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ANALYSIS OF DIOXINS CONCENTRATION IN DOMESTIC WASTE A BURNT TYRE RESIDUE AT GOSA DUMPSITE IN ABUJA, NIGERIA

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ABSTRACT

This study examined the presence of dioxins – a persistent organic pollutant in domestic and burnt tyre waste residues and it's comparison with German safety limits at the Gosa dumpsite in Abuja, Nigeria. The period of sampling and analysis was between January and March, 2011. Burnt tyre ashes and burnt solid waste residues from the dump sites were chemically analyzed to determine the concentration of the seventeen 2,3,7,8-substituted dioxins and furan congeners in absolute quantities using high resolution capillary column gas chromatography and low resolution mass spectrometry. The result of the analysis performed using the International Toxic Equivalent Factor (NATO/CCMS) for the calculation of the individual Toxic Equivalent Quotients (TEQs) of the seventeen 2,3,7,8- substituted dioxins and furan congers and a summation of the individual I-TEQs per sample shows that there is significant quantity of about 44 ng/kg TM of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), a contaminant in Agent Orange, in one out of the five (1/5) analyzed samples. The maximum Total Polychlorinated dibenzo-p-dioxins/furans (PCCD/F) concentration recorded in this study was 1,350 ng/kg TM from sample Point 3. This was greater than the German Federal Soil Protection and Contamination Sites Ordinance (GFSPCSO) for Total PCDD/F equivalents for target concentration, agricultural, playground and residential landuse (which dominate the area under study) but less than its industrial landuse equivalent. There was also the presence of dioxins in the burnt domestic waste analysed with the Total PCDD/F (TEQ) of 6.6 ng/kg TM. The land usage of the area under investigation is closely interwoven across the land mass. Therefore, the results indicate that the population and activities within the area of study are under threat of health hazards that may arise from the high concentration of dioxins recorded by this study.

Keywords: Dioxins, Burnt tyres, Domestic waste, ITEF, TEQs, TCDD, PCCD/F, Dumpsite, Abuja.

Contribution/ Originality

This study contributes to the existing literature by providing a better understanding of the potential pollution from burnt tyres and domestic wastes residue in Nigeria's Federal Capital City. This study adopts the method of chemically analyzing burnt residue of tyres and domestic

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waste to determine the concentration of the seventeen 2,3,7,8-substituted dioxins and furan congeners in absolute quantities using high resolution capillary column gas chromatography and low resolution mass spectrometry estimation.

1. INTRODUCTION

1.1. Background to the Problem

Over the last six decades, global attention has been focused on the man-environment relationship as exemplified by several frameworks aimed at reducing potential risks from human activities on human, animal and plant populations [1]. This has been demonstrated in the establishment of effective legal framework at both national and international levels to combat environmental issues. One of such environmental issues is how to effectively manage waste without causing problem to the environment. Waste management is a global issue because of its impact (especially when not properly managed) on regional-scale climate. To effectively manage a problem that is inherently global, regional scale solutions must be applied.

However, no convention or international measure exists for the comprehensive management of waste, as noted by ISWA (International Solid Waste Association) [2]. Although the environmental, economic and social implications of rapidly increasing waste problems have gained recognition over recent decades, and the need for a response to the waste management problem on an international scale has long been accepted but until today, there is no international response to address the minimization and management of waste in coordinated manner. Waste dumpsites which are not operated in accordance with standard and effective environmental regulations cause enormous environmental problems by exposing water, soils and air to pollution, which thereby endanger the vital components of life and nature that require protection. Through water, soils and air, the harmful substances get into the food chain or directly into the human body. The lasting risks to human health call for an urgent solution to waste problem especially as consumption increases with corresponding increase in global population, which will ultimately increase environmental degradation [3].

Although certain harmful items have been banned from burning or burying on farm property (tyres, lead acid and household batteries, household hazardous wastes, plastics, used motor oil and filters, etc.) by Minnesota Statutes [4] the practice of burning still persist in locations and climes where waste management is still at an organic level. According to Cal Recovery Inc [5] a typical tyre compound contains the following constituents: natural and synthetic rubber; reinforcing fillers; oils; antioxidants; zinc oxide; accelerators; and sulfur, all of which can be potentially harmful and injurious to human, plant and animal populations if improperly disposed. Unfortunately, waste tyres are being burnt between farmlands, shelters of scavengers and near settlements at the Gosa dumpsite (see Plate 1). Additionally, the Wupa River (a tributary of Rubuchi River) is located downstream of Gosa dumpsite (see Figure 1) which is a major source of water for small-scale irrigation, and other domestic utilization at Gosa settlement and other settlements further downstream. Spillmann, et al. [3] have highlighted in details the consequences of improper disposal of synthetic waste of this nature on ground and surface found close to dumpsites.

