PLASTIC WASTE POISONING FOOD AND THREATENING COMMUNITIES IN AFRICA, ASIA, CENTRAL & EASTERN EUROPE AND LATIN AMERICA

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PLASTIC WASTE POISONING FOOD AND THREATENING COMMUNITIES IN AFRICA, ASIA, CENTRAL & EASTERN EUROPE AND LATIN AMERICA

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IPEN is a network of non-governmental organizations working in more than 100 countries to reduce and eliminate the harm to human health and the environment from toxic chemicals.

www.ipen.org

Arnika is a Czech non-governmental organisation established in 2001. Its mission is to protect nature and a healthy environment for future generations both at home and abroad.

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CONTENTS

Black smoke rises from community cookers fueled by waste plastic in Indonesia, polluting skies and poisoning food chains.

Tropodo, Indonesia. Photo: Jindrich Petrlik

OVERVIEW: HARMFUL POLLUTANTS IN PLASTICS AND THEIR HEALTH RISKS

Plastics and food packaging contain chemical contaminants from manufacturing along with many additives to make them inflammable (flame retardants), more flexible (plasticizers), grease-resistant (fluorinated chemicals known collectively as PFASs), sterile (biocides), and other substances to create many other properties. Many of these additives are toxic and they leak from products during use and can be released during recycling and from recycled products.

It is well established that toxic chemicals are released into the environment not only during the production and the use of plastics, but also during their disposal (Hahladakis, Velis *et al.* 2018, Basel Convention Secretariat and Stockholm Convention Secretariat 2019), in particular when burning or incineration is involved (Blankenship, Chang *et al.* 1994, Thornton, McCally *et al.* 1996, Yasuhara, Katami *et al.* 2006, Stockholm Convention on POPs 2008). When plastics are burned as fuel, new toxic chemicals can be created. For example, burning chlorine-containing plastics such as PVC forms polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs). These highly toxic substances are commonly referred to as dioxins.[1] Burning plastics containing brominated flame retardants creates brominated dioxins and furans (PBDD/Fs), a group of toxic chemicals similar to chlorinated dioxins. Dioxins and other POPs are regarded as the most toxic substances on the planet, having serious health effects at extremely low doses and thus requiring a joint effort in eliminating them from the environment.

Even small amounts of these plastic chemical additives, as well as the highly toxic byproducts that plastic waste disposal methods can create,

1 The synonym "dioxins" is used for this group of chemicals as well, while "brominated dioxins" applies to PBDD/Fs, another group of polyhalogenated dibenzo-p-dioxins and dibenzofurans. We use both these shorter synonyms in this report.

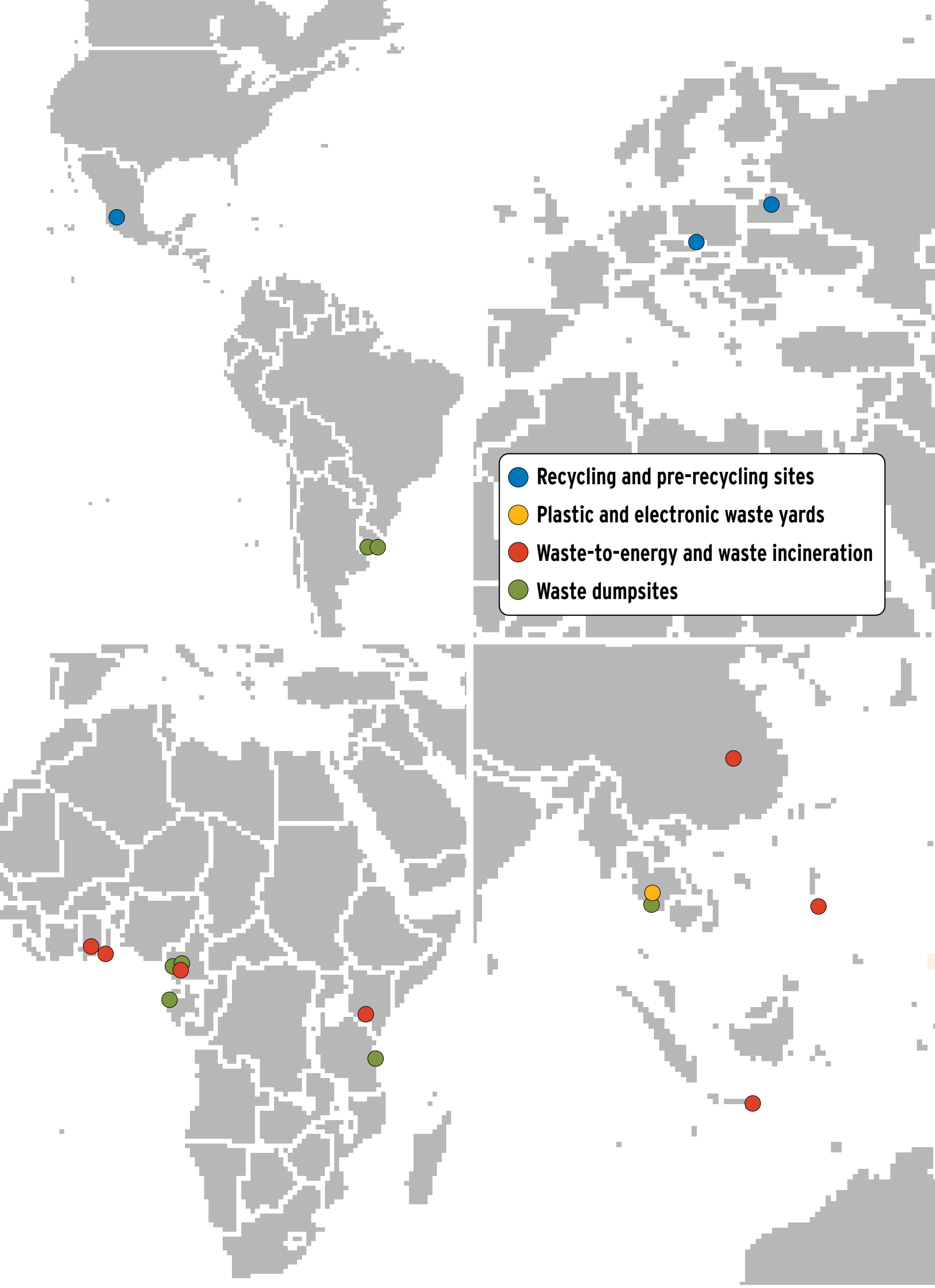
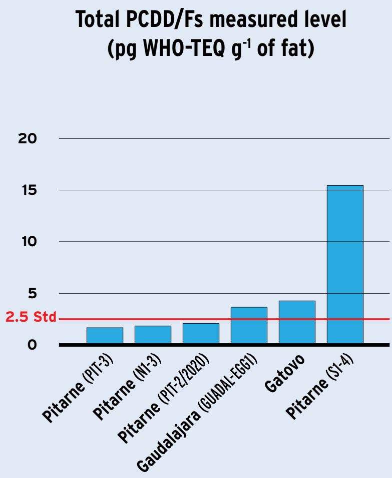

Recycling and pre-recycling sites
Plastic and electronic waste yards
Waste-to-energy and waste incineration
Waste dumpsites

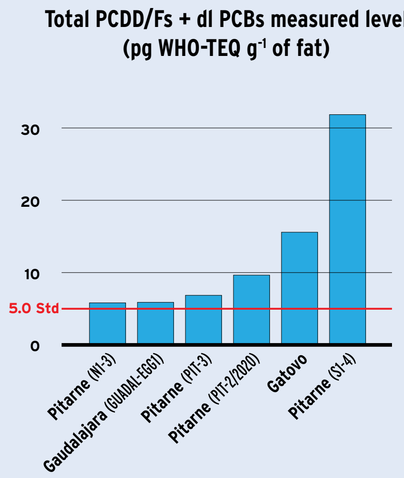
TABLE 1: OVERVIEW OF RESULTS OF CHEMICAL ANALYSES

POPs in thirty-six free-range chicken egg samples from plastic waste hot spots around the world, and six egg reference samples from commercial farms, bought in supermarkets. Samples were taken in 2014 – 2020. Levels of POPs are in ng g^{-1} fat if not specified otherwise. Samples are grouped according to classification of hot spots.

