E3 Journal of Environmental Research and Management Vol. 7(2). pp. 0029-0037, December, 2016
Available online http://www.e3journals.org
ISSN 2141-7466 © E3 Journals 2016
DOI : http://dx.doi.org/10.18685/EJERM(7)2_EJERM-16-017

Full Length Research Paper

Dioxin emission and industrial solid waste in Kano metropolis, Nigeria

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Accepted 24 October, 2016

This study assesses Dioxin and solid waste in Kano Metropolis, Nigeria. The main sources of Dioxin considered included products and residues, from production and waste combustion from tanneries, grain mills, upholstery, plastics, textiles, petroleum and metals industries. The study covered the four industrial zones of Sharada (zone 1), Bompai (zone 2), Challawa (zone 3) and Hadejia (zone 4) with about 225 major manufacturing industries in Kano State. Samples were collected in stages using stratified, purposive and random sampling methods. Questionnaire and checklist were used for data collection. Environmental compartments considered included air, water, land, products and residues for the year 2014. Descriptive statistics were used to analyze data on identification of relevant industries, and estimation of Dioxin emission potentials. The results obtained showed that tannery, milling, textile, metal, upholstery, petroleum and plastic industries were the maint sources of Dioxin emission within the study area, having extremely high potential releases of 92.1290380335gTEQ/A from 165 industries in Kano metropolis for year 2014. Tanneries potentially contributed 93.51% of the total emissions of Dioxin. The study found out that emission of Dioxin and related compounds reflects the poor pollution control and waste management practices been carried out by the industries.

Keywords: Dioxin, Waste, Emission, Toxic, Pollution

INTRODUCTION

The term 'Dioxins' is used to describe a group of unintentionally produced Persistent Organic Pollutants (POP) including Polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) and certain dioxin-like polychlorinated biphenyls (PCBs) with similar toxic properties (WHO, 2010). Just like other POPs, they resist photolytic, biological, and chemical degradation; break down slowly in the environment; and accumulate in in the body fat of animals (URT, 2005). These chemicals are environmental contaminants detectable in almost all compartments of the global ecosystem in trace amounts; and unlike other POPs they have never been produced intentionally and have never served any useful purpose unlike other POPs, but are formed as unwanted by-products in many industrial and combustion processes (Heidalore et al.1990)

Dioxins are released through natural and man-made sources. Although insignificant, natural hazards such as forest fires and volcanic eruptions do release Dioxins (WHO, 2010). Man-made sources can be divided into primary and secondary sources. The primary sources include industrial and thermal (combustion) processes. Secondary sources are Dioxin reservoirs transferred from primary sources and are present in sewage sludge, compost, and liquid manure used for fertilization in agriculture and gardens, (Heidalore, *et al*., 1990).

The European Commission, under the Waste Framework Directive (WFD) 2006/12/EC as amended by the new WFD Directive 2008/98/EC (European Commission, 2008) defines waste as "any substance or object the holder discards, intends to discard or is required to discard." According to Organization for Economic Co-operation and Development-OECD, (2003), "wastes are materials that are not prime products (that is product produced for the market) for which the generator has no further use in terms of his\her own purposes for

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production, transformation or consumption, and of which he/she wants to dispose".

According to the United States Code of Federal Regulations (1995), solid waste includes garbage, refuse, sludge, and other discarded solid materials, including waste materials resulting from industrial, commercial, and agricultural operations, and from community activities. The Code further classifies solid waste according to sources of generation as commercial, institutional, residential, agricultural, and industrial solid wastes. Irrespective of its source, waste is known to cause harm to health and the environment if not properly managed.

Industrial solid waste, as defined by Zero Waste America (2010), is solid waste generated by industrial and manufacturing processes. The US Environmental Protection Agency, proposes the waste management hierarchy as the most environmentally sound strategies for waste management (USEPA, 2011). For various reasons, including costs and available technology, disposal is usually employed by industries in most developing countries. Common practices of solid waste disposal include land filling, burial, dumping, and waste burning. The latter, whether controlled or uncontrolled is usually the preferred option of solid wastes disposal mostly because it is not costly and it quickly takes the waste out of sight.

