of cables, acid baths and other plastic parts in order to liberate copper and other metals (Gangwar *et al*., 2019). Recyclers in Nigeria do not engage in acid or chemical bath of electronic components to extract materials from them, rather, they disassemble obsolete e-waste to recover metals and other perceived working parts such as memory chips, integrated circuits (IC), aluminum, copper and steel unlike their counterparts in China, Pakistan and India (Awasthi & Li, 2017). Some informal recyclers may focus specifically on e-waste alone, others engage in recycling wastes containing all types of metals. Recyclable and reusable components such as thePrinted wiring boards (PWBs) are separated, collected, and either sold to traders in Nigeria or exported, mostly to Asian destinations (Nnorom & Odeyingbo, 2020).In few cases, recyclers deal directly with end-processing units, by

selling recovered metals to industries such as refineries and those who re-melt. However, the common practice among recyclers is to sell extracted materials to middle-men who take them to end processing units. Many recyclers are also active in the collection of waste components and lead solder, and then dip the stripped boards in acid baths to remove gold and copper. The residual toxic solution may then be dumped in surrounding areas. Another informal treatment method performed is to burn the plastic coating from metal components such as PVC wires, to recover the valuable metal content, resulting in a harmful release of toxic dioxins and furans (Uchida, 2018). The release of persistent organic pollutants and toxic metals causes serious and irreparable damage to the surrounding environment and inhabitants. Below are some of the crude techniques performed during informal e-waste treatment (Orlins & Guan, 2016).

i. Manual material separation using simple tools like stones, hammers and bare hands.
ii. Heating printed circuit boards over coal-fired stoves to remove components
iii. Using open-pit acid baths to recover valuable metals
iv. Chipping and melting plastics without proper ventilation
v. Open burning of unwanted material and cables to access internal copper wires
vi. Dumping unwanted materials in fields and riverbanks

As reported regarding some areas in African countries by (Khan, 2016), informal recycling activities focus primarily on recovering steel, aluminum and copper, while the recovery of other metals is said to be very inefficient. Uchida (2018) reports that the acid baths commonly used in India to extract gold from PCBs (printed circuit boards) result in a recovery rate of up to 20%, whereas modern techniques performed in formal facilities can achieve a recovery rate of 95%, and with lower emission levels. Ohajinwa*et al*. (2017) estimated an effective material recovery rate of just 52% from the waste processed by the informal sector in Nigeria.

2.2.6 Activities in informal e-waste refurbishing

Refurbishing is the act of repairing and rebuilding of old and/or non-functioning electronic devices; turning them into second-hand and functioning equipment either by replacing or repairing defective components. Refurbishers or repairers transform old and/or non-functioning electric and electronic equipment into second-hand and functioning equipment either by replacing or repairing defective components and/or by performing cleaning and repair activities in order to make the second hand equipment appealing to the customers. Although sometimes a distinction is made between refurbishers and repairers, the dividing line between the two groups cannot be drawn exactly. In this study, both groups taken together are generally referred to as refurbishers. In addition to refurbishing and repair operations, most refurbishers also engage in marketing and sales of the refurbished products. For the scope of this study, this activity is included in the profile of refurbishers. Each refurbisher in Lagos typically focuses on a distinct group of products such as cooling and freezing equipment, air-conditioners, small household equipment, TVs, computers or mobile phones (Osibanjo *et al*., 2016).

Though the professionals in this field often like to distinguish themselves (repairers from refurbishers), there is no significant difference between their activities. The informal repair shops also offer second-hand appliances for sale. Although the repair markets trade various categories of second-hand products and appliances, these informal second-hand shops which trading e-waste tend to specialize in two major types of product, either large household (LHH) appliances or Information and Communications Technology (ICT) products. LHH appliances include washing machines, refrigerators,

air conditioners and TVs. ICT products are mostly Personal Computers (PCs) and portable electronic products such as MP3 and mobile phones (Wang & Lin, 2021). It is quite easy to distinguish these two kinds of shop by their products. Other than the signage boards outside the shops, second-hand shops for LHH appliances normally place numbers of large appliances outside of their shops. Many repair shops for large household appliances are family-based. The shop layout allows them to repair products inside the house and sell them in their front yards.

These informal repair/second-hand shops, which mostly locate on the same street, form an informal second-hand market. These second-hand shops do not only sell LHH appliances, but also sell other categories such as furniture, kitchen equipment (such as Range Hood and hot water heaters) and heating radiator units. Although the ICT repair shops only sell portable electronic products, technicians in these shops are versatile and are able to mend other categories of appliances if requested. Mobile phones are the most common products for on sale. "(Used) mobile phones are easy to obtain from customers and also easy to sell due to a large demand," suggested an owner of an ICT repair shop. Most repair shops use handy tools and have low overheads so the price from their repair services is quite acceptable. The obsolete products resources for large appliance repair shops mainly come from informal collectors while resources for the ICT repair shops mostly come from individual clients or ICT street traders(Wang & Lin, 2021). It is worth noting that some obsolete appliances were sold as new products after refurbishment and repackaging. The price of these repacked products are often much lower than those from formal retailers.

2.2.7 Techniques for improving informal e-waste recycling

Waste is considered an irrelevant good that is no longer useful or desirable which sometimes referred to as objects or substances that is discarded by its owners. Disposal

practices or techniques are operations which include physico-chemical or biological treatment, incineration and deposition of E-waste in secured landfill or dump site. A dump is a piece of land allocated for the public to dispose unwanted waste. The methods and manner of disposing waste depends on the classes or types of waste and the indiscriminately discarded of waste is not only unpleasant, but sometimes has effect on public health and environment. The four common methods of e-waste disposal by (Ogbenna and Raymond, 2018) are incineration, land-filling, open dumping and recycling.

i. **Incineration:** is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incinerator and other high temperature waste treatment systems are described as "thermal treatment". Incineration consists of high temperature used for combustion of solid waste after separating the non-combustibles from the combustibles. Through incineration,the hazardous nature and volume of a substance or material are decreased, and the inert remains from incineration can be more safely discarded (Quina*et al*., 2018). Ideal for discarded waste fractions that are not recyclable, incineration is a process to transform waste into energy oxidation or other thermal treatment (burning) to produce district heating and electricity through hygienic and environmentally safe methods. The incineration process produces bottom ash that is land-filled or used as gravel, and fly ash that can also be land-filled or used for such purposes as neutralizing empty mines (Cieślik *et al*., 2015).

ii. **Land filling:** this is an area usually used for buried waste materials that are being disposed off and it is the oldest way of managing waste, this is common to closed mining site and depression site. Disposal to landfill by Abdel-Shafy *et al*.,

(2018) describes land-filling as a method for treating waste when recycling is not possible or appropriate. Waste discarded to a modern formal landfill is stored in a controlled manner where it remains safe for a long period of time. According to European Union restrictions, as specified in article 6 of the WEEE Directive European Commission (2014) the land-filling of WEEE that has been separately collected by member states, which includes Sweden, is prohibited if proper pre-treatment has not been performed.

iii. **Open burning:** is defined as a fire where any material is burned on the ground or in an open receptacle other than a furnace, incinerator, or other equipment connected to a stack or chimney. Also, open burning is the burning of unwanted material in the open air where smoke and toxic fumes are released into the atmosphere directly.

iv. **Recycling:** is the process of converting waste materials into new materials and objects. The recyclability of a material depends on its ability to reacquire the properties it had in its virgin state. It is an alternative to "conventional" waste disposal that can save material and help lower greenhouse gas emissions.Recycling (material recovery):according to Quina *et al*., (2018), the main objective of recycling waste is to generate clean commodity materials that are similar to and can replace primary raw materials. Through recycling, end-of-life goods are broken down into secondary materials that can be recirculate back into raw material flows, reducing the demand for primary (virgin) raw materials that are otherwise extracted through energy intensive processes.

2.2.8 Techniques for improving informal e-waste refurbishing

i. **Avoidance:** at the top of the waste management pyramid is the absence of waste. Avoiding the production, consumption, and disposal of devices all together, for

example through technological developments making a device obsolete, eliminates the use of rare resources and exposure to harmful waste flows (Liebmann, 2015).Another approach to avoiding negative impacts on the environment and human health is to avoid the use of harmful materials in the production of equipment (Mahdevari *et al*., 2014). Replacing hazardous content with non-hazardous materials helps to avoid the impacts that would otherwise be present when dealing with waste equipment.

ii. **Reduction:** similar to avoidance, limiting the volume of waste generated is the next most effective option toward lowering environmental and/or human health impacts from end-of-life treatment. Again, this can be seen as a literal reduction in the volume of waste generated through a decrease in production and consumption volumes, or a reduction of hazardous materials embedded in the equipment used (Liebmann, 2015). Replacing toxic content for less harmful materials reduces potential impacts from discarded equipment.

iii. **Reuse and repair:** the next step in the waste management/techniques hierarchy giving a further reduction of environmental and human health impacts is the reuse of products. As it relates to consumption of raw materials and energy, Cooper andGutowski(2017) discuss that the demand for virgin materials decreases by a third with a substantial secondhand market, and the energy used throughout the useful life of a computer is just one quarter of what is required to manufacture the computer. Choosing to re-circulate a used product back into the market extends its lifetime and decreases volume of problematic waste generated. Repair, included in the category of reuse, is the replacement or fixing of a broken component, bringing a device back to working order for further use. Reparation also includes refurbishment and remanufacturing, which are the upgrading of a device to achieve a higher quality

result, and cannibalization which is the extraction of parts or components for reuse or refurbishment of other units (Cheung*et al*., 2015). Specialized equipment and valuable parts may also be upgraded for reuse, and equipment with no resale value may be broken down for components that can be reused (Iacovidou & Purnell, 2016). Although reuse and repair are more desirable than recycling according to their position in the waste management hierarchy, exports for reuse become problematic when the goods are repaired or eventually dumped or treated under unregulated conditions that result in negative impacts.

2.2.9 Level of awareness of on health hazards in informal recycling

Awareness level affects informal WEEE workers behaviour in handling and processing e-waste (Ohajinwa *et al.,* 2017). From the survey to measure the effect of awareness on health hazards involved in informal e-waste activities, the report proven that there were no awareness in informal sector as regards the hazardous effects involve in the activities. According to Heacock *et al.*(2016) the unsafe, unregulated and unaccountable collection, processing, and redistribution of old or abandoned electrical/electronic equipment are performed by workers at temporary sites, residences, workshops, and open public spaces due to lack of awareness and management. Awareness helps to changes attitudes, also encouraging the workers to seek out proper and safety ways of handling and processing e-waste in order to reduce the hazardous effects on human health and environment.

The processes of managing E-waste stream in Minna Niger State, Nigeria are not adequately spelt out and practised. Most of what happens is that individuals, dealers and importers buy these wastes for direct reuse or dismantle to collect components for recycling and discard the remnants along with other municipal solid wastes (Okorhi *et*

al., 2015). Although the gradual and steady increase in the generation of E-waste intensifies the interest for recycling to conserve natural resources and protect the environment, the sad aspect of this problem is that, most of the technicians/scavengers are not aware of the risks involved in the crude methods employed in collection and dismantling E-waste to extract valuable components; neither do they know of better practises. The collection, recycling and refurbishment of e-waste is associated with severe health and safety risks for the engaged workers. While it is a source of livelihood for the urban and rural poor of this region, it often causes severe risks to man and the environment (Orlins & Guan, 2016). Lack of awareness or knowledge is always a barrier to proper working conditions and save guiding health and environmental hazards involved in informal e-waste sector.

The lack of adequate awareness on health hazard in recycling activities in the sector promotes the growth of informal economy in Minna, Niger State. According to Shah (2014) for effective e-waste collection and enhanced recycling rates to occur, there is a need for greater public awareness. Similarly, other studies attribute shortfalls in e-waste management to poor recycling attitudes, while public ignorance and existing awareness levels are not always enough for the proper management of e-wastes (Masud *et al.*,2019).

2.2.10 Level of awareness on health hazards in informal e-waste refurbishing

Awareness level affects informal WEEE workers behaviour in handling and processing e-waste (Yu*et al*., 2017).From the survey to measure the effect of awareness on health hazards involved in informal e-waste refurbishing activities, the report proven that there were no awareness in informal sector as regards the hazardous effects involve in the activities. The workers' knowledge of the association between their health status and their work was generally poor. Apart from the physical injuries, they did not believe

their work played any negative role in their health conditions. In the refurbishing sector, many workers are engaged in hand soldering using lead containing solder paste. As most workers bow over the solder gun for quite long time periods per day, and as many refurbishers work in small, poorly ventilated workspaces, many refurbishers are exposed to lead fumes over long-time intervals. Many refurbishers claimed that the solder fumes cause itchy eyes. Few refurbishers claimed that they suffer from muscle pain after long days of work(Yu*et al*., 2017).The main risks to human health and the environment arise from the presence in e-waste of heavy metals, POPs, flame retardants and other potentially hazardous substances.

E-waste is a complex and difficult form of waste to recycle, and problems such as elevated concentrations of heavy metals in the air have even been found in state-of-the-art facilities in developed countries. Workers and local residents are exposed to toxic chemicals through inhalation, dust ingestion, dermal exposure and oral intake. Inhalation and dust ingestion impose a range of potential occupational hazards including silicosis (Mehta, 2019). They are particularly important routes of human exposure to dioxins, lead, copper, cadmium, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyl (PCB), chromium, mercury and other metals and carcinogens (Mehta, 2016). Electrical shocks are another occupational hazard (Campbell & Dini, 2016). Upon contact with these toxic elements from e-waste, human health risks include breathing difficulties, respiratory irritation, coughing, choking, pneumonitis, tremors, neuropsychiatric problems, convulsions, coma and even death (Srivastava & Dhingra, 2021). E-waste workers are also exposed to other hazards leading to physical injuries and chronic ailments such as asthma, skin diseases, eye irritations and stomach disease (Poole &Basu, 2017). Particulate matter collected from e-waste recycling areas

can lead to inflammatory response, oxidative stress and DNA damage (Feng*et al*., 2020).

2.2.11 Level of awareness on environmental hazard in informal recycling

E-waste informal processing units of the National Capital Region are all operating in shabby and small rooms of residential or unauthorized colonies, environmental protection measures were also absolutely nil across the areas and units with zero emission, effluent or waste processing(Mattern, 2017). Waste was visibly dumped in open or to community bins located close to drains with risk of contaminating soil, surface, sub-surface and ground water. The open drains running through these colonies carry wastes and effluents of hazardous chemical contaminants along with plastics and dust metals released during the processing of e-waste (Omari, 2018). The growing volumes of e-wastes across the world threaten components of the environment. Burning of e-wastes can release highly hazardous dioxin like chemicals. Leaching of heavy metals like arsenic from the e-wastes contaminates groundwater. Open dumping of e-wastes with other solids wastes can cause leaching of toxic substances to the soil that can harm the soil biota (Binegde, 2014).

Even the greenest products cannot prevent tertiary emissions if inappropriate recycling technologies are used, and this is a big challenge in developing countries, where backyards recycling with open sky incineration, cyanide leaching and burning of circuit boards impacts negatively on the health of the citizens and the environment (Govender, 2016). The toxins made up of dangerous carcinogens and chemicals leach out, poisoning the soil and dirtying underground water aquifers causing contamination of the surface water Steffan *et al*. (2018), which later enter into crops, animals and the human body. As a result of the toxic substances contained in electronic products, the usual

management practice of e-waste crushing (compression) before or during discarding in landfills can increase the volumes of leachate leaked into the environment (Luhar & Luhar, 2019). In the city of Guiyu, Southeast China, known as the largest e-waste recycling site in the world, wind patterns disperse toxic particles released by open-air burning across the Pearl River Delta Region, which is home to 45 million people. In this way, toxic chemicals from e-waste enter the food chain, which is a significant route for heavy metals exposure to humans. These chemicals are not biodegradable and persist in the environment for long periods increasing exposure risk (Martin*et al*., 2017).

According to Modi (2020) e-waste has the potential to cause global warming, climate change, and depletion of the ozone layer, which is the result of the earth's limited capacity to assimilate e-waste. Klevor(2015) has observed that e-waste from older obsolete refrigerators; freezers and air conditioning units contain ozone-depleting chlorofluorocarbons (CFCs). This ozone destroying gas escapes from electronic items dumped in landfills. Goyal (2017)of the opinion that e-waste is contributing to acute chemical hazards and the long-term contamination at the dumpsites as well as emitting ozone-depleting substances and greenhouse gases into the atmosphere. Koka (2017) report that despite recycling efforts, e-waste results in approximately 5000 tons of copper being released annually into the environment. Table 2.3: shows WEEE Hazardous ComponentsandAssociatedEffectsonHumanHealthandtheEnvironment.

Table 2.3: WEE Hazardous Components andits AssociatedEffectsonHumanHealth and Environment

S/N	COMPONENT	ENVIRONMENTAL EFFECT	HEALTH EFFECT
1.	Lead (Pb)	•Accumulates in the environment •Potential to leach and contaminate drinking water supplies.	•Exposure to lead, even at very low levels, is highly toxic •damage to the central and peripheral nervous systems •Lead exposures can significantly reduce the IQ of school-aged children •In adults, lead exposure has been related to increased blood pressure and hypertension, conditions known to increase the risk of cardiovascular disease. •Affects blood system and kidneys in humans •Exposures can cause infertility and miscarriage •endocrine hormone disruption •Lead inhibits the various enzymes of the haemoglobin metabolism thus reducing the oxygen balance and the respiratory volume
2.	Cadmium (Cd)	•Danger ofCumulative effects in the environment due to its acute and chronic toxicity.	•Irreversible effects on human health. •Accumulates in the human body, particular in the kidneys. •Biological half-life of cadmium in the human body is between 15 and 25 years (measured in the kidneys) •Cadmium and its compounds are carcinogenic •Bone deformation may also result
3.	Mercury (Hg)	•Accumulates in living organisms and concentrate through the food chain, particularly in fish.	•Negative effects on brain functioning and development •Mercury dusts and vapours are very toxic. It is subject to almost complete absorption via the lungs. •Mercury is finally stored in the liver and kidneys •Chronic poisoning causes malfunction of the central nervous system, the symptoms being apathy, unretentive memory, over-excitability and general trembling. •It has mutagenic and teratogenic potential

4.	Hexavalent Chromium		•Can cause strong allergic reactions, even in small concentrations. •Acute poisoning with chromium (VI) compounds becomes apparent in the form of damage to the kidneys. •Chronic poisoning results in changes in the gastro-intestinal tract as well as in accumulation in the liver, kidneys, thyroid gland and bone marrow •Chromium(VI) compounds are highly mutagenic
5.	PVC(Polyvinyl Chloride Plastics)	•The production and burning of PVC products generates dioxins and furans, which contribute to air pollution	•Is an important irritant and allergen of eyes, skin and respiratory tract •Aggravates respiratory ailments. •Repeated exposure damages the liver, kidneys and spleen •Malignant tumours may occur. •definitely carcinogenic and teratogenic (deformities and skeletal changes on inhalation)
6.	Brominated Flame Retardants		•Exposure to these chemicals in early life could induce neurotoxic effects •Exposure to Polybrominated Biphenyls (PBBs) is believed to cause an increased risk of cancer of the digestive and lymph systems. •The liquid produces severe, poorly healing irritation and burning of the eyes, the respiratory organs, the skin and the gastro-intestinal tract. •Deep, painful necroses form on the skin and the mucous membranes. •High concentrations cause oedemas of the glottis, larynx and lungsas well as inflammation of the lungs. •Bromine vapours are even more hazardous as they produce bronchial spasms and pneumonia.

Source: (Oladele, 2009)

2.2.12 Directive on e-waste generation

The WEEE directive of the European parliament and of the council (2002/96/EC) entered into force in 2003. The aim of the legislation is the prevention of e-waste generation, and to promote the reuse, recycling and other forms of recovery of such waste so as to reduce disposal. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment and, in particular, those operators directly involved in the treatment of e-waste (Ilankoon *et al*., 2018). It is based on the principle of producer responsibility and promotes the green design and production of electronic products. It includes separate collection of e-waste, and the use of best available clean-up strategies and treatment, recovery and recycling techniques, and makes producers responsible for financing the take-back and management of e-waste (Jain & Jain, 2020). The global electrical and electronics industry has come under increasing pressure to adopt EPR policies because of the European legal framework and Directives (Leal*et al*., 2019). However, despite extensive legislation targeting the e-waste problem, experience in the first few years of implementation of the WEEE directive has shown that it is facing difficulties. Less than half of the collected e-waste is currently treated and reported according to the directive's requirements. The prevalence of loopholes and difficulties in enforcement has reduced the effectiveness of the EU legislation. It has been found that, of the vast majority of e-waste, 67 per cent is completely unaccounted for, being either land filled or destined for illegal export to developing countries (Forti*et al*., 2020).

