ENVIRONMENTAL, FOOD AND HUMAN BODY BURDEN OF DECHLORANE PLUS IN A WASTE RECYCLING AREA IN THAILAND: NO ROOM FOR EXEMPTIONS

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Contents

Abstract

Dechlorane Plus is a widely used polychlorinated flame retardant, despite its endocrine disrupting effects in humans. It has been marketed and used as a replacement for brominated flame retardants. The scientific expert committee under the Stockholm Convention, the POPs Review Committee, has concluded that it meets all Stockholm Convention criteria (persistence, bioaccumulation, toxicity and potential for long-range transport) and recommends its listing into the Annex A of the Convention for global elimination. This will be considered by the Conference of Parties in May 2023.

In this study, Dechlorane Plus levels in e-waste recycling communities in northeastern Thailand were determined through a comprehensive set of samples taken at various stages of the processing pathways of the waste. In total, fifty-eight environmental and food samples were taken. Human blood serum samples were taken from forty e-waste workers.

Widespread Dechlorane Plus contamination of the environment and of the concerned communities was confirmed. Concentrations ranged between 0.005 and 108 ng/g dry matter in dust, 0.005 and 4.9 ng/g dry matter in soil, 0.24 and 15.4 ng/g dry matter in sediment, 0.002 and 0.10 ng/g in fish, 0.002 and 0.03 ng/g in snails, and 0.15 and 12.6 ng/g lipid in eggs. One composite ash sample contained 1.7 ng/g dry matter of Dechlorane Plus. Waste (shredded plastic pieces), rice, and crab samples did not contain Dechlorane Plus above the laboratory limit of quantification. The results revealed a clear difference in Dechlorane Plus blood serum concentrations between e-waste workers (mean value of 12.57 ng/g lipid) and a reference group of organic farm workers (mean value of 0.32 ng/g lipid).

The study clearly links environmental and blood serum levels of Dechlorane Plus in Thai workers with recycling activities of e-waste plastics and end-of-life vehicles. E-waste dismantling and recycling activities were found to be the source of Dechlorane Plus in the dust of the small-scale community-based workshops, and transport, storage and shredding of various types of plastic residues a source of Dechlorane Plus contamination of the outdoor environment. A nearby waste dumpsite was determined to be a source of Dechlorane Plus contamination of various surrounding environmental compartments and a possible source for contamination of foodstuffs obtained from its surroundings. In particular, e-waste and end-of-life vehicles recycling was a source of egg contamination in many households.

Continued use of Dechlorane Plus for production and use in electronics and vehicles will lead to continued poisoning of the workers handling these wastes and their communities.
Dechlorane Plus concentrations found in chicken eggs in this study were comparable with levels in eggs from waste disposal sites in Tanzania, previously reported in the scientific literature. It should be noted that blood serum concentrations in Thai workers were lower than previously reported in the scientific literature for e-waste workers in China. This highlights that workers' exposure to Dechlorane Plus is to be expected at other location where e-waste, end-of-life vehicles, industrial machines, outdoor power equipment, and other Dechlorane-Plus treated articles are being processed and recycled. A similar pattern was found for the other samples in this study.

This study provides information showing the impact of the use of Dechlorane Plus on e-waste recycling communities. It underscores the need to list Dechlorane Plus in Annex A of the Stockholm Convention without any exemptions to prevent continued occupational exposure and poisoning of workers´ communities.

Sources and levels of Dechlorane Plus exposure to workers in the recycling sector in northeastern Thailand compared to background concentrations

Figure 1: Example of a community based small-scale e-waste and ELV recycling workshop in Thailand, run within a household.

1. Introduction

Dechlorane Plus is a polychlorinated flame retardant that has been in use since the 1960s. It is used in electrical wire and cable coatings, plastic roofing materials, connectors in TV and computer monitors, and as a non-plasticizing flame retardant in polymeric systems, such as nylon and polypropylene plastic. Dechlorane Plus is released to the environment during production, processing, and use, as well as from waste disposal and recycling activities. Since the listing of the polybrominated diphenyl ethers (mainly DecaBDE) under the Stockholm Convention for global elimination, increased production, use, and environmental detection has been seen for Dechlorane Plus (Rauert et al., 2018). This is a clear example of regrettable substitution, where one toxic substance was replaced with another toxic chemical. Dechlorane Plus is persistent, i.e., it is chemically stable in various environmental compartments with minimal or no abiotic degradation. It is expected to bind to organic carbon in soil and sediments, reducing its bioavailability for microorganisms and hence the potential for biodegradation. Scientific data shows that Dechlorane Plus also bioaccumulates and is transported to locations far from production sites and places of use. It has adverse effects on the environment, and on mammals and humans. Studies have reported effects such as oxidative damage, indications of neurodevelopmental toxicity, and potential for endocrine disruption. The endocrine effects have also been seen in epidemiology studies, where associations between Dechlorane Plus and effects on the sex- and thyroid hormone pathways were found (SC, 2021).