However, burning of waste, which typically occurs at low temperatures (200 ^{o} C -700 ^{o} C) and low oxygen supply, poses potential adverse effects to the surrounding environment. Research has shown that hydrocarbons and chlorinated materials in manufacturing and combustion processes under suitable temperatures and pH, promote the emission of a wide range of toxic substances including volatile organic compounds (VOC), hydrogen chloride, heavy metals, carbon monoxide, oxides of sulphur and nitrogen and Dioxins (Saskatchewan Environmental Ministry, 2010).

Dioxins are a group of highly toxic chemically related compounds that are persistent environmental pollutants (World Health Organization, 2010). It is formed during the combustion (burning) of materials and the manufacture of certain chlorinated chemicals (California Environmental Protection Agency, 2010). They are tricyclic aromatic compounds (Secretariat of the Stockholm Convention, 2009) and include several types of poly halogenated aromatic hydrocarbons: polychlorinated dibenzofurans (PCDFs); some types of poly-chlorinated biphenyls (PCBs); and polychlorinated dibenzo-*p*-dioxins (PCDDs). The term is also sometimes used to refer to 2, 3, 7, 8-tetrachlorodibenzo-p-dioxins (TCDD) which is the most potent member of the group (Olivier *et al*., 2008).

The Stockholm Convention on Persistent Organic Pollutants (SSC, 2009) classifies Dioxins as Persistent Organic Pollutants (POPs). These are organic chemical that possess a particular combination of physical and chemical properties such that, once released into the environment, they remain intact for exceptionally long periods of time; become widely distributed throughout the environment; accumulate in the fatty tissues of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and are toxic to both humans and wildlife (USEPA, 2011), causing diseases such as cancer, endocrine and reproductive disorders (International POPs Elimination Network-IPEN, 2011).

Dioxins were never produced intentionally as marketable products (Roland, 2010). They are unwanted byproducts of a wide range of anthropogenic activities. Factors promoting the formation of Dioxins include presence of organic material, metallic catalyst, chlorine or chlorinated compounds and a temperature of between 200 ˚C – 650 ˚C (Eric, 2011). The major sources of Dioxin emission into the environment are combustion and industrial activities (Heidalore, Hutzinger, and Timms, 1990).

Combustion sources of Dioxins including incineration and open burning of wastes at dumpsites, landfills, residences, and industrial/factory premises, constitute significant release as a result of incomplete combustion. In combustion and incineration processes, the presence of chlorine or chlorine compounds and a temperature range between 200-650℃ provide the optimum conditions for the formation of dioxins. Dioxins may still form at higher temperatures (800-1200℃) but in much smaller quantities (Department of the Environment, Water, Heritage and the Arts, Australia (DEWHA, 2005). Significant emission from industrial processes; include sources such as pulp and paper industries, metallurgical processes, manufacture of flame-retarded plastics, textiles, leather dyeing and finishing, food processing especially dairy products, and the manufacturing of some herbicides and pesticides (Heidalore, Hutzinger, and Timms, 1990; UNEP, 2005).

Short-term exposure of humans to high levels of dioxins may result in skin lesions such as chloracne, patchy darkening of the skin; and altered liver function. Long-term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. Chronic exposure of animals to dioxins has resulted in several types of cancers. TCDD was classified by the WHO's International Agency for Research on Cancer (IARC) in 1997 as a known human carcinogen. More than 90% of human exposure is through food, mainly meat and dairy products, fish and shellfish (WHO, 2010).

As a result of their global and wide range distribution, persistence and toxic effects, Dioxins have received much global attention. In 2001, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) performed an updated comprehensive risk assessment of PCDDs, PCDFs, and established a provisional tolerable monthly intake (PTMI) of 70 picogram/kg per month. A joint WHO/ FAO Codex Alimentarius Commission, established a 'Code of Practice for the Prevention and Reduction of