2.2.13 Public health in e-waste recycling and refurbishing

The public health is an acts of focuses on the process and pattern of prolonging life as well as preventing disease and promoting health living. Feltham-King and Macleod(2020) describes Public health as the "science and art of controlling disease",

prolonging life and improving quality of life through proper efforts of organized and informed various choices of individual, communities, society, organizations, private and public. Public health is described as the ways of preventing diseases vectors and promotion of health by an organized community effort (Campbell-Lendrum *et al*., 2015). Public health is the science and an acts of averting epidemic diseases, strengthen physical health, prolonging life through appropriate organized efforts by the entire residents of the community cleanliness of the region or area, the regulation of community pollutions, the education of the individual in principles of personal hygiene, the institutes of medical services for the early detections and preventive treatment of disease, and the improvement in technology that will guarantee the residence within the community a standard living for upkeep of health (Gostin & Wiley, 2016). .

Public health also aims at improving the quality of life through prevention and treatment of pandemic disease, including mental health. This is done through the monitoring of cases and health indicators, and through the promotion of healthy behaviors. public health initiatives which are frequent includes promotion of hand washing and breastfeeding, delivery of vaccinations, suicide prevention, smoking cessation, obesity enlighten, increasing healthcare accessibility and distribution of condoms to control the spread of sexually transmitted diseases(Andrade *et al.,* 2019). Public health is a field that is a multidisciplinary. Examples are: epidemiology, biostatistics, social sciences and management of health services. Other vital subfields includes environmental health, community health, behavioral health, health economics, public policy, mental health, health education, occupational safety, disability, gender issues in health, and sexual and reproductive health.

Public health is also considered as a way of ensuring social justice, value and priority to human life. Although public health does not only include actions taken to prevent

prevalent of epidemic diseases, but regular diagnosis for symptom and treatment taken to prevent diseases and reduce infection. Public health can also be describe as perception aimed at elongating life, refining health, and enhancing the standard of living by improving health status, preventing epidemic diseases and other health issues(Wymer, 2015). Many industries today, some organizations by public services, health workers personnel, environmental protection personnel and some individuals has contributed exigently to the prevention of both the symptom of illness as well as any epidemic resulting from e-waste shops and other maintenance facilities. Mainly, the causes of illness to society is inhaling of harmful substance from either e-waste, or something else which sometime causing chronic diseases, sleeplessness, pungent odour among others (Tulchinsky & Varavikova, 2014). Hence, as a matter of urgent the act of enlightening, educating individual towards ensuring health development will go a long way to promote public health.

Health development: This is the act of exceedingly enhancement in the health status of a particular person and certain group of people, which is very important and crucial in health status development(Yardley *et al*., 2015).

Health education: This involves some form of learning and communication designed that will improve skills knowledge and development of human life health, which the individual and community considered suitable for promotion in their health status(World Health Organization, 2020). It is then essential to move towards improving health by educating both the individual and the community in the direction of enhance the living condition.

Health needs assessment: Is all about the problems of health among a group of people and change within the groups (Pennel *et al*., 2016). The point is to choose significances

wellbeing. Find out whether people can appreciate wellbeing benefit care or cross the board of social and ecological change, and adjust any reasonable change as opposed to clinical, moral and monetary contemplations.

Also, public health can be characterized as individual perspectives of position in life towards their ways of life and esteem arrangement of where they live, and in connection to their objectives, suspicions, values and concerns. It includes physical wellbeing, mental state, and level of freedom, social connections and individual convictions. Vulnerability to a particular ailment, ill health or injury, risk factors, which may be recognized and concentration for health advancement(White, 2017).

2.2.14 E-waste management practices

E-waste management is an effective recovery of all reusable materials from old, nonfunctioning, abandoned and disposed electrical/electronic equipment; and safe disposal of the hazardous substances in them to prevent such toxic material from contaminating the environment (Waste Management, 2012). Management of e-wastes involves collection, keeping, treatment and disposal of electrical and electronic waste or scraps in a safe manner to repudiate and prevent human and its environment from harmful effect e-waste (Azodo*et al.,* 2017). E-waste covers all electrical and electronic products that have reached their end of life or unserviceable. These products possess valuable substances (non-precious metals, including iron, steel, copper, aluminum; and precious metals, such as gold, silver, palladium and platinum) and hazardous elements (such as; lead-containing glass, mercury, cadmium, batteries, flame retardants, chlorofluorocarbons) that can have harmful effects on human health and the environment, if not properly handled (Ari,2016).

A persistent increase in legal and illegal trade of waste electrical and electronic equipment (WEEE) globally has caused equally increasing concern of poor WEEE management techniques (Oteng-Ababio *et al.*, 2016). The management of waste in general has traditionally been the responsibility of federal, state and local governments and in Niger State, Niger state Environmental Protection Agency (NISEPA) is responsible for the management of waste, electrical electronics equipment inclusive. However, the inadequacies of the governments to manage and handle waste in most developing countries such as Nigeria, has necessitated the involvement of private, informal and community-based groups to participate in the management of waste in general and specifically e-waste. In Niger state just like many other states e-waste collection, sorting and recycling is largely controlled by informal sector with the formal sector taking up a little share of the e-waste market. According to (Heacock *et al.* 2016), the unsafe, unregulated and unaccountable collection, processing, and redistribution of old or abandoned electrical/electronic equipment are performed by informal e-waste workers at temporary sites, residences, workshops, and open public spaces due to lack of awareness and management.

Laha (2015) among others gives the rudiment general practices of e-waste management among the populaces include using acid baths, burning cables, breaking of e-waste item into smaller parts using forceful approach, and dumping of e-waste materials into an unjustifiable position. Meanwhile, these workers may have embarked on e-waste risky processes and practices due to some challenges they may likely to have been facing such as lack of required knowledge, little or no access to latest technology and personal protective equipment among others (Heacock *et al.*, 2016).

In contrast, the informal sector recyclers are known to be well registered, regulated and employ environmentally sound technologies to manage e-waste, therefore minimizing the threat hazardous elements contained in e-waste pose to human health and environment, while maximizing the benefits inherent in e-waste. Despite the effectiveness of the formal sector, the informal sector operators dominates the e-waste management sector, they have active strong networks, employ very cheap labor and are able to access areas, communities and door to door collection of e-waste paying for the collected waste (Ndidi & Emmanuel, 2018).

There is need for e-waste specific policies to address the challenges on e-waste management strategies. From all indication and available information it seems that Niger State lacks management awareness on recycling and refurbishing. Notwithstanding, e-waste management is carried out through the solid waste and hazardous management acts under the environmental protection Agency. Some innovations have been achieved in waste management ranging from open dumping which is still available in some low-income countries, to uncontrolled landfill, to the recycling and controlled landfill. Incineration, pyrolysis-gasification and anaerobic digestion process of management in converting waste-to-energy technology. E-waste will be minimized and sustainable waste management will be achieved in Niger State through proper collection, equipped awareness and proper disposal techniques.

2.3 Review of Related Empirical Studies

Benedicta (2012) conducted a study on e-waste management in Lagos state, Nigeria. The study seeks to determine the relationship between socio economic factors and informal e-waste management practices in Lagos State, Nigeria. The research adopted both Quantitative and Qualitative survey design. Stratified random sampling and quota sampling techniques were used. The target population was 1,000 and sample of 100

respondents was taken from 32 Local Recyclers (waste scavenging); 21 Electronic Importers; 27 Electronic Repairers and 20 working in the Computer and Photocopying Services.These groups are identified as active stakeholders in the management of e-waste in Ikeja Computer village and Olusosun Dumpsite, Lagos State. Quantitative structured questionnaires and semi-structured interviews items (20 items) were used for data collection. The data was collected and analyzed using frequency count and SPSS for descriptive analysis. The study revealed that even though health hazards associated with the interaction with e-waste were evident, stakeholders in the informal management of e-waste were willing to continue in the trade due to the economic benefits it offers. Though there is provision for management of hazardous waste in the National. Policy guidelines as well as regulations set by the National Environmental Standards and Regulations Enforcement Agency for importation of electronic devices, the lack of effective management systems and implementation creates a loophole for the presence of e-waste in Lagos state. The study recommended that Nigeria develops an effective policy framework which encourages the development and manufacture of national IT knowledge and appliances. There should be efficient systems to enforce regulations and prohibit the importation of e-waste into the country. The government should also encourage investors in standard recycling of resultant e-waste from local consumption and encourage national IT initiatives that will reduce the dependence on importation of electronics and promote green development.

The above study is similar to the present study because it focuses on hazards and management of e-waste, the both studies also utilized qualitative and quantitative method of survey research. The both study also laid emphasis on occupational activities involved in e-waste. Also, they both are similar in terms of techniques and directive on e-waste generation. The differences between the above study and this study are that the

review study was carried out in Lagos state while the present study was carried out in Niger state. The study focuses on trans-boundary movements of e-waste, while the present study focuses on effects, awareness and management processes of e-waste. Also, the above study found that there is lack of effective management system and implementation of regulation and policies of e-waste in Lagos state while the present study assessedthe awareness level of health hazards involve in e-waste activities in Niger State. The above study seeks to determine the relationship between socio economic factors and informal e-waste management practices in Lagos State, Nigeria, while the present study assessed informal e-waste recycling and refurbishing activities in Niger State.

Okorhi *et al.* (2014) carried out a study on the New Technology frontiers in waste electrical and electronic equipment: addressing the e-waste management strategies in south- eastern Nigeria (Abia, Anambra, Ebonyi, Enugu and Imo States). The study was designed to examine the WEEE management strategies in south eastern Nigeria (Abia, Anambra, Ebonyi, Enugu and Imo States). The approach of this survey is qualitative and quantitative methods. The target population was 5,000 and sample of 650 respondents was taken from 500 End-Users of EEE/WEEE; 90 Distributers of EEE/WEEE and; 60 personnel from Monitoring Agencies of EEE/WEEE. In addition to the questionnaire, participatory techniques and interview schedules of structured and unstructured questions were also employed to obtain further information. The content validation was done by three officers from the Monitoring Agencies of NESREA, ESWAMA and LGA Health Office. Data was collected and analyzed by quantitative technique using statistical instruments like SPSS and Microsoft Excel. Percentage was used in the data interpretation. Also, observations noted during survey served to give credence to the statistical data analysis. The study identified factors influencing WEEE

management strategies to be missing public awareness on e-waste toxicity; inability to distinguish between WEEE and near end-of-life EEE; government haziness to applying long-term and sustainable management approaches; absence of regional standardized recyclable facilities; inability to establish and pursue take-back programmes; false declarations of WEEE at point of entry; co-loading of near E.o.L. EEE and WEEE with used vehicles, as well as, absence of regional statistics on WEEE. The study identified the specific challenges relating to the management strategies in place, control of used EEE import and relevant guidelines/legislations on WEEE. It suggested the need for new technology frontiers in supporting appropriate management strategies of WEEE in the region.The study Recommended strategies should reflect and encourage efficient planning, collection, storage, treatment and final disposal of WEEE, Extended Producer Responsibility programme, best practiced Recycling and Environmental Sound Management options that could be implemented in an e-waste controlled environment, as well as discourage illegal importation of WEEE and counterfeit EEE.

The above study is related to this study because both studies laid emphasis on the effects of e-waste on human health and environment, and managements. The both study also focuses on awareness and regulations related to e-waste. Also, both studies employed same methods of data analysis. The above study differs from the present study in terms of the geographical area, (south eastern and north central). The above study focuses on the elements of e-waste and factors influencing the generation of e-waste while the present study focuses on the strategies of managing e-waste and occupational activities involved in e-waste. The above study identified the specific challenges relating to the management strategies, control of used EEE import and relevant guidelines/legislations on WEEE, while the present study sought the activities, techniques and awareness level of health hazards of e-waste in Niger State.

Ndidi and Emmanuel (2018) carried out a study on "assessment of e-waste collection and disposal activities in government agencies, business and residential areas in Minna metropolis, Niger State. This study was designed to assess e-waste collection and disposal activities in government agencies, business and residential areas in Minna metropolis, Niger state, Nigeria. The research adopted a descriptive survey design. The target population was 226,661 and sample of 311respondents was taken from NESREA 34, NISEPA 53, FME 24, USER 100 and REPAIRERS 100 in Minna metropolis Niger State. Structured questionnaire items (22 items) were used for data collection. The instrument was validated by three experts and Cronbach Alfa (K-R20) statistic was used to ascertain the extent of homogeneity of the items and reliability coefficient of 0.89 was obtained. Data was collected and analyzed using statistical package for social science (SPSS version 20), mean and standard deviation were used to answer the research questions, while ANOVA was used to present the hypothesis at 0.05 level of significant. The study also reveals that, E-waste is sorted out from solid waste at the point collection before disposal, E-waste is dumped indiscriminately along the streets and the individual that generate E-waste are responsible for the disposal. The study also revealed that there is lack of current and effective e-waste legislation and the national regulations regarding importation of used electrical electronics goods are not fully enforced, measures for enforcement of e-waste management are not provided. The study recommended among others, that government should put in place effective monitoring system for management of e-waste in Niger State Nigeria.

The above study is related to this study because both studies focus on the proper and effective management of e-waste. The above study also laid emphasis on regulations and policies guiding the e-waste. Similarly, both studies are carried out in the same geographical Area. Also, employed the same instruments and data analysis tools. While

the major contrasts between the above study and this study is that the above study laid emphasis on the assessment of e-waste management activities in Niger state, while the present study laid emphasis on the activities of informal recycling and refurbishing of e-waste in Niger State. Also the focuses on hazardous components involved in e-waste, while the present study focuses on the hazardous health effects and awareness of informal recycling of e-waste.

Ogbuanya and Yekinni(2019) also carry out a study on "Advancing Electronic Waste Management Techniques among Electrical/Electronic Technicians' Workshops for Sustainable Healthy Society in Nigeria". This study focused on the advancement of e-waste techniques among electrical/electronic technicians' workshops for sustainable healthy society in Nigeria. The participants for the study included 87 university engineering lecturers and 54 public health officers. Study adopted survey research design and structured questionnaire for data collection. The study was validated by three experts and reliability coefficient of 0.79 was achieved. Data obtained was analyzed using percentage, mean and standard deviation while t-test and ANOVA were used to test hypotheses. The result claimed that all e-waste components are hazardous except aluminum. Meanwhile, the level of hazardous varies and depends on type of e-waste and level of abundance. Result claimed that e-waste in electrical/electronic technician workshop have severe consequences such as uncontrolled fire and inflammatory/respiratory problem among others in the environment. Result confirmed that electrical/electronic technicians adopted unsafe method for managing e-waste such as dumping of e-waste inside flowing water and swamp and using e-waste for land filling. Result explained further that electrical/electronic technicians are facing challenges-exposure to injury and unavailability of modern equipment among others- in managing e-waste. The study recommends among other, technique for managing e-

waste in electrical/electronic workshop include establishment of recycling site and establishment and implementation of regulation.

The present study was designed to checkmate the informal e-waste recycling and refurbishing activities in Niger state, while the above study is designed to assess advancement of e-waste techniques among electrical/electronic technicians' workshops for sustainable healthy society in Nigeria. The present study focuses on the hazardous effects of e-waste on health and environment, while the above study focuses on the hazardous component involved e-waste. The above study found that e-waste in electrical/electronic technician workshop have severe consequences such as uncontrolled fire and inflammatory/respiratory problem among others in the environment, while the present study find out the level of hazardous effect of informal recycling activities in e-waste. The above study also revealed that electrical/electronic technicians are facing challenges-exposure to injury and unavailability of modern equipment among others in managing e-waste, while the presents study revealedthe level of awareness of hazardous effect involved in the e-waste activities, managements and regulations. The above study and the present study also differ in terms of geographical location. The above study is similar to the present study because they both employed the same instruments and data analysis tools. Also, both studies focus on the effective techniques/management of e-waste.

Another similar research was conducted by Folorunsho(2016) on the "Analysis of Domestic Solid Waste Management Strategies in Tunga, Chanchaga Local Government Area, Niger State, Nigeria". The study analyzed domestic solid waste management strategies in Tunga, Chanchaga Local Government of Niger State, Nigeria. The primary data used in this study was obtained by direct field observations, questionnaire

administration, oral interviews, images and photos of the study area. 327 out of 2040 households were sampled, and the respondents was taken from Niteco 103, Low Cost 77, Sauke-Kahuta 16, Farm Center 29, Aero- Park 28, NSTA Garage 27, Top Medical 17, Maje 18, Abdulsalam Garage 12households in Niger State. The research questions were answered using tables of frequencies and percentages, bar and pie charts, Chi Square and Kruskal Wallis tests. The Chi Square analysis showed a significant difference between the frequency of wastes generated and waste disposed in the study area with an alpha value of 0.01, while the Kruskal Wallis H test showed no significant difference in the effectiveness of the domestic solid waste management strategies in the study area (α= 0.646). The data was also calculated and analyzed using statistical package for social science (SPSS). The findings of this study showed 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. The study thus recommended 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 this study because both studies focused on themanagement's process of e-waste. The study is also related in research design adopted for the study. The study is also similar in term of regulations related to e-waste management. The studies are both carried out in the same geographical location. The major difference is that the above study analyzed the domestic solid waste management strategies in Tunga, Chanchaga Local Government of Niger State, while the present study revealed the impacts of informal recycling and refurbishing of e-waste on human

health and environment in Niger State. The above study focuses on management strategies on domestic solid waste, while the present study focuses on the awareness, effects and regulation guiding the generation of e-waste. The above study deals with domestic solid waste, while the present study deals with electrical electronics waste.

Bakari *et al.* (2012) carried out a study on "E- Waste Disposal in Tanzania: The Implications for Income Generation and Poverty Reduction". The study set out to investigate the existing practices and levels of understanding with regard tothe business potential that could be realized from the disposal process of ICT waste, through recycling, re-use extraction of useful parts, reassembling and repair works resulting from the used e-waste products. The study used the Rapid Assessment Methodology (RAM) approach, which is reckoned for its multiplicity of methods and instruments in studying given phenomenon. Twenty-four institutions (24) both public and private; and the Informal sector were surveyed; and a sample of seventy five (75) respondents was involved in the study. The scope of the study spanned to five administrative regions of Dares Salaam, Arusha, Morogoro, Mbeya and Mwanza, while the informal sector involved Gerezani, Kariakoo, Kinondoni, Msimbazi, Kigogo and Pugu-Kinyamwezi Dump. While from the institutions we involved managerial staff, ICT experts, Supplies officers, and environmentalists, in the Informal sector we involved computer vendors, refurbishers, recyclers, collectors and repairers. Quantitative structured questionnaires and semi-structured interviews items were used for data collection. The data was collected and analyzed using frequencies count. The study findings came to the conclusion that ICT waste had high economic and business potential, which could be harnessed to generate income, create employment and hence reduce poverty. The participants in the informal sector indicated that they had been able to generate income, pay school fees for their children and improve the standard of life. However, it was

clear that there was no clear policy on the e-waste disposal, sufficient information about the process and skills for disposing the materials safely and avoid hazards. The study thus recommended for consumers' awareness campaign, capacity building for vendors to improve recycling, reassembling and extraction skills. Moreover, the informal sector should be motivated to better exploit such opportunities for improved social economic conditions and reduction of poverty. The study recommends the need to put in place policies which will guide the disposal of e-waste in the country.

The study reviewed is related to this present study in terms of activities and practices involved in handling e-waste as regards regard business potential that be realized from the recycling and refurbishing process, such as income that influences standards of living in a society. The above study also is related to the present study in the aspects that both focus on the same management of e-waste. The both studies are also similar in terms of waste disposal process. Also, both study employed the same instruments for data collection. The major difference is that the reviewed study is carried out in Tanzania, while the present study was carried out in Nigeria. The above study focuses on implication for income generation and poverty reduction, while the present study focuses on impacts of informal recycling of e-waste on health and environment. The above study also laid emphasis on existing practices and level of understanding in disposal process of ICT waste, while the present study laid emphasis on level of awareness of effects of informal e-waste recycling on health and environment and guiding principle and regulations. The above study found that there is high economic and business potential which generate income, creates employment and reduce poverty, while the present study revealed the level of awareness and guidelines in handling e-waste in informal sector.

