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

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Abstract

The study assessed Metal Steel Waste Management Practices in Ajaokuta Steel Company, Kogi State, Nigeria. Two research questions and two null hypotheses guided the study. A descriptive survey research design was adopted for the study. The study was conducted in Ajaokuta Steel Company, Kogi State, Nigeria. A total of 144 respondents which consists of 60 engineers, 50 technologists and 34 technicians in Ajaokuta steel company as total respondents from the study. 25 item structured questionnaire, developed was used to collect data for the study from the respondents. The instrument was divided into two parts (1 & 2), part 1 consist of instructions and personal data as section A while part 2 consist of two categories sections B & C of the questionnaire items and were face validated by three experts. The overall reliability coefficient for the entire 25 items questionnaire was determined to be 0.968. Weighted mean and standard deviation were used to answer the research questions while ANOVA was used to test the null hypotheses 1 & 2 at 0.05 level of significance. The findings of the study revealed that all metal wastes collection practices items were agreed on by the respondents. Hence, metal wastes collection practices were required for Metal Steel Waste Management in Ajaokuta steel company. It was also found out that the metal wastes recycling practices in Ajaokuta steel company were observed as agreed on by the respondents. In addition, the findings on hypotheses 1 revealed that there is significant difference in the mean ratings of the responses of the three groups of respondents (60 engineers, 50 technologists and 34 technicians) as regards the metal waste collection practices. In the same vein, hypotheses 2 revealed that there is no significant

difference in the mean ratings of the respondents as regards the metal wastes recycling practices. It was therefore recommended among others that metal steel waste management practices should be utilize by Ajaokuta steel company in other to reduce wastes and improve its profitability. Engineers, technologists and technicians should be given further academic and professional training on maintaining precision rules during production of components in other to reduce metal wastes.

Background to the Study

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

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

type of size. According to Corrosionpedia (2015) billets are used as raw materials or feedstock in extrusion, forging, rolling and other metal processing operations. The lime section mill removes impurities from the steel being manufactured and wire rod mill produces wire rod of different sizes that are used in building sector. The medium section and structural mill also produce rail tracks and these processes thus generate metal steel waste down the production line.

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

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

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

Recycling practices involved the act of processing used or abandoned materials for use in creating new products. Dennis (2011) defines recycling as the process of adding value to the waste to make it economically useful. The need to recycle metal waste is clear, because allowing metal waste to end up in landfills poses risk, since metal contain toxic chemicals like mercury that could poison the nearby soil and the ground water. But the recycled

metal can be used to manufacture new metal products which is considerably less expensive than mining for ore to obtain new metals. According to Rupali *et al.* (2015) recycling of solid waste materials saves natural resources, energy, reduces waste, air and water pollutants and reduce greenhouse gas emissions. Chattered Institute of Purchasing and Supply (CIPS) (2007) reported that a key development in the metal waste management is focus on preventing the production of waste through waste minimization and the re-use of waste materials through recycling. Hence, unused and unrecyclable metal wastes could be avoided if the activities of the personnel (technicians, technologists and engineers) are taken into consideration.

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

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

Statement of the Research Problem

Metals are usually very strong, durable and highly resistant to every day wear and tear. As such, they have been used since ancient times for a lot of things. Even today, with the advances in technology, the importance of metal has broadened greatly. Metals like iron and steel among others are the main materials used in construction of buildings, bridges, manufacturing of automobiles, machinery, military ammunitions, electronics, production of medicine equipment, jewelry and decorative products among other uses (Eleke, 2007). These have created a huge opportunity for many countries to generate revenue. Nigeria, at one time, generated huge percentage of its national income from metal production.