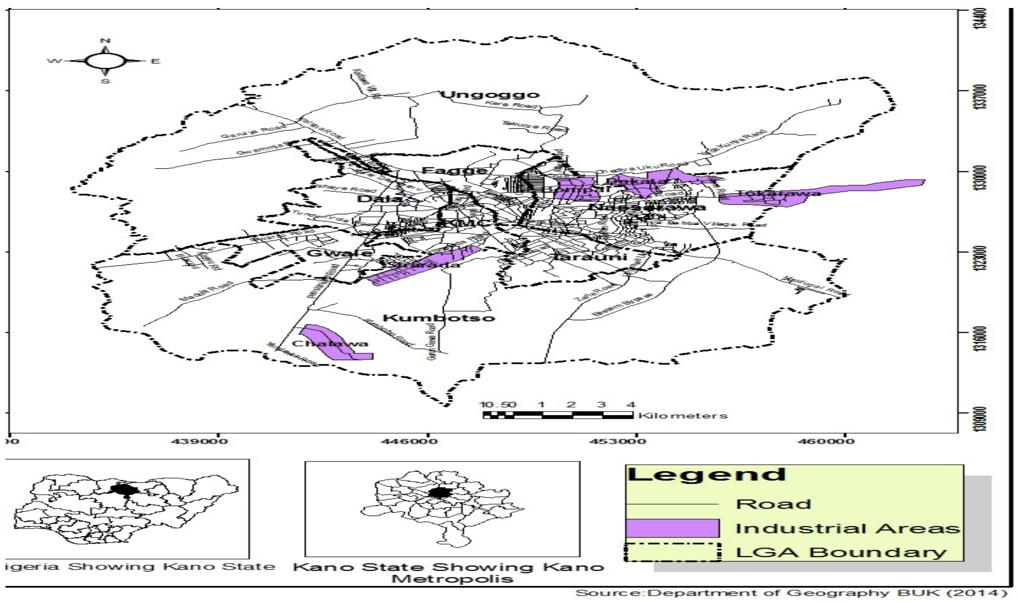

Figure 1: Map of the Study Area showing the Industrial areas
Source: Department of Geography BUK 2014

Dioxin and Dioxin-like PCB Contamination in Foods and Feed' (Codex, 2006). After its establishment in May 2004, the Stockholm convention on POPs has been conducting periodic assessment of POPs including dioxins in ambient air in several countries including Nigeria, as an effectiveness evaluation (MONET Africa, 2009). In 2008, WHO and United Nations Environment Programme (UNEP) conducted a survey of POPs, including dioxins, in human milk (FMENV, 2010). In 2010, the Global Environment Facility (GEF)/ UNEP enhanced the capacity of some laboratories in some less developed countries, on POPs analyses (FMENV, 2011).

At the national level, Dioxin releases from municipal, agricultural and medical waste are being controlled in some States. After the development of the Nigerian National Implementation Plan (NIP) for the Stockholm Convention on POPs, this highlighted Dioxins and Polychlorinated Biphenyls (PCBs) as POPs of concern in Nigeria (Federal Ministry of Environment, 2010). Federal Medical Centers were equipped with incinerators for safe disposal of medical waste; and baseline inventories of Dioxin emission from burning of municipal and agricultural wastes, were conducted in several States of the Federation. Currently, a pilot intervention project is ongoing in Kano and Anambra States which aims at reducing emissions from open burning of Municipal and Agricultural wastes through introduction of best environmental practices using best available techniques. However, Dioxin release from industrial activities is yet to be given sufficient attention, despite indications of possible emissions that could lead to severe pollution, from various industrial activities. As a result, this study identifies relevant industrial sources of Dioxin emission and their distribution in Kano Metropolis, Kano state, Nigeria. The study also estimate potential Dioxin emissions into air, water, land, products and residues, from production and waste combustion from tanneries, grain mills, upholstery, plastics, textiles, petroleum and metal industries.

MATERIALS AND METHODS

The Study Area

Kano Municipality is located within latitude $11^0 50'$ to $12^0 07'$ N and longitude $8^0 22'$ to $8^0 47'$ E, and at an altitude of 472 meters above sea level (Mohammed et al. 2014). Kano Municipality covers a landmass of 137 km^2 comprising eight Local Government Areas of Kano Municipal, Gwale, Fagge, Dala, Tarauni, Nassarawa, Ungogo and Kumbotso. It has a population of 2,828,861 at the 2006 Nigerian census, (NPC, 2007). It is bordered by Minjibir, Gezawa, Dawakin Kudu, Madobi and Tofa LGAs to the Northeast, East, South East and South West LGAs respectively (Mohammed et al. 2014). Figure 1 displays the industrial areas of Kano metropolis.