Chimere, *et al.* (2017) carried out a study on "Health Risks Awareness of Electronic Waste Workersin the Informal Sector in Nigeria". The study was designed to assess the health risk awareness levels of e-waste workers in informal sectors of three states (Ibadan, Lagos, and Aba) in Nigeria. A cross-sectional study was used to assess healthrisk awareness of 279 e-waste workers (repairers and dismantlers) and 221 butchers from the informalsector in three locations in Nigeria.A questionnaire was used to obtain information onsocio-demographic backgrounds, occupational history,knowledge, attitude, and work practices. The data was analysed using Analysis of Variance.All analyses were performed using SPSS version 23.0 while ANOVA was used to present the hypothesis at 0.05 level of significant. The study reveals that health risk awareness levelof the e-waste workers was significantly lower compared with their counterparts in the same informalsector.Overall, the occupational health risk awareness level is dependent on job designation, location and position in the business, especially among dismantlers.

A positive correlation existed between the workers' knowledge and their attitude and practice.Therefore, increasing the workers' knowledge may decrease risky practices. The study recommended among other, the National Environmental Standards and Regulations Enforcement Agency (NESREA) should appreciate, understand and work with the informal associations.The enforcement agencies must be seen not to be antagonistic so as to influence the workers in the informal sector to align with government policies. Although the informal associations are self-organizing, they can be encouraged to abide by government regulations if they perceive that they are appreciated by the enforcement agencies. NESREA in combination with Ministry of Health can work together with the informal associations to develop effective grassroots communication methods which will improve the workers' health risk knowledge and

work practices. The study reviewed was related to the present study in that the both studies focus on health risk awareness level of e-waste workers in informal sector.The study is also related in research design adopted for the study. The both studies identified increased in workers knowledge and skills will reduce risky practices. The above study is carried out in three states (Ibadan, Lagos, and Aba), while the present study is carried out in Niger State. The above study focus on the risk awareness of e-waste workers in the informal sector in Nigeria, while the present study focus on the impact of informal recycling and refurbishing of e-waste on human health and environment in Niger State.

2.4 Summary of Literature Reviewed

Rapid increase in e-waste generation has been a great concern globally and Niger State has her share in it. Considering the inflow and huge generation of used electrical electronics equipment (UEEE) in the state there is urgent need for proper measure to reduce the impacts of electronic waste and handling in Nigeria. The concept of e-waste revealed that e-waste substances consist of appliances which use electricity which have reached the end of their life tenure. Such appliances include computers, refrigerators and other forms of consumer electronics. Many of such appliances retain some value even when they are discarded and may also are hazardous to health due to the various components of which they are made of. Many computers, LCD screens, cooling appliances, mobile phones may consist of precious metals, plastics with brominated flame retardant, chlorofluorocarbons (CFC) foam and other materials. EOL equipment has a great effect on our environment and human health when not properly handle. E-waste management in Niger State requires special skills in handling the activities, effective awareness, proper techniques, and strict adherence to the regulations guiding the management of e-waste in order to minimize the volume of waste in Niger State. The reviewed literatures revealed that handling skill, awareness, and techniques/

technical approach has to be put in place for effective waste reduction. Individual, communities, State and federal government need to show serious commitment to minimize e-waste in the environment. This study attempts to assess the effective use of techniques and awareness to in curbing the effect of e-waste in Minna Metropolis, Niger State.

Literature review on theoretical framework indicates that the theory of planned behaviour best principle to describe attitude of people toward waste creation, and the theory of reason action is the best describe the role of people's believes in involvement, and while health believe model ensure the proper awareness and regulations, and no accumulation of e-waste that can hinder better health and environment in Minna, Niger State. The literature reviewed indicated that e-waste contains toxic chemicals which when not properly handle causes a lot of harmful damage to the environment and human health. A well examination of environmental laws in Niger State revealed that NISEPA concentrate on domestic waste control and hardly address e-waste generation, handling, awareness and disposal practices considering its peculiarity in terms of hazardous components.

It then becomes necessary that research be carried out in electronic waste assessment on the activitiesof informal recycling and refurbishing of e-waste in Minna, Niger State.It is clear from literature that waste generated in Minna Metropolis Niger State are seen littered along the street and corners in our environment, some are collected wholesomely along with solid waste and disposed in general dumpsite without sorting, this hampers the effort of local recyclers from extracting the valuable metals contained in the e-waste. Several empirical studies were reviewed most of them found out that inadequate waste management, lack of awareness and knowledge, and inappropriate

implementation of techniques and regulations guiding e-waste recycling and refurbishing in Nigeria. However, out of all empirical studies reviewed, none was pointing towards assessing the way e-waste managed in Minna, Niger State especially how the informal sector collect, recycle, refurbished and disposed in the environment. This study therefore, designed to fill this gap.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

The survey design adopted for this study is called mixed research design. Mixed research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (example, use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration (Johnson *et al.*,2007).The survey design is also called mixed research design because it employed the use of qualitative and quantitative survey design. A mixed research design is characterized by the combination of at least one qualitative and one quantitative research component.The importance of the mixed method research is that result can be shown quantitatively and explained why it was obtained qualitatively.

Quantitative data was obtained from descriptive survey research design which employed questionnaire to seek information from the environmental protection workers while qualitative data was obtained through interviews from collector, recyclers and refurbishers of e-waste on the handling practices, awareness and guidelines on proper managements of informal e-waste in recycling and refurbishing in Niger State.

3.2 Area of the Study

The study was carried out in Minna Metropolis Niger State. Niger State is on the latitude 9.9309 ° N and longitude 5.5983° E. Minna is chosen for the study because of its commercial activities, taste for modern technology and there is electronic waste dumping around the streets, reasonable numbers of private individual involvement in collection, recycling and refurbishing of electronic waste, also the clusters are densely

populated at that usage, disposal of electronic waste, and lots of generation are in the metropolis than rural areas.

3.3 Population

The target population used for this study comprised of 428 subjects from Minna metropolis which includes 100Refurbishers from the Association of Electrical and Electronics Repairers in Minna Chapter, 100 local recycler, 100 collectors, 68 Niger State Environmental Protection Agency(NISEPA) staff, 49 National Environmental Standard Regulations Enforcement Agency (NESREA) staff, and 11 Federal Ministry of Environment (FME)staff in Minna metropolis.

Table 3.1 Population of the Study

S/N	Population of the Study	Size
1	E-waste collectors	100
2	E-waste recyclers	100
3	E-waste refurbishers	100
4	NISEPA	68
5	NESREA	49
6	FME	11
7	**TOTAL**	**428**

Source: Minna Regulatory agency (NISEPA, NISREA, FME), Researcher(2021).

3.4 Sample and Sampling Technique

True Non-Probability Sampling techniques,and snowball sampling were used to select 30 e-waste collectors, 40 Electronic Recyclers, while convenient sampling was used to select40 Electronic Refurbishers from the Association of Repairers in Minna metropolis, and 97 regulatory staffs were gotten from the nominal roll of the various establishment; out of which 50 from Niger State Environmental Protection Agency(NISEPA), 7 from Federal Ministry of Environment (FME), and 40 from National Environmental Standard and Regulations Enforcement Agency (NESREA) in Minna.

A simple random sampling was used to draw 80% of the entire population for this study which totals 166 respondents to respond to the questionnaire items, while a total of 41 persons which represent 20% of the entire sample size for the study were interviewed.

Table 3.2 Sample size

S/N	Sample Size	Questionnaire	Interview	Total Size
1	E-waste collectors	20	10	30
2	E-waste recyclers	30	10	40
3	E-waste refurbishers	30	10	40
4	NISEPA	45	5	50
5	NESREA	36	4	40
6	FME	5	2	7
7	**TOTAL**	**166**	**41**	**207**

3.5 Instrument for Data Collection

The instrument used for data collection titled: Questionnaire on the Assessment of Informal E-waste Recycling and Refurbishing Activities" (QAIEWRRA).QAIEWRRAwas divided into eight sections; SectionAtoI. Section A was used to elicit information on the personal data of the respondents. While section B have 12 items and was designed to obtain information from respondents on the activities involved in informal e-waste collection in Niger State, Section C consistof 13 items, designed to obtain information from respondents on the activities involved in informal e-waste recycling in Niger State, Section D has 15 items, designed to obtain information from respondents on the activities involved in informal e-waste refurbishing in Niger State, Section E with 15 items, designed to obtain information from respondents on the techniques for improvements in informal e-waste recycling in Niger State, Section F have 15 items, designed to obtain information from respondents on the techniques for improvements in informal e-waste refurbishing in Niger State, Section G contains 15 items, designed to obtain information from respondents on theawareness level of health hazards in informal e-waste recycling in Niger State, Section H with 15 items, designed to obtain information from respondents on the awareness level of health hazards in

informal e-waste refurbishing in Niger State. While section I was a structured question interview. The questionnaire items were structured using five-pointlikert rating scale with response options of: Strongly Agreed (SA) rated 5 points, Agreed (A) rated 4 points, Undecided (U) rated 3 points, Disagreed (D) rated 2 points, and Strongly Disagreed (SD) rated 1 point used for research question one, two, three,four and five in section B, C, D, E and F. While Highly Aware (HA) rated 5 points, Aware (A) rated 4 points, Undecided (U) rated 3 points, Moderately Aware (MA) rated 2 points, and Not Aware (NA) rated 1 point used for research question six and sevenrespectively.

Qualitative approach adopted in answering questions from the respondentswere structured interviewed conducted with 10 collectors, 10 recyclers, 10 refurbishers, and 11 regulatory staff totaling 41 persons for the interview. Interview question one was designed to obtain information from respondents on the activities involved and equipment's used in carrying out the e-waste collection process. While Interview question Two was also designed to obtain information on the activities involved and the equipment's used in carrying out the activities in informal e-waste recycling in Niger State, Interview Question Three, designed to obtain information on the activities carried out and equipment's used in carrying out the activities in informal e-waste refurbishing in Niger State, Interview Question Four, designed to obtain information from respondents on the techniques adopted by the personnel involved to improve informal e-waste recycling. Interview Question Five, designed to obtain information from respondents on the techniques adopted by the personnel involved to improve informal e-waste refurbishing. Interview Question Six was designed to obtain information the respondents on the health hazards in informal e-waste recycling and reasons why the personnel still partake in e-waste recycling, and Interview Question Seven was designed

to obtain information the respondents on the health hazards in informal e-waste refurbishing and reasons why the personnel still partake in e-waste refurbishing.

3.6 Validation of the Instrument

The instruments werevalidated by three experts, one in Niger State Environmental Protection Agency, and other two fromthe Department of Industrial and Technology Education, Federal University of Technology Minna. The experts made the required corrections, suggestion and inputs on the instruments.

3.7 Reliability of the Instrument

A pilot test was conducted in Federal Capital Territory (FCT) Abuja and Thirty(30) copies were distributed to 30 subjects consisting of 10 Electronic Refurbishers, 10 Recyclers, and 10 Regulatory staff in FCT Area. Federal Capital Territory (FCT) Abuja which is outside the study area, and also the regulatory bodies in FCT has the same operation with those of the study area. The coefficient of internal consistency of the instrument was calculated using Cronbach's Alpha and was found to be 0.82.

3.8 Method of Data Collection

The questionnaire was administered to the respondents by the researcher with the aid of four research assistants. The method of data collection was through questionnaire from respondents by the researcher and research assistant directly. The questionnaire was administered to the respondents and collected after one-week interval from the date of administrations as to allow the respondent attends to the items in the questionnaire at their convenient time. Also, an interview was conducted by the researcher to seek the opinions of the collectors, recyclers, refurbishers and regulatory agency on the subject matter. The respondents were informed four days prior to the date the interview was held. The interview was via visual and audio records by the researcher after taking due permission from the respondents though not all granted the permission. Questions were

asked based on the items drafted related to the aim and objective of the study and their responses were taking, summarized and added to the study.One hundred and sixty-six (166) copies of questionnaire were administered and One hundred and fifty-six (156)copies of questionnaire were returned (i.e collectors = 20, Recyclers = 30, Refurbishers = 30, Regulatory Agency = 76). Therefore, the total returned rate of the questionnaire was 94%.Meanwhile, twenty-five (26) persons granted the interview out of forty-one (41) persons (i.e collectors = 5, Recyclers = 5, Refurbishers = 7, Regulatory Agency = 9), while the remaining fifteen (15) persons refused to be interviewed.

3.9 Method of Data Analysis

The data collectedwas analyzed using mean and standard deviation. Mean and standard deviation was used to answer the research questions. To enhance speedy and accurate result, all statistical calculations were done using the Statistical Package for Social Sciences (SPSS) version 21. One-way Analysis of Variance (ANOVA)was used to test the null hypothesis at 0.05 level of significance, because it involved four groups of respondents. ANOVA is more useful when it is used for testing significant difference of sample means among three or more groups (Uzoagulu, 2011).Turkey Honestly Significant Difference (HSD) test of multiple comparisons was employed as Post-Hoc which determined where there is difference in the responses and where the difference lies. In order to determine the agreement level of the items of the research questions, the ratings of the respondents was interpreted using real limits of numbers. Real limits are boundaries located exactly half-way between adjacent categories used to define continuous variables in a research.

Decisions was based on the 5 point rating scale such that, any item that has a mean between 4.50 and 5.00was regarded as strongly agreed, while items with mean between 3.50 and 4.49 was regarded as agreed, items with mean 2.50 and 3.49 was regarded as

disagreed, 1.50 to 1.49 was regarded as strongly disagreed and 0.50 to 1.49 was regarded as undecided. Hypotheses testing were tested based on 0.05 level of significance, hence any item below 0.05 level of significance is regarded as significant and therefore rejected, while any item above the 0.05 level of significance is regarded as not significant and therefore accepted.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Research Question One

What are the activities in informal e-waste collection in Minna, Niger State?

Table 4.1 Below represents the Mean and Standard Deviation of Respondents on the activities in informal e-waste collection in Minna, Niger State.

N1=20, N2=30, N3=30, N4=156

S/N	ITEM	ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	The collection of e-waste in the informal sector is done by informal collectors also known as scavengers	4.3	0.53	4.37	0.49	4.5	0.51	4.51	0.5	4.44	0.51	Agreed
2	The scavengers normally operates door-to-door collection of e-waste	4.13	0.57	4.3	0.53	4.65	0.49	4.29	0.69	4.31	0.63	Agreed
3	The scavengers purchase obsolete EEE from private, corporate and institutional consumers at relatively low prices and bring them to the scrap yard	4.17	0.59	4.3	0.53	4.7	0.47	4.38	0.59	4.37	0.58	Agreed
4	Informal Collectors sometimes travel long distances and also sift through waste bins, visit landfills for waste collection	4.13	0.73	4.53	0.57	4.75	0.44	4.3	0.92	4.37	0.80	Agreed
5	Informal collectors of e-waste are mostly seen moving around with a pushcart and sacks.	4.33	0.66	4.6	0.5	4.7	0.47	4.32	0.84	4.42	0.72	Agreed

6	Collectors engage in e-waste dismantling and metal recovery like cable burning.	4.2	0.66	4.5	0.57	4.55	0.51	4.45	0.5	4.42	0.56	Agreed
7	Informal collector uses crude method of separating e-waste equipment.	4.23	0.77	4.37	0.61	4.5	0.61	4.47	0.53	4.41	0.61	Agreed
8	Informal collectors do not pay anything for these items as they find them dumped at street corners and even at the dumpsites	3.93	0.78	4.27	0.64	4.45	0.51	4.37	0.73	4.28	0.71	Agreed
9	Collection of e-waste is undertaken with the most rudimentary technologies without the fear of health hazard.	4.13	0.51	4.2	0.71	4.55	0.6	4.51	0.68	4.38	0.67	Agreed
10	All e-waste collections done are brought to the scrap yard	4.3	0.6	4.33	0.61	4.55	0.6	4.43	0.6	4.40	0.60	Agreed
11	Scavengers also engages in selling of valuable recovered materials	4.27	0.64	4.37	0.61	4.65	0.59	4.51	0.64	4.46	0.64	Agreed
12	Scavengers also visit waste dumping grounds for e-waste collection	4.00	0.53	4.53	0.63	4.6	0.6	4.45	0.87	4.40	0.76	Agreed

KEY: N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Result in Table 4.1 showed that the mean of all the items were within 4.28 – 4.46 which is an indication that the activities are actively carried out in the study area. The standard deviation values for the 12 items in Table 4.1 ranges from 0.51 - 0.80, which indicates that the responses of the respondents are not far from one another. The implication of this is that the respondents have similar opinion on the collection activities in Minna metropolis, Niger State. The closeness of the responses added valve to the reliability of the mean. Hence, the mean of all the respondents signify that all respondents agreed with the collection activities of informal e-waste in Minna Niger State.

Interview conducted with collectors and regulatory agency based on collection activities shows that collection of e-waste is actively practiced and if not done, it makes our environments use air and pose threat to human existence. Some of the activities include; door to door collection of e-waste, picking of e-waste materials from dumpsite, separation of e-waste from other waste, purchase of obsolete Electrical/Electronic Equipment, dismantling e-waste to recover useful material, Selling of valuable recovered materials. Meanwhile, the more reason why the scavengers are actively involved is to earn a living.

4.2 Research Question Two

What are the activities in informal e-waste recycling in Minna, Niger State?

Table 4.2 Below shows the Mean and Standard Deviation of Respondents on the activities in informal e-waste recycling in Minna, Niger State

N1=20, N2=30, N3=30, N4=156

S/N	ITEMS	ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1.	Recyclers in informal sectors disassemble obsolete e-waste to recover metals, such as aluminium, copper and steel.	4.23	0.57	4.63	0.49	4.25	0.44	4.64	0.51	4.51	0.54	Strongly Agreed
2.	Recyclers in informal sector shred e-waste into separate recyclable material such as plastic and metals	4.23	0.77	4.53	0.57	4.00	0.00	4.49	0.60	4.38	0.62	Agreed
3.	Recyclers produce quite a significant amount of wastes, as the devices contain many fractions that are of no economic value	4.00	0.74	4.37	0.56	3.90	0.45	4.36	0.96	4.23	0.82	Agreed
4.	Recyclers make use of primitive tools in dismantling obsolete electrical electronics equipment to retrieve valuable elements	4.17	0.83	4.43	0.63	4.00	0.56	4.49	0.58	4.35	0.66	Agreed
5.	Recycler uses open-pit acid baths to recover valuable metals	4.03	1.00	4.40	0.56	3.90	0.55	4.46	066	4.29	0.74	Agreed

6.	Separations of dismantled device into different fractions and units.	3.90	0.71	4.27	0.58	3.55	0.76	4.45	0.64	4.19	0.73	Agreed
7.	Treatment of e-waste materials to reduce plastic content	4.10	0.71	4.37	0.72	3.70	0.98	4.51	0.60	4.30	0.75	Agreed
8.	Recyclers also engage in the open incineration of cables and other plastic parts in order to remove copper and other metals.	4.00	0.87	4.20	0.81	3.65	0.88	4.49	0.64	4.23	0.80	Agreed
9.	Open burning of unwanted material and cables to access internal copper wires	3.80	0.71	4.27	0.64	3.60	0.99	4.58	0.52	4.24	0.76	Agreed
10.	Fractions are usually disposed of or burned in an uncontrolled manner in or around recycling clusters.	3.90	0.80	4.27	0.52	3.60	0.88	4.54	0.53	4.24	0.72	Agreed
11.	Sorting of the useful components from the dismantled e-waste devices and disposal of the non-valuables into riverbanks	4.10	0.71	4.23	0.63	3.25	1.25	4.47	0.70	4.20	0.87	Agreed
12.	Removal of toxic content from the disassembled e-waste equipments	4.10	0.76	4.17	0.65	3.40	1.19	4.39	0.61	4.17	0.80	Agreed
13.	Informal recyclers also engage in the activities of reselling the valuable disassembled components	4.07	074	4.23	0.68	3.35	1.09	4.50	053	4.23	0.78	Agreed

KEY:N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Table 4.2 showed the analysis of the responses of respondents on the activities of informal e-waste recycling in Minna. The mean score lies between 4.17 – 4.51. Also, the standard deviation ranges from 0.54 - 0.87. The closeness of the responses adds value to the reliability of the mean, which mean that the informal e-waste recycling activities are actively done. Meanwhile, the mean of all the respondents also signify that respondents agreed with the activities involved in e-waste recycling in Minna Niger State.

From the interview conducted with recyclers and the regulatory bodies showed that the recycling activities is carried out in Minna to reduce the e-waste in the environment and also dismantled e-waste into different categories, remove and sale the valuable materials. Some of the activities carried out are: disassemble obsolete e-waste to recover metals, such as aluminium, copper and steel, dump unwanted materials in fields and riverbanks. Recyclers alsofixed the price of the recovery material, and also sold the recovery materials to the traders.

4.3 Research Question Three

What are the activities in informal e-waste refurbishing in Minna, Niger State?