Although relatively high concentrations of Dechlorane Plus have been found in water, sediments, and wild animals from e-waste recycling locations, few studies have comprehensively investigated

Dechlorane Plus concentrations in multiple environmental matrices for the same location, especially in e-waste recycling areas. Most studies have focused on a single matrix such as the air or sediment in and around the Great Lakes or serum, air, and soils in China. Data on Dechlorane Plus contamination in various compartments of locations where e-waste is being recycled is more limited. More research is required to better quantify the Dechlorane Plus pollution of multiple environmental matrices, especially in e-waste recycling areas (Li et al., 2018).

The main goal of this study was therefore to comprehensively determine the levels of Dechlorane Plus in e-waste and end-of-life vehicle (ELV) recycling communities in Thailand. In addition to the main waste streams (e-waste and ELV), parts from industrial, mainly agricultural, machines and outdoor power equipment are processed by community members in Thailand. The study also aimed to provide further evidence for the urgent need to list Dechlorane Plus in Annex A of the Stockholm Convention, and to show likely impacts of exemptions for its continued production and use. It focused on community-based e-waste and ELV separation and dismantling in northeastern Thailand and was conducted in villages with both informal and official e-waste recycling workshops and waste dump site. Similar sites with small-scale e-waste recycling workshops can be found in China, other Asian countries, and elsewhere in the world.

In the Thai communities in the study, the waste is stored and dismantled in small workshops directly at workers homes. The working areas are usually situated right next to their homes, in outdoor living and resting areas also used for eating. It is also common that an outdoor kitchen area is situated right next to the dismantling workshop.

2. Materials and methods

The spread of Dechlorane Plus into the environment caused by e-waste and ELV recycling was studied by sampling at various stages of the processing pathways of the waste. Composite samples were taken as follows:

1. Dismantling of the e-waste and ELV is conducted in small workshops at workers homes. Samples of dust and free-range chicken eggs were taken.
2. Sorting and grinding of separated waste plastic takes place in shredding workshops. Samples of dust, soil, waste (shredded plastic), and free-range chicken eggs were taken.
3. Non-utilizable leftovers are transported to a dumpsite located within rice fields and burnt. Samples of soil, sediment, dust, fish, rice, and wild animal samples were taken at the dumpsite and its surroundings.
4. Ash from the dumpsite is brought back to a workshop and processed. One ash sample was taken.

Different types of biological and food samples were taken:

- Muscle tissue of fish and soft tissue of snails and crabs
- Free-range chicken eggs
- Rice harvested in fields surrounding the dumpsite
- Blood serum samples of e-waste workers

Figure 2: Both e-waste and ELV, mainly motorcycles, are dismantled in small scale recycling workshops in Thailand. EARTH-Arnika teams take dust samples.

In total, fifty-eight composite samples of environmental matrices and food were taken in December 2021 and February 2022. No water or air samples were taken for technical reasons. Reference (background) samples of dust, soil, sediment, fish, snails, and rice were taken in presumed clean areas of organic farms located 15 km away from the e-waste recycling communities. A reference sample of industrially produced chicken eggs was obtained in a supermarket.

Human blood serum samples were taken from 40 adults, both men and women (25 and 15, respectively), employed in waste recycling. Samples were also taken from a control group of 26 adult organic farm workers and agriculturalists, both men and women (7 and 19, respectively), who have never worked in the waste processing business or lived in such an area. Samples were taken in November 2022 in collaboration with the local hospital. All participants signed an informed consent form before participating in the study. A detailed questionnaire was completed for each participant covering age, gender, weight, height, lifestyle, health, and working patterns.