Data utilized for the study

The categories of industries, items produced, and the data on types of industrial waste generated were obtained from Industrial Census conducted by Pollution

Control Department of Kano State Ministry of Environment in 2013.

The Industrial Waste Management Report of selected industries provided information on waste management practices of industries concerned.

Sampling Techniques

Sampling was achieved in four stages:

Stage 1 - Stratified sampling: Industries in all four industrial zones were stratified into categories based on similarities in; usage, production processes, and dioxin emission precursors present; and seven relevant categories selected based on higher Emission Factor (EF) in UNEP (2005) Toolkit.

Stage 2 - Purposive: One product/process type was purposively selected from each relevant category based on higher annual production, widespread product usage/availability, and availability of EF in the UNEP Toolkit.

Stage 3 - Systematic Random selection: Applying equal-probability systematic sampling using the formula i: $k=N/n$ ………………………………………………………………………………………i

Where k is the sampling interval, n is the sample size, and N is the population size (Black 2004). For example, out of the total of 12 textiles companies identified, four were selected using a sampling interval of 3. This was done for all industries, giving the following breakdown for the respective industries: 8 tanneries, 4 rice mills, 8 upholsteries, 17 plastics, 4 textiles, 4 metals and 5 petroleum industries, respectively totaling 50 industries.

Data Analysis

A list of industries with relevance to waste management was obtained from Kano State Ministry of Environment and used for classification and categorization. Relevant categories of industries were then identified based on the presence of precursors (chlorine, metals, heat, and technology) of dioxin formation in their industrial processes. The sampling method adopted complied with the UNEP standardized toolkit for the identification and quantification of dioxin and furan releases (UNEP, 2005).

With the aid of a structured questionnaire, the following information were obtained from the sampled industries:

Annual volume of production,

Annual volume of waste generated

Annual Percentage of waste recycled or burned.

Type of raw materials used.

Manufacturing processes involved.

Data generated from the above information were used to quantify the level of potential Dioxin emission in accordance with the 2005 UNEP Standardized Toolkit designed for the Identification and Quantification of Dioxin Emissions as shown in the following formulae (ii and iii) (adapted from UNEP Toolkit 2005):

SR = EF of R *AR ii

where:

SR (Source Strength) = Dioxin Emission per year for all vectors.

Emission factor (EF) = amount of PCDD/PCDF (in µg TEQ) that is released to any of the five vectors (air, water, land, product, residue) per ton of material manufactured/used or burned. These are default values (constants) provided by UNEP (2005) in the toolkit.

R = Vector (air, water, land, product, residue).

AR (Activity Rate) = the amount of product manufactured/used or waste burned per year.

Therefore,

SR (PCDD/PCDF released per year) = (Σ Emission Factor Air * AR) + (Σ Emission Factor Water * AR) + (Σ Emission Factor Land * AR) + Σ Emission Factor Product * AR + (Σ Emission Factor Residue* AR)……………………………………………………………………………………………iii

Dioxin emission is expressed in grams Toxic Equivalent factor (TEQ) per year.

For both manufacturing process and waste burning, emission factors vary with different product types as shown in Tables i and ii.

For ease of comparisons, results were converted from µg TEQ/A to gTEQ/A using the metric conversion system

RESULTS AND DISCUSSION

Relevant Industrial Sources of Dioxin Emission and their Distribution in Kano Metropolis

The relevant sources of Dioxin emissions and their distribution across four industrial zones in Kano Metropolis were as displayed in Table iii. In terms of sources, plastics had the highest number of industries (57), while grain mills and textiles both had the lowest number of industries (12 each). In terms of distribution, Bompai had highest potential sources of Dioxin (55 industries), while Challawa had the lowest among the zones. The number of industries in a category had minimal influence on its amount of Dioxin.