With the area looking to accommodate a huge population in the near future, it is pertinent to quickly deal with the issues surrounding the dumpsite within the area now rather than later. This is necessary as the geology and hydro-geomorphology formation of the Gosa area (and indeed much of the Northern part of the FCT) is a Basement Complex type [6] which is typically endowed with huge groundwater reserves which could be polluted due to the percolation of Dioxins released from burnt tyres. This is in addition to other damaging effects of Dioxins on soils, vegetation, animal and human populations.

Plate-1. Tyres are regularly burnt at Gosa dumpsite

Figure-1. Google earth image of study area

1.2. Scrap Tyre Management

A number of approaches are currently adopted for disposing scrap tyres depending largely on the availability of technology, and demand of products from the scrap tyre management process. Srinivas [7] states that scrap tyres can be used for energy recovery (tyre derived fuel - TDF) which can be used at cement kilns, paper or power plants; rubber recycling which entail grinding scrap tyres into crumb rubber while removing steel, fiber and other contaminants; and landfilling where scrap tyres can be cut into pieces or shredded before landfilling. Others include civil engineering applications for tyre derived products, mostly 1" tyre chips which could replace conventional construction materials such as road fill, gravel, crushed rock or sand. According to Reschner [8] the benefits of using tyre chips instead of conventional construction materials are amongst others: reduced density, improved drainage properties and better thermal insulation.

There are however, 2 main processes for scrap tyre management. These are ambient scrap tyre processing and cryogenic tyre recycling [8].

1.2.1. Ambient Scrap Tyre Processing

The process is called ambient, because all size reduction steps take place at or near ambient temperatures (Figure 2), i.e. no cooling is applied to make the rubber brittle [8]. The full procedure according to Reschner [8] involves firstly, processing scrap tyres into chips of 2" (50 mm) in size in a preliminary shredder (A). The tyre chips then enter a granulator (B). In this processing step the chips are reduced to a size of smaller than 3/8" (10 mm), while liberating most of the steel and fiber from the rubber granules. After exiting the granulator, steel is removed magnetically and the fiber fraction is removed by a combination of shaking screens and wind sifters (C). Most applications call for finer mesh material, mostly in the range of 10 to 30 mesh. For this reason, most ambient grinding plants have a number of consecutive grinding steps (D). Ambient grinding can be operated safely and economically if the bulk of the rubber output needs to be relatively coarse material, i.e., down to approximately 20 mesh material.

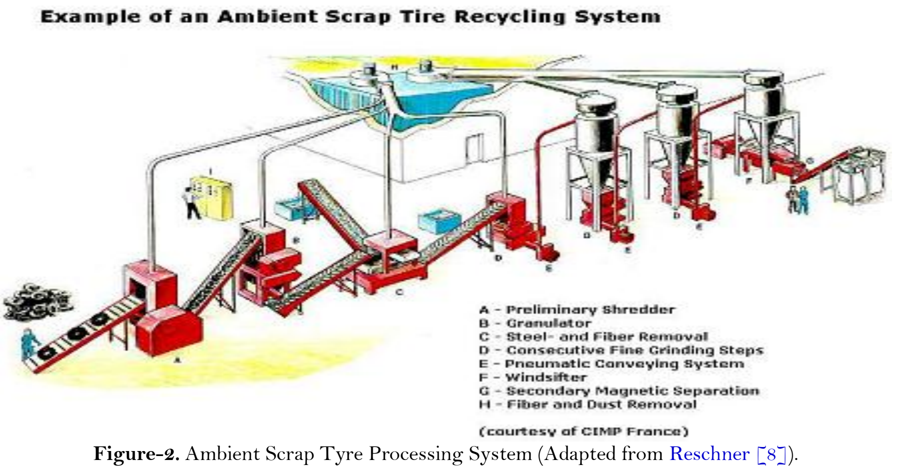

Figure-2. Ambient Scrap Tyre Processing System (Adapted from Reschner [8]).

1.2.2. Cryogenic Scrap Tyre Recycling

Cryogenic scrap tyre recycling (Figure 3) adopts a procedure where the whole tyres or tyre chips are cooled down to a temperature of below –80° C (-112° F) at which rubber becomes nearly as brittle and glass, and size reduction can be accomplished by crushing and breaking. This type of size reduction requires less energy and fewer pieces of machinery when compared to ambient size reduction. Another advantage of the cryogenic process is that steel and fiber liberation, is much easier, leading to a cleaner end product. However, the major drawback for this process is the prohibitive cost for the large amount of liquid nitrogen (LN2) required.

