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Measurements of Carcinogenic Pollutants at Cement Industries in Nigeria and Neighbouring Countries

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Abstract

The source identification of Polychlorinated Dibenzo-p-Dioxins (PCDDS) and Polychlorinated Dibenzo-p-Furans (PCDFS) in West Africa has been the most difficult problem to tackle due to the unavailability of the facility to analyse the samples and high cost of sampling equipment. This study is based only on the determination of the PCDDS/PCDFS at cement industries in Nigeria, Cameroun and Benin Republic. The sampling adopted the gravimetric (method) principle for extractive source analysis using *Paul Gothe Bochum* stack sampler and PCDDS/PCDFS traps from Concept Life Sciences Laboratory in the UK. The traps were exposed using the standard guidelines and transported back to the same laboratory for analysis in the UK. The parameters recorded during PCDDS/PCDFS sampling are stack temperature, ambient temperature, pressure, flow rate and moisture content at isokinetic mode. The PCDDS/PCDFS results from different cement industries are: Nigeria (Plant A = 0.0209 ng/TEQ/Nm^3; Plant B = 0.0316 ng/TEQ/Nm^3), Cameroun (Plant C = 0.0062 ng/TEQ/Nm^3; Plant D = 0.0143 ng/TEQ/Nm^3) and Benin Republic (Plant E = 0.0101 ng/TEQ/Nm^3). All the results recorded are below Nigerian emission standards and international emission standards. By comparing the standards, the disparity between Nigeria and other international countries is high while other neighbouring countries do not have the PCDDS/PCDFS standard. This might be due to typographical errors or the paucity of data for PCDDS/PCDFS from different sources to review the standards. Based on the nature of PCDDS/PCDFS on humans and ecosystems, the major concern is long-range transmission and accumulation in the food chain and animals. From this study, it is observed that the determination of PCDDS/PCDFS from other sources will be a great achievement for the implementation of reduction mechanism strategies. It is being recommended that the Nigerian Government should carry out a national emission inventory along with neighbouring countries. Also, existing standards and regulations on open burning, industries, mobiles and dumpsites should be strictly implemented.

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1. Introduction

Environmental pollution issues have occupied a pride of place in global discourse for some time due to human activities and natural sources. In the quest for environmental protection, air pollution has been most difficult to tackle because of the relative difficulty in air sampling and analysis compared to the other components, and it is probably more critical than the others from health and ecological considerations. There are two highly contaminating toxic chemicals having serious carcinogenic effect on human and environs as major pollutants viz: Dioxins and Furans (Muhammad and Amina, 2019). Dioxin and furans are family of chlorinated hydrocarbon

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compounds which are categorized into three main classes as: polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxin like polychlorinated biphenyl (DL-PCBs) (Safe *et al.*, 2012). Unfortunately, there is no facility in Africa at the present time for the analysis of these air pollutants (Muhammad and Amina, 2019). In a recent global burden disease evaluation, the number of deaths due to ambient $PM_{2.5}$ (respirable faction) in Nigeria was estimated at 49,100 for 2017, of which children under age five accounted for 29,900, or 61 percent in total (IEA, 2018). The health impact of air pollutants is determined by its concentration and duration of exposure. The air we breathe represents a medium which is taken in daily by all people just as we take in food and drink. On the average, an adult breathes approximately 20 m^3 per day of air which corresponds to a mass of 25 kg. While humans can live without solid food up to 40 days, it is impossible to live longer than a few minutes without air to breathe. Several updates to the Harvard Six Cities study and the study of the American Cancer Society group continue to cite consistent and significant associations between long-term exposure to $PM_{2.5}$ and mortality (Krewski *et al.*, 2009; Lepeule *et al.*, 2012). Also, several epidemiological studies carried out identified long-term exposure of ambient $PM_{2.5}$ as major contributor to premature mortality, primarily due to respiratory, cancer and heart diseases which lead to chronic bronchitis, hospital admissions, work loss days, restricted activity days and acute lower respiratory infections in children (Hunt *et al.*, 2016; World Bank, 2016).

PCDDs and PCDFs are produced from different anthropogenic activities like forest fires, domestic and hospital waste incineration (Urban *et al.*, 2014). They are by-products of the synthesis or combustion of chlorine-based compounds that include some of the most toxic chemical substrates. Polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) are produced accidentally due to inadequate combustion, as well as during the manufacturing and formulation of chlorinated pesticides and other substances. There are about 70 dioxins, out of which seven are considered most toxic to humans, aquatic and terrestrial organisms, causing congenital mental retardation (endocrine disrupting) and physical disorders. Many industrial processes are likely to generate a huge amount of industrial waste, which is openly burned without any safety measure, producing huge quantity of Polychlorinated dibenzo-pdioxins. Dioxins are highly poisonous chemicals that are everywhere in the environment by burning processes, such as commercial or municipal waste incineration, backyard burning, and the use of fuels, such as wood, coal, or oil (Muhammad and Amina, 2019). In this study, stack emission measurement were carried out at five different cement industries within West Africa to determine the level of PCDDs / PCDFs.