Uneven distribution of industries could lead to serious point source contamination, with severe health effects on the workers and nearby residents. However, due to the long-range transport tendencies of Dioxins they would still be transported to other areas far away from source of production, implying that non-industrial residential areas are also at risk of dioxin exposure. In a research conducted by Federal Ministry of Environment, air samplers exposed for three months in Jambolo were

Table i: Emission Factors for Manufacturing Process into all Environmental Media

Product	Emission Factor µg TEQ /Ton				
	Air	Water	Land	Product	Residue
Tanneries	NA	NA	NA	1000	NA
Agricultural	NA	NA	NA	NA	NA
Upholstery	NA	NA	NA	100	NA
Plastics	0.4	NA	0.5	0.03	10
Textiles	NA	25	NA	100	NA
Metals	10	NA	NA	NA	15
Petroleum	0.1	NA	NA	NA	NA

Source: Author's Field Work, 2014 adapted from UNEP Toolkit 2005
**NA (Not Available)

Table ii: Emission Factors for Waste burning into all Environmental Media

Product	Emission Factor µg TEQ /Ton				
	Air	Water	Land	Product	Residue
Tanneries	400	NA	400	NA	400
Agricultural	30	NA	10	NA	NA
Upholstery	400	NA	400	NA	400
Plastics	400	NA	400	NA	400
Textiles	400	NA	400	NA	400
Metals	400	NA	400	NA	400
Petroleum	400	NA	400	NA	400

Source: Author's Field Work, 2014 adapted from UNEP Toolkit 2005

Table iii: Relevant industrial Sources of Dioxin Emission and their distribution in Kano Metropolis

Category	Products	Distribution				
		Sharada	Challawa	Hadeija	Bompai	Total
Tannery	**Footwear,Leather bags and Wallets**	6	13	2	5	26
Grain Mills	**Rice, Sorghum, Wheat.**	1	1	7	3	12
Upholstery	**Wood, Foam, Textiles, Gums, Sealants, Lacquers, Poish.**	11	2	5	10	28
Plastics	**PVC pipes, Polythene bags, Sacks, Mat, Mattress and Shoe soles.**	19	4	13	21	57
Textiles	**Cotton, Rugs, Real wax, Towels, Blankets and thread.**	4	2	0	6	12
Metals	**Iron and Steel, Copper wires, Aluminum, Roofing sheets, cooking stoves and kitchen-wares.**	6	2	2	3	13
Petroleum	**Engine oil, LPG gas and other lubricants.**	3	1	6	7	17
Total		50	25	35	55	165

Source: Author's Field Work, 2014

analyzed and found to contain 264.63pgTEQ, (FMENV, 2013); the location for air sampling was far from any known emission source emission sources.

These types of industries found in the study area are the major emissions of Dioxins as exemplified in the studies by Heidalore, Hutzinger, and Timms, (1990); and UNEP, (2005), which identified these same industries as relevant sources for dioxin emission. Another study by Codex (2006) on dioxin reduction in food and feed identified milling as a source of Dioxin emission. These results also agree with the study conducted by Chien-Min (2004), which listed chemical industries and fuel consumption as sources of Dioxins in Taiwan. It also agrees with the study conducted by Quinn, Jordaan, Bouwman and Pieters, (2007), which listed ferrous & non ferrous metal production, mineral production, power generating as relevant sources of Dioxin production in Potchefstroom, South Africa. However, the current study did not consider mineral production as relevant source category due to the very few industries present and their relatively low volume of product manufactured. There is limited published information on distribution of relevant sources known to release Dioxin across the Kano industrial zones.

Environmental and Health Implications of Dioxin Emissions

The risk of getting cancer from dioxin - over and above the risk of cancer from other sources - is one in a hundred for the most sensitive people who eat diets rich in animal fats; this is a worst case scenario, (AOAC, 2009). For the average person, the risk of cancer from dioxin is one-in-a thousand, also considered a serious risk level, (AOAC, 2009). In like manner, Yakasai et al.(2013) studied the pattern of gynecological malignancies in Aminu Kano Teaching Hospital and found that 10.7% of women under the study had gynecological malignancy, of which 48.6% had cervical cancer, 30.5% had ovarian cancer, 11.2% had endometrial cancer and 9.24% had choriocarcinoma.

Ibrahim, Abdullahi, Hassan-Hanga, and Atanda (2014) studied the pattern of childhood malignant tumors at the Aminu Kano teaching hospital and the results revealed various forms of malignant lymphomas (Burkitt's, Non-Hodgkin, and Hodgkin); retinoblastoma; nephroblastoma 12.5%, acute leukemia's 14.1%; neuroblastoma 5.5%, rhabdomyosarcoma 1.9%; and CNS and Hepatic tumors 4.3%. 51% of patients were alive at 12 months and the mortality was 24%. The study concluded that childhood cancer was common in Kano.

