E-Waste Environmental-Land Concerns and Population Projection Impact Using Arithmetic and Geometric Methods in Nigeria

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***Abstract*:-Nigeria has been identified as a major dumping ground for e-waste from developed countries of the world arising from the need to do business globally and also in other to bridge the digital divide in development and commerce. The need for global business and communication has led to rapid technological growth which in itself has triggered a high rate of electronic equipment production and invariably also high rate of electronic waste (e-waste). This electronic waste is becoming a major global issue. This paper is to project the e-waste generation per inhabitants in Nigeria using the 1.9kg per inhabitants, the arithmetic and geometric population projection methods to project the population for 2020, 2030, 2040 and 2050. In the worst case scenario using geometric projection the population of Nigeria will be 453 million and the e-waste generated will be 861 thousand metric tonnes. Comparing this to other substance like pure water, coarse sand and topsoil the equivalent is 861 thousand m^3, 1.4 million m^3 and 1.2 million m^3 respectively. Some recommendation as contained in the conclusion is that government should enact and enforce legislation on e-waste, empower regulatory bodies to live up to their responsibilities, adopt an e-waste management system and control importation of UEEE gadgets.**

***Keywords*: E-waste, UEEE gadgets, EEE, Environmental land, Population projection**

I. INTRODUCTION

Electronic waste or e-waste is the term given to describe any electronic product, or product containing electrical components, that has reached the end of its usable life cycle (Sthiannopkao and Wong, 2013).

The invention and discovery of Electrical and Electronics Equipment (EEE) have greatly made life more easy and convenient due to their efficiency and time saving. Information Communication Technology systems in today's world, would not have been possible to achieve without electronics technology (Adediran and Abdulkarim, 2012). These Electrical and electronics equipment (EEE), in particular the electronic devices, become technologically obsolete in a relatively very short time as a result of continuous improvements and innovation of new models. This rapid technological growth leads to high rate of production of electronic equipment which invariably also leads to high rate of electronic waste (e-waste). Electronic equipment that has reached their end of life becomes a waste of Electrical and Electronic Equipment (Waste-EEE), or simply Electronic Waste (e-waste).

The total amount of e-waste produced has reached approximately 41 million ton in 2014 and increasing at a rate of 3-5% every year (Kumar, Holuszko and Espinosa, 2017). According to Electronic Takeback Coalition (2010), about 20 to 50 million metric tonnes of eWaste are generated worldwide on a yearly basis. Electronic waste is one of the fastest-growing waste streams globally and as per the United Nations Environment Programme (UNEP) estimates; total e-waste generation is expected to cross 50 million tonnes annually (UN.org). The disused materials pose a great environmental challenge as regards to disposing them. Only about a maximum of 18 percent are recycled, some end up in landfills, some are incinerated causing serious environmental pollution (Dharini et al, 2017) and while the rest find their way to third or less developed countries like Nigeria.

Types of E-waste

E-waste for short - or Waste Electrical and Electronic Equipment (WEEE) - is the term used to describe old, end-of-life or discarded appliances using electricity. It includes computers, consumer electronics, fridges etc which have been disposed of by their original users. Common items of electrical and electronic waste are (Josh, 2015):

a. Large household appliances (refrigerators/freezers, washing machines, dishwashers)
b. Small household appliances (toasters, coffee makers, irons, hairdryers)
c. Information technology (IT) and telecommunications equipment (personal computers,telephones, mobile phones, laptops, printers, scanners, photocopiers)
d. Consumer equipment (televisions, stereo equipment, electric toothbrushes)
e. Lighting equipment (fluorescent lamps)
f. Electrical and electronic tools (handheld drills, saws, screwdrivers)
g. Toys, leisure and sports equipment
h. Medical equipment systems (with the exception of all implanted and infected products)
i. Monitoring and control instruments

j. Automatic dispensers.

II. LITERATURE REVIEW

In this age where information is power, one major way to ensure advancement is to acquire Information and Communication Technology (ICT), which is a veritable tool for development. Nigeria as a developing country is in a hurry to catch up with the developed world, as such there is massive importation of electronic ICT equipment (Ukem, 2008).

E-wastes are electronic wastes. These are used or discarded electrical or electronic device that have reached end of their useful life. The stack reality is that we cannot do away with e-wastes because of technological advancement in the world of electronic gadgets (Ojewale, 2018). E-waste, or electronic waste, is waste from all sorts of electronics ranging from computers and mobile phones, to household electronics such as food processors, pressure, cookers etc. Electronic waste or e-waste is the disposal of electronic goods such as cell phones, mp3 players, televisions, and computers (Terada, 2012). Alake and Ighalo (2012) defined e-waste as waste electrical and electronic equipment (WEEE) that are non-biodegradable, industrial and synthetic.