The preliminary treatment of scrap tyres (de-beading, pre-shredding) is pretty much the same as in ambient plants. In the cryogenic process, the 2" (50 mm) tyre chips are cooled in a continuously operating freezing tunnel (B) to below –120°C and then dropped into a high RPM hammer mill (C). In the hammer mill, chips are shattered into a wide range of particle sizes, while, at the same time, liberating fiber and steel. Because the rubber granules may still be very cold upon exiting the hammer mill, the material is dried (E) before classification into different, well defined particle sizes (F). Generally speaking, cryogenic scrap tyre processing is more economical if clean, fine mesh rubber powder is required [8].

Figure-3. Cryogenic Scrap Tyre Recycling System (Adapted from Reschner [8]).

2. METHODOLOGY

2.1. Study Area

Gosa, the study area is located about 30 kilometers off the Jabi express road in Idu Industrial Layout, between longitudes 7^{0} 16'30" and 7^{0} 21' 35"E and latitudes 8^{0} 54' 30" and 8^{0} 57'15"N (Figure 4). The area is found along the Umaru Musa Yar'Adua Expressway linking the city's airport and the city centre. The predominant activities around the area are primary activities including agriculture. Gosa settlement is located within the vicinity of the dumpsite, in addition to other housing developments that are springing up.

2.2. Scope of Analysis

The study compared the content of dioxins in burnt domestic waste and burnt tyre waste residue with safety values of the German Federal Soil Protection and Contamination Sites Ordinance (GFSPCSO) for Total PCDD/F (Polychlorinated dibenzo-p-dioxins/furans) equivalents. This aim was achieved through the determination of the level of PCDD/Fs in burnt domestic waste and burnt tyre waste residues at the dumpsite; and the value of the Total PCDD/F in (i) and (ii) was compared with the (GFSPCSO) safety limits.

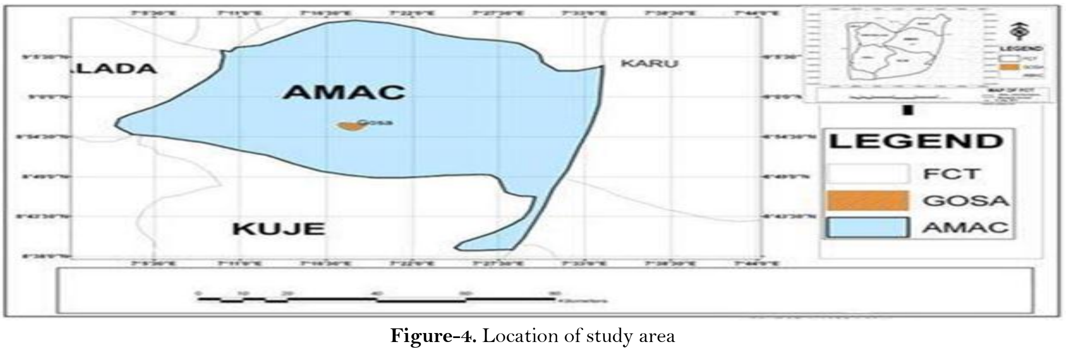

Figure-4. Location of study area

Source: Modified from [6]

2.3. Sampling Procedure and Sample Collection

Grid point sampling was adopted in sample collection using Global Positioning System (GPS). This comprised of five independent grid point samples of experimental units which was collected from the following: Burnt domestic waste; Burnt tyres; White ashes from burnt tyres; Greenish ashes from burnt tyres; and Black ashes from burnt tyres. Each of these samples was a composite sample of zero to zero point one five meters (0 - 0.15m) depth for burnt domestic waste and zero to zero point zero five meters (0 - 0.05m) depth for burnt tyre ashes (see Appendix I for sampling protocol). In order to ensure that the integrity of the samples was well preserved, the sampling was carried out around 11.00am in the morning of a dry and sunny day. The sampled ash and residues were stored in a sterilized brown glass bottle and labeled accordingly before they were taken to the Gesellschaft Fur Bioanalytic (GBA) Laboratory for analysis.