A research by Mohammed et al. (2008) analyzed the profile of cancers recorded from1995-2004 in the Kano cancer registry. The results revealed a steady rise in frequency of cancer over the period, where a total of 1990 cancer cases were recorded comprising of 1001 (50.3%) males and 989 (49.7%) females. Cancers of the cervix (22.9%), Breast (18.9%), Ovarian (8.2%), non-melanoma skin cancer (6.3%), and Uterus (6.2%) were the most frequent female cancers. In males, cancer of the prostate (16.5%), bladder (10.2%), non-melanoma skin (9.9%), colorectum (9.3%) and connective tissue (6.3%) were most common. Burkitt's lymphoma (31.4%), other lymphoreticular cancers (23.8%) and retinoblastoma (20%) predominated in children.

Considering the serious risk level of dioxin, extremely high dioxin emission potentials in Kano (as shown by this study), and the rising prevalence of cancer in Kano, it would be place to consider dioxin exposure as a major causal agent of cancer in Kano State. Neurological disorders, which are also strongly associated with dioxin exposure also, have a serious prevalence in Kano. Mukhtar-Yola, Belonwu, Farouk and Mohammed (2005) studied the prevalence of congenital malformations among inborn babies at Aminu Kano teaching hospital. Results of the study reveal that prevalence of congenital malformations was 5.5/1000 total births and it was concluded that the contribution of congenital malformations in Kano may be higher than the study reports as diagnosis is often missed because of low autopsy rates and non-availability of advanced diagnostic facility. Nonetheless, a prevalence of 5.5/1000 is considered serious. Other neurological diseases in Kano include myelopathies, Central nervous system infections, GullainBarre syndrome, Parkinson's disease, (Owolabi et al. 2010).

There are also increased cases of diabetes among pregnant women (Omole-Ohonsi and Ashimi, 2011), and in children (Adeleke et al. 2010). Emokpae et al. (2006) observed the pattern of hormonal abnormalities and testicular pathology in azoospermic male in Kano; the results revealed 40% of infertile men studied had abnormal hormonal levels. The researchers concluded that endocrine disorders contribute highly to male infertility, they claimed that the main reason for the endocrinopathies is not known. They however suggested environmental factors, endocrine disruptors and genetic polymorphism have been suggested to be contributory; these factors have all been associated with dioxin exposures.From the prevalence of the diseases associated with dioxin exposures it is suggested that the extremely high emissions in Kano are important contributors to these diseases. The close proximity of industries with residential areas increases exposure of residents to these high dioxin emissions. Dioxin’s ability to travel wide further exposes more people to contamination. Beat Available Techniques (BAT) and Best Environmental Practice (BEP) measures backed by strict regulations, monitoring and enforcement, must be put in place in the industrial sector to control dioxins and other toxic emissions from industrial practices

Table iv: Annual Potential Dioxin Emissions from Industrial Manufacturing and Waste Combustion processes in Kano Metropolis

Industrial Category	Activity Rate		Annual Emission gTEQ/A	% Emission
	Vol. manufactured (tons/annum)	Vol. burned (tons/annum)		
Tannery	72800	10920	85.904	93.51
Grain Mills	22320	446.4	0.17856	0.19
Upholstery	1092	43.68	0.270816	0.28
Plastics	50160	250.8	0.8492088	0.89
Textiles	18360	459	2.8458	2.97
Metals	52000	130	2.08	2.17
Petroleum	4.335	0.54196	0.0006528	6.61E-4
Total	216736.335	12250.4242	92.1290380335	

Source: Author's fieldwork 2014.

Annual Potential Dioxin Emissions from Industrial Manufacturing and Waste Combustion processes in Kano Metropolis

Table iv describes the activity rate, (comprising annual volume of manufactured products and waste burned) and the annual dioxin emissions from each industry in Kano metropolis. In terms of products manufactured, metals had the largest volume (4000 t/a) and petroleum the lowest (0.255 t/a). The difference is as a result of difference in product demand and consumption. In terms of waste combusted, tanneries had the largest volume (420 t/a), and petroleum the lowest (0.03188t/a). Volume of waste burned is influenced by rate of recycling in each sector. For example according to the respondents interviewed during fieldwork, 99.75% of metal waste was recycled and only 0.25% was burned while in tanneries 75% of waste was recycled and up to 15% was burned.