Fig 1: used computers - e-waste (source: Balde et al, 2017)

Fig 2:Used phone batteries (source: Idowu, 2017)

Fig 3: used phone (source: Iyatse, 2016)

According to Chatterjee (2012), electronics waste is becoming a major global issue. Huge accumulation of e-waste and their recycling through primitive means for extraction of precious metals are real concern in the developing countries due to presence of hazardous materials in e-waste. The global quantity of e-waste generation in 2016 was around 44.7 million metric tonnes (Mt), or 6.1 kg per inhabitant. It is estimated that in 2017, the world e-waste generation will exceed 46 Mt. The amount of e-waste is expected to grow to 52.2 Mt in 2021, with an annual growth rate of 3 to 4% (Balde et al, 2017).

A study conducted in 2015/2016 in Nigeria shows that around 71,000t of used electrical and electronic equipment (UEEE) were imported annually into Nigeria through the two main ports in Lagos. Around 69 % were stuffed in cars, buses, and trucks imported. UEEE imported in containers, with and without vehicles, contributed around 18,300 t of UEEE per year with 52% imported in containers with vehicles. EU member states were the origin of around 77% of UEEE imported into Nigeria (Balde et al, 2017).

Most of e-waste generated is dumped in the landfill and metals like lead serve to harm the nature of soil. Due to the scarcity of lands there are limited chances of getting fresh dump yards hence the available yards are overflowing with such wastes. The effect and consequences of toxic waste by comparing the difference in the properties of the soil structure prior and after e-waste landfill at various concentrations was carried out by Dharini et al (2017). According to their result it can be inferred that the soil samples subjected to harmful landfills are infertile and are made unfit for vegetation permanently

In their paper ‘Challenges of Electronic Waste Management in Nigeria’ Adediran and Abdulkarim focused on issues relating to e-waste, it identifies the sources of e-waste as well as their components and the dangers in them. Alternative initiatives and means of managing the e-waste, both internationally and nationally.

According to Ewium et al (2014), Nigeria has been identified as a major dumping ground for e-waste from developed countries of the world arising from increasing demand for information communication technology (ICT) and other electronic gadgets since 2001 with introduction of GSM.

The quest and desire to bridge the increasing digital divide coupled with the poor economic condition of most Nigerian citizens have encouraged the striving market of imported used EEE in Nigeria. Tons of these used EEE that find their way into the country are obsolete and expired. Therefore discarding them becomes a major challenge every year (Obaje, 2013)

Environmental Concerns of E-waste

Any appliance that runs on electricity has the potential to cause damage and pollution to the environment if it is not disposed off in a responsible way. The chemicals produced are non-biodegradable and they persist in the environment for prolonged time periods thus increasing exposure risks. Generally, treating and processing e-waste is an expensive task and space becomes a huge challenge. The problem is convoluted by the toxicity of the waste that is being handled by workers and dumped unsafely in municipal yards.

According to Ewuim et al (2014), e-waste has been implicated as being deleterious to soil quality, soil fauna and flora especially from studies outside Nigeria.

Josh (2015) opined that even in advanced countries recycling and disposal of e-waste pose a significant risk to workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaching of material such as heavy metals from landfills and incinerator ashes.

The main environmental concerns are resource depletion and dangerous substances arising from waste from electrical and electronic equipment. Some electronic equipment and/or its components contain substances that are considered dangerous to the environment and human health if they are disposed of carelessly. Although these dangerous substances are usually only contained in small amounts, they have great potential for causing serious environmental damage. Electronic waste contains more than 1,000 different substances hazardous substances like lead, mercury, beryllium, cadmium, chromium, lithium and brominated flame retardants and so on, which pollutes the environment with the attendant environmental health risk to wildlife and humans (Toxic Links, 2014 and Josh, 2015)

In this way, toxic heavy metals and chemicals from e-waste enter the "soil-crop-food pathway," one of the most significant routes for heavy metals' exposure to humans. These chemicals are not biodegradable—they persist in the environment for long periods of time, increasing the risk of exposure (Otuya, 2018).

According to Otuya (2018), dangers posed by improper disposal on the environment ultimately impacts on human include birth defects (irreversible), brain, heart, liver, kidney, cancer(s), nervous system, reproductive system and skeletal system damage.

Soil can be contaminated in three ways from e-waste:

1) Through direct contact with contaminants from e-waste or the byproducts of e-waste recycling and disposal
2) Indirectly through irrigation from contaminated water and
3) Through incinerated e-waste toxic gases in the atmosphere find their way back to the soil by rainfall.