Ajaokuta Steel Company did not only generate auspicious revenue to develop the economy of the country but also created wealth and job opportunities for her citizens. However, despite the numerous importance of metals, metal waste management is apparently poor and little or no attention has been given to the impact of metal waste activities on human and general livelihood of the communities which poses very dangerous signal to the existence of people working or living around ASCL in Kogi State. The mismanagement of metal steel wastes has become a problem which is a big threat to human lives, aquatic existence and ecosystem. Some of the hazards of metal steel waste like dust and fumes irritate the eyes, skin and upper respiratory system and also causes lung fibrosis or lung cancer. The toxic chemical from metal causes skin burns and also pollute the environment. Muataz, *et al.* (2017) reported that the increasing negative impacts of metal wastes have generated a growing public health concern about environmental pollution. As there are many injuries and long-term illnesses associated with working in dangerous scrap metal yards. For instance, Eleke (2007) lamented that several workers in the steel manufacturing industries that have experienced radiation accidents, caused by radioactive materials suffer from nausea diarrhea, loss of weight, premature aging and leukemia. The problem of this study therefore is put in a question form: what are the metal steel waste management practices in Ajaokuta Steel Company, Kogi State, Nigeria?

Aim and Objectives of the Study

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

1. Determine metal wastes collection practices in Ajaokuta steel company.
2. Find out metal wastes recycling practices in Ajaokuta steel company.

Research Questions

The following research questions guided the study:

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

Research Hypotheses

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

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

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

Methodology

A descriptive survey research design was adopted for this study. The study was carried out in Ajaokuta Steel Company Limited (ASCL) in Kogi State, Nigeria. ASCL lies on the coordinates of 7°33'22''N 6°39'18''E. The 2006 census put the area population at 122,321 and Ajaokuta occupies a land area of 1,362 square kilometers, which is about 5% of the total land of Kogi State, Nigeria. Mismanagement and inadequate utilization of steel wastes by the steelworkers (Engineers, Technologists and Technicians) necessitated the choice of ASCL as an area of study. The target population for this study was 150 respondents comprising 60 engineers, 50 technologists and 40 technicians, all from ASCL, Kogi State, Nigeria. The population of the study were not too large; hence the entire population was utilized for the study.

The instrument that was used for data collection was a structured questionnaire titled: Metal Steel Waste Management Practices Questionnaire (MSWMPQ). All sections of the research questions were structured on 4-point rating scale options of strongly agree (SA), agree (A), disagree (DA), and strongly disagree (SD) with assign numerical values of 4, 3, 2, and 1 were used. The instrument was content and face validated by three experts in the Department of Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology Minna, Niger State. The overall reliability coefficient for the entire 25 items questionnaire is 0.968. The result indicated that the instrument is reliable and it is therefore considered appropriate. Mean and standard deviation were the statistical tools used to analyze the data for answering research question; while Analysis of Variance (ANOVA) was used to test the null hypotheses respectively at 0.05 level of significant. The decision on the post hoc test and hypotheses formulated for the study was based on comparing the significant value with ($p<.05$) level of significant, that is where the significant value is less than ($P<.05$) it was rejected, while equal or greater than ($p<.05$) level of significant the hypotheses was accepted.

Research Question 1

What are the Metal Wastes Collection Practices in Ajaokuta Steel Company?

The data from answering research question is presented in Table 1.1

Table 1.1

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

S/N	ITEMS	$\bar{x}_R$	SD	Remark
1.	Metal wastes are collected based on approved standard.	3.22	0.81	A
2.	Metal wastes collected are kept in the scrap yards.	3.72	0.47	SA

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

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

Data in Table 1.1 revealed that three (3) out of the 13 wastes collection practices items had their mean values within the real limit of 3.50 – 4.00, indicating that the 3 wastes collection practices items were strongly agreed on by the respondents on metal wastes collection practices in Ajaokuta steel company. Similarly, the table further revealed that 10 items had their mean values within the real limit of 2.50 – 3.49, indicating that the 10 metal wastes collection practices were agreed on by the respondents on metal wastes collection practices. All the 13 standard deviation on each item were within the real limit of 1.96 indicating that the respondents were not too far from the mean or from one another in their responses.