Locality	Recycling and pre-recycling sites (RE)	Plastic and electronic waste yards (WY-E)	Waste to energy and waste incineration (WI)	Dumpsites (DU)	Reference samples (Ref)	EU egg standard / limits
Chlorinated dioxins PCDD/Fs (pg TEQ g^{-1} fat)	1.6 - 15.4	6 - 661	1.7 - 200	2.16 - 26	0.0012 - 0.9	2.5
Dioxin-like polychlorinated biphenyls DL PCBs (pg TEQ g^{-1} fat)	2.3 - 16	3 - 195	0.9 – 32	3.41 - 18	0.001 - 0.34	-
Total sum of chlorinated dioxins + dioxin-like polychlorinated biphenyls PCDD/F + DL PCBs (pg TEQ g^{-1} fat)	5.8 - 32	12 - 856	2.6 – 232	9.6 - 35	0.0032 - 0.9	5.00
Total sum of chlorinated dioxins and dioxin-like polychlorinated biphenyls PCDD/Fs + DL PCBs - DR CALUX (pg BEQ g^{-1} fat)	8.1 - 37	13 - 840	5.2 – 560	12	<0.6 - 1.2	-
Brominated dioxins PBDD/Fs (pg TEQ g^{-1} fat)	<1.4 - 5.4	7 - 300	0.33 – 27	0.17 - 3	<1.8 - <21.3	-
Short-chain chlorinated paraffins SCCPs	235	97 - 2067	65 – 162	50 - 1950	25 - 136	-
Sum of various isomers of hexabromocyclododecane HBCD	<LOQ - 4602	< LOQ - 1961	< LOQ – 379	5.2 - 314	< LOQ - 1036	-
Sum of polybrominated diphenyl ethers PBDEs	<LOQ - 230	3.1 - 1457	< LOQ – 27159	< LOQ - 164	< LOQ - 9.5	-
Sum of the novel brominated flame retardants N-BFRs	<LOQ - 6.2	< LOQ - 124	< LOQ – 2166	< LOQ - 6.2	< LOQ - 3.7	-
Sum of perfluorinated substances PFASs (ng g^{-1} of fresh weight)	1.5	1.15 - 97	0.3 - 2.4	4.7 - 9.8	0.1 - 0.34	-
Linear perfluorooctanesulfonic acid L-PFOS (ng g^{-1} of fresh weight)	0.86	0.36 - 76	0.11 - 1.2	2.3 - 7.3	<0.01	-

Levels of chlorinated dioxins and dioxin-like PCBs are expressed in total WHO-TEQ calculated according to toxic equivalency factors (TEFs) set by a WHO experts panel in 2005 (van den Berg, Birnbaum et al. 2006). These TEFs were used to evaluate dioxin-like toxicity in pooled samples of chicken eggs in this study. Additionally, dioxins are measured via "Bioanalytical methods" meaning methods based on the use of biological principles like cell-based assays, receptorassays or immunoassays. They do not give results at the congener level but merely an indication of the TEQ level, expressed in Bioanalytical Equivalents (BEQ) to acknowledge the fact that not all compounds present in a sample extract that produce a response in the test may obey all requirements of the TEQ-principle.

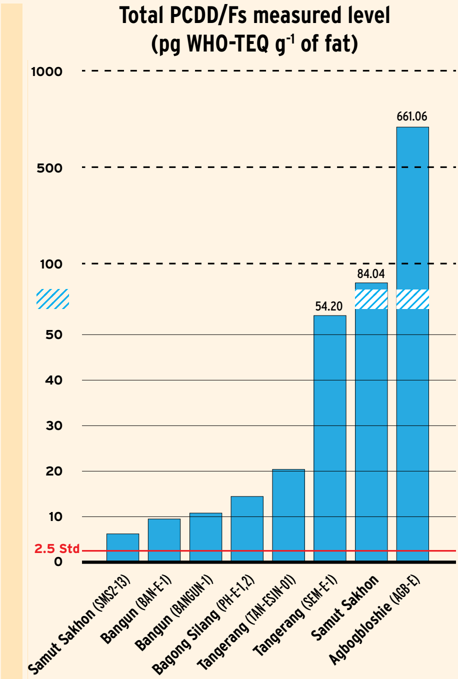


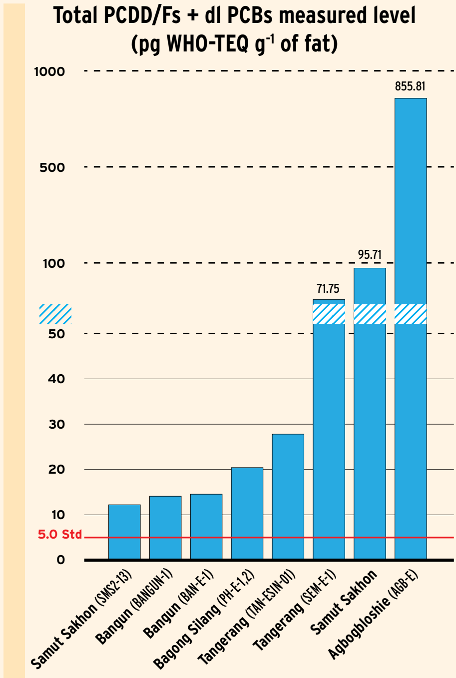


Car shredder in Gatovo, Belarus

Photo: Martin Skalsky, Arnika

WASTE YARDS & LARGE E-WASTE SITES

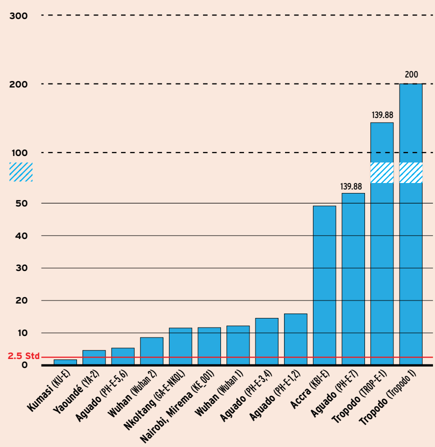




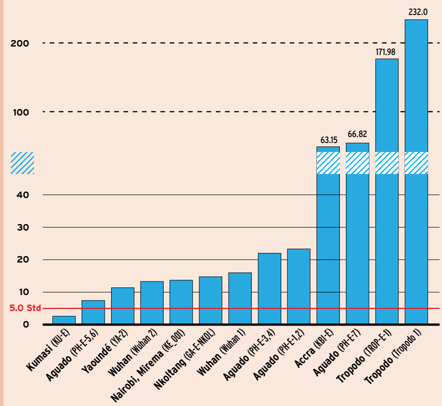
Electronic waste strewn at a site in Cerro de Montevideo, Uruguay

Photo: María Cárcamo, RAPAL Uruguay

Total PCDD/Fs measured level (pg WHO-TEQ g^{-1} of fat)



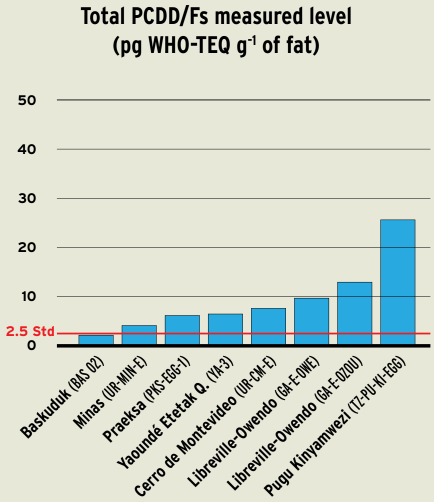
Total PCDD/Fs + dl PCBs measured level (pg WHO-TEQ g^{-1} of fat)

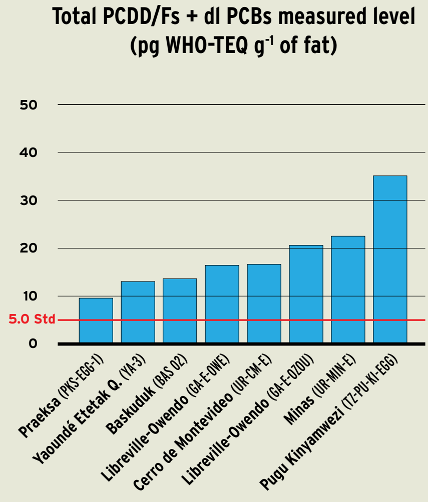


Waste incineration facility in Wuhan, China

Photo: Jindrich Petrlik

DUMPSITES & REFERENCE SAMPLES





Dumpsite near community in Pugu Kinyamwwezi, Tanzania

Photo: AGENDA, Tanzania

can cause damage to immune and reproductive systems, cancers, impaired intellectual functions, and/or developmental delays. Most of the persistent organic pollutants (POPs) were found to last for a long time in the environment and accumulate in animals, and many of them are regulated globally by the Stockholm Convention. The majority of these chemicals are lipophilic and accumulate in fatty tissues of organisms.

Some developing countries, such as Ghana, Indonesia, Malaysia, Nigeria, the Philippines, Tanzania, Thailand and Vietnam have become destinations for waste exports, including plastic waste, paper for recycling and/or electronic waste (e-waste). These wastes may contain a whole range of POPs added intentionally to the products now present in the waste chain, including brominated flame retardants (BFRs), short-chain chlorinated paraffins (SCCPs), and per- and polyfluoroalkyl substances (PFASs).

The issue with plastic is not only a waste management problem, as claimed by the plastic industry (Dunn 2019). Instead, it is something that has to be solved by minimization of its production from the start and eliminating toxic additives from plastic production. Less burned plastic will also decrease the generation of vast amounts of toxic chemicals, including POPs.

This study focuses on POPs, whose releases are closely related to plastic wastes. The POPs include additives in the plastic as such, as well as unintentionally produced POPs (UPOPs) generated mostly by burning, incineration and/or other thermal treatment of plastics.

USING EGGS TO ASSESS CONTAMINATION WITH PERSISTENT ORGANIC POLLUTANTS

Eggs have a significant lipid content which accumulates POPs from the hen that lays them. In addition, free-range chickens pick food from among the soil and dust in the local area, including soil earthworms, worms and other soil fauna, ingesting some soil in the process, and therefore they act as *active samplers* and their eggs provide an indicator of the POPs environmental contamination levels in that locality (Van Eijkeren, Zeilmaker et al. 2006, Hoogenboom, ten Dam *et al.* 2014, Piskorska-Pliszczynska, Mikolajczyk *et al.* 2014). Eggs have been found to be sensitive indicators of exposure to POPs pathway from soil pollution to humans. And eggs from contaminated areas can readily lead to exposures which exceed thresholds for the protection of human health. Analysis of commercially produced eggs from hens kept in large farms, mostly without access to outdoor soil and fed on relatively uncontaminated feed, acts as an indicator of background levels for eggs. These *reference samples* provide a basis for comparison of contaminated eggs.