Much of the soil contamination whether by direct or indirect source is persistent and these pollutants remain in the soil for a long time, some evolving into even more toxic species than in their original form. Shredding or burning of e-waste produces ash which can be heavily contaminated by both heavy metals and flame retardants (polybrominated diphenyl ethers or PBDEs) that leach into underlying soil. Excess heavy-metal accumulation in soils is toxic to humans and other animals (Toxic Links, 2014). These chemical substances can be very harmful to micro-organisms in the soil and plants, as well as animals and wildlife in the food chain that rely on these plants for food and survival. Plants often suffer from damaged cell structure, altered metabolism, and reduced growth in contaminated soils. In addition, some plant species can be doubly impacted by e-waste through the contamination of underlying soil and through direct contact with

III. RESULTS AND ANALYSIS OF E-WASTE GENERATION IN NIGERIA

In this section background information will be given that will give us and insight into the population of Nigeria and the e-waste generation rate. This will be the basis of the calculations and analysis.

The highest per capita e-waste generators (at 17.3 kilograms per inhabitant) is Australia, Europe (including Russia) is the second largest generator of e-waste per inhabitant with an average of 16.6 kg per inhabitant. However, Europe has the highest collection rate (35%). The Americas generates 11.6 kg per inhabitant and collects only 17%, comparable to the collection rate in Asia (15%). Africa, meanwhile, generates 1.9 kg per inhabitant, with little information available on its collection rate.

The Nigeria population was put at eight-eight million, nine hundred and ninety-two thousand, two hundred and twenty (88,992,220) in 1991 and this grew by fifty one million, eleven thousand, three hundred twenty-two (51,011,322) to one hundred and forty million, three thousand, five hundred and forty-two (140,003,542) in the 2006 census (Agande, 2006). Nigeria is the 39th the most populous country in the

world, has 36 states and 774 local government areas (World Population Review).

Other facts about Nigeria population from worldometer website.

- Nigeria population is equivalent to 2.6% of the total world population.
- The population density in Nigeria is 221 per Km^2 (571 people per mi^2).
- The total land area is 910,770 Km^2 (351,650 sq. miles)
- 51.9 % of the population is urban (104,282,822 people in 2019)

From figure 1 it is observed that the population of Nigeria has grown from about 40 million in 1954 to a staggering figure of over 180 million people 2019. Figure 2 shows the yearly growth rate of the population and it is observed that the population growth rate has been on the increase since the 1960s and it pecked in the 1980s and from the 1990s till date it has almost been stable.

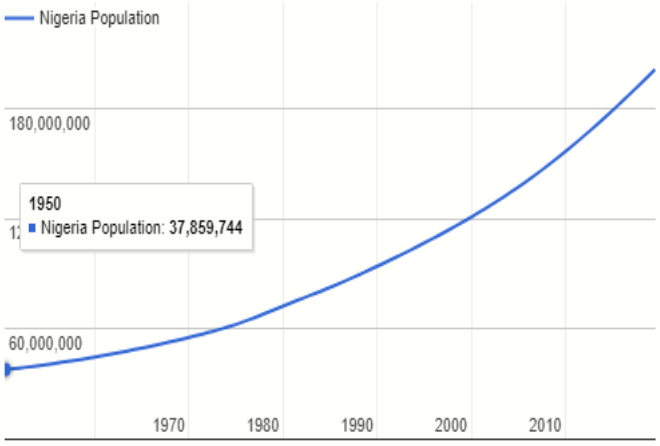

Fig 1: showing Nigeria population 1950-2019 (source: worldometer website)

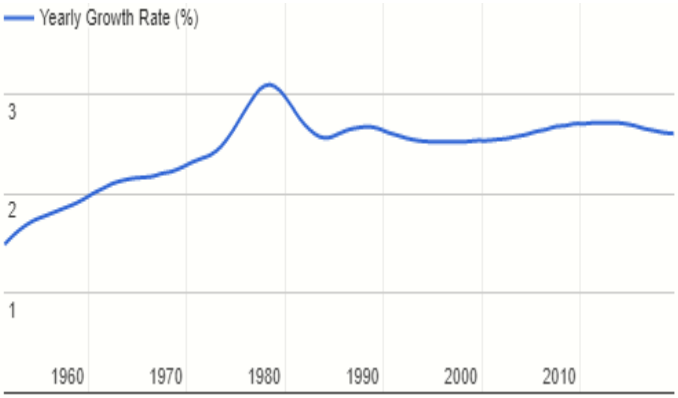

Fig 2: show yearly growth rate of Nigeria population (source: wrldometer website)

Table 1: showing population of Nigeria

Year	1970	1980	1990	2000	2010
Population	55,981,400	73,460,724	95,269,988	122,352,009	158,758,261

(Source: Word Population prospects, 2017).

