OCCURRENCE OF DIOXIN AND FURANS IN LANDFILLS IN AFRICAN COUNTRIES AND KUWAIT

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Introduction

Humans generate a huge amount of residues that affect the environment. At present, the global generation of municipal solid waste is estimated at about 1.3 billion tonnes per year, and it is expected to increase to approximately 2.2 billion tonnes per year by 2025[1]. Landfilling is the simplest and most commonly used method of disposing of municipal solid waste (MSW) in most developing countries. Nevertheless, landfilling waste produces a variety of environmental problems such as greenhouse gases, percolation of leachate into soil and groundwater resulting in widespread contamination. Although this practice has been phased out across most developed countries, it is still an issue in transition/developing countries.

Disposal of waste in landfill sites is known as one of the main sources that release dioxins and furans to the atmosphere[2]. Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) commonly known as dioxins and furans are a type of persistent organic pollutants (POPs) listed in the Stockholm Convention (UNEP,2001). They comprise a group of 210 congeners (75 PCDDs and 135 PCDFs) 17 of which (the 2,3,7,8-chlorinated congeners) are of scientific and public interest due to their toxicity and their potential effects on human health. This is mainly due to their persistence and bioaccumulative behavior in the environment and food chain. To our knowledge, there is scarce data on the concentration of these pollutants in landfills in African countries and the Middle East. The aim of this work is to fill this gap by providing real data of the concentration of these chemicals in landfill sites of five African countries and Kuwait.

Materials and methods

Sampling sites and sample collection

Thirty-five topsoil (0-5cm) samples were collected in landfills, dumping sites, urban and agricultural locations in Kuwait and 5 African countries (Ghana, South Africa, Togo, Nigeria, and Sierra Leone) to carry out a PCDD/F survey. Most of the so-called landfills in Africa and Kuwait are open-air waste dumping sites where the waste is disposed of without any control.

Analytical method

The target analytes were extracted with hexane-dichloromethane (1:1) mixture on an accelerated solvent extractor ASE-350 (Dionex, CA, USA) equipped with 33 ml stainless-steel extraction cells. Ten grams of samples were spiked with 13C12-labelled extraction standards (EPA-1613 labeled compound stock solution) purchased from Cambridge Isotope Laboratories (MA, USA). Two hours later, the cell was sealed and placed in the extractor carrousel to start the extraction process on the following conditions: temperature 100 ^{o}C, pressure 1500 psi, static time 5 min, 1 extraction cycle[3].

Clean-up of the extract was performed in an automated Multi-column Sample Cleanup system (Power Prep™; FMS, Inc, MA, USA). The instrumental analysis was carried out on an AutoSpec Premier high-resolution mass spectrometer (Waters, Manchester, UK) coupled with an Agilent 7890 gas chromatograph equipped with 2 split/splitless inlets and 2 fused silica columns. PCDD/Fs gas chromatographic separation was carried out on a DB-5 ms (60 m x 0.25 mm i.d. x 0.25 µm film thickness; J&W Scientific, CA, USA). The target analytes were quantified by the isotope dilution method; full details of the cleanup and the final determination method have been previously published[4].

Results and discussion:

The PCDD/F I-TEQ concentrations in landfills and dumping site samples collected ranged from 1.48 to 7422 pg/kg I-TEQ (table 1). The highest concentration corresponded to an e-waste landfill from Accra, Ghana. These findings are similar to the levels reported by Tue et al, 2019[5] in samples collected at the same site (6.8–5200 pg/g I-TEQ). Secondly, the Kissy dumpsite located in Sierra Leone showed a high concentration of the target analytes (3342 pg/g I-TEQ). The are where these sites are located hosts a large community of people who make a living out of waste. This fact poses a huge health risk for those who live in this area and not only from the hygienic point of view but also because of the POPs in the environment. In 2013, a study estimated that the total dioxins and furans released from this dumpsite were 128.914 g TEQ/year[6]. To place this estimation into context, air samples collected at the boundaries of British landfill[7] sites showed median concentrations of 19 WHO-TEQ fg/m^3 which assuming a sampling rate of 800 m^3/day will represent around 6.10^{-9} g TEQ/year. Moreover, Belview Landfill (South Africa) and a Landfill Accra (Ghana) also stood out 281.5 and 285.7 pg/g I-TEQ.

In the case of Kuwait, the site studied in this work is a hazardous waste landfill that treats oil-contaminated soil with a temperature desorption system which seems to decrease significantly the dioxin burden of the raw material (195.45 to 10.06 or 4.79 pg/g I-TEQ). Nevertheless, one of the samples of a supposed treated landfilled soil showed a very high concentration of dioxins (1096 pg/g I-TEQ) which could be caused by a very high contaminated raw soil or a malfunctioning of the decontamination system.

Table 1: PCDD/F concentrations of the samples collected in landfills and dumping sites in Africa and Kuwait

Sampling location	Concentration (I-TEQ pg/g)
E-WASTE DUMP, Accra, Ghana	7422
McCarthy Hill Accra Burned soil, Ghana	46.10
Landfill Accra, Ghana	285.7
Ondestepoort Landfill, Gauteng, South Africa	1.48
Mamelodi Landfill, Gauteng, South Africa	1.76
Belview Landfill, Cape Town, South Africa	281.5
City Dump soil Lome, Togo	18.55
Waste Dump site soil, Enugu, Nigeria	174
Benue Makurdi, Waste, Nigeria	10.21
Anambra, Awka, Kwata, Nigeria	23.37
Kissy Landfill, Granville, Sierra Leone	3342
King Tom Landfill, Sierra Leone	195.5
Hazardous waste landfill (contaminated soil) Shuaiba, Kuwait	195.45
Hazardous waste landfill treated (decontaminated soil) Shuaiba, Kuwait	10.06
Hazardous waste landfill (treated landfilled soil) Shuaiba, Kuwait	4.79
Hazardous waste landfill (treated landfilled soil) Shuaiba, Kuwait	1,096

Table 2: PCDD/F concentrations of the soil samples collected in urban and agricultural locations

Sampling location	Concentration (I-TEQ pg/g)
Opposite Korle Bu hospital, Ghana	29.90
Aplacu Accra, Ghana	0.58
McCarthy Hill Accra Top soil, Ghana	0.76
Agriculture soil Lome, Togo	0.40
Benue Makurdi, Wadata market, Waste, Nigeria	0.85
Benue Makurdi, Grams School, Waste, , Nigeria	8.77
Murray town, Sierra Leone	4.87
Mount Aureal, Sierra Leone	7.36
Tower Hill, Sierra Leone	7.83

Along with the landfill samples, agricultural and urban soils were also collected (Table 2) which ranged from 0.40 to 29.90 pg/g I-TEQ. These findings are consistent with the concentrations reported in USA[8] for urban and rural soils.

The concentrations of dioxins and furans found in this study in someos the landfill/dumping sites in Ghana, Sierra Leone and one of the samples of Kuwait make clear that this sites pose a huge srisk for the environment (contamination of surface and groundwater, volatilization to the atmosphere) and for the people who work or live close to those sites. That is why, it is mandatory to setup appropriate landfill technology in those countries or

establish alternative disposal methods to get rid of wastes such as incineration facilities equipped with the most advanced technology.

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