POLIS

In this study, free-range chicken eggs have been used to investigate POPs contamination of the food chain in the vicinity of plastic waste disposal sites and facilities. The analyses of recently sampled eggs were conducted in European laboratories between June 2019 and March 2020. Previously analyzed egg samples from 2014 to 2019 have also been included.

In this study, the analyzed eggs were collected from the following types of plastic waste management and disposal facilities and operations: 1) plastic and electronic waste yards; 2) waste dumpsites with significant amounts of plastic wastes; 3) recycling and shredder plants which deal with significant amounts of plastic waste; and 4) waste incineration and co-incineration operations.

The localities chosen for sampling are sites where higher exposure to unintentionally produced POPs, such as dioxins, was expected due to the activities on or near the sites.

Results include the chemical analyses of one individual free-range and 35 pooled chicken egg samples and six[2] reference samples from supermarkets. The samples come from twenty-five hot spots in fourteen countries within Africa, Asia, Europe, and Latin America.

The eggs were analyzed for the contamination of chlorinated and brominated dioxins, which are the very toxic byproducts of POPs incineration or reprocessing and recycling technologies. Additionally, the eggs were analyzed for persistent organic chemicals (POPs) that are already or are in the process of being banned globally through the Stockholm Convention. These POPs cover halogenated compounds such as polychlorinated biphenyls (PCBs), additives in plastics (primarily PVC) such as short-chain chlorinated paraffins (SCCPs), flame retardants present in electronics, motor vehicles, and aerospace, polybrominated diphenyl ethers (PBDEs) and in construction materials and furniture (HBCD) and water and grease-repellent perfluorinated chemicals.

Different types of persistent organic pollutants have a wide range of health effects. Many of them are endocrine disruptors impairing the healthy development of a child and even the fetus, causing immunological disorders

2 There were two reference samples bought in supermarkets in Prague which are merged here as one reference sample, as the second one (PHA-2) was analyzed for SCCPs only while the first one (PHA-1) was analyzed for most other POPs presented in this study excluding PBDD/Fs, DR CALUX dioxin activity, and PFASs. The result of the analysis of PHA-2 was part of a previously published study on SCCPs in eggs, Adu-Kumi, S., J. Petrlík, E. Akortia, M. Skalský, J. Pulkrabová, J. Tomáško, L. Bell, J. N. Hogarh, D. Kalmykov and A. Arkenbout (2019). "Short-chain chlorinated paraffins (SCCPs) in eggs from six countries." *Organohalogen Compounds* 81(2019): 337-339.

At an hospital in Cameroon, medical waste is burned without sufficient controls against soil, air, or water contamination. Photo: CREPD

or cancer. They are being found in breast milk and cord blood in alarming concentrations. Due to their persistence and bioaccumulation they tend to negatively affect the health of present as well as future generations.

TABLE 2. ANALYZED SUBSTANCES IN EGGS AND THEIR HEALTH EFFECTS

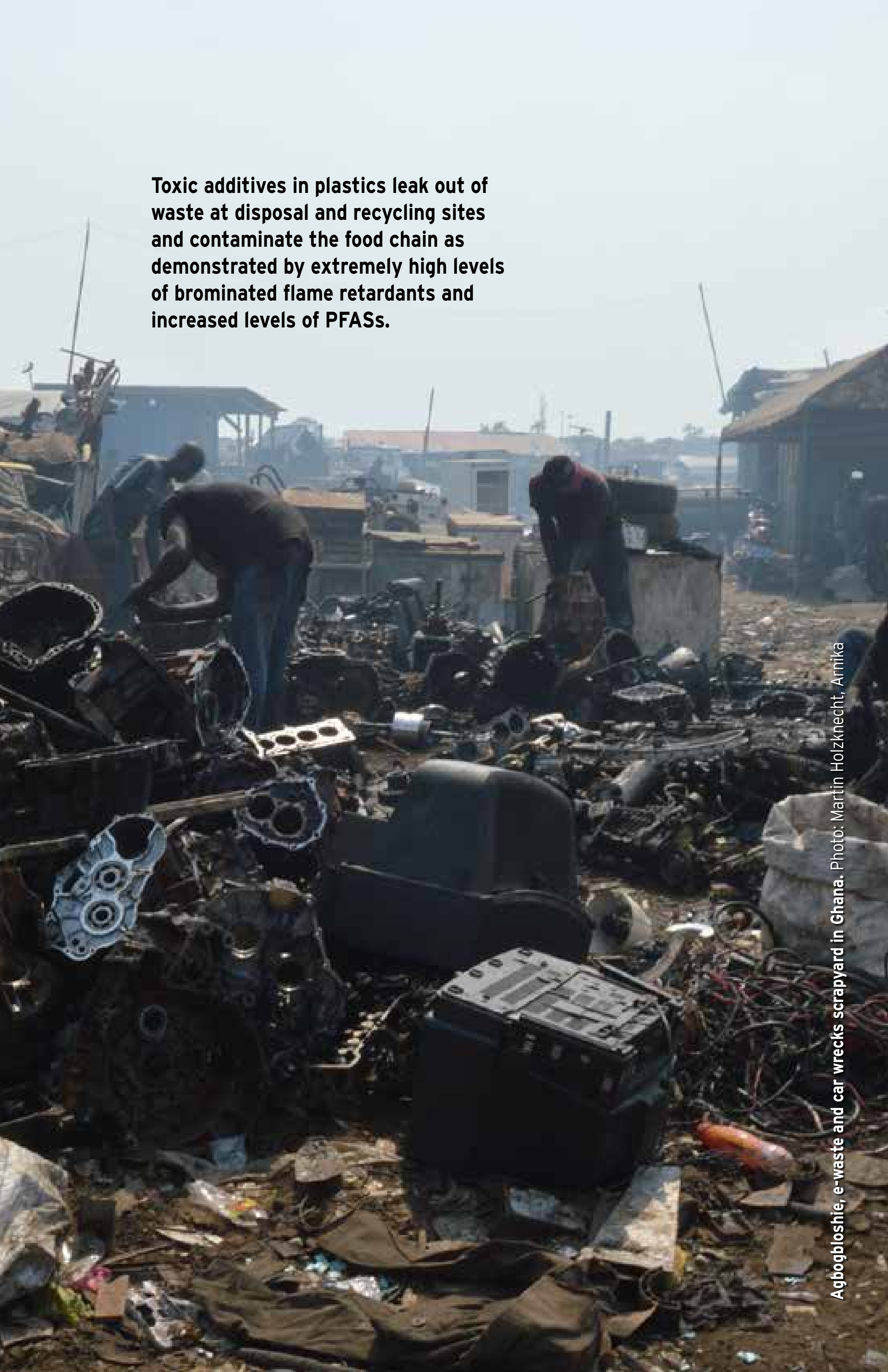
Substances based on their properties in materials	
Specific chemicals	**Health effects**
Flame retardants: Polybrominated diphenyl ethers (PBDEs)	
PentaDBE, OctaBDE Banned since 2009 Where used? PentaBDE in polyurethane foam for car and furniture upholstery OctaBDE (10-18% of the weight) in CRT television and computer casings and other office electronics made of acrylonitrile butadiene styrene (ABS) plastic	Endocrine-disrupting chemicals (EDCs). May adversely impact the development of the nervous system and children's intelligence
DecaBDE Banned since 2017 Where used? DecaBDE (7-20% of weight) in many different plastic materials including high-impact polystyrene (HIPS), polyvinylchloride (PVC), and polypropylene (PP) used in variety of electronics, in car vehicles and airspace	

Table 2. Continued

Specific chemicals	Health effects
Flame retardants	
Hexabromcyclododecane (HBCD) Banned since 2013 Where used? Used in polystyrene building insulation	Highly toxic to aquatic organisms and has negative effects on reproduction, development, and behaviour in mammals, including transgenerational effects
Unintentionally occurring POPs in wastes	
Polychlorinated dioxins and furans (PCDD/Fs) and dioxin-like PCBs Banned since 2001 Where used? Byproducts of pesticides use (Agent Orange). Formed by incineration of plastics esp. PVC, impurities in PCBs, and other chlorinated chemicals.	Extremely toxic - Numerous epidemiologic studies revealed health effects resulting in cardiovascular disease, diabetes, cancer, porphyria, endometriosis, early menopause, alteration of testosterone and thyroid hormones, and altered immune system response, an increase in birth defects and stillbirths.
Polybrominated dioxins and furans (PBDD/Fs) Not banned yet Where used? Unintentionally produced POPs found at sites with PBDE-containing e-waste and/or plastic waste. Also formed by sunlight exposure during normal use, as well as during disposal/recycling processes of flame-retarded consumer products	Affect brain development, damage the immune system and fetus or induce carcinogenesis
Flame retardants and plasticisers	
Short chain chlorinated paraffins Banned since 2017 Where used? SCCPs used as additional additives in plastics (PVC)	Toxic to aquatic organisms at low levels, disrupt endocrine function, and are suspected to cause cancer in humans

Specific chemicals	Health effects
Water and grease-repellents Perfluorinated chemicals (PFAS)	
Perfluorooctanesulfonic acid (PFOS) Banned since 2009 Where used? Used in stain-resistant application including Scotchguard, in textiles, in the packaging and paper industries in both food packaging and commercial applications to impart grease, oil and water resistance, in firefighting foams	PFOS has been shown to cause cancer, neonatal mortality, delays in physical development, and endocrine disruption
Perfluorooctanoic acid (PFOA) Banned since 2019 Where used? PFOA and related substances used in the manufacture of many fluoropolymers, in the semiconductor industry, in firefighting foams, ski waxes, paper packaging, in textiles, carpets and upholstery.	Higher maternal levels of PFOS and PFOA are associated with delayed pregnancy, reduced human semen quality and penis size. PFOA is associated with high cholesterol, ulcerative colitis, thyroid disease, testicular cancer, kidney cancer, pregnancy-induced hypertension, and immune system effects and it is transferred to the fetus through the placenta and to infants via breast milk
Perfluorohexane sulfonate (PFHxS) with its salts Proposed for a ban in 2021 Where used? Used as surfactant (foam formation for reduction of fuels fires) and surface protector (metal plating processes, consumer products such as carpets, textile, and in leather industry).	Trigger hypersensitivity and suppression of immune system (asthma, allergic reactions), changes of lipids and protein metabolism pathways, changes in liver and thyroid functioning, and can also affect the reproductive system

Toxic additives in plastics leak out of waste at disposal and recycling sites and contaminate the food chain as demonstrated by extremely high levels of brominated flame retardants and increased levels of PFASs.