Research Question 2

What are the Metal Wastes Recycling Practices in Ajaokuta Steel Company?

The data from answering research question is presented in Table 1.2

Table 1.2

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

S/N	ITEMS	$\bar{x}_R$	SD	Remark
1.	Metal wastes collected are sent to the scrap yards for recycling.	3.66	0.57	SA

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

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

Data in Table 1.2 revealed that one (1) out of the 12 metal wastes recycling practices item had a mean value within the real limit of 3.50 – 4.00, indicating that the one (1) metal wastes recycling practices item was strongly agreed on by the respondents on metal wastes recycling practices in Ajaokuta steel company. In addition, the data further revealed that 11 items had their mean values within the real limit of 2.50 – 3.49, indicating that the 11 metal wastes recycling practices items were agreed by the respondents on metal wastes recycling practices. All the 12 standard deviation on each items were within the real limit of 1.96 indicating that the respondents were not too far from the mean or from one another in their responses.

Hypotheses 1

$H0_1$: There is no significant difference in the mean response of the engineers, technologists and technicians on metal waste collection practices in Ajaokuta steel company.

Table 1.3

One way Analysis of Variance Summary Table Showing the Difference in the Mean Response of the Engineers, Technologists and Technicians on Metal Wastes Collection Practices in Ajaokuta Steel Company.

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

(P<0.05) SD = Significant different

Table 1.3 revealed that there were significant differences (P<0.05) in the mean ratings of the respondents (engineers, technologists and technicians) as regard the metal wastes collection practices. These data supported the hypothesis, F(2, 141) = 22.526, p = .002. The mean and standard deviation for the engineers were 3.47 and 0.24 respectively. Similarly, the mean and standard deviation for technologists were 2.90 and 0.71. In addition, the mean and standard deviation for technicians were 3.11 and 0.10 respectively. Hence, hypothesis one was rejected. This mean, there was significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes collection practices in Ajaokuta steel company. Showed that there was no statistical difference between the responses of engineers and technicians P = .092; and engineers and technologists P = .092. However, there was significant difference in the mean response of technologists and technicians P= .001; on metal wastes collection practices. This could be as a result of gap in knowledge between the technicians and the technologists on metal wastes collection practices.

Hypotheses 2

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

The data for testing hypotheses two were presented in Table 1.4.

Table 1.4

One way Analysis of Variance Summary Table Showing the Difference in the Mean Response of the Engineers, Technologists and Technicians on Metal Wastes Recycling Practices in Ajaokuta Steel Company.

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

(P<0.05) NS = No Significant

Table 1.4 revealed that there was no significant difference (P<0.05) in the mean ratings of the respondents on metal wastes recycling practices. These data supported the hypothesis, F(2, 141) = 11.061, p = .072. The mean and standard deviation for engineers were 3.05 and 0.32 respectively. Similarly, the mean and standard deviation for technologists were 2.62 and 0.71. Furthermore, the mean and standard deviation for technicians were 2.83 and 0.05 respectively. Hence, hypothesis two was retained. This mean, there was no significant difference in the mean achievement scores of engineers, technologists and technicians as regards the metal wastes recycling practices in Ajaokuta steel company.

Findings/Discussion

The finding in Table 1.1 relating to research question one revealed that the respondents agreed with all the items on the metal wastes collection practices. The findings of Abhishek, & Awasthi, (2017) were inline with the finding of the study that keeping of metal wastes collected in the scrap yards; keeping of metal wastes bin in a very strategic location were very important and its play a vital role in metal wastes collection practices. Similarly, Anne, (2019) further argued that, sending collected metal wastes out to mills or foundries and sorting out of metal wastes based on recyclable and non-recyclable materials were legitimate metal wastes collection practices in ASCL as also agreed by the author.