2. Materials and Methods

2.1. Description of the Study Area

The sampling was carried out at cement industries located in Nigeria, Cameroun, and Benin Republic. These involved different locations at each aforementioned country to confirm the variations based on different type of materials used for the production of its cement. Two cement industries each were studied in Nigeria and Cameroun while one cement industry was monitored in Benin Republic. Figure 1 represents the sampling stations for the measurements within West Africa.

2.2. Sampling and Analysis

For stack emission monitoring of dioxin and furan, sampling adopted the gravimetric (method) principle for extractive source analysis. Sampling was undertaken on sampling train of the stack flue gas with the *Paul Gothe Bochum* stack sampler as the probe. The Paul-Gothe stack sampler ensured that such sampling train was in iso-kinetic balance with the flue gas conditions in the stack. The period of sampling lasted for six hours as specified in the procedure using across the sampling ports of the stack at different probe segments, during which the stack velocity, temperature, pressure, moisture content and mass concentration were determined as in EN 13284-1 European guideline (European Standard, 2017) . The traps from Concept Life Sciences Laboratory, UK contain quartz filter, washing bottle and Amberlite XAD-2. The quartz filters were conditioned and weighed before and after sampling in order to determine the mass concentration of particulates collected. Mass concentrations were collected on a pre-weighed filter media dried to constant weight, re-weighed after sampling under the same conditions, with sampled air volume measured. The nozzle of the sampler probe was fitted with filter media, which collects the fine particulate as the air passes through the gas pump with silica gel during sampling. The measuring device extracts the dioxin and furans isokinetically according to the European guideline EN 1948-1. Semi-volatile organic compounds associated with particulate matter are collected in the front-half components of the sampling train. Semi-volatile organic compounds not collected by high efficiency glass or quartz fibre are adsorbed on porous,



Figure 1: Sampling Stations within West Africa (NOP, 2019).

polymeric resin, Amberlite XAD-2. The borosilicate or quartz liner encased in a stainless-steel tube is required to perform stack monitoring. This stainless-steel tube is capable of maintaining the exit gas temperature at 120 ± 14 °C or at required temperature necessary to prevent condensation during sampling (Figure 2). The exposed traps for dioxins and furans were sealed up with foil paper after the sampling for further analysis at Concept Life Sciences in United Kingdom.

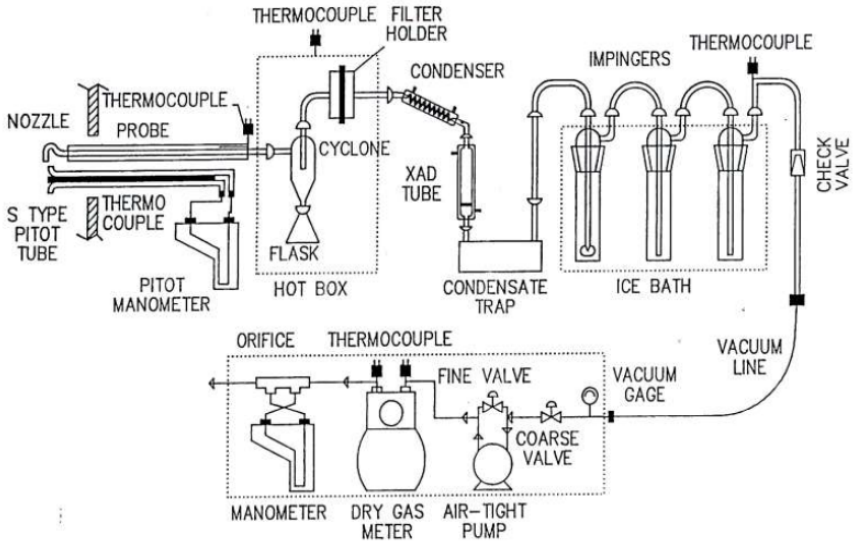


Figure 2: Schematic Diagram for the Sampling Train of Dioxin and Furan sampling.

After the extraction of the samples in the laboratory, the analytes were injected into Gas Chromatography/Mass Spectrometry (GC/MS) instrument for the determination of PCDDs / PCDFs concentrations. This instrument has capability to separate chemical mixtures (the GC component) and identifies the components at a molecular level (the MS component).