Agbogbloshie, e-waste and car wrecks scrapyard in Ghana. Photo: Martin Holzknecht, Arnika

KEY FINDINGS

The levels of POPs in free-range chicken egg samples show that the current plastic waste sorting, dumping and open burning practices lead to serious contamination of the food chain in developing countries. The recycling of some plastics can also lead to serious contamination with POPs as shown by some of the examples included in this study. This applies to PVC and e-waste in particular.

EGGS CONTAMINATION FROM PLASTIC AND E-WASTE SCRAP YARDS

Toxic POPs additives in plastics leak out of them at disposal and recycling sites and contaminate the food chain as demonstrated by extremely high levels of brominated flame retardants and increased levels of PFASs in pooled free-range chicken egg samples in this study. An adult eating half an egg per day from a free-range chicken foraging in the vicinity of the Bangun dumpsite would exceed the proposed tolerable daily intake (TDI) of PFOS (EFSA CONTAM 2018b) by 3 and almost 16 times respectively.

The eggs from large plastic and e-waste scrap yards, as well as eggs from areas where plastic waste is used as fuel or where it is incinerated, are contaminated with extremely high levels of POPs. Agbogbloshie and Tropodo rank among the sites with the highest pollution by POPs globally, according to levels found in free-range chicken eggs and soil and ash samples (Petrlik, Adu-Kumi *et al.* 2019, Petrlik, Ismawati *et al.* 2020).

The maximum level of dioxin contamination in free-range chicken eggs from hot spots in this study is six times higher than the levels measured in a global report by IPEN in 2005.[3] Among results published in recent years only the dioxin levels in free-range chicken eggs from Bien Hoa, a former US military base in Vietnam (Traag, Hoang *et al.* 2012, Hoang, Traag *et al.* 2014, Kudryavtseva, Shelepchikov *et al.* 2020) are similar compared to those presented in this study (see Annex 3).

3 A maximum level of 126 pg TEQ g^{-1} fat of PCDD/Fs was measured in eggs from Helwan, Egypt. The highest level of 661 pg TEQ g^{-1} fat of PCDD/Fs measured in this study was from Agbogbloshie, Ghana, but two more samples in this study coming from Tropodo, Indonesia, also exceeded the maximum level previously measured in Helwan.

Agbogbloshie, Ghana. Photo: Martin Holzknecht, Arnika

The mixing of plastics and electronic waste creates an "ideal" combination for the creation of unintentionally produced POPs, such as chlorinated or brominated dioxins. Halogenated plastics like PVC or plastics treated with brominated flame retardants are donors of chlorine and bromine, while electronics contain a variety of metals, including copper which is a typical catalyst for the creation of polyhalogenated dioxins and furans (Olie, Addink *et al.* 1998, Tame, Dlugogorski *et al.* 2003). The burning of this kind of mixture occurring at e-waste sites very often leads to much more severe contamination with dioxins than other open burning of wastes at general dumpsites, and the results of this study confirm that.

The maximum levels of PBDEs in egg samples in this study taken from sites affected by plastic waste are comparable only to the most seriously contaminated e-waste sites in China, such as for example Guiyu (Annex 6). Eating half an egg from the sample most contaminated by dioxins and dl-PCBs among those from the vicinity of the dumpsite in Pugu Kinyamwezi, Tanzania exceeds EFSA's TDI by 7.5 times. One egg from this locality can contain around 220 pg TEQ of dioxins and dl-PCBs, which almost equals the TDI for 13 persons weighing 70 kg each. One egg from the sample taken in Agbogbloshie would be enough to reach the TDI for 251 persons of 70 kg each. The new TDI for dioxins and dl-PCBs established by EFSA in 2018 is 0.25 pg TEQ per kg body weight per day (EFSA CONTAM 2018).

BURNING OF PLASTIC WASTE IS IDEAL FOR POPs CREATION

POPs accumulate not only in air releases, but they also bind to particulate matters and/or ash produced by burning plastic waste. The measured levels of dioxins, but also of other POPs, in the ash residues from Agbogbloshie, and the medical waste incinerators in Accra and Nkoltang or ash from burning plastic waste in tofu factories in Tropodo were many times higher than those measured in soil or sediments. These residues, accessible to domestic animals for food, can become a major source and/or important contributor for POPs contamination of the food chain, which then accumulates in dairy products, eggs and meat. This was also confirmed for several hot spots in this study, e.g. Tropodo, Accra – hospital, Samut Sakhon or Agbogbloshie (Petrlík, Dvorská *et al.* 2018, Petrlik, Adu-Kumi *et al.* 2019, Petrlik, Ismawati *et al.* 2020). The waste reprocessing plant in Aguado using waste incineration ash to make bricks (Calonzo, Petrlik *et al.* 2005) and their subsequent use by local residents most likely contributes to the high dioxin levels in the free-range chicken eggs from this locality in the Philippines.

ONE EGG FROM THE SAMPLE TAKEN IN AGBOGBLOSHIE WOULD BE ENOUGH TO REACH THE TDI FOR 251 PERSONS OF 70 KG EACH.

The thirty-six free-range chicken egg samples from twenty-five plastic waste hot spots in this study include some samples with the highest levels of POPs ever measured in poultry eggs:

1. Four samples from this study are among the ten highest ever measured levels of chlorinated dioxins in chicken eggs globally, and they are the second, sixth, seventh, and tenth highest. (See Annex 2)
2. Seven samples have the highest levels of brominated dioxins ever measured in eggs, although, in general, PBDD/Fs are not measured in eggs very often.
3. Six egg samples in this study are among the ten highest ever measured levels of HBCD in poultry eggs globally, however, not all six come from sites affected by plastic waste disposal or recycling. One of the samples is a reference egg sample from a convenience store in Karaganda. (See Annex 3)
4. Four samples in this study are among the ten highest ever measured levels of PBDEs in free-range eggs globally. The extremely high level of 27,159 ng g^{-1} fat of PBDEs, and decaBDE in particular, was measured in a pooled egg sample from Tropodo, Indonesia. (See Annex 5)

POPs RELEASE DURING THE USE PHASE OF PLASTICS: EGG CONTAMINATION FROM USE OF POLYSTYRENE FOAM AND FROM THE VICINITY OF PLASTICS RECYCLING FACILITIES

The examples of eggs from the store in Karaganda and from Pitarne in the Czech Republic, where the chickens were most likely contaminated by foraging on the polystyrene insulation of the house, show that even the use of plastics with POPs additives can be a source of food chain contamination, which is why the use and disposal of such plastics should be strictly regulated.

E-waste scrap yards or the burning of plastic waste as fuel became obvious sources of serious POPs-contamination of food chains in different parts of the world, but even some recycling operations can be sources of contamination to their surroundings as demonstrated in the cases of hot spots in Mexico, the Czech Republic and Belarus in this study. The results of the contamination of chicken eggs demonstrated in this study show that although their contamination in these locations is not as high as in e-waste sites, it still exceeds the maximum levels suggested to be tolerable by public authorities controlling food contamination such as EFSA, by up to six times. Plastics from electronic waste or cars seem to be most problematic even in these operations and should be addressed by stricter controls of additives like brominated flame retardants, as well as of their leakage from recycling plants.

PLASTICS USED AS FUEL AS A PREREQUISITE FOR EGG CONTAMINATION

The results of the analyses of free-range eggs from two sites where plastic waste was being used as fuel, either in tofu production or in so-called "community cooker" stoves, show that using plastic waste as fuel leads to serious contamination of the environment with dioxins. There is enough evidence that the higher the concentrations of PVC in burned waste, the higher the levels of dioxins released. PVC is linked to the generation of dioxins, and this and other chlorine-containing plastics may also contribute to the formation of dioxins in Tropodo and Nairobi – Mirema. For example, the BAT/BEP Guidelines of the Stockholm Convention for residential combustion sources suggest: "*Many studies show that combustion of chlorine containing waste such as PVC, leads to increased formation of unintentional persistent organic pollutants (Gullett, Lemieux et al. 1999).*" This suggestion is followed by a table showing the results of PVC burning (see Table 9).

Chemical contaminants enter the food chain both through the waste piling up in communities and through the ash residues of incinerated plastics.
Photos: Arnika and Ecoton

TABLE 9. THE RELATION OF PCDD/F EMISSION FACTORS ON PVC CONTENT IN BURNED MATERIAL.

PVC content [%]	0	0.2	1	7.5
Average Emission factor in I-TEQ/kg [ng]	14	80	200	4,900
Range I-TEQ/kg [ng]	2 - 28	9 - 150	180 - 240	3,500 – 6,700

Source: Stockholm Convention on POPs 2008

This study reveals an increasing share of brominated dioxins in environmental contamination and there is no doubt that the cause of this should be sought in the treatment of plastics with brominated flame retardants. In some cases, brominated dioxins contribute significantly to the contamination levels in egg samples and at the same time to the total dioxin exposure of the human body. This is mainly the case for the samples from Agbogbloshie, Wuhan, Tangerang, Samut Sakhon, Bagong Silang, and Guadalajara. At almost all these sites, e-waste plastics play a significant role.