2.4. Sample Analysis

The analysis of the samples includes a determination of the concentration of the seventeen 2, 3, 7, 8-substituted PCDD/F congeners in absolute quantities, in individual I-TEQs and a summation of the individual I-TEQs per sample. The determination was performed using high resolution capillary column gas chromatography in combination with low resolution mass spectrometry. Prior to GC-MS analysis, the air-dried sample was homogenized and sieved smaller 0.2 mm (according to VDI 3499) and particles like glass, metal etc. were removed. Matrix-specific extraction, analyte-specific cleanup and analysis occur in accordance with a standard operating procedure (EPA METHOD 8280A). According to this procedure an internal standard (a mixture of twelve [sup.13C] labeled PCDD/F congeners) was added to the samples for identification and quantification of the relevant PCDD/Fs. After dissolution and drying, the samples were extracted (exhausting extraction) in a soxhlet apparatus with toluene. Of the extracts, 80% was used for analysis. The remaining 20% was stored for a second analysis (if need be). The fractions to be analyzed were cleaned by extraction with sulfuric acid. The resulting extracts were led on alumina, silica gel, and activated carbon on Celite 545® (extracts cleaning by column chromatography) and concentrated again. After adding an injection standard the analyses were performed using high resolution gas chromatography and low resolution mass spectrometry capable of performing selected ion monitoring at resolving power of at least 10,000 (10 percent valley definition). Based on the ordered elution and comparison to internal and external standard solutions, recovery percentages were determined of the internal PCDD/F congeners, as well as the quantities of PCDD/F congeners in the samples.

Regarding the GC/MS, 2 columns were used:

i. DB DIOXIN from J&W (60m x 0.25 mm x 0.15 µm) for quantification of the 4-6 chlorinated PCDD/PCDF and to control the quantification of the 7 and 8 chlorinated congeners.

ii. Optima 5ms from Macherey-Nagel (25m x 0.2mm x 0.2 µm) for the quantification of the 7 and 8-chlorinated PCDD/PCDF and to control the quantification of 4-6 chlorinated PCDD/PCDF.

The GC/MS-system is from Fisons (earlier Carlo Erba, now Thermo Finnigan, GC 8130/MD800). The temperature program depends on the actual column. The starting temperature for the DB DIOXIN is 140°C (2‘), then heating to 270°C and holding the temperature for 1 hour. The starting temperature for the Optima 5ms is 70°C then heating to 320°C and holding the temperature for 5 minutes. Every congener is analysed with two or three characteristic signals. For example is 2, 3, 7, 8- TCDD determined with the masses 319.90 and 321.90, excluding the mass of 317.90 (the mass of 13C- marked 2, 3, 7, 8- TCDF) and verifying with the mass of 323.90. A comparison with the chromatogram of the other column follows. This takes time and makes the evaluation of a chromatogram very difficult.

2.5. Data Analysis Technique

The data analysis method used was the International Toxic Equivalent Factor (NATO/CCMS) for the calculation of the individual Toxic Equivalent Quotients (TEQs) of the seventeen 2, 3, 7, 8-substituted PCDD/F congeners and a summation of the individual I-TEQs per sample to yield the sample toxicity inform of Total PCDD/F. TEQ is an overall expression of congener concentrations normalized to TCDD determined by multiplying all congener concentrations by their corresponding TEF [9-11]. It provides important information about the overall toxicity of all dioxins found at the sampled sites. The Total PCDD/F equivalents of the samples were computed using the Equation below:

$$\text{Total PCDD/F} = \sum_{i=1}^{n} (c_i \; X \; TEF_i) \qquad (1)$$

Where:

c_i = concentration;

TEF_i = Toxic Equivalent Factor;

i^{th} = congener;

n = total number of congeners.

In addition to the summary statistics for individual congeners presented above, a statistical summary of surface soil Total PCDD/F of the GFSPCSO for each of the landuse categories was used to compare the results.

3. RESULTS AND DISCUSSIONS

The results for samples of burnt waste from burnt domestic waste, burnt tyres, white ashes from burnt tyres, green ashes from burnt tyres, black ashes from burnt tyres and the values obtained are compared with the GFSPCSO safety standard, and presented under this section.

3.1. Analysis of Dioxin Content in Burnt Domestic Waste

The result of analysis of the seventeen 2, 3, 7, 8-substituted PCDD/F congeners as presented in Table 1 shows the congeners in concentration ranging from 6.9 to 1200 ng/kg. Thirteen out of the seventeen were below detection level with a resultant sample toxicity or Total PCDD/F of 6.63ng/kg TM from four congeners.