3. Results and Discussion

The results of dioxins and furans and their properties during sampling at different cement industries for Nigeria, Cameroun and Benin Republic are presented in Table 1. Also, the international standards for dioxins and furans are in Table 2.

The total dioxins and furans concentrations of the cement industries in Nigeria are far below NESREA limits (100000 ng/TEQ /Nm^3) of National Environmental (Non-Metallic Minerals Manufacturing Industries Sector) Regulations 11, 32 Schedule IV of 2011 (NESREA, 2011). On the other hand, there are no standards for Cameroun and Benin Republic to benchmark the level of total PCDDs/PCDFs. However, the level of total PCDDs/PCDFs at Cameroun and Benin Republic cement industries are below other international standards. By comparing Nigerian standard with other international standards, the disparity is very high due probably to typographic error or paucity of data on PCDDs/PCDFs to review the existing standards and procedures.

Table 1: Results for dioxins and furans with the properties during sampling at different Cement industries within West Africa

Country	**Nigeria**		**Cameroun**		**Benin Republic**
Location/Parameter	**Plant A**	**Plant B**	**Plant C**	**Plant D**	**Plant E**
Stack Temperature (°C)	112.00	134.33	197.00	77.00	101.00
Ambient Temperature (°C)	41.00	43.00	42.25	37.00	46.17
Flow rate (Nm^3/hr)	1303261.0	1018332	111072.6	28272.6	325778.33
Pressure (hPa)	1004	981.67	967.00	1003.5	985.7
Moisture Content (%)	8.00	8.50	10.63	9.00	5.83
Production capacity (mmtpa)	2.20	2.50	0.30	0.10	0.5
Total Dioxin, PCDDs (ng/Nm^3)	0.0143	0.0076	0.00363	0.0061	0.0082
Total Furan, PCDFs (ng/Nm^3)	0.0066	0.0240	0.0026	0.0082	0.0019
Total Dioxins and Furans Concentration (ng/TEQ/Nm^3)	0.0209	0.0316	0.0062	0.0143	0.0101
NESREA Limit for Dioxins and Furans Concentration (mg/TEQ/Nm^3)	0.1	0.1	-	-	-
(ng/TEQ/Nm^3)	100000	100000	-	-	-

N-Normal; TEQ = Toxic Equivalents

For Nigeria and West African countries, it is difficult to estimate the emission of total PCDDs/PCDFs from different sources due to the lack of emission inventory. Since early 1950s, other countries have been able to identify the sources and levels of PCDDs/PCDFs which enabled them to reduce/monitor the level of PCDDs/PCDFs emissions. In the last 30 years, the United State Environmental Protection Agency (USEPA) and other bodies have reduced the production of dioxin levels in United State of America by 90 percent (Urban *et al.*, 2014). Some countries that have

carried out emission inventory are trying to reduce the production of PCDDs/PCDFs because of the impacts on humans and ecosystems.

Table 2: International Environmental Standards for Dioxin and Furan (CPCB, 2004).

Country	Sources	Standards for Dioxin and Furan
Hong Kong	Municipal Solid Waste Incinerator	13 ng / m^3 (Total Mass)
	Chemical Waste Treatment	0.1 ng I-TEQ / m^3
United States of America (USA)	Municipal Solid Waste Incinerator (more than 35 tonnes / day)	13 ng / m^3 (Total mass) about 0.1 to 0.3 ng I-TEQ / m^3
	Hazardous waste incinerator	0.2 ng I-TEQ / m^3
European Union	Waste incinerators	0.1 ng I-TEQ / m^3
Japan	Capacity more than 4 tonnes / hour Capacity from 2 to 4 tonnes / hour Capacity less than 2 tonnes / hour	0.1 ng I-TEQ / m^3 1.0 ng I-TEQ / m^3 5.0 ng I-TEQ / m^3
Canada	All New incinerators	0.08 ng I-TEQ / m^3

I-TEQ = International Toxic Equivalents

The major concerns on the negative impacts of PCDDs/PCDFs within Nigeria and West Africa countries are:

i. Whenever emission is released into the air, some dioxins may be transported long distances. Because of this, they are present almost everywhere in the world.
ii. The release of dioxins via air, contaminate water and settle down into sediments. This can also be further transported or swallowed by fish and other organisms across the borders.
iii. Dioxins may be transported through animals because it can be highly concentrated in the food chain. In animals, dioxins tend to accumulate in fat.