All the samples were analyzed in an accredited laboratory of the University of Chemistry and Technology, Prague (Czechia). Dechlorane Plus isomers were isolated from the samples by triple extraction with n-hexane:diethylether (9:1, v/v) followed by cleanup on a silicagel column. The analysis was performed using gas chromatography coupled with mass spectrometry and negative chemical ionization (GC-MS-NCI).

3. Results

Samples of outdoor dust (road dust, household outdoor living areas), soil, sediment, rice, two fish samples taken at reference organic farms, and the supermarket chicken eggs did not have concentrations of Dechlorane Plus above the laboratory limit of quantification (LOQ). Two food samples of fish and snails taken at organic farms had low concentrations of Dechlorane Plus, with snails just above the limit of quantification (0.019 and 0.006 ng/g for fish and snails, respectively). Dechlorane Plus concentrations in blood serum of organic farm workers and agriculturalists were above LOQ in only 1 of 26 samples (0.75 ng/g lipid).

Concentrations of Dechlorane Plus detected in the environment and food samples of e-waste recycling communities and blood serum of e-waste workers are summarized in Table 1 below. They ranged between 0.005 and 108 ng/g dry matter in dust, 0.005 and 4.9 ng/g dry matter in soil, 0.24 and 15.4 ng/g dry matter in sediment, 0.002 and 0.10 ng/g in fish, 0.002 and 0.03 ng/g in snails, and 0.15 and 12.6 ng/g lipid in eggs. The composite ash sample contained 1.7 ng/g dry matter of Dechlorane Plus. Waste (shredded plastic pieces), rice, and crab samples did not contain concentrations of Dechlorane Plus above LOQ. Dechlorane Plus concentrations in blood serum of e-waste workers ranged between 0.30 and 89.3 ng/g lipid.

Table 1: Summary statistics of Dechlorane Plus (sum of syn and anti isomers) concentrations in samples of environmental matrices and food from e-waste recycling area and in blood serum of e-waste workers. Summary statistics were calculated by using the value of half of LOQ for not quantified isomers.

	Unit	N	> LOQ	min	max	median	mean
Dust	ng/g dry matter	22	95 %	0.005	108	10.2	18.8
Soil	ng/g dry matter	9	56 %	0.005	4.9	0.08	0.80
Sediment	ng/g dry matter	2	100 %	0.24	15.4	7.8	7.8
Ash	ng/g dry matter	1	100 %	1.7	1.7	1.7	1.7
Waste	ng/g	2	0 %	0.005	0.005	0.005	0.005
Rice	ng/g	1	0 %	0.005	0.005	0.005	0.005
Fish[1]	ng/g	7	86 %	0.002	0.10	0.02	0.04
Snails[2]	ng/g	4	75 %	0.002	0.03	0.01	0.02
Crabs[3]	ng/g	3	0 %	0.002	0.002	0.002	0.002
Eggs	ng/g lipid	7	71 %	0.15	12.6	0.97	3.9
Blood	ng/g lipid	40	85 %	0.30	89.30	7.27	12.57

N – number of samples
> LOQ – samples with concentrations above LOQ
[1]Climbing perch, climbing gourami (*Anabas testudineus*), Broadhead catfish (*Clarias macrocephalus*), Nile Tilapia (*Oreochromis niloticus*)
[2]Apple snail (*Pomacea canaliculata*)
[3]Thai rice field crab (the genus *Esanthelphusa* could be identified)

4. Discussion and conclusions

Results are discussed in the context of local circumstances and are also compared with background concentrations and data in scientific literature.

4.1 Environmental samples

A comparison of the dust concentrations in differently used areas of six e-waste and ELV recycling workshops is shown in Figures 1, 2, and 4. Dust samples were taken in the working (storage of waste, dismantling activities) and living (resting, eating, and/or cooking) parts of the households. All workshops were currently operating except one, which was closed 10 years previously (last column). A clear gradient is visible in Figure 3, with concentrations in the working area dust of some workshops being one order of magnitude higher than in the living areas. Also, the dust samples from the closed workshop contained far less Dechlorane Plus compared to dust from the currently operating workshops. Differences in detected dust concentrations among operating workshops might be attributed, among other factors, to the specialization of each individual workshop. It can be concluded that **e-waste dismantling and recycling activities are a source of Dechlorane Plus in household dust in Thai small-scale community-based workshops. Notably, Dechlorane Plus was detected in the dust of the closed workshop even a decade after termination of the recycling activities.**