Table-1. Dioxin content in burnt domestic waste

Congeners of PCDD/F	Concentration (ng/kg TM)	TEF	TEQ (c_i x TEF)
2,3,7,8-TetraCDD	<3.0	1.0	-
1,2,3,7,8-PentaCDD	<5.0	0.5	-
1,2,3,4,7,8-HexaCDD	<8.0	0.1	-
1,2,3,6,7,8-HexaCDD	<8.0	0.1	-
1,2,3,7,8,9-HexaCDD	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDD	180	0.01	1.8
OctaCDD	1200	0.001	1.2
2,3,7,8-TetraCDF	<3.0	0.1	-
1,2,3,7,8-PentaCDF	<5.0	0.05	-
2,3,4,7,8-PentaCDF	6.9	0.5	3.45
1,2,3,4,7,8-HexaCDF	<8.0	0.1	-
1,2,3,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,7,8,9-HexaCDF	<8.0	0.1	-
2,3,4,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDF	18	0.01	0.18
1,2,3,4,7,8,9-HeptaCDF	<12	0.01	-
OctaCDF	<25	0.001	-
Total PCDD/F = $\sum_{i=1}^{n} (c_i \text{ X } TEF_i)$			**6.63 ng/kg TM**

Source: Laboratory Analysis, 2011

Table-2. Dioxin content in burnt tyres

Congeners of PCDD/F	Concentration (ng/kg TM)	TEF	TEQ (c_i x TEF)
2,3,7,8-TetraCDD	<3.0	1.0	-
1,2,3,7,8-PentaCDD	<5.0	0.5	-
1,2,3,4,7,8-HexaCDD	<8.0	0.1	-
1,2,3,6,7,8-HexaCDD	<8.0	0.1	-
1,2,3,7,8,9-HexaCDD	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDD	<12	0.01	-
OctaCDD	<25	0.001	-
2,3,7,8-TetraCDF	<3.0	0.1	-
1,2,3,7,8-PentaCDF	<5.0	0.05	-
2,3,4,7,8-PentaCDF	<5.0	0.5	-
1,2,3,4,7,8-HexaCDF	<8.0	0.1	-
1,2,3,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,7,8,9-HexaCDF	<8.0	0.1	-
2,3,4,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDF	<12	0.01	-
1,2,3,4,7,8,9-HeptaCDF	<12	0.01	-
OctaCDF	<25	0.001	-
Total PCDD/F = $\sum_{i=1}^{n} (c_i \text{ X } TEF_i)$			-/-

Source: Laboratory Analysis, 2011

3.2. Analysis of Dioxin Content in Burnt Tyres

There is no value for Total PCDD/F in this sampled point because the laboratory analysis revealed that the seventeen 2, 3, 7, 8-substituted PCDD/F congeners tested were below detection level. The result of the analysis is presented in Table2 .

Table-3. Dioxin content in White ashes from burnt tyres

Congeners of PCDD/F	Concentration (ng/kg TM)	TEF	TEQ (c_i x TEF)
2,3,7,8-TetraCDD	44	1.0	44
1,2,3,7,8-PentaCDD	210	0.5	105
1,2,3,4,7,8-HexaCDD	190	0.1	19
1,2,3,6,7,8-HexaCDD	240	0.1	24
1,2,3,7,8,9-HexaCDD	180	0.1	18
1,2,3,4,6,7,8-HeptaCDD	1400	0.01	14
OctaCDD	2600	0.001	2.6
2,3,7,8-TetraCDF	650	0.1	65
1,2,3,7,8-PentaCDF	830	0.05	41.5
2,3,4,7,8-PentaCDF	1200	0.5	600
1,2,3,4,7,8-HexaCDF	1600	0.1	160
1,2,3,6,7,8-HexaCDF	1100	0.1	110
1,2,3,7,8,9-HexaCDF	38	0.1	3.8
2,3,4,6,7,8-HexaCDF	980	0.1	98
1,2,3,4,6,7,8-HeptaCDF	4200	0.01	42
1,2,3,4,7,8,9-HeptaCDF	260	0.01	2.6
OctaCDF	1700	0.001	1.7
$\text{Total PCDD/F} = \sum_{i=1}^{n} (c_i \; X \; TEF_i)$			**1351.2 ng/kg TM**

Source: Laboratory Analysis, 2011

3.3. Analysis of Dioxin Content in White Ashes from Burnt Tyres

The result of analysis of the seventeen 2, 3, 7, 8-substituted PCDD/F congeners as presented in Table 3 shows the congeners in concentration ranging from 38 to 4200 ng/kg. Here, the seventeen congeners of PCDD/F analysed were all present with a resultant sample toxicity or Total PCDD/F of 1351ng/kg TM. Refer to section 3.4 for data analysis technique.

The concentrations of higher-chlorinated congeners of PCDD/F in this sample point were remarkably higher than those of lower-chlorinated congeners. This could be attributed to the fact that PCDD/Fs congeners of the lower homolog groups, such as tetra (T)-, penta (Pe)-, and hexa (Hx)-CDD/Fs, tend to volatilize from soil, whereas the higher homolog groups, such as hepta (Hp)- and octa (O)-CDD/Fs, due to their extremely low vapor pressures, are expected to be bound to the soil, as suggested by Freeman and Schroy [11] and Van Den, et al. [12].