Table 4.3 Below Represents the Mean and Standard Deviation of on the activities in informal e-waste refurbishing in Minna, Niger State N1=20, N2=30, N3=30, N4=156

S/N	ITEMS	ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1.	Refurbishersreplace damage component in electric and electronic equipment	4.30	0.65	4.30	0.53	3.70	0.66	4.36	0.56	4.25	0.62	Agreed
2.	Refurbishersengaged in hand soldering using lead containing solder paste to join wires together	4.27	0.45	4.27	0.45	3.35	0.88	4.32	0.55	4.17	0.64	Agreed
3.	Refurbishing activity is done by repairing defective components	4.37	0.56	4.27	0.45	2.80	0.83	4.37	0.51	4.15	0.76	Agreed
4.	Refurbishersmake use of multi-meter to check for the electrical continuity	4.20	0.71	4.27	0.64	2.70	0.80	4.28	0.58	4.06	0.83	Agreed
5.	Refurbishers engages the use of soldering iron to fuse relays and diodes on the circuit board	4.33	0.76	4.10	0.61	2.65	0.93	4.33	0.72	4.07	0.92	Agreed
6.	Power supply tester is used by refurbishers to check for proper power supply be it on computer or Television	4.27	0.83	4.00	0.74	2.60	0.88	4.28	0.79	4.01	0.97	Agreed
7.	Refurbishers also engage in marketing and sales of the refurbished products.	4.30	0.60	3.67	0.66	2.45	0.94	4.37	0.63	3.97	0.93	Agreed
8.	Screwdrivers are also used to open and tight hardware components of	4.23	0.63	3.83	0.75	2.55	0.94	4.31	0.66	3.98	0.91	Agreed

	electronic and electrical equipments											
9.	Refurbishers use multi-tester in testing voltage resistance and continuity to measure the power functions of the motherboard of the computer	4.30	0.66	4.10	0.76	2.75	0.85	4.39	0.57	4.11	0.85	Agreed
10.	Refurbishers make use of chip extractor forsafely and quick removing ICs from the sockets	4.17	0.65	4.20	0.85	2.70	0.92	4.49	0.50	4.14	0.88	Agreed
11.	Wire cutters are use to cut copper, brass and also use to strip and splice wire with easy	4.13	0.51	4.23	0.63	2.55	0.83	4.51	0.50	4.13	0.85	Agreed
12.	In refurbishing sector, needle-nose pliers are both for cutting and holding to bend, re-position and snip wire	3.97	0.61	3.93	0.83	2.55	0.94	4.43	0.74	4.01	0.97	Agreed
13.	Refurbishers make use of rework station forde-soldering the surface-mounted electronic components	4.03	0.89	4.07	.64	2.40	1.05	4.50	.66	4.06	1.01	Agreed
14.	In Refurbishing sector, Re-work station is used by the refurbishersfor re-soldering of surface-mounted electronic components	4.03	0.61	4.13	0.57	1.95	1.19	4.45	0.66	3.99	1.08	Agreed
15.	Refurbishers use hot air gun from work station to heat devices and melt solder which it easy to pick and position tiny components on the circuit board	4.23	0.50	4.03	0.96	2.45	1.05	4.51	0.55	4.01	0.97	Agreed

KEY:N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Table 4.3 showed the analysis of the responses of Refurbishers, Recyclers, Collectors and Regulatory bodies on the activities of informal e-waste refurbishing in Minna. The respondents agreed to the whole items with mean score ranging between 3.97 – 4.25. The table also showed that the standard deviations of all items are within the ranges of 0.62 - 1.08, indicated that respondents were not far from the mean of their responses on the activities of informal e-waste refurbishing. The mean of all the respondents also signify that respondents agreed with the activities involved in e-waste refurbishing in Minna Niger State.

Interview with refurbishers showed that refurbishing involved repairing of non-functioning electric and electronic equipment into second-hand and functioning equipment and is usually done when electrical electronic equipment fails to perform it designed function. Some of the activities includes: Replacement of damage components, transform old and/or non-functioning electric and electronic equipment into second-hand and functioning equipment, replacing or repairing defective components, sales of products such as TVs, computers and mobile phones.

4.4 Research Question Four

What are the techniques for improving informal e-waste recycling in Minna, Niger State?

Table 4.4 Below Shows the Mean and Standard Deviation of Respondents on the techniques for improving informal e-waste recycling in Minna,
Niger State.

N1=20, N2=30, N3=30, N4=156

	ITEMS	ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Complete separation and recover of copper and aluminium from domestic and industrial insulated wires and cables (Granulation of cables)	3.80	0.71	3.67	0.71	3.05	0.39	4.61	0.49	4.07	0.80	Agreed
2	Removing components from printed circuit boards by heating over coal-fired grills	3.63	0.61	3.40	0.62	3.10	0.64	4.46	0.62	3.92	0.82	Agreed
3	Separating and sorting electronic componentsinto several categories(ICs, transistors, capacitors)	3.70	0.70	3.27	0.52	2.90	0.72	4.46	0.53	3.88	0.84	Agreed
4	Dismantling of e-waste by tools to separate hazardous components as well as valuable components.	3.57	0.63	3.20	0.55	3.05	0.69	4.53	0.50	3.91	0.84	Agreed
5	Shredding the circuit boards for refurbishing and exporting purposes	3.60	0.62	3.13	0.63	2.75	0.72	4.45	0.64	3.81	0.92	Agreed
6	Proper disposing unsalvageable materials in fields and riverbanks	3.37	0.56	3.20	0.61	2.65	0.67	4.26	0.98	3.68	1.01	Agreed
7	Technical knowledge upgrade of recyclers	3.40	0.72	3.13	0.86	2.55	0.94	4.58	0.52	3.81	1.05	Agreed
8	Through incineration, the hazardous nature and volume of a substance or material are decreased, and the inert remains from incineration can be more safely discarded	3.43	0.82	2.93	0.91	2.40	1.05	4.43	0.52	3.69	1.08	Agreed
9	Reduction of hazardous materials embedded in the equipment used.	3.37	0.96	2.73	0.91	2.35	0.93	4.47	0.66	3.65	1.17	Agreed
10	Replacing hazardous content with non-hazardous materials helps to avoid the impacts that would otherwise be present when dealing with waste	3.30	0.99	2.53	1.01	2.55	0.83	4.58	0.50	3.68	1.19	Agreed

	equipment.											
11	Chipping and melting of mixed plastics to extract valuable materials	3.57	0.82	2.77	0.94	2.45	0.69	4.55	0.57	3.75	1.11	Agreed
12	Leaching and the amalgamation of PCBs to recover precious metals.	3.27	1.01	2.77	0.73	2.60	0.88	4.50	0.53	3.69	1.09	Agreed
13	separation of the particles by physical methods using the differences in densities or magnetic properties	3.33	0.84	2.53	0.86	2.35	0.75	4.59	0.52	3.67	1.18	Agreed
14	Equipping the recycler with proper awareness and regulatory law	3.20	1.03	2.60	0.77	2.55	1.00	4.58	0.50	3.67	1.18	Agreed
15	Complete disassembly of devices to critically remove valuables items without having much fragments or damaging equipments	3.27	0.83	2.73	0.87	2.55	0.83	4.34	0.97	3.60	1.18	Agreed

KEY: N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Result presented in Table 4.4 revealed that mean of all items on informal e-waste recycling techniques ranges from 3.60 – 4.07. This is an indication that techniques for improvements wereaware of in the study area. The value of the standard deviation of the 15 items ranges from 0.80–1.19. This signifies that the respondents were closer to one another in their responses to the items listed. Hence, the closeness of the responses adds value to the reliability of the mean.

Interview with regulatory bodies showed that technique for improving E-waste recycling in informal sectorinvolves skill adopted to avoid unpleasant methods of handling e-waste. The methods and manner of disposing waste depends on the classes or types of waste and the indiscriminate discard of waste is not only unpleasant, but sometimes has effect on public health and environment. Some of the techniques are: Separating and sorting electronic components into several categories (ICs, transistors, and capacitors), Removing components from printed circuit boards, Re-using materials and products, disassembly of devices to remove valuables items without having much fragments or damaging equipments. Also, sales of the valuable materials to the traders and manufacturers.

4.5 Research Question Five

What are the techniques for improving informal e-waste refurbishing in Minna, Niger State?

Table 4.5 Below Shows the Mean and Standard Deviation of Respondents on the techniques for improving informal e-waste refurbishing in Minna, Niger State.
N1=20, N2=30, N3=30, N4=156

S/N	ITEMS	ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Simple design of components for easy repair, cleaning and replacement (innovation design)	3.90	0.55	3.40	0.62	2.80	0.89	4.34	0.58	3.88	0.83	Agreed
2	Avoiding the production, consumption, and disposal of devices all together	3.83	0.53	3.23	0.50	2.75	0.79	4.39	0.52	3.85	0.83	Agreed
3	Reprocessing of material and products for re-use purpose	3.67	0.61	2.97	0.67	2.45	0.69	4.43	0.55	3.75	0.96	Agreed
4	Proper routine checks in order for such equipment to operate at it maximum output throughout its useful life	3.60	0.77	3.00	0.69	2.55	0.76	4.49	0.64	3.78	1.02	Agreed
5	Avoiding glues that make sorting difficult (low-impact of materials)	3.57	0.68	2.93	0.78	2.25	1.02	4.53	0.64	3.74	1.12	Agreed
6	Proper installation of parts to avoid sparks so as to avoid damage and to operate at its maximum and best performance	3.20	0.61	3.20	0.85	2.25	0.79	4.55	0.60	3.74	1.08	Agreed
7	Introducing refurbishing facilities.	3.47	0.78	2.87	0.90	2.00	0.73	4.50	0.79	3.67	1.21	Agreed
8	Design, production and packaging of IT products by environmentally sound methods	3.20	0.89	2.87	0.78	2.15	0.93	4.53	0.72	3.65	1.20	Agreed
9	Training local manpower to ensure adequate reverse flow of components/modules.	3.40	0.97	2.83	0.87	2.35	0.93	4.58	0.55	3.73	1.16	Agreed
10	Creating a readily available market for the refurbished components for local consumption and export.	3.40	0.81	2.70	1.06	2.45	1.05	4.49	0.76	3.67	1.21	Agreed
	CONTINUATION OF TABLE 4.5											
11	Use of semiconductor device that that can perform multiple functions like amplification, switching,	3.53	0.68	2.80	0.92	2.40	0.88	4.63	0.59	3.78	1.14	Agreed

	voltage stabilizer. Example transistor											
12	Making use of re-work station that perform multiple functions like melting, de-soldering, re-soldering, and make work easier, faster and neater	3.43	0.77	3.10	0.88	2.65	0.67	4.45	0.76	3.76	1.04	Agreed
13	Fuses of correct rating should be used to prolong the lifespan of the equipments	3.57	0.73	3.23	0.82	2.55	0.83	4.47	0.81	3.81	1.06	Agreed
14	Recuperation and restoration of device to attain reliability and consistency to a standard competitive to that of new alternative commodities (Optimization)	3.43	0.90	2.97	0.93	2.25	0.97	4.46	0.62	3.69	1.13	Agreed
15	Upgrading a device to achieve a higher quality through refurbishment and remanufacturing (Reparation)	3.27	0.74	3.17	0.70	2.35	0.93	4.55	0.64	3.76	1.09	Agreed

KEY: N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Table 4.5 showed the mean and standard deviations of responses of the respondents on the techniques for improving in informal e-waste refurbishing. The result showed that mean items ranges from 3.65 – 3.88. This implies that there is awareness of techniques for improving refurbishing of informal E-waste in the study area. Meanwhile, the standard deviation value of the 15 items in the Table 4.5 ranges from 0.83–1.21 which means that the respondents were closer to each other in their responses. Therefore, the closeness of the responses adds value to the reliability of the mean.

From the interview conducted with the refurbishers and the regulatory bodies showed that techniques for improving informal e-waste refurbishing is carried out but at the low level, in which is to reduce the volume of e-waste in circulation. It involved reduction of e-waste material to avoid environmental and health hazards. Some of the techniques includes: Replacement and fixing of a broken component by bringing a device back to working order for further use, Extraction of parts and components for reuse, training local manpower, sales of refurbished products.

4.6 Research Question Six

What is the level of awareness on health hazards in informal e-waste recycling in Minna, Niger State?

Table 4.6 Below Represents the Mean with standard deviation of Respondents on the level of awareness on health hazards in informal e-waste recycling in Minna, Niger State

N1=20, N2=30, N3=30, N4=156

		ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARK
S/N	**ITEMS**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
1	Development of respiratory difficulties and pulmonary diseases	3.80	0.66	3.53	0.68	3.05	0.68	4.64	0.58	4.06	0.87	Aware
2	Burnt handsand bruises	3.90	0.48	3.47	0.68	3.15	0.75	4.62	0.65	4.07	0.85	Aware
3	Brain malfunction and development	2.67	1.03	2.50	0.90	2.60	0.82	4.34	0.70	3.44	1.20	Undecided
4	Neurological disorder among the people living near informal recycling site	3.27	0.94	2.10	1.06	1.80	0.77	4.53	0.53	3.47	1.37	Undecided
5	Lung diseases	3.43	0.63	2.90	0.84	2.05	0.76	4.62	0.56	3.73	1.15	Aware

6	Developed sleeplessness as a results of fumes and dusts from burnt e-waste	3.37	0.72	2.57	0.94	2.25	0.79	4.34	0.92	3.54	1.29	Aware
7	Cancerous diseases as a result of e-waste	2.10	1.06	3.27	0.94	1.80	0.77	4.53	0.53	3.47	1.37	Undecided
8	Developments running nose as a result of gaseous substances	3.37	0.67	2.17	0.93	2.25	0.78	4.36	0.78	3.47	1.23	Undecided
9	Causes blindness	2.50	0.90	2.67	1.03	2.60	0.82	4.34	0.70	3.44	1.20	Undecided
10	It causes premature birth	2.67	1.03	2.50	0.90	2.60	0.82	4.34	0.70	3.44	1.20	Undecided
11	Causes difficulty in breathing and cough	3.27	0.91	2.90	0.96	2.35	0.88	4.45	0.55	3.65	1.11	Aware
12	Recyclers suffer fromdisease like malaria, typhoid, pneumonia, dysentery, and cholera	3.40	0.86	2.73	1.05	2.40	0.99	4.26	0.81	3.56	1.15	Aware
13	Causes diseases like fatigue, pains, and fever	3.37	0.76	2.50	1.07	2.40	0.88	4.36	0.72	3.56	1.18	Aware
14	Causes asthmaticattack due to inhaling of burnt e-waste exhaust gases	3.30	0.65	2.83	0.87	2.10	0.91	4.47	0.66	3.63	1.15	Aware
15	Causes death as a result of release hazardous gases	3.27	0.94	2.10	1.06	1.80	0.77	4.53	0.53	3.47	1.37	Undecided

KEY: N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Result presented in Table 4.6 shows the analysis of the responses with mean items 1, 2, 5, 6, 11, 12, 13 and 14 on awareness level of health hazards in informal e-waste recycling ranges from 3.54 – 4.07. This is an indication that the E-waste recyclers are only aware about eight health hazards in informal e-waste recycling, while not aware about the seven health hazards in e-waste recycling which mean items are 3, 4, 7, 8, 9, 10 and 15, ranges from 3.44 – 3.47. The value of the standard deviation of the 15 items ranges from 0.85 - 1.37.This indicates that the respondents were closer to one another in their responses to their items. Thus, the closeness of the responses adds value to the reliability of the mean.

Interview conducted with the recyclers and the regulatory bodies show that there are low level of awareness of health hazards amongst the recyclers as regards their health issues and the job activities. Awareness helps to changes attitudes, also encouraging the workers to seek out proper and safety ways of handling and processing e-waste in order to reduce the hazardous effects on human health and environment. Most of the recyclers/scavengers are not aware of the risks involved in the crude methods employed in collection and dismantling E-waste to extract valuable components; neither do they know of better practices which in the process shortchange their lives. Some of the health hazards are: Burnt of hands and bruises, running nose as a result of gaseous substances, asthmatic attack due to inhaling of burnt e-waste exhaust gases, respiratory difficulties and pulmonary diseases.

4.7 Research Question Seven

What is the level of awareness on health hazards in informal e-waste refurbishing in Minna, Niger State?

Table 4.7 Below Shows the Mean and Standard Deviation of Respondents the level of awareness on health hazards in informal e-waste refurbishing in Minna, Niger State.

N1=20, N2=30, N3=30, N4=156

		ELECTRONIC REFURBISHERS		ELCETRONIC RECYCLERS		E-WASTE COLLECTORS		REGULATORY AGENCY		AVERAGES		REMARKS
S/N	ITEMS	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Causes respiratory difficulties	4.03	0.49	3.60	0.93	2.95	1.00	4.47	0.50	4.03	0.86	Aware
2	Burnt hands and bruises	3.80	0.61	3.67	0.80	2.85	1.09	4.54	0.53	4.01	0.92	Aware
3	Cause asthmatic attack	3.50	0.68	3.00	0.59	2.70	0.57	4.57	0.52	3.82	0.95	Aware
4	Affects blood system and kidneys in humans	3.37	0.67	2.17	0.95	2.25	0.78	4.36	0.78	3.47	0.79	Undecided
5	Development of lung diseases	3.47	0.51	3.00	0.83	2.55	0.76	4.58	0.55	3.80	1.02	Aware
6	Causes sleeplessness as a results of fumes and dusts from burnt e-waste	3.57	0.97	2.93	0.87	2.25	0.72	4.57	0.60	3.76	1.14	Aware
7	Developed cancerous diseases	3.60	0.86	2.47	0.97	2.50	0.76	4.55	0.55	3.71	1.17	Aware
8	Developments running nose as a result of gaseous substances	3.50	1.01	2.37	1.03	1.85	0.67	4.46	0.76	3.54	1.33	Aware

9	Causes blindness	3.27	0.94	2.10	1.06	1.80	0.77	4.53	0.53	3.47	1.37	Undecided
10	Development of skin diseases from release hazardous gases	3.33	0.88	2.23	0.97	2.05	1.00	4.45	0.60	3.50	1.28	Aware
11	Causes difficulty in breathing and cough	3.20	0.81	2.50	1.11	2.00	0.92	4.50	0.60	3.54	1.27	Aware
12	Causes inflammation of the lungs	2.67	1.03	2.50	0.90	2.60	0.82	4.34	0.70	3.44	1.20	Undecided
13	Causes diseases like fatigue, pains, and fever	3.23	1.07	2.60	1.00	2.30	0.73	4.34	0.68	3.53	1.18	Aware
14	Causes respiratory diseases and skin disease	3.37	1.13	2.57	1.01	2.40	0.94	4.41	0.52	3.60	1.18	Aware
15	itching eyes as a results of solder fumes	3.70	0.70	4.10	0.71	2.90	0.79	4.38	0.85	4.01	0.93	Aware

KEY:N1 = Collectors, N2 = Recyclers, N3 = Refurbishers, N4= Regulatory Agency, SD= Standard Deviation

Table 4.7 display the analysis of responses of respondents on the awareness level of health hazards in informal e-waste refurbishing. The result shows that items 1, 2,3, 5, 6, 7, 8, 10, 11, 13, 14, and 15, range from 3.50 – 4.03. This is a pointer that the E-waste refurbishers are aware of twelve health hazards in informal e-waste refurbishing, while not aware of three health hazards in e-waste refurbishing, which mean items are4, 9, 12 and range from 3.44 – 3.47. The value of the standard deviation of the 15 items range from 0.79–1.37. This indicates that the respondents were closer to one another in their responses to their items. Thus, the closeness of the responses adds value to the reliability of the mean.

From the communication with refurbishers based on the awareness level of health hazards, it shows that the lack proper knowledge and has no idea the health issues associated to their job. Apart from the physical injuries, they did not believe their work played any negative role in their health conditions. Some of the health hazards includes: Itching eye as a results of solder fumes, physical risk and injuries like Burnt hands, muscle pain, inflammation of the lungs, running nose as a result of solder fumes. However, with proper sensitization, public awareness and proper control measures the health hazards associated with informal sector will reduce greatly.

4.8 HypothesisOne

There is no significant difference in the mean responses of E-wastecollectors, Electronic recycler, electronic refurbishers and Regulatory agency on the activities in informal e-waste collection in Niger State, Nigeria.

Table 4.8 Below Shows the Analysis of variance of the mean responses of Respondents on the activities in informal e-waste collection in Minna, Niger State.