One of the sampled workshops was specialized in the separation of metals from motors, cables, and similar items. Cables are collected, sorted, and burned at the dumpsite in order to isolate copper. The ash is then brought back to this workshop, dried, and metals are removed. While no definitive conclusions can be taken based on only one ash sample, chemical analysis indicates that this particular ash sample is not a significant source for Dechlorane Plus. Polychlorinated dioxins (PCDD/Fs), typical

Figure 3: Dust concentrations of Dechlorane Plus in different areas of e-waste and end-of-life vehicle recycling workshops. Individual workshops are indicated by differently colored columns in the graph.

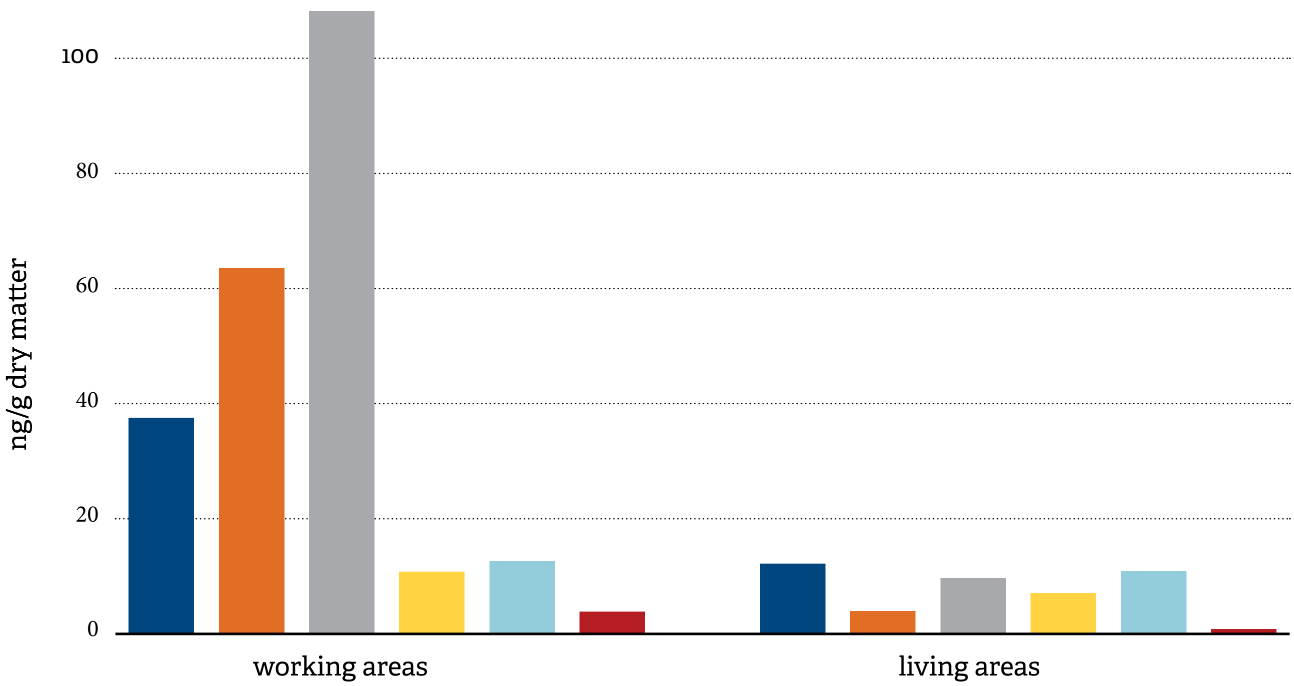


Figure 4: Plastic shredding workshop

persistent organic pollutants (POPs) contaminating after-incineration ash at e-waste recycling sites in Thailand (Mach et al., 2017), were not analyzed in this sample. The concentration of Dechlorane Plus in this ash sample was more than one order of magnitude lower than average concentration in the dust of the working areas of the sampled workshops. Although Dechlorane Plus is widely used as an additive flame retardant in the coatings of electrical wires and cables (SC, 2021), thermal degradation may occur during e-waste burning processes (Wang et al., 2016). However, further research is needed to confirm this interpretation.