The finding in Table 1.2 relating to research question two revealed that the respondents agreed with all the items relating to metal wastes recycling practices. The findings of the study on metal wastes recycling practices were in agreement with the findings of Chris, (2020) that sending of metal wastes collected to the scrap yards for recycling was among important wastes recycling practices. The findings of Detlef, (2019) were also in consonance with the study which stated that, solidifying of scrap metals after melting are transported to factories as raw material for the production of brand-new products, allowing of molten scrap metals to cool and solidify before forming into specific shapes, using of metal sensors such as hydrometallurgy and pyrometallurgy for metal recycling among others were paramount and play important role during metal wastes recycling practices as also agreed by the author.

$H0_1$:- Data from $H0_1$ shows that there was significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal waste collection practices in Ajaokuta steel company. Using Post Hoc test, the null hypothesis of no significant difference was therefore upheld for the two groups (engineers and technicians P = .092; engineers and technologists P = .092) but rejected (technologists and technicians P = .001) The implication of this is that the engineers/technician, engineers/technologists did not differ significantly in their opinions. However, technologists/technicians differ significantly in their opinions on the 13 items.

Generally, the findings of the study on hypothesis one was in line with the findings of Sushovan, (2015) where it was found out that there is significance difference in the mean ratings of the responses of engineers, technologists and technicians. The findings of Wang. *et al.* (2017) gave credence to the findings of this study on hypothesis one as regards the metal waste collection practices in Ajaokuta steel company.

$H0_2$:- Data from $H0_2$ shows that there was no significant difference in the mean ratings of the responses of the three groups of respondents (engineers, technologists and technicians) as regards the metal wastes recycling practices in Ajaokuta steel company. The null hypothesis of no significant difference was therefore upheld for the three groups on metal wastes recycling practices. The implication of this is that the engineers, technologists and technicians did not differ significantly in their opinions on the 12 items. Generally, the findings of the study on hypothesis two was in conformity with the findings of Sushovan, (2015) where it was found out that there is no significance difference in the mean ratings of the responses of engineers, technologists and technicians. The findings of Ogogome, (2015) gave credence to the findings of this study on hypothesis two as regards the metal waste recycling practices in Ajaokuta steel company.

Conclusion

The study is to assess metal steel waste management practices in Ajaokuta steel company, Kogi State, Nigeria. The finding of the study serves as the basis for making the following conclusion: that metal steel waste management practices should be utilize by engineers, technologists and technicians in Ajaokuta steel company in other to reduce wastes and improve its profitability.

Recommendations

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

1. Metal steel waste management practices should be utilized by Ajaokuta steel company in other to reduce wastes and improve its profitability. Furthermore, engineers, technologists and technicians should be trained regularly through workshops and conferences on maintaining precision rules during production of components in other to reduce metal wastes.
2. Funding should be provided by the Federal Government in other to purchase new facilities/equipment in collecting and recycling of metal wastes in Ajaokuta steel company. Recruitment of technicians should be based on technical know-how to operate, maintain and manage metal wastes. Ajaokuta steel company should consistently organize a seminar/workshop for the engineers, technologists and technicians in order to equip them with appropriate information concerning the

development, applications, dissemination and diffusion of adopting new technological practices like the use of automated sensors, optical sorters and magnets to be effective on the job.

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

REFERENCES

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

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

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

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

Collins English dictionary (2013). Engineer Definition and Meaning. Retrieved from https://www.dictionary.com

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

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

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

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

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

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

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

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

Mukuldev, K. (2018). Process Waste Generation and Utilization in Steel Industry. *International Journal of Industrial and Manufacturing Systems Engineering*. Vol. 3, No. 1, 2018, pp. 1-5. doi: 10.11648/j.ijimse.20180301.11.

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

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

Sushovan, S. (2015). Solid Waste Management in Steel Industry-Challenges and Opportunities: World Academy of Science, Engineering and Technology. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering Vol:9, No:3, 2015.*

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