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	1.227	3	.409	1.584	.196	Accepted
Within Groups	39.254	152	.258			
Total	40.481	155				

The result of one-way analysis of variance of the mean of responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers, E-waste collectors as regards informal E-waste collection activities in Minna, Niger State, is presented in Table 4.8. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

Table 4.8 show the one-way between groups analysis of variance that was conducted for the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers, E-waste collectors as regards E-waste collection activities in Minna, Niger State. The result of the analysis showed an f-ratio of 1.584 and a significance criterion (sig) of 0.196 which is greater than p-value of 0.05. Therefore the null hypothesis was accepted. Hence, there is no significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers, E-waste collectors as regards informal E-waste collection activities in Minna, Niger State.

4.9 HypothesisTwo

There is no significance difference in the mean responses of e-waste recyclers, electronic refurbishers and Regulatory Agency on the activities in informal recycling of e-waste in Niger State, Nigeria.

Table 4.9 Below Shows the Analysis of variance of the mean responses of Respondents on the activities in informal recycling of e-waste in Minna, Niger State.

	Sum of Squares	Df	Mean Square	F	Sig.	Remark
Between Groups	5.483	3	1.828	7.035	.000	Rejected
Within Groups	39.491	152	.260			
Total	44.974	155				

The result of one-way analysis of variance of the mean of responses of E-waste regulators, EEE refurbishers, EEE recyclers as regards informal E-waste recycling activities in Minna, Niger State, is presented in Table 4.9. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

The Table 4.9 show the one-way analysis of variance between groups that was conducted for the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers, as regards informal E-waste recycling activities in Minna, Niger State. The result of the analysis showed an f-ratio of 7.035 and a significance criterion (sig) of0.000 which is less than p-value of 0.05. Therefore the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic Recyclers as regards informal E-waste recycling activities in Minna, Niger State. See Table 4.10 on Post-hoc comment.

Table 4.10 Below Shows the Post-hoc comparisons using Tukey HSD test on the difference of Respondents as regards informal E-waste recycling activities in Minna, Niger State.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ELECTRONIC REFURBISHERS	ELECTRONIC REFURBISHERS	-.40000*	.13161	.015	-.7419	-.0581
	E-WASTE COLLECTORS	-.01667	.14714	.999	-.3989	.3656
	REGULATORY AGENCY	-.41140*	.10990	.001	-.6969	-.1259
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	.40000*	.13161	.015	.0581	.7419
	E-WASTE COLLECTORS	.38333*	.14714	.049	.0011	.7656
	REGULATORY AGENCY	-.01140	.10990	1.000	-.2969	.2741
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	.01667	.14714	.999	-.3656	.3989
	ELECTRONIC RECYCLERS	-.38333*	.14714	.049	-.7656	-.0011
	REGULATORY AGENCY	-.39474*	.12810	.013	-.7275	-.0620
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.41140*	.10990	.001	.1259	.6969
	ELECTRONIC RECYCLERS	.01140	.10990	1.000	-.2741	.2969
	E-WASTE COLLECTORS	.39474*	.12810	.013	.0620	.7275

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

Table 4.10 shows the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards informal E-waste recycling activities in Minna, Niger State. The results indicated that the mean response for regulatory agency (whose mean difference was -.41140, and asignificance criterion (sig) of 0.001) was significantly different from the mean response for recyclers (whose mean difference was -.40000with sig of0.015). Also, the mean responses for the refurbisher differ significantly with mean responses of 0.40000 with sig of 0.015 to that of regulatory agency whose mean difference is -0.01140 with sig of 1.000.

4.10 Hypothesis Three

There is no significance difference in the mean responses of e-waste recyclers, electronic refurbishers and environmental protection agency on the activities in informal refurbishing of e-waste in Niger State, Nigeria.

Table 4.11 Below Shows the Analysis of variance of the mean responses of Respondents as regards informal E-waste refurbishing activities in Minna, Niger State

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	7.042	3	2.347	6.834	.000	Rejected
Within Groups	52.208	152	.343			
Total	59.250	155				

The result of one-way analysis of variance of the mean of responses of regulatory agency, Electronic refurbishers, Electronic recyclers as regards informal E-waste refurbishing activities in Minna, Niger State, is presented in Table 4.11. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

The Table 4.11 show the one-way between groups analysis of variance that was conducted for the mean responses of Regulatory agency, Electronic refurbishers, Electronic recyclers, as regards informal E-waste refurbishing activities in Minna, Niger State. The result of the analysis showed an f-ratio of 6.834 and a significance criterion (sig) of 0.000 which is less than p-value of 0.05. Therefore the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards informal E-waste refurbishing activities in Minna, Niger State. See Table 4.12 on Post-hoc comment.

Table 4.12 Below Shows the Post-hoc comparisons using Tukey HSD test on the difference of Respondents as regards informal E-waste refurbishing activities in Minna, Niger State

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ELECTRONICREFURBISHERS	ELECTRONIC REFURBISHERS	0.00000	.15132	1.000	-.3931	.3931
	E-WASTE COLLECTORS	.60000*	.16918	.003	.1605	1.0395
	REGULATORY AGENCY	-.05526	.12637	.972	-.3835	.2730
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	0.00000	.15132	1.000	-.3931	.3931
	E-WASTE COLLECTORS	.60000*	.16918	.003	.1605	1.0395
	REGULATORY AGENCY	-.05526	.12637	.972	-.3835	.2730
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	-.60000*	.16918	.003	-1.0395	-.1605
	ELECTRONIC RECYCLERS	-.60000*	.16918	.003	-1.0395	-.1605
	REGULATORY AGENCY	-.65526*	.14729	.000	-1.0379	-.2727
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.05526	.12637	.972	-.2730	.3835
	ELECTRONIC RECYCLERS	.05526	.12637	.972	-.2730	.3835
	E-WASTE COLLECTORS	.65526*	.14729	.000	.2727	1.0379

*. The mean difference is significant at the 0.05 level

Table 4.12 shows the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulator Agency, Electronic refurbishers, Electronic recyclers as regards informal E-waste recycling activities in Minna, Niger State. The results indicated that the mean response for regulatory agency (whose mean difference was -.65526, and asignificance criterion (sig) of 0.000) was significantly different from the mean response for collectors (whose mean difference was .65526 with sig of0.000). However, the mean responses of the refurbishersdid not differ significantly from that of regulatory agency or recyclers.

4.11 HypothesisFour

There is no significance difference between the mean responses of e-waste recyclers, electronic refurbishers and regulatory agency on the techniques for improving informal e-waste recycling in Niger State, Nigeria.

Table 4.13 Below Shows the Analysis of variance of the mean responses of Respondents as regards techniques for improving in informal E-waste recycling in Minna, Niger State

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	49.650	3	16.550	49.740	.000	Rejected
Within Groups	50.575	152	.333			
Total	100.224	155				

The result of one-way analysis of variance of the mean of responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste recycling in Minna, Niger State is presented in Table 4.13. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

Table 4.13 show the one-way between groups analysis of variance that was conducted for the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste recycling in Minna, Niger State. The result of the analysis showed an f-ratio of 49.740 and a significance criterion (sig) of .000 which is less than p-value of .05. Therefore the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniquesor improving in informal E-waste recycling in Minna, Niger State. See Table 4.14 on Post-hoc comment.

Table 4.14 Below Shows the Post-hoc comparisons using Tukey HSD test on the difference of Respondentsas regards techniques for improving in informal E-waste recycling in Minna, Niger State

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ELECTRONIC REFURBISHERS	ELECTRONIC RECYCLERS	.13333	.14894	.807	-.2536	.5202
	E-WASTE COLLECTORS	.75000*	.16652	.000	.3174	1.1826
	REGULATORY AGENCY	-.80526*	.12437	.000	-1.1283	-.4822
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	-.13333	.14894	.807	-.5202	.2536
	E-WASTE COLLECTORS	.61667*	.16652	.002	.1841	1.0492
	REGULATORY AGENCY	-.93860*	.12437	.000	-1.2617	-.6155
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	-.75000*	.16652	.000	-1.1826	-.3174
	ELECTRONIC RECYCLERS	-.61667*	.16652	.002	-1.0492	-.1841
	REGULATORY AGENCY	-1.55526*	.14496	.000	-1.9318	-1.1787
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.80526*	.12437	.000	.4822	1.1283
	ELECTRONIC RECYCLERS	.93860*	.12437	.000	.6155	1.2617
	E-WASTE COLLECTORS	1.55526*	.14496	.000	1.1787	1.9318

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

Table 4.14 shows the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste recycling in Minna, Niger State. The results indicated that the mean response for regulatory agency (whose mean difference was -.80526, and asignificance criterion (sig) of 0.000) was significantly different from the mean response for refurbishers (whose mean difference was-.80526 with sig of0.000). Which also differ significantly for recyclers (whose means difference was -.93860 with sig of 0.000. However, the mean responses of the refurbishers did not differ significantly from that of recyclers.

4.12 HypothesisFive

There is no significance difference between the mean responses of e-waste recyclers, electronic refurbishers and environmental protection agency on the techniques for improving informal e-waste refurbishing in Niger State, Nigeria.

Table 4.15 Below Shows the Analysis of variance of the mean responses of Respondentsas regards techniques for improving in informal E-waste refurbishing in Minna, Niger State

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	46.481	3	15.494	39.116	.000	Rejected
Within Groups	60.205	152	.396			
Total	106.686	155				

The result of one-way analysis of variance of the mean of responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State is presented in Table 4.14. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

Table 4.14 show the one-way between groups analysis of variance that was conducted for the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State. The result of the analysis showed an f-ratio of 39.116 and a significance criterion (sig) of 0.000 which is less than p-value of 0.05. Therefore the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State. See Table 4.14 on Post-hoc comment.

Table 4.16 Below Represents the Post-hoc comparisons using Tukey HSD test on the difference of Respondentsas regards techniques for improving in informal E-waste refurbishing in Minna, Niger State.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ELECTRONIC REFURBISHERS	ELECTRONIC RECYCLERS	.50000*	.16250	.013	.0779	.9221
	E-WASTE COLLECTORS	1.10000*	.18168	.000	.6281	1.5719
	REGULATORY AGENCY	-.44211*	.13570	.007	-.7946	-.0896
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	-.50000*	.16250	.013	-.9221	-.0779
	E-WASTE COLLECTORS	.60000*	.18168	.006	.1281	1.0719
	REGULATORY AGENCY	-.94211*	.13570	.000	-1.2946	-.5896
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	-1.10000*	.18168	.000	-1.5719	-.6281
	ELECTRONIC RECYCLERS	-.60000*	.18168	.006	-1.0719	-.1281
	REGULATORY AGENCY	-1.54211*	.15816	.000	-1.9530	-1.1312
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.44211*	.13570	.007	.0896	.7946
	ELECTRONIC RECYCLERS	.94211*	.13570	.000	.5896	1.2946
	E-WASTE COLLECTORS	1.54211*	.15816	.000	1.1312	1.9530

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

Table 4.16 show the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State. The results indicated that the mean response for regulatory Agency (whose mean difference was -.94211, and asignificance criterion (sig) of 0.000) was significantly different from the mean response for refurbishers (whose mean difference was0.44221 with sig of0.07). Which also differ significantly for recyclers (whose means difference was 0.5000 with sig of 0.013. However, the mean responses of the refurbishers differ significantly from that of recyclers.

4.13 HypothesisSix

There is no significance difference in the mean responses of Electronic recyclers, electronic refurbishers and Regulatory agency on awareness level of health hazards in informal e-waste recycling in Niger State, Nigeria.

Table 4.17 Below Shows Analysis of variance of the mean responses of Respondents as regards awareness level of health hazards in informal e-waste recycling in Minna, Niger State

	Sum of Squares	Df	Mean Square	F	Sig.	Remark
Between Groups	56.734	3	18.911	47.415	.000	Rejected
Within Groups	60.625	152	.399			
Total	117.359	155				

The result of one-way analysis of variance of the mean of responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste recycling in Minna, Niger State is presented in Table 4.17. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

The Table 4.17 shows the one-way between groups analysis of variance that was conducted for the mean responses of Electronic Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State. The result of the analysis showed an f-ratio of 47.415 and a significance criterion (sig) of 0.000 which is less than p-value of 0.05. Therefore the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste recycling in Minna, Niger State. See Table 4.14 on Post-hoc comment.

Table 4.18 Below Shows the Post-hoc comparisons using Tukey HSD test on the difference of respondents as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ELECTRONIC REFURBISHERS	ELECTRONIC RECYCLERS	.26667	.16306	.362	-.1569	.6903
	E-WASTE COLLECTORS	.75000*	.18231	.000	.2764	1.2236
	REGULATORY AGENCY	-.84474*	.13617	.000	-1.1985	-.4910
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	-.26667	.16306	.362	-.6903	.1569
	E-WASTE COLLECTORS	.48333*	.18231	.044	.0097	.9569
	REGULATORY AGENCY	-1.11140*	.13617	.000	-1.4651	-.7577
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	-.75000*	.18231	.000	-1.2236	-.2764
	ELECTRONIC RECYCLERS	-.48333*	.18231	.044	-.9569	-.0097
	REGULATORY AGENCY	-1.59474*	.15871	.000	-2.0070	-1.1824
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.84474*	.13617	.000	.4910	1.1985
	ELECTRONIC RECYCLERS	1.11140*	.13617	.000	.7577	1.4651
	E-WASTE COLLECTORS	1.59474*	.15871	.000	1.1824	2.0070

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

Table 4.18 shows the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste recycling in Minna, Niger State. The results indicated that the mean response for regulatory agency (whose mean difference was -1.11140, and asignificance criterion (sig) of 0.000) was significantly different from the mean response for refurbishers (whose mean difference was-0.84474 with sig of0.00). Which also differ significantly for recyclers (whose means difference was 1.11140 with sig of 0.000. However, the mean responses of the refurbishers did not differ significantly from that of recyclers.

4.14 Hypothesis Seven

There is no significance difference in the mean responses of Electronic recyclers, electronic refurbishers and Regulatory agency on awareness level of health hazards in informal e-waste refurbishing in Niger State, Nigeria.

The result of one-way analysis of variance of the mean of responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste refurbishing in Minna, Niger State is presented in Table 4.19. The Levene's test of homogeneity of variance that was conducted yielded value higher than the confidence level of 0.05, which the assumption was met.

Table 4.19 Below Shows the Analysis of variance of the mean responses of respondents as regards awareness level of health hazards in informal e-waste refurbishing in Minna, Niger State

	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	53.076	3	17.692	36.890	.000	Rejected
Within Groups	72.898	152	.480			
Total	125.974	155				

The Table 4.19 shows the one-way between groups analysis of variance that was conducted for the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste refurbishing in informal E-waste refurbishing in Minna, Niger State. The result of the analysis showed an f-ratio of 36.890 and a significance criterion (sig) of 0.000 which is less than p-value of 0.05. Therefore, the null hypothesis was rejected. Hence, there is significant difference in the mean response of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste refurbishing in Minna, Niger State. See Table 4.14 on Post-hoc comment.

Table 4.20 Below Shows the Post-hoc comparisons using Tukey HSD test on the difference of respondents as regards techniques for improving in informal E-waste refurbishing in Minna, Niger State

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ELECTRONIC REFURBISHERS	ELECTRONIC RECYCLERS	.13333	.17881	.878	-.3312	.5978
	E-WASTE COLLECTORS	.95000*	.19992	.000	.4307	1.4693
	REGULATORY AGENCY	-.73947*	.14932	.000	-1.1274	-.3516
ELECTRONIC RECYCLERS	ELECTRONIC REFURBISHERS	-.13333	.17881	.878	-.5978	.3312
	E-WASTE COLLECTORS	.81667*	.19992	.000	.2974	1.3360
	REGULATORY AGENCY	-.87281*	.14932	.000	-1.2607	-.4849
E-WASTE COLLECTORS	ELECTRONIC REFURBISHERS	-.95000*	.19992	.000	-1.4693	-.4307
	ELECTRONIC RECYCLERS	-.81667*	.19992	.000	-1.3360	-.2974
	REGULATORY AGENCY	-1.68947*	.17404	.000	-2.1416	-1.2374
REGULATORY AGENCY	ELECTRONIC REFURBISHERS	.73947*	.14932	.000	.3516	1.1274
	ELECTRONIC RECYCLERS	.87281*	.14932	.000	.4849	1.2607
	E-WASTE COLLECTORS	1.68947*	.17404	.000	1.2374	2.1416

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

Table 4.20 shows the result of Post-hoc comparisons using the Tukey HSD test on the difference in the mean responses of Regulatory Agency, Electronic refurbishers, Electronic recyclers as regards awareness level of health hazards in informal e-waste refurbishing in Minna, Niger State. The results indicated that the mean response for regulatory agency (whose mean difference was -.87281, and asignificance criterion (sig) of 0.000) was significantly different from the mean response for refurbishers (whose mean difference was0.73947 with sig of0.00). Which also differ significantly for recyclers (whose means difference was .872881 with sig of 0.000. However, the mean responses of the refurbishers did not differ significantly from that of recyclers.

4.15 Findings of the Study

The following findings emerged from the study based on the data analyzed:

1. E-waste collection is done in informal sector by Scavengers (collectors)who move around on daily basis with either sack or pushcart to collect obsolete e-waste materials which are brought to the scrap yard.
2. Scavengers engage in rudiment ways ofe-waste dismantling and metal recovery like cable burning, and also separation of valuable materials.
3. E-waste is disposed alongside other waste in the landfills by individuals and organizations, E-waste are dumped indiscriminately along the streets and the persons that generate e-waste are responsible for the disposal.
4. Recycling activities are carried out to minimize E-waste; they employ the principles of dismantling obsolete equipments and separation of the valuable ones, which are sold to the manufactures for production of new items to minimize e-waste.
5. Refurbishing, repair and reuse are carried out to minimize E-waste, manufactures also employ the principles of reuse in their product to minimize e-waste, and the suppliers of electrical and electronic equipment are encouraged in implementing the minimization practices of e-waste regulation.
6. There is indiscriminate disposal of E-waste along the streets and also inadequate infrastructure for appropriate e-waste management.
7. There is no proper awareness level and adequate skills in informal e-waste sector on handling practices.
8. There is lack of current and effective e-waste legislation and national regulations regarding importation of used electrical and electronics goods are not fully

enforced and measures for enforcement of e-waste handling practices are not provided.

9. Techniques for improving E-waste activities in Minna, Niger State includes: creating a programme for recycling and refurbishing electronic waste in Niger State, establishment of guideline that will improve collection, recycling and refurbishing practices, and also community participation to be facilitated by public awareness and education.
10. Manufacturers need to replace hazardous materials with non-hazardous components, also Government need to put in place effective monitoring system for management of e-waste in Niger State.
11. Interview conducted with regulatory bodies based on the informal sector revealed that the stakeholders involved in the activities of e-waste shortchanges their life's in the process of trying to make earn a living and also making cleaning the environment from waste materials.
12. There is no significant difference in the mean responses of Regulatory Agency, Electronic refubishers, Electronic recyclers, and E-waste Collectors as regards E-waste collection activities in Minna metropolis.
13. Post-hoc analysis showed that the mean response of the regulatory agency and the recyclers was significantly difference from that of refurbishers and collectors as regards recycling activities in Minna metropolis, Niger State.
14. Post-hoc analysis showed that the mean response of the regulatory agency, refurbishers, and recyclers was significantly difference from that of collectors. While the mean of the regulatory agency did not differs from refurbishers and recyclers as regards refurbishing activities in Minna metropolis, Niger State.

15. The Post-hoc analysis showed that the mean response of the regulatory bodies was significantly different to that of refurbishers, recyclers and collectors. Also the mean response of the refurbishers and recyclers did not differ significantly but significantly differs to that of collectors as regards techniques for improving in informal E-waste recycling in Minna metropolis, Niger State.
16. The Post-hoc analysis showed that the mean response of the regulatory bodies was significantly different to that of refurbishers, recyclers and collectors. Also the mean response of the refurbishers, recyclers and collectors differs significantly as regards techniques for improving in informal E-waste refurbishing in Minna metropolis, Niger State.
17. Post-hoc analysis showed that the mean response of the regulatory bodies was significantly different to that of refurbishers, recyclers and collectors. Also, the mean response of the refurbishers, recyclers does not differ but differ significantlyto that of collectors as regardsawareness level of health hazards in informal E-waste recycling in Minna metropolis, Niger State.
18. There is no significant difference in the mean responses of regulatory agency, E-waste collectors, Electronic recyclers, Electronic refurbishers as regards awareness level of health hazards in informal E-waste refurbishing in Minna metropolis, Niger State. The Post-hoc analysis showed that the mean response of the regulatory bodies was significantly different to that of recyclers and collectors. Also, the mean response of the refurbishers, recyclers differ significantly to that of collectors. However, the mean response for the regulatory agency and refurbishers were not significantly different from one another.