In the studied communities, plastic separated from e-waste is being sorted and shredded in outdoor plastic shredding workshops. While Dechlorane Plus concentrations in random samples of shredded plastic (refrigerator insulation pieces and green plastic pieces) were below the LOQ, floor dust samples from the working areas of the shredding workshops contained concentrations comparable to floor dust samples from the working areas of e-waste dismantling workshops. Plastics processed in the shredding workshops are of a broad variety and obtained from many types of ELV waste, e-waste, as well as potentially also from industrial machines and outdoor power equipment (see an example in Figure 4). More extended sampling at one of the shredding workshops (dust and soil samples at different spots and distances outside of it) suggest that **transport, storage, and shredding of various types of plastic residues is a source of Dechlorane Plus contamination of the outdoor environment of these communities**.

The waste dumpsite is located in a rural landscape of rice fields and is accessed by a road. Soil, dust, and sediments were sampled at increasing distances from the site to examine the influence of the hot spot on its surroundings, and concentrations were the highest at the dumpsite or right next

Figure 5: Road dust and sediment concentrations of Dechlorane Plus at various distances from the dumpsite. Sediment samples were only taken at 0 and 5 m distance from the dumpsite.

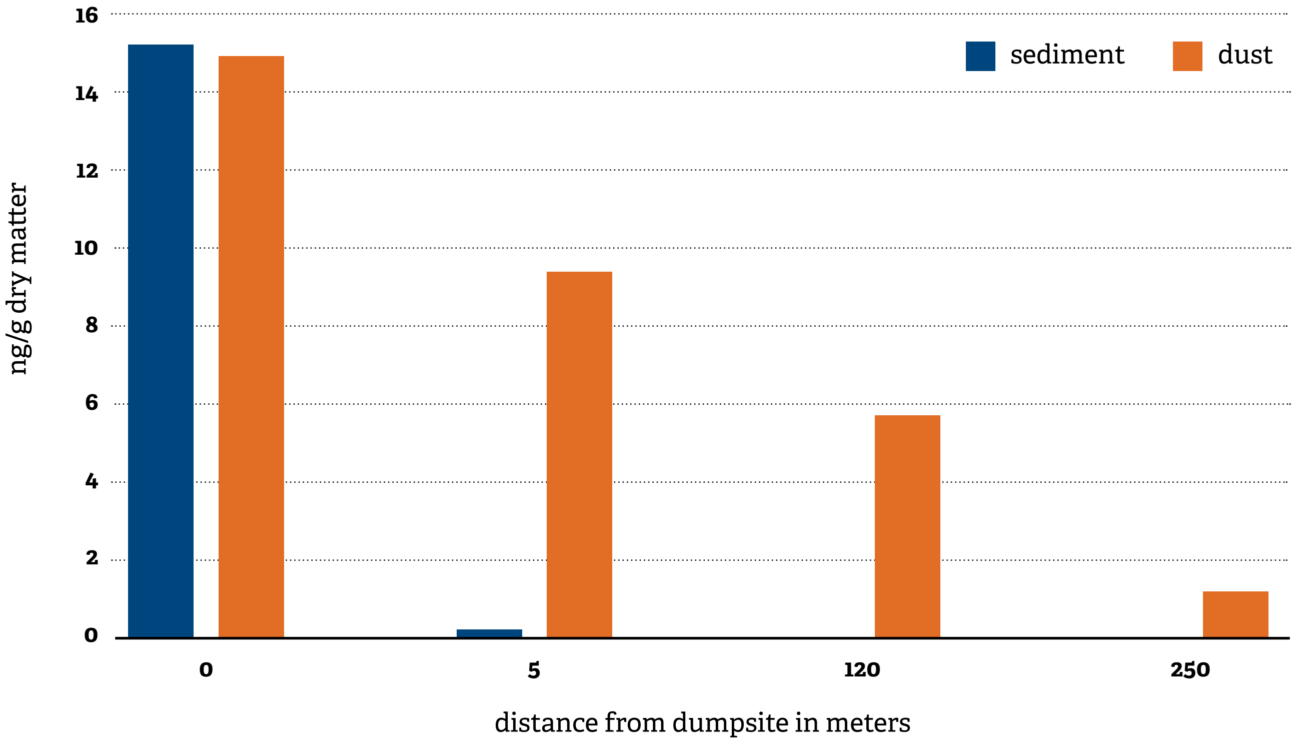
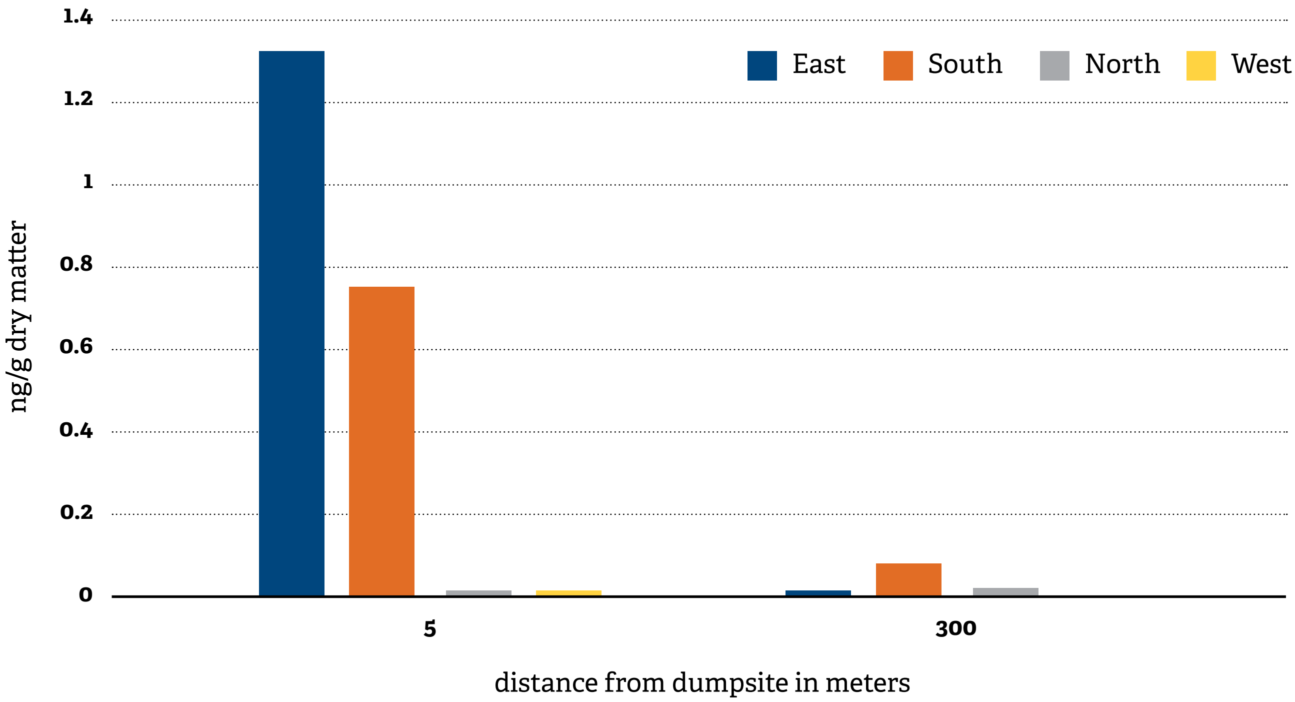