3.4. Analysis of Dioxin Content in Greenish Ashes from Burnt Tyres

There is no value for Total PCDD/F in this sampled point because the laboratory analysis revealed that the seventeen 2, 3, 7, 8-substituted PCDD/F congeners tested were below detection level. The result of the analysis is presented in Table 4.

Table-4. Dioxin content in Greenish ashes from burnt tyres

Congeners of PCDD/F	Concentration (ng/kg TM)	TEF	TEQ (c_i x TEF)
2,3,7,8-TetraCDD	<3.0	1.0	-
1,2,3,7,8-PentaCDD	<5.0	0.5	-
1,2,3,4,7,8-HexaCDD	<8.0	0.1	-
1,2,3,6,7,8-HexaCDD	<8.0	0.1	-
1,2,3,7,8,9-HexaCDD	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDD	<12	0.01	-
OctaCDD	<25	0.001	-
2,3,7,8-TetraCDF	<3.0	0.1	-
1,2,3,7,8-PentaCDF	<5.0	0.05	-
2,3,4,7,8-PentaCDF	<5.0	0.5	-
1,2,3,4,7,8-HexaCDF	<8.0	0.1	-
1,2,3,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,7,8,9-HexaCDF	<8.0	0.1	-
2,3,4,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDF	<12	0.01	-
1,2,3,4,7,8,9-HeptaCDF	<12	0.01	-
OctaCDF	<25	0.001	-
Total PCDD/F = $\sum_{i=1}^{n} (c_i \times TEF_i)$			-/-

Source: Laboratory Analysis, 2011

3.5. Analysis of Dioxin Content in Black Ashes from Burnt Tyres

There is no value for Total PCDD/F in this sampled point because the laboratory analysis revealed that the seventeen 2, 3, 7, 8-substituted PCDD/F congeners tested were below detection level. The result of the analysis is presented in Table 5.

Table-5. Dioxin content in Black ashes from burnt tyres

Congeners of PCDD/F	Concentration (ng/kg TM)	TEF	TEQ (c_i x TEF)
2,3,7,8-TetraCDD	<3.0	1.0	-
1,2,3,7,8-PentaCDD	<5.0	0.5	-
1,2,3,4,7,8-HexaCDD	<8.0	0.1	-
1,2,3,6,7,8-HexaCDD	<8.0	0.1	-
1,2,3,7,8,9-HexaCDD	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDD	<20	0.01	-
OctaCDD	<40	0.001	-
2,3,7,8-TetraCDF	<3.0	0.1	-
1,2,3,7,8-PentaCDF	<5.0	0.05	-
2,3,4,7,8-PentaCDF	<5.0	0.5	-
1,2,3,4,7,8-HexaCDF	<8.0	0.1	-
1,2,3,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,7,8,9-HexaCDF	<8.0	0.1	-
2,3,4,6,7,8-HexaCDF	<8.0	0.1	-
1,2,3,4,6,7,8-HeptaCDF	<20	0.01	-
1,2,3,4,7,8,9-HeptaCDF	<20	0.01	-
OctaCDF	<40	0.001	-
Total PCDD/F = $\sum_{i=1}^{n} (c_i \times TEF_i)$			-/-

Source: Laboratory Analysis, 2011

3.6. Summary of the Analyzed Results and its Comparison with the GFSPCSO

After analyzing the qualitative description of the results with the I-TEF (NATO/CCMS) as presented on Tables 1 to 5 above, it was observed that the toxicity of sample P1 and P3 were 6.6 and 1351 ng/kg respectively. The colours of the ashes are white, greenish and black with highest PCDD/F content in the white coloured ashes. When compared with the GFSPCSO, the Total PCDD/F in the sampled points was well below the German action value of 10,000 ng/kg (Table 6) for industrial and commercial land uses (the study area falls within the Idu District designated by the Abuja Master Plan for industrial purpose which is why the action value of 10,000 ng/kg was adopted for the study).

However, the Total PCDD/F level in both sample P1 and P3 exceed the German action value for target concentration and these sites are between the farmland and the housing area of the scavengers. Additionally, the Total PCDD/F level in sample P3 (1351 ng/kg) exceeds both the German action value of 40 ng/kg and 1000 ng/kg for agricultural and residential land uses, respectively. It is important to note that although the study area is designed by the authorities as Industrial, the current land usage at Gosa dumpsite is closely interwoven among two major uses: residential and agriculture. Land which is used for agricultural purposes is situated in the direct and immediate vicinity of the waste dumps. In addition, the dumpsite is crossed by herds of grazing cattle (see Plate 2). Also, Gosa settlement is found within a distance of just a few hundred meters of the dumpsite, while River Rubuchi is just south of the dumpsite.