4.16 Discussion of Findings

Findings on research question one reveal that E-waste are collected by the collectors (scavengers) which are brought to the scrap yard for further dismantling and separation, these findings are in line with the findings byJackson (2018) who reported that recovery of metals and other perceived working parts such as memory chips, integrated Circuit (IC), Aluminum, Copper and Steels, from obsolete EEE needs to undergo dismantling and separation and the extracted materials are then sold to traders. The informal waste collectors (scavengers) move around the metropolis and pick the obsolete and damage equipment with either their sack or pushcarts (Yevuyibor, 2015; Grant & Oteng-Ababiov, 2012). Some of scavengers get to buy such e-waste for small amounts of money from businesses or private households, while some sift through waste bin and dumpsite for free (Nduneseokwu *et al.,* 2017). Thus, with the insufficient vehicles used for waste transportation there is limit of the amount of waste that is transported to the dumpsites per day.

The finding equally revealed that waste collection is on daily basis and waste collection centers are kept close to business, government offices, and residential areas. The findings goes in line with the report by Ndidiand Emmanuel (2018) cited Oteng-Ababio (2012) stated that despite the effectiveness of the formal sector, the informal sector operators dominate the e-waste sector and have very strong active networks, employ very cheap labour and are able to access areas, communities and door to door collection of e-waste. This statement is true because the waste collectors are everywhere on the street picking the waste without much control by any regulatory body(Nduneseokwu*et al.,* 2017). The result of the analysis in hypothesis 1 showed that there was no significant difference in the mean responses of regulatory agency, Electronicrefurbishers, Electronic recyclers, E-waste collectors as regards E-waste

collection activities in Minna, Niger State. The non-differences in their opinions may likely be because legislation governing E-waste are not made within their reach.

In addition, communication with scavengers and regulatory bodies through interview based on collection activities adopted in Minna metropolis shows that collection activities is carried out regularly on daily and if not done, it pose threat to the environment and human health. One of the scavengers said: "Collection activities is carried out on a daily basis, that they go out to the household and street to pick up waste equipments. Some of the activities include; door-to-door collections of all waste, purchase obsolete equipments, travel long distances and also sift through waste bins, visit landfills for waste collection" (Collector/Scavenger Interview, 2021). The collection of e-waste in the informal sector is done by informal collectors also known as scavengers who normally execute door-to-door collection and purchase obsolete e-waste from private individual, corporate and institutional consumers at relatively low prices and bring them to the scrap yard (Nduneseokwu *et al.,* 2017). In the same manner, interview with collectors/Scavengers revealed similar result. One of the Scavengers said:

> "Collection activities is done on regularly every day. Some of the activities carried out include: buying of e-waste for small amounts of money from businesses or private households, sift through waste bins, visit waste dumping grounds for e-waste, move around with a Pushcart and sacks for collection, separation of e-waste equipment into different categories, e-waste collected are brought to thescrap scrap yard for sale. (Scavenger Interview, 2021)"

The findings on the informal E-waste recycling activities in Minna metropolis Niger State revealed that E-waste is dismantled, disassembled and separated into different

units after collection resulting in recoveryof fractions that are more valuable. This is in agreement with Gangwar*et al*. (2019) who reported that Recyclers disassemble obsolete e-waste to recover metals, such as aluminium, copper and steel. While some recyclers are specialized on e-waste recycling, others engage in the recycling of various types of metal-containing wastes in parallel. Some recyclers also engage in the open incineration of cables, acid baths and other plastic parts in order to liberate copper and other metals. Some informal recyclers may focus specifically on e-waste alone, others engage in recycling wastes containing all types of metals. Nnorom and Odeyingbo (2020) also argued that recyclable andreusable components such as the Printed wiring boards (PWBs) are separated, collected, and sold to traders. Recyclers are also active in the collection of waste components and lead solder, and then dip the stripped boards in acid baths to remove gold and copper. The residual toxic solution may then be dumped in surrounding areas. Uchida(2018) also observed informal treatment method performed is to burn the plastic coating from metal components such as PVC wires, to recover the valuable metal content, resulting in a harmful release of toxic dioxins and furans. The release of persistent organic pollutants and toxic metals causes serious and irreparable damage to the surrounding environment and inhabitants.

Based on interview on recycling activities of e-waste in informal sector, shows that Electrical Electronic Equipments are dismantle and disassemble to retrieve valuable materials. Recyclers also engage in the open incineration of cables, acid baths and other plastic parts in order to liberate copper and other metals (Gangwar *et al*., 2019). Recyclers in Nigeria disassemble obsolete e-waste to recover metals and other perceived working parts such as memory chips, integrated circuits (IC), aluminum, copper and steel unlike their counterparts in China, Pakistan and India (Awasthi & Li, 2017). Recycling activities is done for the purpose of reducing e-waste equipments that

are dangerous to the environment and human health. Recyclers interviewed also contributed that recycling activities are done for the purpose of reducing the e-waste in the environment, and also to earn a living. Another recycler said “Recycling activities is done with the sole aim of earning a living and e-waste equipments are dismantle into fragments with tools like, hammer, pliers, screwdriver and dump unwanted materials in fields and riverbanks (May 05, 2021). One of the recycler further said:

Recycling activities are carried out to recycle obsolete Electrical Electronic Equipments by breaking them into different components and sold them to traders which are in turns to the manufacturers for the production of new products. He further said that the equipment use for the activities are hammer, pliers, screwdriver. Also, their challenges like hitting themselves with hammer why trying to dismantle equipment, and as well tiredness (Recycler, 2021).

Findings on the informal E-waste refurbishing activities in Minna metropolis, Niger State revealed that E-waste is transformed from old to new. These findings are in consonance with Ari (2016) states that refurbishers or repairers transform old and/or non-functioning electric and electronic equipment into second-hand and functioning equipment either by replacing or repairing defective components and/or by performing cleaning and repair activities in order to make the second-hand equipment appealing to the customers. Most refurbishers also engage in marketing and sales of the refurbished products. Osibanjo *et al*. (2016) also reported that each refurbisher typically focuses on a distinct group of products such as cooling and freezing equipment, air-conditioners, small household equipment, TVs, computers or mobile phones. The activities of the refurbishers pose threat to both human health and environment due to the discharge toxic fume.

An interviewed based on refurbishing activities shows that most of the refurbishers said refurbishing activities are done to prolong the life of an Electrical Electronic Equipment. Some of the activities includes: repairing of non-functioning equipment, transforming of old equipment to new, replacing of damage components (Repairer, 2021). The obsolete products resources for large appliance repair shops mainly come from informal collectors while resources for the ICT repair shops mostly come from individual clients or ICT street traders (Wang & Lin, 2021). It is worth noting that some obsolete appliances were sold as new products after refurbishment and repackaging. The price of these repacked products are often much lower than those from formal retailers(Wang & Lin, 2021).

The findings on the techniques for improving in informal e-waste recycling in Minna, Niger State revealed that there should be adequate electronic waste recycling in Niger State. This finding is in agreement with Quina *et al*.(2018) who reported the hazardous nature and volume of a substance or material are decreased, and the inert remains can be more safely discarded through special handling. Therefore, the main objective of recycling waste is to generate clean commodity materials that are similar to and can replace primary raw materials. Through recycling, end-of-life goods are broken down into secondary materials that can be recirculate back into raw material flows, reducing the demand for primary (virgin) raw materials that are otherwise extracted through energy intensive processes. The waste to energy technology is the next level of management which involves incineration, pyrolysis-gasification, and anaerobic digestion, through proper collection and disposal with the theory of reason action and health belief model theory which this research work used as its theory. With the principle of recycling, E-waste will be minimized and Niger State will be able to achieve true and better handling method. The finding revealed the need for an

established guideline from regulatory bodies that will improve the recycling practices in Niger State.Abdel-Shafy *et al*. (2018) describes land-filling as a method for treating waste when recycling is not possible or appropriate.Waste discarded to a modern formal landfill is stored in a controlled manner where it remains safe for a long period of time. According to European Union restrictions, as specified in article 6 of the WEEE Directive European Commission (2014) the land-filling of WEEE that has been separately collected by member states, which includes Sweden, is prohibited if proper pre-treatment has not been performed.

An interview with recycler and regulatory bodies on techniques for improving informal e-waste recycling generally involves method use in disposing e-waste to avoid exposure to environment and public health. One of the recycler said: "recycling techniques involves converting of waste materials into new material and objects. For example, disassemble them into different fragments and separating them into different categories according to their use (Recycler, 2021). In line with the technique, one of the regulatory bodies said: Techniques for improving informal e-waste recycling are the method and skills adopted to recycle the life of old equipment by bring them into new putting environment and public health into consideration.

The findings on the techniques for improving in informal e-waste refurbishing in Minna, Niger State revealed that there should be adequate electronic waste refurbishing in Niger State revealed that refurbishing and repairs are carried out to minimize E-waste and manufacturers employ the principle of reuse in their product to minimize E-waste. Also, limiting the volume of waste generated is the next most effective option toward lowering environmental and/or human health impacts from end-of-life treatment. Again, this can be seen as a literal reduction in the volume of waste generated through a decrease in production and consumption volumes, or a reduction of hazardous materials

embedded in the equipment used. Cooper andGutowski(2017) discuss that the demand for virgin materials decreases by a third with a substantial secondhand market, and the energy used throughout the useful life of a computer is just one quarter of what is required to manufacture the computer. Choosing to re-circulate a used product back into the market extends its lifetime and decreases volume of problematic waste generated. Repair, included in the category of reuse, is the replacement or fixing of a broken component, bringing a device back to working order for further use. With the principle of refurbishing which is avoidance, reduction, reuse and repair, E-waste will be minimized and Niger State will be able to achieve true and better handling method. The finding revealed the need for an established guideline from regulatory bodies that will improve the refurbishing practices in Niger State.

iv. With regards the interview section with refurbishers and regulatory bodies based on the techniques for improving in informal e-waste refurbishing reveals mainly the method adopted to reduced e-waste environmental and health impacts. reduction in the volume of waste generated through a decrease in production and consumption volumes, or a reduction of hazardous materials embedded in the equipment used(Liebmann, 2015). Replacing toxic content for less harmful materials reduces potential impacts from discarded equipment.

Techniques for improving informal e-waste refurbishing involved method adopted by the technicians to bring back the life of damage equipment putting into consideration the health and environmental impact of e-waste hazards; methods like avoiding the use of hazardous materials, replacing damage part and making them work again, repair and reuse (Regulatory body, 2021).

The answer to the research question 6 on awareness of health hazards in informal E-waste recycling in Minna Metropolis, Niger State is proven that there were no much

awareness in informal sector as regards the hazardous effects involves in the activities. Awareness helps to changes attitudes, also encouraging the workers to seek out proper and safety ways of handling and processing e-waste in order to reduce the hazardous effects on human health and environment. Heacock*et al.* (2016) revealed that the unsafe, unregulated and unaccountable collection, processing, and redistribution of old or abandoned electrical/electronic equipment are performed by workers at temporary sites, residences, workshops, and open public spaces due to lack of awareness and management. Lack of awareness or knowledge is always a barrier to proper working conditions and save guiding health and environmental hazards involved in informal e-waste sector.Orlins and Guan(2016) pointed out that it is a source of livelihood for the urban and rural poor of this region; it often causes severe risks to man and the environment. According to Shah (2014), for effective e-waste collection and enhanced recycling rates to occur, there is a need for greater public awareness. Similarly, other studies attribute shortfalls in e-waste management to poor recycling attitudes, while public ignorance and existing awareness levels are not always enough for the proper management of e-wastes (Masud*et al.*, 2019). The result of the analysis of the hypothesis showed that there is significant difference in the mean response of regulatory agency, Electronic refurbishers, and Electronic recyclers as regards health hazards awareness in Minna, Niger State.

An interview conducted with the recyclers and regulatory bodies based on the awareness level of health hazards involved in informal e-waste recycling revealed that the recyclers lack absolutely the health hazards associated with E-waste. One of the recyclers said: that they push boys out to get e-waste while they dismantle them into different units, sold them to the traders and manufactures to earn a living and also is a source of livelihood for rural poor, which some of the changes they face is sustain injury

from hammer why trying to dismantle equipment, tiredness, and as well body pain because it requires a lot of energy while dismantling (Recycler, 2021). The collection, recycling of e-waste is associated with severe health and safety risks for the engaged workers, it often causes severe risks to man and the environment (Orlins & Guan, 2016). In line with Orlinsand Guan(2016)there other physical injuries sustain from braking down of e-waste into smaller part to separate useful material, other health hazards are weakness, tiredness, and body pain which from this revealed that they know little or no health and environmental hazards associated with their activities.

Heacock *et al.* (2016) also argue that with gradual and steady increase in the generation of E-waste, recyclers intensifies their interest for recycling not only to conserve natural resources and protect the environment but to earn a living, sadly most of the recyclers/scavengers are not aware of the risks involved in the crude methods employed in collection and dismantling E-waste to extract valuable components, neither do they know of better practices which shortchanges their life's. Also, in line with health issue the agency is into ensuring that the people involved in the recycling starting from the scavengers are highly protected and environment is protected knowing that most of the materials are thrown anyhow in the country, and what the agency is trying to do to arrest this ugly situation is to register all the recyclers and all those along the chain that are trying to turn the waste into something useable, like reuse, repair, recycle. Also there are check list for all hazardous materials and provide them with the best practices (Regulatory body, 2021).

Findings 0n awareness of health hazards in informal E-waste refurbishing in Minna Metropolis, Niger State revealed that the workers knowledge of the association between their health status and their work is generally poor. Apart from the physical injuries, they did not believe their work played any negative role in their health conditions. The

findings also revealed that many workers are engaged in hand soldering using lead containing solder paste. As most workers bow over the solder gun for quite long time periods per day, and as many refurbishers work in small, poorly ventilated workspaces, many refurbishers are exposed to lead fumes over long-time intervals. This finding may be attributed to Yu*et al*. (2017) that few refurbishers claimed that they suffer from muscle pain after long days of work. Workers and local residents are exposed to toxic chemicals through inhalation, dust ingestion, dermal exposure and oral intake. Inhalation and dust ingestion impose a range of potential occupational hazards including silicosis (Mehta, 2019). It was also discovered that manufacturers need to replace hazardous materials with more environmental friendly components. According to Shah (2014), for effective e-waste collection and enhanced recycling and refurbishing rates to occur, there is a need for greater public awareness.

In view of that it was supported by Xu*et al.* (2021) who suggested EPR as an environmental protection strategy that makes the manufacturer of the product responsible for entire life cycle of the product. Since the aim of EPR is to relieve governments financial burdens in managing E-waste while providing incentives for producers and manufacturers to reduce waste by reusing secondary raw materials from waste and continuously improving their products and processes. A very effective EPR adoption will help to minimize e-waste in the environment. The finding revealed that regulatory body needs to put in place effective monitoring system for handling of e-waste in Niger State. The stakeholders involved; the Regulatory agency, Electronic refurbishers, Electronic recyclers needs to accept the principle of EPR, which will assist in checking and monitoring E-waste handling and management in Niger State.

An interaction with refurbishers and regulatory bodies on the awareness level of the health hazards associating with informal refurbishing sector proved that there is lack of

awareness in the sector. According to Heacock *et al.* (2016), the unsafe, unregulated and unaccountable collection, processing, and redistribution of old or abandoned electrical/electronic equipment are performed by workers at temporary sites, residences, workshops, and open public spaces due to lack of awareness and management. One of the repairers said the health challenge the face is the itching of eye as a result of solder fume and as well the physical injury as a result of hot soldering iron why trying to solder component (Refurbisher, 2021). Also, another refurbisher said that most of the circuit board has tiny components like ICs, diode, relays that are difficult to trace and why trying to trace and fix them with sold iron the fume affect their eye, also get injured most times with screwdriver, steaming machine (Refurbisher, 2021). Also, in line with health issue the agency is into ensuring that the people involved in the recycling starting from the scavengers are highly protected and environment is protected knowing that most of the materials are thrown anyhow in the country, and what the agency is trying to do to arrest this ugly situation is to register all the recyclers and all those along the chain that are trying to turn the waste into something useable, like reuse, repair, recycle. Also there are check list for all hazardous materials and provide them with the best practices (Regulatory body, 2021). Most refurbishers bow over the solder gun for long time periods per day, also work in small, poorly ventilated workspaces which they are exposed to lead fumes over long-time intervals(Yu*et al*., 2017). Some of the hazards includes: respiratory difficulties, difficulty in breathing and cough, cancerous diseases, skin diseases(Yu*et al*., 2017).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Global technological advancement has contributed greatly to the increase in volumes of electronic waste, which has directly increased the activities of informal sector operators. The manners in which E-waste recycling and refurbishing activities are carried out are not of best practiced whichpose threat to the environment and our health. Also, based on otherevidence from the findings it can be concluded that recycling and refurbishing activities are not properly done, low awareness on techniques for improvement in e-waste handling, and also on health hazards. Several threats were associated with electronic waste. Several attempts to reduce E-waste in the environment and improve the handling practices and awareness level yet to yield positive result. Moreso, Regulatory Agency charged with the responsibility of controlling the handling of e-waste and awareness are not adequately checked for effective handling of e-waste in Minna, Niger State. However, this study is set to investigate the informal e-waste recycling and refurbishing activities in Minna, Niger State.

5.2 Recommendations

The following recommendations were made based on the findings of the study:

1. Proper methods of collection, recycling and refurbishing system should be made known to the personnels involved in informal sector by the regulatory agency.
2. Regulatory agency should embark on mass awareness campaigns aimed at improving consumer's environmental consciousness, health and values.
3. Regulatory Agency should ensure regular orientation and skill acquisition programme for the personnel involved in informal E-waste sector on proper

handling method and techniques for improving recycling and refurbishing of e-waste.

4. Niger State Government should put in place effective monitoring system to checkmate handling e-waste in Niger State and also to invest in project for converting toxic substance to non-toxic substances in e-waste at the point of disposal.
5. Principle of reuse in a product should be employ by the manufactures to minimize e-waste, and also electrical and electronic equipment supplier should be adequately encouraged to implement the minimization practices of e-waste regulation.

5.3 Suggestion for Further Studies

1. Evaluation of informal E-waste handling practices by Regulatory Agency in Niger State.

2. Impacts of informal E-waste recycling and refurbishing activities on public health in Nigeria.

3. Challenges and strategies for effectives handling of hazardous substances from e-waste in Nigeria.

4. Evaluation of effective informal E-waste management in manufacturing industries in Nigeria.

5. Evaluation of the impacts of informal e-waste sector in the manufacturing industries in Nigeria.

REFERENCES

Abdelbasir, S. M., Hassan, S. S., Kamel, A. H., & El-Nasr, R. S. (2018). Status of electronic waste recycling techniques: a review. *Environmental Science and Pollution Research*, *25*(17), 16533-16547.

Abdel-Shafy, H. I., & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, *27*(4), 1275-1290.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Akram, R., Fahad, S., Hashmi, M. Z., Wahid, A., Adnan, M., Mubeen, M., & Nasim, W. (2019). Trends of electronic waste pollution and its impact on the global environment and ecosystem. *Environmental Science and Pollution Research*, 26(17), 16923-16938.

Ari, V. (2016). A review of technology of metal recovery from electronic waste. *E-Waste in transition—From pollution to resource*, 121-158.

Arthaya, B., & Nathania, E. (2017). Alternative scheme for handling reversely the waste of mobile phone in Bandung, Indonesia. *INSIST*, 2(1), 36-42.

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

Azodo, A. P., Ogban, P. U. &Okpor, J. (2017) Knowledge and awareness implication on e-waste management among Nigerian collegiate. *Journal of Applied Science and Environmental Management*, 21(6), 1035-1040.

Bakari, J. K., Swai, L. A. &Samzugi, A. S. (2012). E-waste disposal in Tanzania: The implications for income generation and poverty reduction. *Huria: Journal of the Open University of Tanzania*, 12(1), 15-41.

Becker, C. A. (1980). Semantic context effects in visual word recognition: An analysis of semantic strategies. *Memory & cognition*, 8(6), 493-512.

Benedicta, A. I. (2012). E-waste management: a case study of Lagos State, Nigeria. Social and Public Policy Development and International Cooperation, Department of Social Sciences and Philosophy, University of Jyväskylä (Master's Thesis).

Binegde, G. H. (2014). Assessment of electronic waste generation and management in Bole and AkakiKaliti sub cities, Addis Ababa, Ethiopia. (*Doctoral dissertation*, Ambo University).

Campbell, R. B., & Dini, D. A. (2016). *Occupational injuries from electrical shock and arc flash events*. Springer.