In terms of emissions, tanneries had the highest potential Dioxin emission (93.24%) and petroleum had the lowest (6.61e-4%). High emissions result from high emission factors and the number of environmental compartments receiving the emissions. Total potential Dioxin emission was 92.1290380335gTEQ/A for Kano metropolis for the year 2014. This result agrees with that conducted by USEPA in 2000 (USEPA, 2006), which estimated 132.2 gTEQ/A from certain industrial sources.

In comparing this result with similar works done elsewhere, the result differs with that of the inventory conducted by the United Republic of Tanzania-URT in 2005, which estimated Dioxin releases from industrial sources to be 0.96939 gTEQ/A, (URT, 2005). The difference is because chemical sources like tanneries, textiles and plastics were not considered in the Tanzanian inventory. Results also differ from the study by Siegmund *et al.,* (2008), which showed that emission from tanneries was below limits of detection (negligible), for the entire nation of Austria. This difference is explained by the very strict regulations on industrial POPs emissions in the entire EU region. Hence emission factors are zero.

Use of raw materials like Chloranil and Pentachlorophenols, and poor emission control devices during manufacturing, as well as poor waste management options were responsible for the high potential Dioxin emissions in the industrial sector of Kano metropolis. Comparing releases with the EU standard of 7.2e-8 gTEQ/A shows gross dioxin contamination in tannery product. There is need for regulators to impose stricter emission standards for manufacturing processes as well as best waste management options.

CONCLUSION

Quantifying emissions of dioxin and related compounds in the industrial sector reflects the poor waste management practices and poor industrial technologies being applied in Kano specifically and Nigeria as a whole. From the analyses of the questionnaires and the researchers' observations, the use of dyes and preservatives containing Pentachlorophenols and other chlorinated and organic compounds were common in tanneries, textiles, upholstery and plastic industries (Appendices I, II, & III). These chemicals were also found as impurities in the metal and petroleum industries and their combination with other factors like high temperatures, alkaline conditions and metal catalysts, facilitate emissions. These chemicals have been banned or severely restricted in developed countries but are still in continual use in Nigeria. Their continuous use in Nigeria is as a result of their availability, affordability, and lack of knowledge of the adverse effects they pose to human and animal health and the environment at large could spell disaster that needs to be stemmed. Policy makers can create an enabling environment for reduction

of dioxin and other toxic emissions through the following:
Federal government should enforce ban or restrictions of chemicals that have received similar treatment from the various chemicals-related international conventions to which it is a party;
The Federal Government should promote research effective and affordable alternatives to unsound chemicals, while in the short term subsidize cost of imported alternatives.
The Federal Government should strengthen border controls to prevent illegal importation of unhealthy chemicals. This will involve training customs officers on identifying such chemicals;
Federal Government in collaboration with Kano State Government should conduct series of awareness creation for manufacturers through campaigns and training including, adverse effects of Persistent Organic Polluters (POP), Best Available Techniques (BAT) and Best Environmental Practices (BEP);
Federal Government in collaboration with all State Governments should review, update and enforce Federal and State regulations and legislations on industrial practices. This process should discourage use of old technologies in manufacturing, adopting BAT and BEP.
Federal Government in collaboration with all State Governments should develop policies on UPOPs reduction from industrial and transportation sectors;

Kano State government should follow up the signing of the waste management and sanitation by-laws by the judiciary, which was updated through the efforts of the 'Less Burnt for a Clean Earth Project' of the Federal Ministry of Environment in 2014. These by-laws now contain provisions on UPOPs emission reduction through prohibition of open burning of waste.

ACKNOWLEDGEMENT

This Project was conducted under the "Less Burnt for a Clean Earth: Minimization of Dioxin Emission from Open Burning Sources in Nigeria" Project domiciled with the Pollution Control & Environmental Health Depart, Federal Ministry of Environment, funded by Global Environment Facility (GEF), and overseen by the United Nations Development Programme (UNDP).

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