According to the Studies on animals in other countries, it is observed that exposure to low levels of dioxins over a long time, or a high-level exposure at sensitive times and areas, might result in reproductive or developmental problems (Safe *et al.*, 2012). These are the problems that have been linked to dioxins exposure :

i. Birth defects
ii. Cancer
iii. Inability to maintain pregnancy
iv. Decreased fertility
v. Reduced sperm count
vi. Endometriosis
vii. Learning disabilities
viii. Immune system suppression
ix. Lung problems
x. Skin disorders
xi. Lowered testosterone levels
xii. Ischemic heart disease
xiii. Type 2 diabetes

4. Conclusion and Recommendation

In this study, dioxins and furans were measured at five different plants in Nigeria, Cameroun and Benin Republic. The results recorded at all plants in the three countries are far below Nigerian emission standard. Then, disparity in Nigerian standard and other international standards is very high due probably to typographic error or the paucity of data to review the existing standard. Therefore, the major concern of PCDDS/PCDFS is because it has long range of transmission and tendency to accumulate in the food chain and animals. From the recent studies, the impacts of PCDDS/PCDFS are dangerous to the humans and ecosystems.

Based on the nature and impact of PCDDS/PCDFS, it is recommended that the following suggestions should be considered in order to monitor the level of PCDDS/PCDFS in the environment. These are as follows:

- Development of national PCDDS/PCDFS emission inventory program and collaboration with neighbouring countries.
- Review of existing Nigerian Standard and procedures on PCDDS/PCDFS.
- Implementation of newly developed policies, standards and regulations for PCDDS/PCDFS on all sectors.
- Environmental awareness on open burning, dump site, disposal of materials, wood burning, bush burning and illegal land fill.

References

Central Pollution Control Board, CPCB (2004). Dioxin (PCDDs) and Furan (PCDFs) - Critical Persistent Organic Pollutants (POPs). Available at https://www.cpcbenvis.nic.in/cpcb_newsletter/Dioxin.pdf (accessed January 17 2020).

EN 1948-1, (1996). Stationary source emissions - Determination of the mass concentration of PCDDs/PCDFs - Part 1: Sampling. European Standard, CEN, rue du Stassart 36, 1050 Brussels.

European Standard, (2017). EN 13211 of Stationary Source Emissions. Available at https://www.boutique.afnor.org/standard/bs-en-13284-12017 (accessed January 17 2020).

Hunt, A., Ferguson, J., Hurley, F., Searl, A. (2016). Social Cost if Morbidity Impacts of Air Pollution. Available at https://www.oecd-ilibrary.org/content/paper.5jm55j7cq0lv-en (accessed February 21 2020).

International Energy Agency, IEA (2018). Global Burden of Disease. Available at https://www.healthdata.org/gbd/ (accessed retrieved January 17 2020).

Lepeule, J., Laden, F., Dockery, D., Schwartz, J., (2012). Chronic exposure to fine particles and mortality: An extended follow-up of the Harvard Six Cities study from 1974 to 2009. *Environmental Health Perspectives* **120**(7), 965–970.

Muhammad Zubair and Amina Adrees (2019). Dioxins and Furans: Emerging Contaminants of Air. Available at https://www.intechopen.com/books/air-pollution-monitoring-quantification-and-removal-of-gases-and-particles/dioxins-and-furans-emerging-contaminants-of-air (accessed on March 3 2020).

Nations Online Project, NOP (2019). West Africa Map. Available at https://www.nationsonline.org/oneworld/map/west-africa-map.htm (accessed March 2 2020).

National Environmental Standards and Regulations Enforcement Agency, NESREA (2011). National Environmental (Non-Metallic Minerals Manufacturing Industries Sector) Regulations 11, 32 Schedule IV of 2011.

Safe, S., Hutzinger, O., Hill, T.A., (2012). Polychlorinated Dibenzo-p-Dioxins and-Furans (PCDDs/PCDFs)- Sources and Environmental Impact, Epidemiology, Mechanisms of Action, Health Risks. Springer Science & Business Media.

Urban, J.D., Wikoff, D.S., Bunch, A.T., Harris, M.A., Haws, L.C. (2014). A review of background dioxin concentrations in urban/suburban and rural soils across the United States: Implications for site assessments and the establishment of soil cleanup levels. *Science of the Total Environment*. **466**, 586-597.

World Bank, (2004). Reducing Air pollution from Urban Transport Report. https://www.*documents.worldbank.org/curated/en/989711468328204490/pdf/304250PAPER0Reducing0air0pollution.pdf* (accessed March 22 2019).

Krewski, D., Jerrett, M., Burnett, R.T., Ma, R., Hughes, E., Shi, Y. (2009). Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. *Research Report (Health Effects Institute)* **140**, 5–114.