Campbell-Lendrum, D., Manga, L., Bagayoko, M., & Sommerfeld, J. (2015). Climate change and vector-borne diseases: what are the implications for public health research and policy? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1665), 20130552.

Canadian Council of Ministers of the Environment. (1996). *Waste audit users manual: A comprenhesive guide to the waste audit process*. Published by Canadian Council of Ministers of the Environment pp38

Ceballos, D. M. & Dong, Z. (2016). The formal electronic recycling industry: Challenges and opportunities in occupational and environmental health research. *Environment International*, 95, 157-166.

Chen, Y., Li, S., Tan, Q., Li, J., & Miao, Y. (2019). Study on weee collection and recycling scheme in typical Asia-pacific countries. *Environmental Engineering & Management Journal (EEMJ)*, *18*(7).

Cheung, W. M., Marsh, R., Griffin, P. W., Newnes, L. B., Mileham, A. R., & Lanham, J. D. (2015). Towards cleaner production: a roadmap for predicting product end-of-life costs at early design concept. *Journal of Cleaner Production*, *87*, 431-441.

Chimere, M. O., Peter, M. V., Martina, G. V., & Willie, J. G. M. P. (2017). Health risks awareness of electronic waste workers in the informal sector in Nigeria**.** *International Journal of Environmental Research and Public Health*, 14(8), 911.

Cieślik, B. M., Namieśnik, J., &Konieczka, P. (2015). Review of sewage sludge management: standards, regulations and analytical methods. *Journal of Cleaner Production*, *90*, 1-15.

Cometan, B. R. (2019).The Duodoxy: the principles of the logical cosmos. *The Institution of the Philosophy of Millettism.*

Cooper, D. R., &Gutowski, T. G. (2017). The environmental impacts of reuse: a review. *Journal of Industrial Ecology*, *21*(1), 38-56.

Dias, P., Bernardes, A. M., & Huda, N. (2018). Waste electrical and electronic equipment (WEEE) management: An analysis on the australian e-waste recycling scheme. *Journal of cleaner production*, *197*, 750-764.

Echegaray, F. (2016). Consumers' reactions to product obsolescence in emerging markets: the case of Brazil. *Journal of Cleaner Production*, *134*, 191-203.

European Commission (2014). Waste Electrical & Electronic Equipment (WEEE). Retrieved from: http://ec.europa.eu/environment/waste/weee/index_en.htm

Feltham-King, T., & Macleod, C. (2020). Multi-Layered Risk Management In Under-Resourced Antenatal Clinics: A Scientific-Bureaucratic Approach Versus Street-Level Bureaucracy. *Health, Risk & Society*, *22*(1), 31-52.

Feng, X., Shao, L., Xi, C., Jones, T., Zhang, D., &BéruBé, K. (2020). Particle-induced oxidative damage by indoor size-segregated particulate matter from coal-burning homes in the Xuanwei lung cancer epidemic area, Yunnan Province, China. *Chemosphere*, *256*, 127058.

Fishbein, M., &Ajzen, I. (1975). Belief. *Attitude, Intention and Behavior: An Introduction to Theory and Research*, *578*.

Fobbe, L., Lozano, R., & Carpenter, A. (2019). Assessing the coverage of sustainability reports: An analysis of sustainability in seaports. *SPONSORS*, 609.

Forti, V., Baldé, C., Kuehr, R., & Bel, G. (2020). The Global E-waste Monitor 2020. *United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam*.

Folorunsho, J. O. (2016). Analysis of Domestic Solid Waste Management Strategies in Tunga, Chanchaga Local Government Area, Niger State, Nigeria. *Advances in Social Sciences Research Journal*, *3*(6).

Gaidajis, G., Angelakoglou, K., &Aktsoglou, D. (2010). E-waste: environmental problems and current management. *Journal of Engineering Science and Technology Review*, *3*(1), 193-199.

Gangwar, C., Choudhari, R., Chauhan, A., Kumar, A., Singh, A., & Tripathi, A. (2019). Assessment of air pollution caused by illegal e-waste burning to evaluate the human health risk. *Environment international*, *125*, 191-199.

Garlapati, V. K. (2016). E-waste in India and developed countries: Management, recycling, business and biotechnological initiatives. *Renewable and Sustainable Energy Reviews*, *54*, 874-881.

Ghosh, S. K., Lee, J., Godwin, A. C., Oke, A., Al-Rawi, R., & El-Hoz, M. (2016). Waste management in USA through case studies: e-waste recycling and waste energy plant.

Gostin, L. O., & Wiley, L. F. (2016). *Public health law: power, duty, restraint*. Univ of California Press.

Govender, K. (2016). The management of electronic waste: a case study of the Umbogin twin industrial complex and Southgate business park in KwaZulu-Natal, South Africa (Doctoral dissertation).

Goyal, R. (2017). Chapter thirteen air pollution from solid waste management practices: An evolving environmental and public health crisis in urban india. *The Urban Environmental Crisis in India: New Initiatives in Safe Water and Waste Management*, 208.

Grant, R., &Oteng-Ababio, M. (2012). Mapping the invisible and real" African" economy: urban e-waste circuitry. *Urban Geography*, *33*(1), 1-21.

Gutberlet, J. (2015). Cooperative urban mining in Brazil: Collective practices in selective household waste collection and recycling. *Waste Management*, *45*, 22-31.

Heacock, M., Kelly, C. B., Asante, K. A., Birnbaum, L. S., Bergman, A. L., Brune, M. N., Buka, I., Carpenter, D. O., Chen, A., Huo, X., Kamel, M., Landrigan, P. J., Magalini, F., Diaz-Barriga, F., Neira, M., Omar, M., Pascale, A., Ruchirawat, M., Sly, L., Sly, P. D., Van den Berg, M. & Suk, W. A. (2016). E-waste and harm to vulnerable populations: a growing global problem. *Environmental Health Perspectives*, 124(5), 550-555.

Iacovidou, E., & Purnell, P. (2016). Mining the physical infrastructure: Opportunities, barriers and interventions in promoting structural components reuse. *Science of the Total Environment*, *557*, 791-807.

Ibrahim, U. (2017). E-waste environmental pollution and health risk implications for early child care, growth and development in Nigeria. *Sustainable Human Development Review*, *9*(2).

Ilankoon, I. M. S. K., Ghorbani, Y., Chong, M. N., Herath, G., Moyo, T., & Petersen, J. (2018). E-waste in the international context–A review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery. *Waste Management*, *82*, 258-275.

Inglezakis, V. J., & Moustakas, K. (2015). Household hazardous waste management: A review. *Journal of environmental management*, *150*, 310-321.

Islam, M. T., & Huda, N. (2018). Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review. *Resources, Conservation and Recycling*, *137*, 48-75.

Jackson, G. (2018). *Consumer Electronic Waste: Multiple-case Study of Environmental and Social Attitudes towards Recycling & Refurbishment* (Doctoral dissertation, Northcentral University).

Jain, T. K., & Jain, N. (2020). Recycling wastewater for reuse. *Responsible consumption and production*, 592-606.

Johnson, B. R., Onwuegbuzie, A. J. & Turner, L. A. (2007). Toward a definition of mixed methods research. Journal of Mixed Methods Research, 1, 112–133. doi: 10.1177/1558689806298224.

Kaya, M. (2016). Recovery of metals and nonmetals from electronic waste by physical and chemical recycling processes. *Waste management*, *57*, 64-90.

Khan, S. A. (2016). E-products, E-waste and the Basel Convention: regulatory challenges and impossibilities of international environmental law. *Review of European, Comparative & International Environmental Law*, *25*(2), 248-260.

Khan, S. A. (2018). Struggles and actions for legal space in the urban world: The case of informal economy e-waste workers. *Canadian Journal of Law and Society*, *33*(2), 115-135.

Klevor, V. J. K. (2015). *Recovery and Disposal of Ozone Depleting Substances: A Case Study of the Refrigerator Rebate Scheme in Ghana* (Doctoral dissertation, University of Ghana).

Koka, R. E. (2017). *Assessment of Factors Leading to Poor Electronics Waste Management in Arusha City, Tanzania* (Doctoral dissertation, The Open University of Tanzania).

Kumar, A., Holuszko, M., & Espinosa, D. C. R. (2017). E-waste: An overview on generation, collection, legislation and recycling practices. *Resources, Conservation and Recycling*, *122*, 32-42.

Laha, S. (2015). *(In) formality in E-waste Movement & Management in the Global Economy*. The University of Manchester (United Kingdom).

Leal Filho, W., Saari, U., Fedoruk, M., Iital, A., Moora, H., Klöga, M., &Voronova, V. (2019). An overview of the problems posed by plastic products and the role of extended producer responsibility in Europe. *Journal of cleaner production*, *214*, 550-558.

Levinson, M. (2016). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger-with a new chapter by the author*. Princeton University Press.

Li, X. (2013). *Informal e-waste recycling in China* (Doctoral dissertation, The University of New South Wales).

Liebmann, A. (2015). ICT Waste Handling: Regional and Global End-of-Life Treatment Scenarios for ICT Equipment.

Luhar, S., &Luhar, I. (2019). Potential application of E-wastes in construction industry: A review. *Construction and Building Materials*, *203*, 222-240.

Lu, C., Zhang, L., Zhong, Y., Ren, W., Tobias, M., Mu, Z., ... &Xue, B. (2015). An overview of e-waste management in China. *Journal of Material Cycles and Waste Management*, *17*(1), 1-12.

Lydall, M., Nyanjowa, W., & James, Y. (2017). Mapping South Africa's waste electrical and electronic equipment (WEEE) dismantling, pre-processing and processing technology landscape. *Waste research development and innovation roadmap research report. Mintek external report prepared for the Department of Science and Technology and the Council for Scientific and Industrial Research. Retrived October*, *8*, 2020.

Mahdevari, Satar, Kourosh Shahriar, & Akbar Esfahanipour. "Human health and safety risks management in underground coal mines using fuzzy TOPSIS." *Science of the Total Environment* 488 (2014): 85-99.

Martin, T. J., Snape, J. R., Bartram, A., Robson, A., Acharya, K., & Davenport, R. J. (2017). Environmentally relevant inoculum concentrations improve the reliability of persistent assessments in biodegradation screening tests. *Environmental science & technology*, *51*(5), 3065-3073.

Masud, M. H., Akram, W., Ahmed, A., Ananno, A. A., Mourshed, M., Hasan, M., &Joardder, M. U. H. (2019). Towards the effective E-waste management in Bangladesh: a review. *Environmental Science and Pollution Research*, *26*(2), 1250-1276.

Mattern, S. (2017). *Code and clay, data and dirt: Five thousand years of urban media*. U of Minnesota Press.

Mihai, F. C., Gnoni, M. G., Meidiana, C., Ezeah, C., & Elia, V. (2019). waste electrical and electronic equipment (WEEE): flows, quantities, and management- a global scenario. In *Electronic waste management and treatment technology*, (1-34). Butterworth-Heinemann.

Mehta, P. (2019). E-waste, chemical toxicity, and legislation in India. In *Advanced Methodologies and Technologies in Engineering and Environmental Science* (144-156). IGI Global.

Modi, S. (2020). Management of Environmental Problems and Sustainable Development: An Indian Perspective. *Splint International Journal of Professionals*, *7*(1), 33-40.

Ndidi, O. M. & Emmanuel, R. (2018). Assessment of e-waste collection and disposal activities in government agencies, business and residential areas in Minna Metropolis, Niger State. *AU-eJournal of Interdisciplinary Research*, (ISSN: 2408-1906), 3(2).

Nduneseokwu, C. K., Qu, Y., &Appolloni, A. (2017). Factors influencing consumers' intentions to participate in a formal e-waste collection system: A case study of Onitsha, Nigeria. *Sustainability*, *9*(6), 881.

Nia, G. T. (2014). *Factors Influencing Purchase of Personal Computers Devices from the Market in North Cyprus: An Empirical Study* (Doctoral dissertation, Eastern Mediterranean University (EMU)-DoğuAkdenizÜniversitesi (DAÜ).).

Niger State bureau of statistics. Department of budget and Planning (2016). National Population Commission Nigeria, Retrieved from http://www.population.gov.ng.

Nnorom, I. C., &Odeyingbo, O. A. (2020). Electronic waste management practices in Nigeria. In *Handbook of Electronic Waste Management* (323-354). Butterworth-Heinemann.

Nowakowski, P. (2017). A proposal to improve e-waste collection efficiency in urban mining: Container loading and vehicle routing problems–A case study of Poland. *Waste Management*, *60*, 494-504.

Ogbenna, M. N., & Raymond, E. (2018). Assessment of E-Waste Collection and Disposal Activities in Government Agencies, Business and Residential Areas in Minna Metropolis, Niger State. *AU E-Journal of Interdisciplinary Research*, *3*(2).

Ogbuanya, T. C. &Yekinni, S. A. (2019). Advancing electronic waste management techniques among electrical/electronic technicians' workshops for sustainable healthy society. *Insights Ministry of Science and Technology*, 1(4), 555566. DOI: 10.19080/IMST.2019.01.555566

Ohajinwa, C. M., Van Bodegom, P. M., Vijver, M. G., &Peijnenburg, W. J. (2017). Health risks awareness of electronic waste workers in the informal sector in Nigeria. *International journal of environmental research and public health*, *14*(8), 911.

Okorhi, O. J., Amadi-Echendu, J. E. &Aderemi, H. O. (2014). New technology frontiers in waste electrical and electronic equipment: addressing the e-waste management strategies in South Eastern Nigeria. In *Proceedings of the 12th Globelics International Conference on Partnerships for Innovation-Based Development, Chapter: Engineering and Technology, Addis Ababa University Printing Press, Addis Ababa, Ethiopia* (pp. 309-338).

Okorhi, O. J., Amadi-Echendu, J. E., Aderemi, H. O., &Otejere, J. O. S. E. P. H. (2015). Technology paradigm for e-waste management in South-Eastern Nigeria. *Intrenational Association for Management of Techonology: Coral Gables, FL, USA*, 802-823.

Oladele, O. (2009). Citizens' Participation, Opportunities and partnerships In E-Waste Control. In *The conference proceedings of the International Conference on E-Waste Control Abuja, Nigeria: The Abuja Platform on E-Waste organized by the National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria held between 20th-21st July*.

Omari, J. N. (2018). *Investigation of the Current Status of Electronic Wastes, Generation and Management: A Case Study of Nairobi County* (Doctoral dissertation, JKUAT-COETEC).

Orisakwe, O. E., Frazzoli, C., Ilo, C. E., &Oritsemuelebi, B. (2019). Public health burden of e-waste in Africa. *Journal of Health and Pollution*, *9*(22).

Orlins, S., & Guan, D. (2016). China's toxic informal e-waste recycling: local approaches to a global environmental problem. *Journal of Cleaner Production*, *114*, 71-80.

Osibanjo, O., Nnorom, I. C., Adie, G. U., Ogundiran, M. B., &Adeyi, A. A. (2016). Global Management of Electronic Wastes: Challenges Facing Developing and Economy-in-Transition Countries. *Metal Sustainability: Global Challenges, Consequences, and Prospects*, *33*(8), 51.

Oteng-Ababio, M., Owusu, G., & Chama, M. (2016). Intelligent enterprise: wasting, valuing and re-valuing waste electrical and electronic equipment. *The Geographical Journal*, *182*(3), 265-275.

Paleari, S. (2015). The EU waste electrical and electronic equipment directive: The implementation of producer responsibility across the EU-27. *The Journal of Solid Waste Technology and Management*, *41*(2), 173-188.

Park, J. K., Hoerning, L., Watry, S., Burgett, T. & Matthias, S. (2017). Effects of Electronic Waste on Developing Countries. *Advances in Recycling and Waste Management*, 2(2), 1-6.

Pathak, P., & Srivastava, R. R. (2017). Assessment of legislation and practices for the sustainable management of waste electrical and electronic equipment in India. *Renewable and Sustainable Energy Reviews*, *78*, 220-232.

Peersman, G. (2014). *Overview: Data collection and analysis methods in impact evaluation*. UNICEF Office of Research-Innocenti.

Pennel, C. L., McLeroy, K. R., Burdine, J. N., Matarrita-Cascante, D., & Wang, J. (2016). Community health needs assessment: potential for population health improvement. *Population Health Management*, *19*(3), 178-186.

PHA Consulting Associates. (2006). ELECTRONIC WASTE RECOVERY STUDY. Resource RecoveryFund Board.

Poole, C. J. M., &Basu, S. (2017). Systematic Review: Occupational illness in the waste and recycling sector. *Occupational Medicine*, *67*(8), 626-636.

Pirtilä, M. (2020). Improving the municipal solid waste management and recycling system in South Ostrobothnia based on European waste management systems.

Quina, M. J., Bontempi, E., Bogush, A., Schlumberger, S., Weibel, G., Braga, R., & Lederer, J. (2018). Technologies for the management of MSW incineration ashes from gas cleaning: New perspectives on recovery of secondary raw materials and circular economy. *Science of the Total Environment*, *635*, 526-542.

Reike, D., Vermeulen, W. J., &Witjes, S. (2018). The circular economy: new or refurbished as CE 3.0?—exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling*, *135*, 246-264.

Renee, C. (2018). State of the planet: What can we do about the growing e-waste problem? Earth Institute Columbia University. Retrieved from: https://blogs.ei.columbia.edu/2018/08/27/growing-e-waste problem/

Rosenstock, I. M. (1966). Historical origins of the health belief model. *Health Education Monograph*, 2, 1-8.

Schwartz, S. H. (1977). Normative influences on altruism. *Advance in Experimental Social Psychology*, 10, 221–279.

Shah, A. (2014). An assessment of public awareness regarding e-waste hazards and management strategies. *Independent Study Project (ISP) Collection*. 1820. Available online: https://digitalcollections.sit.edu/isp_collection/1820

Shamim, A., Mursheda, A. K., & Rafiq, I. (2015). E-waste trading impact on public health and ecosystem services in developing countries. *J Waste Resources*, *5*(188), 2.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International journal of applied research*, *3*(7), 749-752.

Shevchenko, T., Laitala, K., &Danko, Y. (2019). Understanding consumer E-waste recycling behavior: introducing a new economic incentive to increase the collection rates. *Sustainability*, *11*(9), 2656.

Srivastava, R., & Dhingra, T. (2021). Towards a model for effective e-waste management: a study of the software industry in India. *International Journal of Environment and Waste Management*, *27*(1), 61-78.

Steffan, J. J., Brevik, E. C., Burgess, L. C., &Cerdà, A. (2018). The effect of soil on human health: an overview. *European journal of soil science*, *69*(1), 159-171.

Step Initiative (2014). One global definition of e-waste. Retrieved from: http://www.stepinitiative.org/files/step/_documents/StEP_WP_One%20Global%20Definition%20of%20Ewaste_20140603_amended.pdf

Sun, Z., Xiao, Y., Sietsma, J., Agterhuis, H., & Yang, Y. (2015). A cleaner process for selective recovery of valuable metals from electronic waste of complex mixtures of end-of-life electronic products. *Environmental science & technology*, *49*(13), 7981-7988.

Tanner, T., Surminski, S., Wilkinson, E., Reid, R., Rentschler, J., & Rajput, S. (2015). The triple dividend of resilience: realising development goals through the multiple benefits of disaster risk management.

Tansel, B. (2017). From electronic consumer products to e-wastes: Global outlook, waste quantities, recycling challenges. *Environment international*, *98*, 35-45.

Theis, N. (2021). The Global Trade in E-Waste: A Network Approach. *Environmental Sociology*, *7*(1), 76-89.

Tran, C. D., &Salhofer, S. P. (2018). Processes in informal end-processing of e-waste generated from personal computers in Vietnam. *Journal of Material Cycles and Waste Management*, *20*(2), 1154-1178.

Tulchinsky, T. H., &Varavikova, E. A. (2014). Environmental and occupational health. *The New Public Health*, 471.

Uchida, N., Matsukami, H., Someya, M., Tue, N. M., Viet, P. H., Takahashi, S., & Suzuki, G. (2018). Hazardous metals emissions from e-waste-processing sites in a village in northern Vietnam. *Emerging Contaminants*, *4*(1), 11-21.

United Nations University and Step Initiative. (2014). One global definition of e-waste. Bonn: United Nations University.

USITC (United States International Trade Commission). (2013). Used electronic products: an examination of U.S. exports, Washington D.C. (Publication 4379).

Uzoagulu, M. (2011). Fundamental of Educational Research. *Enugu: Macmillan Publishers.*

Waste Management (2012). What is e-waste management? Retrieved on 30th May, 2021 from:http://www.wastemanagement.in/what-is-e-waste-management.html

Wang, Y., & Lin, B. (2021). Performance of alternative electricity prices on residential welfare in China. *Energy Policy*, *153*, 112233.