RECOMMENDATIONS

INTERNATIONAL AGENCIES

Establish global controls on hazardous chemicals in plastic products and waste

- Phase out the use of hazardous chemicals in plastic, including in any new UN Plastic Treaty agreement.
- Restrict the production of plastic for non-essential uses.
- Establish a "Right to Know" regulation that requires companies to publicly disclose toxic additives in products.
- Ban the use of contaminated recycled plastics in new products and the recycling of plastic material that contains POPs and EDCs.
- Strengthen the Basel Ban to ban the export of plastic waste and e-waste
- Remove all exemptions for plastics under the Basel Convention.
- Strengthen dioxin, PBDE, and SCCP contaminated waste restrictions within the Stockholm Convention to prevent the export of POPs waste, including plastic waste containing high levels of BFRs.

NATIONAL GOVERNMENTS

Establish and implement effective policies to reduce plastic production and waste in a real circular economy.

- Ratify the Basel Ban amendment
- Ban/reduce the export/import of hazardous waste
- End subsidies to fossil fuel extraction and plastic production facilities.
- Audit 'chemical recycling' plants claiming to produce outputs for plastic production and cancel permits if they are not.
- Refuse permits for 'chemical recycling' pyrolysis plants producing fuels.

- Support non-combustion technologies for medical waste and POPs-containing waste.
- Legislate strong penalties for illegal cross-boundary trade in plastic waste
- End public investment, renewable energy credits and subsidies for plastic-to-energy projects and infrastructure.
- Subsidise independent plastic substitution research and development centres

PLASTICS INDUSTRY

Take responsibility for safe plastic production, use, and disposal.

- Invest in new plastics-free materials and closed loop-systems that do not generate waste, or contribute to climate change.
- Redirect R&D efforts to natural materials substitution
- Stop putting toxic chemical additives in plastics
- List plastics ingredients on labels

CIVIL SOCIETY

Educate governments and citizens on the hazards of plastics production and waste

- Raise awareness of the toxic hazards in the plastic life-cycle
- Promote legislation to ban non-essential and toxic plastics
- Promote consumption of reusable and recyclable plastic product substitutes
- Highlight the need for governments to ratify international plastic control agreements
- Campaign for a purchasing boycott of plastic packaging, plastic toys and PVC.

ANNEX 1
SAMPLING AND ANALYTICAL METHODS

The samples of free-range chicken eggs and reference eggs from Gabon, Indonesia, Kenya, Mexico, the Philippines, Tanzania and Uruguay were sampled during the period from April 2019 until January 2020. Samples from Pitarne in the Czech Republic were taken by the end of 2017 as part of the project focused on plastic waste recycling sites, and reference samples were collected in Prague in April 2018 and February 2019. One additional sample from Pitarne was taken in August 2020.

The analyses of recently sampled eggs were conducted in European laboratories between June 2019 and March 2020 closely following sampling campaigns in the above-mentioned countries.

Previously sampled eggs were analyzed in the same laboratories, but in previous years, and the description of their sampling and analyses is included in previous reports for Africa (Petrlik, Adu-Kumi *et al.* 2019), China (Petrlik 2016), Kazakhstan (Petrlík, Kalmykov *et al.* 2016), and Thailand (Mach, Petrlík *et al.* 2017, Petrlík, Dvorská *et al.* 2018).

Thirty-five pooled samples and one individual sample of free-range chicken eggs were collected at twenty-five hot spots in fourteen countries, over four continents. Just as in previous studies, six samples of eggs purchased in a supermarket or convenience stores (in Prague, Accra, Beijing, Jakarta, Karaganda, and Bangkok) served as background samples as they were not from free-range hens and therefore unlikely to be exposed to POPs chemicals in soil and dust (DiGangi and Petrlik 2005). A basic description of these twenty-five localities can be found later in Annex 6.

Pooled samples of more individual egg samples were collected at each of the selected sampling sites in order to obtain more representative samples. In one case it was not possible to obtain more eggs, so we then decided to analyze an individual egg (PH-E-7) and returned to potentially resample that site, which was successful (see sample PH-E-S-5/2).

DR CALUX: Free-range chicken eggs from the seventeen pooled samples (for specific egg samples see Tables in Annex 1) and three pooled samples of commercial eggs (non free-range) were analyzed for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and dioxin-like polychlorinated biphenyls (dl-PCBs) using the DR CALUX® method. These were sent to a Dutch ISO 17025 certified laboratory (BioDetection Systems B.V., Amsterdam) performing the cell-based screening analysis DR

CALUX® according to the European Standard EC/644/2017. The procedure for the BDS DR CALUX® bioassay has previously been described in detail (Besselink H 2004). Briefly, rat liver H4IIE cells stably transfected with an AhR-controlled luciferase reporter gene construct were cultured in an α-MEM culture medium supplemented with 10% (v/v) FCS under standard conditions (37°C, 5% CO2, 100% humidity). Cells were exposed in triplicate on 96-well microtiter plates containing the standard 2,3,7,8-TCDD calibration range, a reference egg sample (analysed by HRGC-HRMS; for the bioassay apparent recovery), a procedure blank, a DMSO blank and the sample extracts in DMSO. Following a 24-hour incubation period, cells were lysed. A luciferin-containing solution was added and the luminescence was measured by using a luminometer (Mithras, Berthold Centro XS3).

The DR CALUX® bioassay method has been shown to be a cost-efficient semi-quantitative effect-based toxicity screening analysis for all kinds of stable dioxin-like compounds (PCDD/Fs, dl-PCBs, PBDD/Fs, PBBs, chlorinated and brominated polycyclic aromatic hydrocarbons, N-dioxins)[4]; however, for confirmation it is recommended to go for more specific PCDD/Fs and dl-PCBs congener analyses, which also allows examination of fingerprints of dioxins (PCDD/F congener patterns), specific for different sources of pollution. Thirty-five free-range egg samples as well as all six commercial eggs samples were analyzed for content of individual PCDD/Fs and an extended list of PCB congeners by HRGC-HRMS at the accredited laboratory of the State Veterinary Institute in Prague, Czech Republic. Samples of eggs collected in Bangun and Tropodo in May 2019 (Bangun 1 and Tropodo 1) were analyzed for specific PCDD/Fs and dl-PCBs congener in MAS laboratory, Muenster, Germany, simultaneously with analysis for brominated dioxins. The sample from Praeksa, Thailand was analyzed in Axys Varilab laboratory in the Czech Republic, also by HRGC-HRMS. Only one sample from Yaounde, TKC Quarter, was not analyzed for PCDD/Fs and dl-PCBs by HRGC-HRMS.

The twenty-eight free-range and all six reference egg samples (see Annex 3 and 4) were also analyzed for PBDEs and HBCD, and short-chain chlorinated paraffins (SCCPs). The thirteen free-range samples and one reference sample (from Jakarta) were also analyzed for the range of 17 PFASs,

4 “Bioanalytical methods“ means methods based on the use of biological principles like cell-based assays, receptor assays or immunoassays. They do not give results at the congener level but merely an indication of the TEQ level, expressed in Bioanalytical Equivalents (BEQ) to acknowledge the fact that not all compounds present in a sample extract that produce a response in the test may obey all requirements of the TEQ-principle. European Commission (2012). Commission Regulation (EU) No 252/2012 of 21 March 2012 laying down methods of sampling and analysis for the official control of levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in certain foodstuffs and repealing Regulation (EC) No 1883/2006 Text with EEA relevance European Commission. Official Journal of the European Communities: L 84, 23.83.2012, p. 2011–2022.

including PFOA, PFOS and PFHxS. All of these analyses were conducted in a Czech certified laboratory (University of Chemistry and Technology in Prague, Department of Food Chemistry and Analysis).

Identification and quantification of PBDEs were performed using gas chromatography coupled with mass spectrometry in negative ion chemical ionization mode (GC-MS-NICI). Identification and quantification of HBCD isomers and selected PFASs were performed by liquid chromatography interfaced with tandem mass spectrometry with electrospray ionization in negative mode (UHPLC-MS/MS-ESI).

The extract, which was prepared the same way as for the other analyses, was transferred into cyclohexane and diluted. Identification and quantification of SCCPs was accessed via gas chromatography/time-of-flight high resolution mass spectrometry (GC/TOF-HRMS) in the mode of negative chemical ionization (NCI).

Fifteen pooled samples of free-range chicken eggs and three samples from supermarkets were also analyzed for polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs) in the MAS laboratory, Muenster, Germany. The accredited method MAS_PA002, ISO/IEC 17025:2005 was used to determine PBDD/Fs. The basic steps of the analyses can be summarized as follows:

- Addition of $^{13}C_{12}$-labelled PBDD/F internal standards to the sample extract
- Multi-step chromatographic clean-up of the extract
- Addition of $^{13}C_{12}$-labelled PBDD/F - recovery standards
- HRGC/HRMS analysis
- Quantification via the internal labelled PBDD/F-standards (isotope dilution technique and internal standard technique).

ANNEX 2

CHLORINATED DIOXINS IN EGGS

We compared the results of the analyses for dioxins in eggs from this study to maximum levels measured in free-range chicken eggs in other studies.

Graph showing maximum levels of PCDD/Fs measured in chicken eggs in different countries. Samples before 2006 are in WHO-TEQ 1998. Sources of information are listed in Table 5.