Plate-2. Cattle grazing within the dumpsite

Table-6. Summary of Total PCDD/F equivalents in the sample Points and its comparison with the GFSPCSO for different land use

Sampled Points	Total PCDD/F Observed (ng/kg TM)	Total PCDD/F of GFSPCSO for different Land use (ng/kg TM)				
		TC	ALU	PG	RA	ILU
P1 (Burnt Domestic Waste)	6.6	5	40	100	1,000	10,000
P2 (Burnt Tyres)	-/-	-	-	-	-	-
P3 (White Ashes in Burnt Tyres)	1351	5	40	100	1,000	10,000
P4 (Greenish Ashes in Burnt Tyres)	-/-	-	-	-	-	-
P5 (Black Ashes in Burnt Tyres)	-/-	-	-	-	-	-

TC = Target concentration

ALU = Agricultural Land Use

PG = Play ground

RA = Residential Area

ILU = Industrial Land Use

Burning of tyres has been in practice within the FCT and its environs for a considerable period of time. Although considered by the Podoll, et al. [13] a tremendous and hazardous problem because of its potential to generate an unwanted Persistent Organic Pollutant – Dioxins [14-19] the major reason for its persistence is the collection of the steel inside the tyres by waste scavengers (see Plate 3) who are not regulated.

Based on the result of the analysis, it can be concluded that the dioxin content in the burnt domestic waste are relatively low when compared with that of burnt waste tyres. The highest concentration of dioxins occurred in the white- bluish coloured ash of burnt tyre waste with all the congeners present and its sample toxicity (Total PCDD/Fs) exceeds the German safety value for agricultural and residential land use.

Plate-3. Scavengers at Gosa dumpsite amidst smoke from burnt tyres

4. CONCLUSION

With the absence of strict controls and monitoring by the Abuja Environmental Protection Agency (AEPB), the burning of used tyres and subsequent emission of PCDD/F will continue not just at Gosa dumpsite but also at several other dumpsites within Abuja. Sadly, the situation applies to thousands of other dumpsites across Nigeria. As motor vehicles are the major means of transportation in Nigeria, the future appears even bleak with the absence of recycling technology to cope with the huge amounts of waste tyres being generated daily. It is clear that regular environmental monitoring and control should be adopted on the dumpsite to check and monitor the status of pollutants such as Dioxins and the long term damage they bring to bear on the vital components of the environment – humans, soils, plants, water, air and animals.

In Nigeria, there is the complete absence of adequate and potent legal framework and industrial infrastructure to address the issue of scrap tyre disposal in an environmentally safe and economically sound manner. Given the heavy reliance on road transport, it is assumed that volume of waste tyres generated daily will be high. It is therefore, expedient to adopt a technology that utilizes scrap tyres for civil engineering applications, particularly rubber modified asphalt (RMA) which is a tested material for road surfacing. This will not only be environmentally sound but also save the huge cost of road construction in Nigeria.

In light of the findings, it is suggested that:

i. Rearing of cows and other agricultural activities in the vicinity of the dumpsite be discouraged;
ii. Scavengers should be properly educated on the health hazards of Dioxins and should be encouraged to use protective gear while scavenging at the dumpsite;
iii. Appropriate legislative and institutional framework be instituted against tyre burning;
iv. Technological infrastructure should be provided to recycle and/or process scrap tyres which could be used for other applications including civil engineering;
v. Additional research and investigation should focus on a) quantitative chemical analysis of air for PCDD/F; b) heavy metal analysis in burnt tyres; c) effect of PCDD/F on fauna;

and comprehensive chemical analysis of the small stream (Rubochi River) within the catchment area of the dumpsite.

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Appendix-I. Sampling Report

Sample-1.

Sampling Protocol	**Sample: Solid**
Project: Gosa dumpsite	Executed by; Oleka, John and Engr Michael Struve.
Date: 18.01.2011	
Time: 14: 48	Weather: very hot and sunny.
Test Point: P1	Location: 317053, 997588

Reason of Sample Drawing: Program to identify the risk and hazards of dioxins contamination in the dumpsite

Types of Sample		**Method of Sample Drawing**	
Soil		Sampling Device	
Sludge		Spot Sample	
Slag		Mixed Sample	X
Waste	Burnt domestic waste	Number of Samples	

Digging Depth (m):	**0 -0.15**	**Sample Container:**	**Brow glass**
Digging Depth (elevation):		Sample Mass (kg)	0.219

Description		**Additional Parameter**	
Colour:	Black, white, grey	Mass Density:	
Smell:		Misc.	
Specification: burnt domestic waste near burnt tyres			

Source: Summary of Field Work, 2011

Sample No.:	P1	Sample Name (lab):	1160166

Comment: cattle are feeding in this waste!