World Health Organization. (2020). Health policy and system support to optimize community health worker programmes for HIV, TB and malaria services: an evidence guide.

White, S. C. (2017). Relational wellbeing: re-centring the politics of happiness, policy and the self. *Policy & Politics*, *45*(2), 121-136.

Wymer, W. (2015). Formulating effective social marketing and public health communication strategies. In *Innovations in Social Marketing and Public Health Communication* (pp. 3-31). Springer, Cham.

Xu, J., Ye, M., Lu, W., Bao, Z., & Webster, C. (2021). A four-quadrant conceptual framework for analyzing extended producer responsibility in offshore prefabrication construction. *Journal of Cleaner Production*, *282*, 124540.

Yardley, L., Morrison, L., Bradbury, K., & Muller, I. (2015). The person-based approach to intervention development: application to digital health-related behavior change interventions. *Journal of medical Internet research*, *17*(1), e4055.

Yao, L., Liu, T., Chen, X., Mahdi, M., & Ni, J. (2018). An integrated method of life-cycle assessment and system dynamics for waste mobile phone management and recycling in China. *Journal of Cleaner Production*, *187*, 852-862.

Yevuyibor, J. T. (2015). *Negotiating Life An Analysis of the Life of Scrap Dealers in the Tema-Ashaiman Metropolis* (Doctoral dissertation, University of Ghana).

Yu, E. A., Akormedi, M., Asampong, E., Meyer, C. G., &Fobil, J. N. (2017). Informal processing of electronic waste at Agbogbloshie, Ghana: workers' knowledge about associated health hazards and alternative livelihoods. *Global health promotion*, *24*(4), 90-98.

Zhang, S., Ding, Y., Liu, B., & Chang, C. C. (2017). Supply and demand of some critical metals and present status of their recycling in WEEE. *Waste Management*, *65*, 113-127.

APPENDIX A

Validation Letter

Department of Industrial and Technology Education,
Federal University of Technology Minna, Niger State.
15th March. 2021

Federal University of Technology Minna, Niger state.
Department of Industrial and Technology Education
Sir,

REQUEST FOR RESEARCH INSTRUMENT VALIDATION

Your kind gesture is needed to ascertain the credibility and suitability of this instrument on the **assessment of informal e-waste recycling and refurbishing activities in Niger State.**

I therefore request that you validate the attached instruments (questionnaire).

You are obliged to remove or add items (s) necessary for the actualization of the set goal. The proficiency of the project is based on the accuracy of this instrument, and as such, your kind opinions on the above subject matter are highly valuable.

Thank you.

Validated by:

Name: _____

Sign: _____

Date: _____

Yours faithfully,
Abdulsalam Abdulmajeed
MTech/SSTE/2018/8723

07065927372

APPENDIX B

VALIDATION CERTIFICATE

This is to certify that the instrument on the research work titled: **investigation into the assessment of informal e-waste recycling and refurbishing activities in Niger State.** Was validated by me:

Name of First Validates': ISAH BAKHADI MUHAMMED

Institution: NIGER STATE ENVIRONMENTAL PROTECTION AGENCY

Department: WASTE MANAGEMENT

Signature and Date: 06/04/2024

Name of Second validates': Dr I E. Raymond

Institution: F UT Minna

Department: I.T.E

Signature and Date: 06/04/2024

Name of Third validates': Dr D. Ibrahim

Institution: F UT Min

Department: I T E

Signature and Date: 06/04/2024.

Name of Research Student: Abdulsalam Abdulmajeed

Matriculation Number: MTech/SSTE/2018/8723

Programme of Study: MTech Industrial and Technology Education (Elect/Elect Technology)

2

APPENDIX C

INSTRUMENT FOR DATA COLLECTION

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION. (ITE)

QUESTIONNAIRE ON ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES (QAIEWRRAA).

INSTRUCTION: Please complete this questionnaire as faithfully as possible and sincerely tick [√] the column that best represents your perception about each item. Your response will be used only for the purpose of this research.

PERSONAL DATA:
Sex**:** Male [ ] Female [ ]
E-wasteRefurbishers [ ]E-wasteRecyclers [ ] E-wasteCollectors [ ]Environmental protection agency [ ]

SECTION B

The activities involve in informal e-waste collection in Niger State, Nigeria.

Please indicate your option using Strongly Agreed (SA), Agreed (A), Disagreed (D), Undecided (U), and Strongly Disagreed (SD) on the activities involved in informal e-waste collection

S/NO	ITEMS	SA 5	A 4	U 3	D 2	SD 1
1	The collection of e-waste in the informal sector is done by informal collectors also known as scavengers					
2	The scavengers normally operates door-to-door collection of e-waste					
3	The scavengers purchase obsolete EEE from private, corporate and institutional consumers at relatively low prices and bring them to the scrap yard					
4	Informal Collectors sometimes travel long distances and also sift through waste bins, visit landfills for waste collection					
5	Informal collectors of e-waste are mostly seen moving around with a pushcart and sacks.					
6	Collectors engage in e-waste dismantling and metal recovery like cable burning.					
7	Informal collector uses crude method of separating e-waste equipment.					
8	Informal collectors do not pay anything for these items as they find them dumped at street corners and even at the dumpsites.					
9	Collection of e-waste is undertaken with the most rudimentary technologies without the fear of health hazard.					

10	All e-waste collections done are brought to the scrap yard					
11	Scavengers also engages in selling of valuable recovered materials					
12	Scavengers also visit waste dumping grounds for e-waste collection					

SECTION C

The activities in informal e-waste recycling in Niger State, Nigeria.

Please indicate your option using Strongly Agreed (SA), Agreed (A), Undecided (U), Disagreed (D), and Strongly Disagreed (SD) on the activities of informal e-waste recycling in Niger State.

S/NO	ITEMS	SA 5	A 4	U 3	D 2	SD 1
1	Recyclers in informal sectors disassemble obsolete e-waste to recover metals, such as aluminium, copper and steel.					
2	Recyclers in informal sector shred e-waste into separate recyclable material such as plastic and metals					
3	Recyclers produce quite a significant amount of wastes, as the devices contain many fractions that are of no economic value					
4	Recyclers make use of primitive tools in dismantling obsolete electrical electronics equipment to retrieve valuable elements					
5	Recycler uses acid baths to recover valuable metals					
6	Separations of dismantled device into different fractions and units.					
7	Treatment of e-waste materials to reduce plastic content					
8	Recyclers also engage in the open incineration of cables and other plastic parts in order to liberate copper and other metals.					
9	Open burning of unwanted material to access internal copper wires					
10	Fractions are usually disposed off or burned in an uncontrolled manner in or around recycling clusters.					
11	Sorting of the useful components from the dismantled e-waste devices and disposal of the non-valuables into riverbanks					
12	Removal of toxic content from the disassembled e-waste equipments					
13	Informal recyclers also engage in the activities of reselling the valuable disassembled components					

SECTION D

The activities in informal e-waste refurbishing in Niger State, Nigeria.

Please indicate your option using Strongly Agreed (SA), Agreed (A), Undecided (U) Disagreed (D) and Strongly Disagreed (SD) on the activities of informal e-waste refurbishing in Niger State, Nigeria.

S/NO	ITEMS	SA 5	A 4	U 3	D 2	SD 1
1	Refurbishers replace damage component in electric and electronic equipment					
2	Refurbishers engaged in hand soldering using lead containing solder paste to join wires together					
3	Refurbishing activity is done by repairing defective components					
4	Refurbishers make use of multi-meter to check for the electrical continuity					
5	Refurbishers engages the use of soldering iron to fuse relays and diodes on the circuit board					
6	Power supply tester is used by refurbishers to check for proper power supply be it on computer or Television					
7	Refurbishers also engage in marketing and sales of the refurbished products.					
8	Screwdrivers are also used to open and tight hardware components of electronic and electrical equipments					
9	Refurbishers use multi-tester in testing voltage resistance and continuity to measure the power functions of the motherboard of the computer					
10	Refurbishers make use of chip extractor for safely and quick removing ICs from the sockets					
11	Wire cutters are use to cut copper, brass and also use to strip and splice wire with easy					
12	In refurbishing sector, needle-nose pliers are both for cutting and holding to bend, re-position and snip wire					
13	Refurbishers make use of rework station for de-soldering the surface- mounted electronic components					
14	In Refurbishing sector, Re-work station is used by the refurbishers for re-soldering of surface-mounted electronic components					
15	Refurbishers use hot air gun from work station to heat devices and melt solder which it easy to pick and position tiny components on the circuit board					

SECTION E

The techniques for improving informal e-waste recycling in Niger State, Nigeria.

Please indicate your option using Strongly Agreed (SA), Agreed (A), Undecided (U), Disagreed (D) and Strongly Disagreed (SD) on the techniquesfor improving informale-waste recycling in Niger State, Nigeria.

S/NO	ITEMS	SA 5	A 4	U 3	D 2	SD 1
1	Complete separation and recover of copper and aluminium from domestic and industrial insulated wires and cables (Granulation of cables)					
2	Removing components from printed circuit boards by heating over coal-fired grills					
3	Separating and sorting electronic components into several categories (ICs, transistors, capacitors)					
4	Dismantling of e-waste by tools to separate hazardous components as well as valuable components.					
5	Shredding the circuit boards for refurbishing and exporting purposes					
6	Proper disposing unsalvageable materials in fields and riverbanks					
7	Technical knowledge upgrade of recycler					
8	Through incineration, the hazardous nature and volume of a substance or material are decreased, and the inert remains from incineration can be more safely discarded					
9	Reduction of hazardous materials embedded in the equipment used.					
10	Replacing hazardous content with non-hazardous materials helps to avoid the impacts that would otherwise be present when dealing with waste equipment.					
11	Chipping and melting of mixed plastics to extract valuable materials					
12	Leaching and the amalgamation of PCBs to recover precious metals.					
13	separation of the particles by physical methods using the differences in densities or magnetic properties					
14	Equipping the recycler with proper awareness and regulatory laws					
15	Complete disassembly of devices to critically remove valuables items without having much fragments or damaging equipments					

SECTION F

The techniques for improving informal e-waste refurbishing in Niger State, Nigeria.

Please indicate your option using Strongly Agreed (SA), Agreed (A), Undecided (U), Disagreed (D), and Strongly Disagreed (SD) on the techniquesfor improving informale-waste refurbishing in Niger State, Nigeria.

S/NO	ITEMS	SA 5	A 4	U 3	D 2	SD 1
1	Simple design of components for easy repair, cleaning and replacement (innovation design)					
2	Avoiding the production, consumption, and disposal of devices all together					
3	Reprocessing of material and products for re-use purpose					
4	Proper routine checks in order for such equipment to operate at it maximum output throughout its useful life					
5	Avoiding glues that make sorting difficult (low-impact of materials)					
6	Proper installation of parts to avoid sparks so as to avoid damage and to operate at its maximum and best performance					
7	Introducing refurbishing facilities.					
8	Design, production and packaging of IT products by environmentally sound methods					
9	Training local manpower to ensure adequate reverse flow of components/modules.					
10	Creating a readily available market for the refurbished components for local consumption and export.					
11	Use of semiconductor device that that can perform multiple functions like amplification, switching, voltage stabilizer. Example transistor					
12	Making use of re-work station that perform multiple functions like melting, de-soldering, re-soldering, and make work easier, faster and neater					
13	Fuses of correct rating should be used to prolong the lifespan of the equipments					
14	Recuperation and restoration of device to attain reliability and consistency to a standard competitive to that of new alternative commodities (Optimization)					
15	Upgrading a device to achieve a higher quality through refurbishment and remanufacturing (Reparation)					

SECTION G

What is the level of awareness on health hazards in informal e-waste recycling in Niger State, Nigeria?

Please indicate your option using Highly Aware(HA), Aware (A), Undecided (U), Moderately Aware (MA) and NotAware (NA) on the level of awareness on health hazards in informal e-waste recycling in Niger State, Nigeria

S/NO	ITEMS	HA 5	A 4	U 3	MA 2	NA 1
1	Development of respiratory difficulties and pulmonary diseases					
2	Burnt of hands and bruises					
3	Brain malfunctioning and development					
4	Neurological disorder among the people living near informal recycling site					
5	Lung diseases					
6	Developed sleeplessness as a results of Fumes and dusts from burnt e-waste					
7	Cancerous diseases as a result of e-waste					
8	Developments of running nose as a result of gaseous substances					
9	Causes blindness					
10	It causes premature birth					
11	Development of difficulty in breathing and cough					
12	Recyclers suffer from diseases like malaria, typhoid, pneumonia, dysentery, and cholera					
13	Developed skin diseases from the release of hazardous gases					
14	causes asthmatic attack due to inhaling of burnt e-waste exhaust gases					
15	Causes death as a result of release hazardous gases					

SECTION H

What is your level of awareness on health hazards in informal e-waste refurbishing in Niger State, Nigeria?

Please indicate your option using Highly Aware(HA), Aware (A), Undecided (U), Moderately Aware (MA) and NotAware (NA) on the level of awareness on health hazards in informal e-waste refurbishing in Niger State, Nigeria.

S/NO	ITEMS	HA 5	A 4	U 3	MA 2	NA 1
1	Causes respiratory difficulties and pulmonary disease					
2	Burnt of hand and bruises					
3	Causes asthmatic attack					
4	Affects blood system and kidneys in humans					
5	Developments of lung diseases					
6	Causes sleeplessness as a results of Fumes and dusts from burnt e-waste					
7	Developed cancerous diseases					
8	Developments of running nose as a result of gaseous substances					
9	Causes blindness					
10	Developed skin diseases from release hazardous gases					
11	Causes difficulty in breathing and cough					
12	Causes inflammation of the lungs					
13	Causes diseases like fatigue, pains, and fever					
14	Developed respiratory diseases and skin					
15	Itching eye as a results of solder fumes					

APPENDIX D

SECTION D (INTERVIEW GUIDE)

QUESTIONNAIRE ON ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES (QAIEWRRAA).

Research Question 1

What are the activities in informal e-waste collection in Niger State, Nigeria?

Interview Questions

1. What kind of activities is carried out by those involved in informal e-waste collection?
2. What are the equipments used in carrying out the collection process?

Research Question 2

What are the activities in informal e-waste recycling in Niger State, Nigeria?

Interview Questions

1. What are the kinds of activities carried out in informal e-waste recycling?
2. What are the equipments used in carrying out activities in informal e-waste recycling?

Research Question 3

What are the activities in informal e-waste refurbishing in Niger State, Nigeria?

Interview Questions

1. What are the kinds of activities carried out in informal e-waste refurbishing?
2. What are the equipments used in carrying out activities in informal e-waste refurbishing?

Research Question 4

What are the techniques for improving informal e-waste recycling in Niger State, Nigeria?

Interview Question

What are the techniques adopted by the personnel involved to improve informal e-waste recycling?

Research Question 5

What are the techniques for improving informal e-waste refurbishing in Niger State, Nigeria?

Interview Question

What are the techniques adopted by the personnel involved to improve informal e-waste refurbishing?

Research Question 6

What is the level of awareness of health hazards in informal e-waste recycling in Niger State, Nigeria?

Interview Questions

1. What are the health hazards in informal e-waste recycling?
2. In view of the release of hazardous emission, why do personnel still partake in informal e-waste recycling?

Research Question 7

What is the level of awareness of health hazards in informal e-waste refurbishing in Niger State, Nigeria?

Interview Questions

1. What are the health hazards in informal e-waste refurbishing?
2. With regards to the emission of harmful gas, why do personnel still partake in informal e-waste refurbishing?

APPENDIX E

Training manual

A researcher is a person that carries out academic or scientific research.

Research assistant is a researcher employee, and often on a temporary contract, by a university, a research institute or a privately held organization for the purpose of assisting in academic or private research. Research assistants usually work under the supervision of primary researcher who led research project.

Roles of Research Assistant

- A research assistant assists in distributing an instrument to the respondents in the field.
- A research assistant helps to interpret to the respondents where the is language barriers.
- Request or acquire equipment or supplies necessary for the project
- A research assistant guides the respondent where he might face difficulties.
- A research assistant shows the respondents how to tick appropriately the column provided in the instrument.
- A research assistant also helps to retrieve distributed questionnaires from the respondents after which it has been assessed.
- Prepare materials for submission
- Maintain accurate records of interviews, safeguarding the confidentiality of the subjects as necessary.
- Recruit and or interview subjects.
- Provide ready access to all experimental data

APPENDIX F

Hypothesis 1

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05
		1
EEE REPAIRERS	30	4.3000
EEE RECYCLERS	30	4.3667
EEE COLLECTORS	20	4.5000
REGULATORY AGENCY	76	4.5132
Sig.		.356

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

hypothesis 2

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05	
		1	2
EEE REPAIRERS	30	4.2333	
EEE COLLECTORS	20	4.2500	
EEE RECYCLERS	30		4.6333
REGULATORY AGENCY	76		4.6447
Sig.		.999	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

hypothesis 3

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05	
		1	2
EEE COLLECTORS	20	3.7000	
EEE REPAIRERS	30		4.3000
EEE RECYCLERS	30		4.3000
REGULATORY AGENCY	76		4.3553
Sig.		1.000	.983

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

hypothesis 4

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05		
		1	2	3
EEE COLLECTORS	20	3.0500		
EEE RECYCLERS	30		3.6667	
EEE REPAIRERS	30		3.8000	
REGULATORY AGENCY	76			4.6053
Sig.		1.000	.801	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Hypothesis 5

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05			
		1	2	3	4
EEE COLLECTORS	20	2.8000			
EEE RECYCLERS	30		3.4000		
EEE REPAIRERS	30			3.9000	
REGULATORY AGENCY	76				4.3421
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

hypothesis 6

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05		
		1	2	3
EEE COLLECTORS	20	3.0500		
EEE RECYCLERS	30		3.5333	
EEE REPAIRERS	30		3.8000	
REGULATORY AGENCY	76			4.6447
Sig.		1.000	.350	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Hypothesis 7

Tukey HSD[a,b]

OCCUPATION TYPE	N	Subset for alpha = 0.05		
		1	2	3
EEE COLLECTORS	20	2.9500		
EEE RECYCLERS	30		3.6000	
EEE REPAIRERS	30		4.0333	4.0333
REGULATORY AGENCY	76			4.4737
Sig.		1.000	.063	.057

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.811.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

RQ1

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

APPENDIX G

Reliability Statistics

Cronbach's Alpha	N of Items
.970	12

RQ2

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.807	13

RQ3

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.712	15

RQ4

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.826	15

RQ5

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

RQ6

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.721	15

RQ7

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.822	15

APPENDIX H

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: 01/06/2021

THE STATE COORDINATOR,
NATIONAL ENVIRONMENTAL
STANDARD AND REGULATIONS
ENFORCEMENT AGENCY. [NESREA]

Sir/Ma,

TO WHOM IT MAY CONCERN

The bearer ABDULSALAM ~~ABDULMAJEED~~ Bidemi with Registration Number M.Tech/SSTE/2017/7823 is A Master student of Industrial and Technology Education Department.

He is carrying out a research titled: ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES IN NIGER STATE, NIGERIA

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

We will appreciate your anticipated co-operation.

Thank you.

31/05/2021

Dr. E. Raymond
Postgraduate Coordinator, ITE.

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: 01/06/2021

STATE COORDINATOR,
FEDERAL MINISTRY OF
ENVIRONMENT, MINNA,
NIGER STATE. [FME]

Sir/Ma,

TO WHOM IT MAY CONCERN

The bearer ABDULSALAM ABDULMAJEED BIDEMI with Registration Number M.Tech/SSTE/2017/7823 is A Master student of Industrial and Technology Education Department.

He is carrying out a research titled: ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES IN NIGER STATE NIGERIA

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

We will appreciate your anticipated co-operation.

Thank you.

31/05/2021

Dr. E. Raymond
Postgraduate Coordinator, ITE.

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: 07/06/2021

THE G.M.
NIGER STATE ENVIRONMENTAL
PROTECTING AGENCY
(NISEPA)

Sir/Ma,

TO WHOM IT MAY CONCERN

The bearer ABDULSALAM ~~ABDULMAJEED~~ BIDEMI with Registration Number M.Tech/SSTE/2018/7823 is A Master student of Industrial and Technology Education Department.

He is carrying out a research titled: ASSESSMENT OF INFORMAL E-WASTE RECYCLING AND REFURBISHING ACTIVITIES IN NIGER STATE, NIGERIA

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

We will appreciate your anticipated co-operation.

Thank you.

31/05/2021

Dr. E. Raymond
Postgraduate Coordinator, ITE.