Total PCDD/F pg WHO TEQ g^{-1} fat

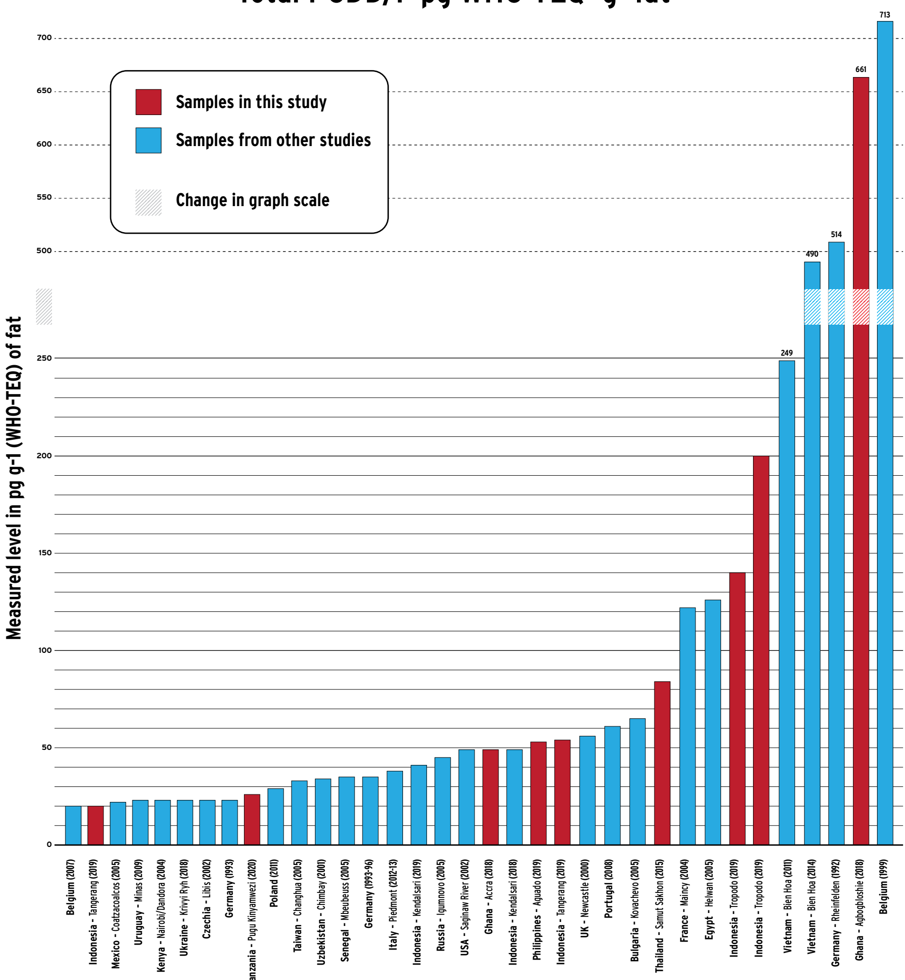


TABLE 5: OVERVIEW OF POULTRY EGG SAMPLES WITH THE HIGHEST MEASURED LEVELS OF CHLORINATED DIOXINS (PCDD/Fs) SINCE THE 1990s.

Country	Year	Locality	PCDD/Fs pg WHO-TEQ g^{-1} fat	Source	Comments
Belgium	2007	Not specified	20	Van Overmeire, Pussemier *et al.* 2009	-
Indonesia	2019	Tangerang	20	This study	Open burning of plastic waste
Mexico	2005	Coatzacoalcos	22	DiGangi and Petrlik 2005	Petrochemical complex; hazardous waste incinerator
Uruguay	2009	Minas	23	Reyes 2010, Uruguay 2017	Cement kiln co-incinerating PCBs
Kenya	2004	Nairobi - Dandora	23	DiGangi and Petrlik 2005	Open burning at dumpsite
Ukraine	2018	Krivyi Ryh	23	Petrlík, Straková *et al.* 2018	Metallurgical and coke plants
Czechia	2002	Libis	23	Greenpeace CZ 2002	Chlor-alkali plant, dioxin-contaminated site
Germany	1993	Not specified	23	Fürst, Fürst *et al.* 1993	Either PVC burning or PCP - not clear from (Fürst, Fürst *et al.* 1993)
Tanzania	2020	Pugu Kinyamwezi	26	This study	Open burning of waste
Poland	2011	Not specified	29	Piskorska-Pliszczynska, Strucinski *et al.* 2016	PCP treated wood
Taiwan	2005	Changhua county	33	The Epoch Times 2005	Metallurgical plants (steelworks); (duck eggs)
Uzbekistan	2001	Chimbay	34	Muntean, Jermini *et al.* 2003	Potential use of 2,4,5-T in cotton cultivation
Senegal	2005	Mbeubeuss	35	DiGangi and Petrlik 2005	Mixed waste dumpsite, potential PCP contamination
Germany	1993-96	Not specified	35	Malisch 1998	Not specified (free-range chicken eggs)
Italy	2012-13	Piedmont region	38	Squadrone, Brizio *et al.* 2015	Secondary aluminium smelter

Country	Year	Locality	PCDD/Fs pg WHO-TEQ g^{-1} fat	Source	Comments
Indonesia	2019	Kendalsari	41	This study	Secondary aluminium smelters / contaminated ash
Russia	2005	Igumnovo	45	DiGangi and Petrlik 2005	Chlorine chemical industry area; Hazardous Waste Incinerator (HWI)
USA	2002	Saginaw River	49	MDEQ 2003	Floodplain downstream from chlorine chemical industry
Ghana	2018	Accra - hospital WI	49	Petrlik, Adu-Kumi *et al.* 2019	Medical waste incinerator ash
Indonesia	2018	Kendalsari	49	SVÚ Praha 2018	Secondary aluminium smelter
Philippines	2019	Aguado	53	This study	Medical waste incineration; incineration ash
Indonesia	2019	Tangerang	54	This study	Open burning of plastic waste and e-waste plastics
UK	2000	Newcastle	56	Pless-Mulloli, Schilling *et al.* 2001a	Waste incineration ash
Portugal	2008	Not specified	61	Cardo, Castel-Branco *et al.* 2014	PCP treated wood
Bulgaria	2005	Kovachevo	65	DiGangi and Petrlik 2005	Industrial area with coal-burning power plants
Thailand	2015	Samut Sakhon	84	Petrlik, Teebthaisong *et al.* 2018	Artisanal e-waste and general waste recycling; open burning
France	2004	Maincy	122	Pirard, Focant *et al.* 2004	Old waste incinerator operating between 1974-2002
Egypt	2005	Helwan	126	DiGangi and Petrlik 2005	Metallurgical workshops
Indonesia	2019	Tropodo	140	This study	Plastic waste used as fuel in tofu factories / ash
Indonesia	2019	Tropodo	200	This study	Plastic waste used as fuel in tofu factories / ash

Country	Year	Locality	PCDD/Fs pg WHO-TEQ g^{-1} fat	Source	Comments
Vietnam	2011	Bien Hoa	249	Traag, Hoang *et al.* 2012	Former US military base, dioxin-contaminated site
Vietnam	2014	Bien Hoa	490	Kudryavtseva, Shelepchikov *et al.* 2020	Former US military base, dioxin-contaminated site
Germany	1992	Rheinfelden	514	Malisch, Schmid *et al.* 1996	Waste from chlor-alkali chemical plant
Ghana	2018	Agbogbloshie	661	Petrlik, Adu-Kumi *et al.* 2019	E-waste and automobile scrapyard
Belgium	1999	Not specified	713	van Larebeke, Hens *et al.* 2001	Dioxin contamination of feed

ANNEX 3
HBCD IN EGGS

Highest levels of HBCD measured in eggs globally.

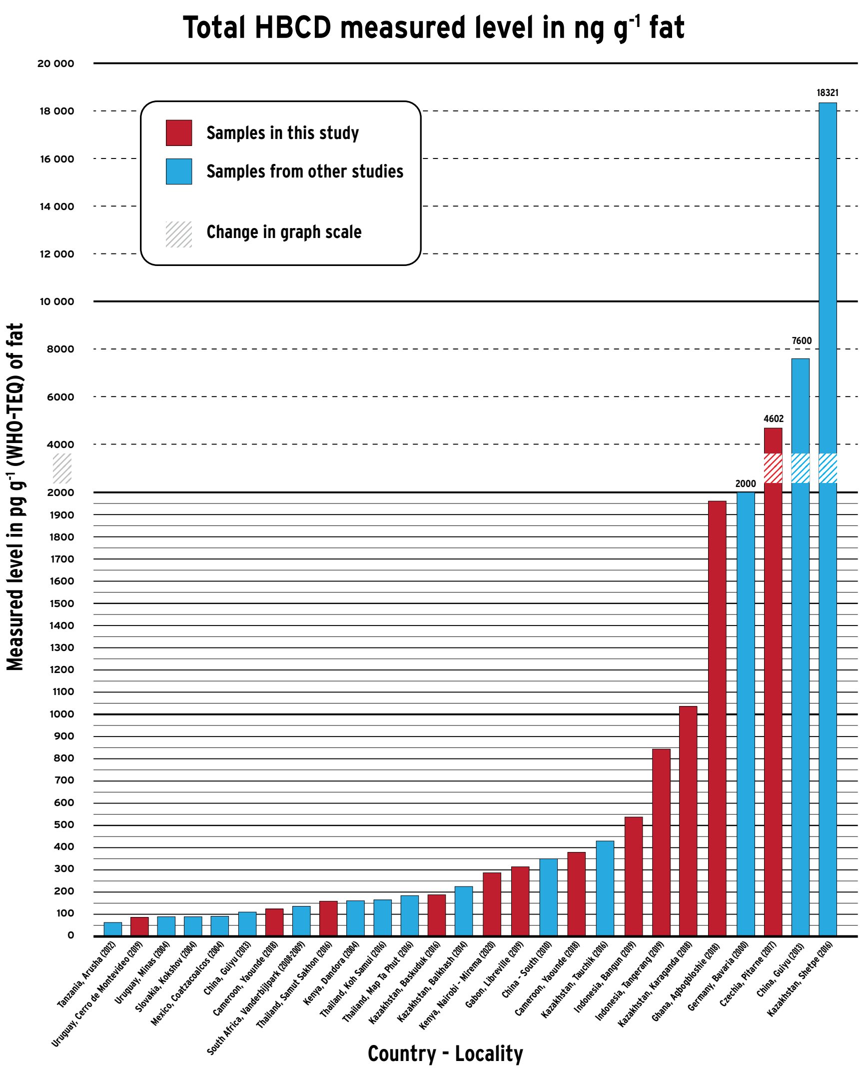


TABLE 6: LEVELS OF HBCD IN ng g^{-1} FAT MEASURED IN CHICKEN OR GOOSE EGGS IN DIFFERENT STUDIES WORLDWIDE ABOVE 50 ng g^{-1} FAT.