Sample2.

Sampling Protocol	**Sample: Solid**
Project: Gosa dumpsite	Executed by; Oleka, John and Engr Michael Struve
Date: 18.01.2011	
Time: 12:17	Weather: very hot and sunny.
Test Point: P2	Location: 317236, 998292

Reason of Sample Drawing: Program to identify the risk and hazards of dioxins contamination in the dumpsite

Types of Sample		**Method of Sample Drawing**	
Soil		Sampling Device	
Sludge		Spot Sample	
Slag		Mixed Sample	X
Waste	Burnt tyres	Number of Samples	

Digging Depth (m):	**0 -0.05**	**Sample Container:**	**Brow glass**
Digging Depth (elevation):		Sample Mass (kg)	0.094

Description		**Additional Parameter**	
Colour:	Black, white	Mass Density:	
Smell:		Misc.	
Specification: ashes from burnt tyres, very light material 94g in 0.5 liter glass			

Sample No.:	P2	Sample Name (lab):	1160166

Source: Summary of Field Work, 2011

Comment: very light and good transferable material

Sample-3.

Sampling Protocol	**Sample: Solid**
Project: Gosa dumpsite	Executed by; Oleka, John and Engr Michael Struve
Date: 18.01.2011	
Time: 12:23	Weather: very hot and sunny.
Test Point: P3	Location: 317245, 998287

Reason of Sample Drawing: Program to identify the risk and hazards of dioxins contamination in the dumpsite

Types of Sample		**Method of Sample Drawing**	
Soil		Sampling Device	
Sludge		Spot Sample	
Slag		Mixed Sample	X
Waste	Burnt tyres	Number of Samples	
Digging Depth (m):	0 -0.05	Sample Container:	Brow glass
Digging Depth (elevation):		Sample Mass (kg)	0.475

Description		**Additional Parameter**	
Colour:	White, bluish	Mass Density:	

Smell:		Misc.	
Specification: ashes from burnt tyres			

Sample No.:	P3	Sample Name (lab):	1160166

Source: Summary of Field Work, 2011

Comment: materials seems heavy like soil

Sample-4.

Sampling Protocol	Sample: Solid
Project: Gosa dumpsite	Executed by; Oleka, John and Engr Michael Struve
Date: 18.01.2011	
Time: 14:45	Weather: very hot and sunny.
Test Point: P4	Location: 317050, 997588

Reason of Sample Drawing: Program to identify the risk and hazards of dioxins contamination in the dumpsite

Types of Sample		Method of Sample Drawing	
Soil		Sampling Device	
Sludge		Spot Sample	
Slag		Mixed Sample	X
Waste	Burnt tyres	Number of Samples	

Digging Depth (m):	0 -0.05	Sample Container:	Brow glass
Digging Depth (elevation):		Sample Mass (kg)	0.163

Description		Additional Parameter	
Colour:	Greenish	Mass Density:	
Smell:		Misc.	
Specification: light ashes from burnt tyres			

Sample No.:	P4	Sample Name (lab):	1160166

Source: Summary of Field Work, 2011

Comment: cattle beside this toxic

Sample-5.

Sampling Protocol	Sample: Solid
Project: Gosa dumpsite	Executed by; Oleka, John and Engr Michael Struve
Date: 18.01.2011	
Time: 14:50	Weather: very hot and sunny.
Test Point: P5	Location: 317050, 997588

Sample Points	Coordinates Northing		Description
	Easting	Northing	
1	317053	997588	Burnt domestic waste
2	317236	998292	Burnt tyres
3	317245	998287	White ashes from burnt tyres
4	317050	997588	Greenish ashes from burnt tyres
5	317050	997588	Black ashes from burnt tyres

Reason of Sample Drawing: Program to identify the risk and hazards of dioxins contamination in the dumpsite

Types of Sample		**Method of Sample Drawing**	
Soil		Sampling Device	
Sludge		Spot Sample	
Slag		Mixed Sample	X
Waste	Burnt tyres	Number of Samples	

Digging Depth (m):	**0 -0.05**	**Sample Container:**	**Brow glass**
Digging Depth (elevation):		Sample Mass (kg)	0.205

Description		**Additional Parameter**	
Colour:	Black	Mass Density:	
Smell:		Misc.	
Specification: ashes from burnt tyres, very light material 94g in 0.5 liter glass			

Sample No.:	P5	Sample Name (lab):	1160166

Source: Summary of Field Work, 2011

Comment: cattle beside this toxic waste