Arithmetic Change (Projection)

The arithmetic growth rate is expressed by the following equation:

$$r = \left(\frac{P_t - P_0}{t}\right) \div P_0 \times 100 \quad \text{------ (1)}$$

Table 2: showing arithmetic projected population of Nigeria

Year	Population	Incremental value
1970	55,981,400	0
1980	73,460,724	17,479,324
1990	95,269,988	21,809,264
2000	122,354,009	27,084,021
2010	158,758,261	36,404,252
Total		102,776,861
Mean		20,555,372

Projected Population 2020	160,813,633
Projected Population 2030	162,869,005
Projected Population 2040	164,924,377
Projected Population 2050	166,979,749

Geometric Change (Projection)

- A geometric series is one in which the population increases or decreases at the same rate during each unit of time, usually a year.

- If this constant rate of change is represented by r and the initial population is represented by P_0, then after t years the final population is given by the following equation:

$$P_t = P_0(1+r)^t \quad \text{--------- (2)}$$

So that, the geometric growth rate r can be expressed in the following equation:

$$r = \sqrt[t]{\frac{P_t}{P_0}} - 1 \quad \text{--- (3)}$$

Table 3: showing Geometric projected population of Nigeria

Year	Population	Incremental value	Geometric incremetal rate
1970	55,981,400	0	0.00
1980	73,460,724	17,479,324	0.31
1990	95,269,988	21,809,264	0.30
2000	122,354,009	27,084,021	0.28
2010	158,758,261	36,404,252	0.30
Total		102,776,861	
Geometric mean		0.30	

Projected Population 2020	206,385,739
Projected Population 2030	268,301,461
Projected Population 2040	348,7918,99
Projected Population 2050	453,429,469

Table 4: showing projected e-waste generation of Nigeria per inhabitants

Geometric Projection	**Projected Population**	**Projected eWaste generation (Kg)***	**Convert Kg to metric tonne****
2020	206,385,739	392,132,904	392,133
2030	268,301,461	509,772,776	509,773
2040	348,791,899	662,704,608	662,705
2050	453,429,469	861,515,991	861,516
Arithmetic Projection	**Projected Population**	**Projected eWaste generation (Kg)***	**Convert Kg to metric tonne****
2020	160,813,633	305,545,903	305,546
2030	162,869,005	309,451,110	309,451
2040	164,924,377	313,356,316	313,356
2050	166,979,749	317,261,523	317,262

*Africa e-waste generation rate 1.9 kg per inhabitant, according to UNU ** calculateme.com
1kg = 0.001t

The arithmetic population shows that the population increases by a constant value every ten years. The population will increase from 160 million in 2020 to 169 million in 2050 which is an increase of about 6.7 million. The e-waste generation at 2020 is projected to be 305.5 million Kg which increases to 317 million Kg. For the geometric projection the population of 2020 wills more than double by 2050 from 206 million to 453 million. The e-waste will generation will increase from 392 million Kg in 2020 to 861.5 million Kg in 2050 indicating that the eWaste will also more than double by 2050.

The e-waste generation per inhabitant will increase from 305 thousand metric tons in 2020 to 317 thousand metric tons in 2050 using the arithmetic projection estimates for population growth and for the geometric growth of population the e-waste will increase by more than 400 thousand metric tons from 2020 to 2050.

IV. CONCLUSION

The e-waste generation rate of 1.9kg per inhabitant in Africa as applied to Nigeria shows that e-waste will continue to increase except something is done. Calculating the e-waste generation using two population projection method shows that population will grow from over 161 million in 2020 to over 453 million in 2050 and the e-waste generation will increase from 305 million kg in 2020 to 861 million kg in 2050. When comparing the e-waste generated to substances like water, coarse sand, topsoil it shows that by 2050 an equivalent of 861 m^3 of pure water, 1.4 million m^3 of coarse sand and 1.2 million m^3 of topsoil.

Not only the quantity of e-waste generated/generation is the challenge but the fact is that also e-waste also constitutes chemicals which are detrimental to health and as such is globally associated with environmental-land contamination and pollution.

Technology is advancing at an exponential rate; new electronics are faster, smaller, and more convenient to use. What about that old phone, computer, or camera that is discarded because there are newer and fresher alternatives? We live in a consumer driven society that is constantly buying, upgrading, and replacing current technology (Park et al, 2017).

The problem of e-waste is not only a global issue but a local one it constitutes a major environmental and health challenges in Nigeria as a country. For us as a country to combat the monster e-waste Nigeria needs:

a) To enact and enforce legislation on e-waste management
b) To empower it regulatory bodies to carry out their functions
c) Develop and adopting standard waste management system and options specifically for e-waste
d) Control importation and shipping of used electronic gadgets

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