All other than free-range chicken egg samples are marked in parentheses after the name of the locality.

Country	Year	Locality	HBCD in ng g^{-1} fat	Source of information
Tanzania	2012	Arusha	63	(Polder, Müller et al. 2016)
Uruguay	2019	Cerro de Montevideo	86	this study
Uruguay	2004	Minas	89	(Blake 2005)
Slovakia	2004	Kokshov - Baksha	89	(Blake 2005)
Mexico	2004	Coatzacoalcos	91	(Blake 2005)
China	2013	Guiyu	110	(Zeng, Luo et al. 2016)
Cameroon	2018	Yaoundé - TKC Quarter	124	this study
South Africa	2008-2009	Vanderbijlpark	136	(Quinn 2010)
Thailand	2016	Samut Sakhon	159	this study
Kenya	2004	Dandora	160	(Blake 2005)
Thailand	2016	Koh Samui	165	(Petrlik, Teebthaisong et al. 2017)
Thailand	2016	Map Ta Phut	184	(Petrlik, Teebthaisong et al. 2017)
Kazakhstan	2016	Baskuduk	188	this study
Kazakhstan	2014	Balkhash - Rembaza	225	(Petrlik, Kalmykov et al. 2017)
Kenya	2020	Nairobi - Mirema	287	this study
Gabon	2019	Libreville - Owendo	314	this study
China	2010	South China	350	(Zheng, Wu et al. 2012)
Cameroon	2018	Yaoundé - hospital WI	379	this study
Kazakhstan	2016	Tauchik	430	(Petrlik, Kalmykov et al. 2017)
Indonesia	2019	Bangun	538	this study
Indonesia	2019	Tangerang (SEM-E-1)	844	this study
Kazakhstan	2015	Karaganda, supermarket	1036	this study
Ghana	2018	Agbogbloshie	1961	this study
Germany	2007	Bavaria	2000	(Hiebl and Vetter 2007)
Czechia	2017	Pitarne	4602	this study
China	2013	Guiyu	7600	(Zeng, Luo et al. 2016)
Kazakhstan	2016	Shetpe	18321	(Petrlik, Kalmykov et al. 2017)

ANNEX 4

PBDEs IN EGGS

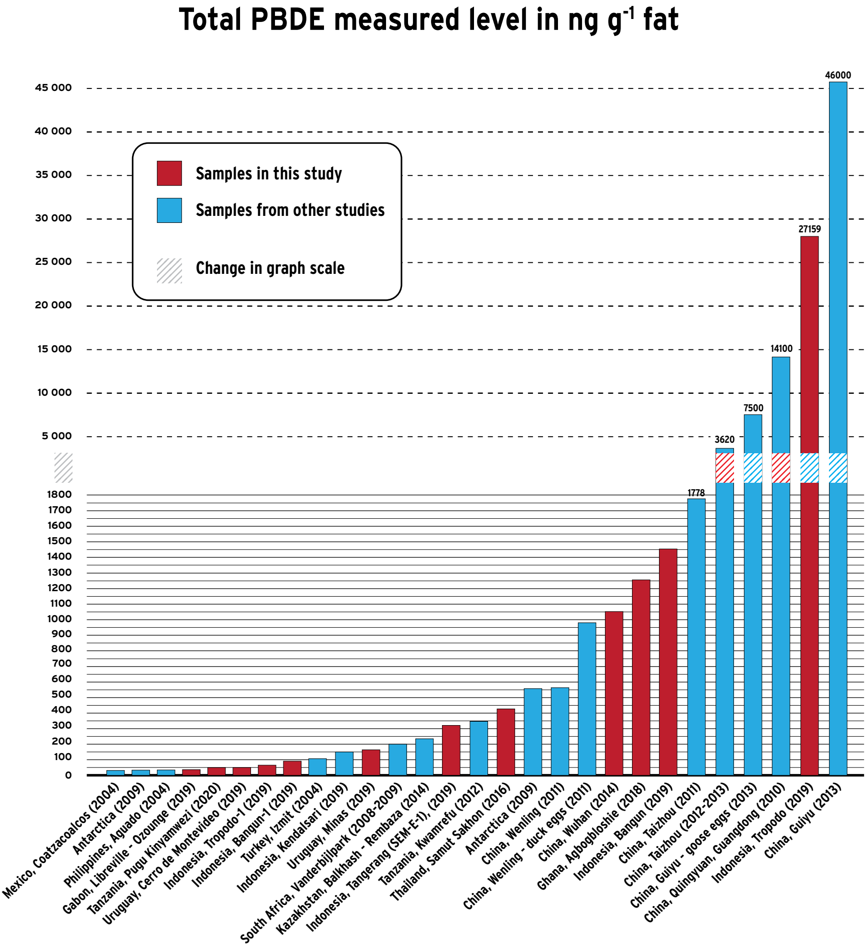


Figure 9: Graph showing the levels of PBDEs in ng g^{-1} fat measured in free-range chicken or duck eggs in different studies worldwide above a sum total of 30 ng g-1 fat of PBDEs. Only samples that were also analyzed for decaBDE (congener BDE 209) have been included. There are two examples of wild birds from Antarctica included as well for comparison. Specific data and sources of information can be found in Table 7.

TABLE 7: LEVELS OF PBDEs IN ng g^{-1} FAT MEASURED IN FREE-RANGE CHICKEN EGGS IN DIFFERENT STUDIES WORLDWIDE, ABOVE A SUM TOTAL OF 30 ng g^{-1} FAT OF PBDEs.

Only samples that were also analyzed for decaBDE (congener BDE 209) have been included. There are two examples of wild birds from Antarctica and some duck or goose eggs included as well for comparison. All samples other than chicken eggs, are marked by specification of the bird species in parenthesis after the name of the locality.

Country (year)	Locality	PBDEs in ng g^{-1} fat	Source of information
Mexico (2004)	Coatzacoalcos	31	(Blake 2005)
Antarctica (2009)	King George Island (chinstrap penguin)	33	(Yogui and Sericano 2009)
Philippines (2004)	Aguado	34	(Blake 2005)
Gabon (2019)	Libreville - Ozounge	36	this study
Tanzania (2020)	Pugu Kinyamwezi	50	this study
Uruguay (2019)	Cerro de Montevideo	50	this study
Indonesia (2019)	Tropodo	65	this study
Indonesia (2019)	Bangun (Bangun-1)	91	this study
Turkey (2004)	Izmit	107	(Blake 2005)
Indonesia (2019)	Kendalsari	150	(Petrlik, Ismawati *et al.* 2020)
Uruguay (2019)	Minas	164	this study
South Africa (2009)	Vanderbijlpark	200	(Quinn 2010)
Kazakhstan (2014)	Balkhash – Rembaza	235	(Petrlik, Kalmykov *et al.* 2017)
Indonesia (2019)	Tangerang (SEM-E-1)	321	this study
Tanzania (2012)	Kwamrefu	347	(Polder, Müller *et al.* 2016)
Thailand (2016)	Samut Sakhon	427	this study
Antarctica (2009)	King George Island (south polar skua)	558	(Yogui and Sericano 2009)
China (2011)	Wenling	564	(Qin, Qin et al. 2011)
China (2011)	Wenling (duck)	982	(Labunska, Harrad *et al.* 2013)
China (2014)	Wuhan	1,054	this study
Ghana (2018)	Agbogbloshie	1,258	this study
Indonesia (2019)	Bangun (BAN-E-1)	1,457	this study
China (2011)	Taizhou (duck)	1,778	(Labunska, Harrad *et al.* 2013)
China (2012-2013)	Taizhou	3,620	(Labunska, Harrad *et al.* 2014)
China (2013)	Guiyu (goose)	7,500	(Zeng, Luo *et al.* 2016)

Country (year)	Locality	PBDEs in ng g^{-1} fat	Source of information
China (2010)	Quingyuan, Guang-dong,	14,100	(Zheng, Wu et al. 2012)
Indonesia (2019)	Tropodo	27,159	this study
China (2013)	Guiyu	46,000	(Zeng, Luo et al. 2016)

The sample with an extremely high level of PBDEs taken in October 2019 in Tropodo also contained a very high level of novel BFRs (nBFRs)[5] at 2,166 ng g^{-1} fat (Petrlik, Ismawati *et al.* 2020).

5 This group of chemicals substituted already banned polybrominated diphenyl ethers (PBDEs). Unfortunately, they are often persistent and display similar health effects as the globally banned brominated flame retardants. The group is comprised of the following chemicals: 1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPE), decabromodiphenyl ethane (DBDPE), hexabromobenzene (HBB), octabromo-1,3,3-trimethylphenyl-1-indan (OBIND), 2,3,4,5,6-pentabromoethylbenzene (PBEB), and pentabromotoluene (PBT).

ANNEX 5
CHICKEN EGGS IN THIS STUDY

TABLE 8: OVERVIEW OF SAMPLES OF CHICKEN EGGS IN THIS STUDY.

Country	Activity	Locality	Sample ID	Matrix	Month/year of sampling	Number of eggs in pooled sample	Fat content (%)
Belarus	RE	Gatovo	Gatovo	Eggs	06/2014	3	15.4
Cameroon	DU	Yaoundé - TKC Quart.	YA-1	Eggs	08/2018	6	19.6
Cameroon	WI	Yaoundé - hospital	YA-2	Eggs	08/2018	5	14.6
Cameroon	DU	Yaoundé - Etetar Quart.	YA-3	Eggs	08/2018	6	14.3
Czech Rep.	RE	Pitarne	N1-3	Eggs	11/2017	3	12
Czech Rep.	RE	Pitarne	S1-4	Eggs	11/2017	4	12.1
Czech Rep.	RE	Pitarne	PIT03	Eggs	09/2017	3	13
Czech Rep.	Ref	Prague	PHA-1 and 2	Eggs	04/2018 02/2019	6 and 10	10.2
Gabon	WI	Nkoltang	GA-E-NKOL	Eggs	11/2019	5	13.6
Gabon	DU	Libreville - Owendo	GA-E-OWE	Eggs	11/2019	5	13.8
Gabon	DU	Libreville - Ozounge	GA-E-OZOU	Eggs	11/2019	5	11.2
Ghana	WY-E	Agbogbloshie	AGB-E	Eggs	12/2018	4	14.7
Ghana	Ref	Accra (supermarket)	ACC-M-E	Eggs	12/2018	6	8.8
Ghana	WI	Accra – hospital	KBI-E	Eggs	12/2018	6	12.3
Ghana	WI	Kumasi – hospital	KU-E	Eggs	12/2018	5	14.7
China	WI	Wuhan	Wuhan 2	Eggs	09/2014	3	12.5
China	WI	Wuhan	Wuhan 1	Eggs	03/2014	6	15.5
China	Ref	Beijing	Control	Eggs	10/2014	3	10.1
Indonesia	WY-E	Bangun	Bangun 1	Eggs	05/2019	3	13
Indonesia	WY-E	Bangun	BAN-E-1	Eggs	11/2019	3	9.5

Country	Activity	Locality	Sample ID	Matrix	Month/year of sampling	Number of eggs in pooled sample	Fat content (%)
Indonesia	WY-E	Tangerang	SEM-E-1	Eggs	11/2019	3	16.2
Indonesia	WY-E	Tangerang	TAN-ESIN-01	Eggs	11/2019	5	13.7
Indonesia	WI	Tropodo	Tropodo 1	Eggs	05/2019	3	15
Indonesia	WI	Tropodo	TROP-E-1	Eggs	10/2019	6	13.9
Indonesia	Ref	Jakarta	JAK-SUP	Eggs	11/2019	6	9.5
Kazakh-stan	DU	Baskuduk	BAS 02	Eggs	10/2016	3	15.6
Kazakh-stan	Ref	Karaganda	KAR-SU	Eggs	04/2015	6	14
Kenya	WI	Nairobi - Mirema	KE_001	Eggs	01/2020	5	14.0
Mexico	RE	Guadal	GUDAL-EGG1	Eggs	04/2019	5	14
Philippines	WY-E	Bagong Silang	PH-E-1-2	Eggs	09/2019	2	13.8
Philippines	WI	Aguado	PH-E-3-4	Eggs	11/2019	4	16.1
Philippines	WI	Aguado	PH-E-5-6	Eggs	11/2019	3	13.0
Philippines	WI	Aguado	PH-E-7	Eggs	11/2019	1	14.4
Philippines	WI	Aguado	PH-E-S-5/2	Eggs	01/2020	4	12.4
Tanzania	DU	Pugu Kinyamwezi	TZ-PU-KI_EGG	Eggs	01/2020	9	18.0
Thailand	Ref	Bangkok	supermar-ket	Eggs	02/2016	6	11.6
Thailand	WY-E	Samut Sakhon	Samut Sakhon	Eggs	02/2015	3	11.6
Thailand	WY-E	Samut Sakhon	SMS 2-13	Eggs	02/2016	3	19.4
Thailand	DU	Praeksa	PKS-EGG-1	Eggs	11/2015	4	18.1
Uruguay	DU	Cerro de Montevideo	UR-CM-E	Eggs	09/2019	4	8.9
Uruguay	DU	Minas	UR-MIN-E	Eggs	09/2019	4	11.8

ANNEX 6
SUMMARIZED INFORMATION ABOUT THE SELECTED SITES

TABLE 9: INFORMATION ABOUT THE SITES INCLUDED IN THIS STUDY, INCLUDING THEIR GROUPING INTO CATEGORIES OF SAMPLED SITES.

Group	Locality (Country)	Samples	Brief Characteristics
Recycling and pre-recycling including shredder plants (RE)	Guadalajara (Mexico)	GUADAL-EGG1	Shredder of e-waste plastics and preparation of plastic recyclate
	Pitarne (Czech Republic)	N1-3	Recycling of PVC insulation of wires involving heat and pressure; production of roofing from recyclate
		S1-4	
		PIT03	
	Gatovo (Belarus)	Gatovo	Car shredder plant
Plastic and electronic waste yards (WY-E)	Bangun (Indonesia)	Bangun 1	Mainly plastic waste yard, most waste imported from outside of Indonesia
		BAN-E-1	
	Tangerang (Indonesia)	SEM-E-1	Mainly plastic waste yard, most waste imported from outside of Indonesia
		TAN-ESIN-01	
	Bagong Silang (The Philippines)	PH-E-1 and 2	E-waste site (neighborhood dismantling area)
	Samut Sakhon (Thailand)	Samut Sakhon	Waste sorting workshop with regular open burning including e-waste, small metal smelters and waste sorting and recycling workshops in other parts
		SMS2-13	
	Agbogbloshie (Ghana)	AGB-E	One of the largest e-waste sites, regular open burning and smoldering of copper cables, car wreck dismantling

Group	Locality (Country)	Samples	Brief Characteristics
Waste-to-energy and waste incineration (WI)	Tropodo (Indonesia)	Tropodo 1	Local tofu factories using plastic waste as fuel
		TROP-E-1	
	Aguado (Philippines)	PH-E-3 and 4	Hazardous waste incinerator with related facility producing bricks from incineration ash.
		PH-E-5 and 6	
		PH-E-7	
		PH-E-S-5/2	
	Wuhan (China)	Wuhan 1	Large municipal solid waste incinerator and smaller medical waste incinerator
		Wuhan 2	
	Yaoundé - hospital (Cameroon)	YA-2	Small medical waste incinerator and open burning of plastic waste
	Accra - hospital (Ghana)	KBI-E	Abandoned medical waste incinerator with ash residues left within the hospital area
	Kumasi - hospital (Ghana)	KU-E	Small medical waste incinerator operating a limited amount of hours / week
	Nkoltang - medical waste incinerator (Gabon)	GA-E-NKOL	Small medical waste incinerator in a town east of the City of Libreville
	Nairobi - Mirema (Kenya)	KE_001	Community cooker with large stoves burning waste as fuel under high temperatures

Group	Locality (Country)	Samples	Brief Characteristics
	Cerro de Montevideo (Uruguay)	UR-CM-E	Dumpsite alongside the road with observed e-waste
	Minas (Uruguay)	UR-MIN-E	Dumpsite, often catching fire
	Yaoundé - TKC Quarter (Cameroon)	YA-1	One of the dumpsites in the City of Yaoundé, regular open burning
	Yaoundé - Etetak Quarter (Cameroon)	YA-3	One of the dumpsites in the City of Yaoundé, regular open burning
	Libreville - Owendo (Gabon)	GA-E-OWE	Large waste dumpsite in the City of Libreville, open burning occurs
Dumpsites (DU)	Libreville - Ozounge(Gabon)	GA-E-OZOU	Large waste dumpsite in the City of Libreville, open burning occurs; some electronic waste observed
	Pugu Kinyamwezi (Tanzania)	TZ-PU-KI_EGG	Large municipal solid waste dumpsite called "Pugu Kinyamwezi City Solid Waste Dumpsite" on the south-western edge of Dar es Salaam
	Praeksa (Thailand)	PKS-EGG-1	Partly abandoned dumpsite in Praeksa, in the Samut Prakan Province; large fire occured in 2014
	Baskuduk (Kazakhstan)	BAS 02	Large old dumpsite, partly fenced, on the north-western edge of Aktau, Baskuduk in the Mangystau region
Reference samples (Ref)	Prague (Czech Republic)	PHA-1(and2)	Sample PHA-1 bought in a supermarket in Prague; sample PHA-2, used only for SCCPs, also bought in a supermarket
	Jakarta (Indonesia)	JAK-SUP	Eggs bought in a supermarket in Jakarta
	Bangkok (Thailand)	Supermarket	Eggs bought in a supermarket in Bangkok
	Accra (Ghana)	ACC-M-E	Eggs bought in one of the major supermarkets in Accra
	Karaganda (Kazakhstan)	KAR-SU	Eggs bought in a convenient store in Karaganda

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www.earththailand.org/en

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