Figure 6: Soil concentrations of Dechlorane Plus in different distances and directions from the dumpsite. Concentrations in soil samples taken north and west from the hotspot were below the laboratory limit of quantification. Dechlorane Plus was not analyzed in the sample taken at 300 m distance from the dumpsite in western direction.



to it. Sediment concentrations in a pond outside the dumpsite were two orders of magnitude lower than in a pond within the dumpsite. Dust concentrations on the access road decreased with distance but Dechlorane Plus was still detectable in samples taken at a 250 m distance (Figure 5). No concentrations above LOQ were found in soil samples taken north and west from the dumpsite, while decreasing levels of Dechlorane Plus were detected with increasing distance in the other two major directions (Figure 6). **The dumpsite and its traffic are a source of Dechlorane Plus contamination of various environmental compartments in its surroundings.**

Since most studies reporting Dechlorane Plus concentrations in dust are focused on indoor dust, the ability to compare the levels in outdoor household dust with other studies is limited. Wang et al. (2011) studied Dechlorane Plus in house dust of an e-waste recycling area in Qingyuan county (located approximately 50 km north of Guangzhou, a major urban center in South China) and determined a median concentration of 541 ng/g (this value refers to a mix of indoor and yard dust samples, Dechlorane Plus concentrations detected in samples of indoor and samples of yard dust were not significantly different). Li et al. (2018) found Dechlorane Plus concentrations of 3.8 to 2.1×10^3 ng/g dry matter in soil, 1.1×10^3 to 7.2×10^3 ng/g dry matter in sediment, and 1.4×10^1 to 1.1×10^3 ng/g dry matter in road dust of the e-waste recycling town Guiyu in southeastern China. Although Dechlorane Plus levels in the environment of these e-waste recycling communities in China were higher than in the sampled communities in northeastern Thailand, it should be noted that these different sites differ in size and period of operation. The Qingyuan case study covered 1300 dismantling and recycling workshops with over 80,000 workers and Guiyu has hosted 300 individual workshops involved in the dismantling or processing of e-waste since the 1990s. The studied area in northeastern Thailand is much smaller.

Figure 7: Chicken freely roaming in an e-waste recycling workshop

4.2 Food samples

The composite sample of rice grown in fields around the dumpsite did not contain Dechlorane Plus concentrations above the LOQ. Locals occasionally gather aquatic animals from the freshwater ponds around the dumpsite to be consumed as food. Crab samples did not contain Dechlorane Plus concentrations above the LOQ, but concentrations in most of the fish and apple snail samples were above LOQ. However, only a few samples of foodstuff were taken and low Dechlorane Plus concentrations were detected also in some of the background samples of fish and snail. One reason for this could be airborne dust from the contaminated sites spreading to surrounding areas. The sampling results indicate that **the dumpsite might be a source of Dechlorane Plus contamination of foodstuffs obtained from its surroundings, and possibly of surrounding areas**.

Since eggs are a frequently used indicator of environmental pollution from persistent organic pollutants (Petrlik et al., 2022), eggs samples were taken from chicken freely roaming in and around the households and sometimes directly in the workshops (Figure 7). The majority of the sampled eggs had Dechlorane Plus concentrations above the LOQ with a maximum of 12.6 ng/g lipid. The reference eggs did not contain Dechlorane Plus above the LOQ. Therefore, it can be assumed that **e-waste and end-of-life vehicles recycling is a source of egg contamination by Dechlorane Plus when conducted in or around households**. It is, however, important to note that chicken eggs are rarely consumed by locals in the studied communities and chicken meat is only a minor source of protein (chicken are raised for cock fights). However, it is well known that chicken eggs are a source of food in many e-waste recycling communities (Zheng et al., 2012; Petrlik et al., 2022; Haarr et al., 2023).

Due to various methodological reasons and different size and period of operation of e-waste recycling workshops, a comparison with data from the scientific literature must be conducted with caution. Ghelli et al. (2021) reviewed studies of Dechlorane Plus concentrations in various foodstuffs, including eggs. They found the highest mean concentration of Dechlorane Plus in all categories of foodstuffs reported for Chinese chicken eggs (124 ng/g lipid) that were collected in southern China as reference for egg samples from an e-waste treatment area in Qingyuan county (located approximately 50 km north of Guangzhou, a major urban center in South China) that contained 1599 ng/g lipid Dechlorane Plus (Zheng et al., 2012). Haarr et al. (2023) studied levels of Dechlorane Plus in free range chicken eggs from locations near waste disposal sites in Tanzania. The median concentrations ranged from 0.5 ng/g lipid to 2.8 ng/g lipid, and the highest concentrations were found at an informal dumpsite on Zanzibar.

Chicken eggs from the studied Thai e-waste recycling communities contained concentrations of Dechlorane Plus lower than levels reported in eggs from China. To understand the differences, assessment of the size of the workshops, period of operation, e-waste tonnages, and waste management practices would need to be undertaken. Based on available literature, Chinese case studies typically cover notably larger workshops. Studied eggs from Thailand contained comparable concentrations with eggs from waste disposal sites in Tanzania.

Recycling of e-waste and ELV vehicles is a source of Dechlorane Plus emissions to the environment and serious source of human exposure. While levels measured in this study are concerning, it is also clear that the scale of the problem can be much bigger as shown in China depending on the size, period of operation, or tonnage of processed waste.

4.3 Blood samples

The sampling revealed a clear difference in Dechlorane Plus blood serum concentrations between the e-waste and organic farm workers, with a mean value of 12.57 ng/g lipid vs. 0.32 ng/g lipid, respectively. Dechlorane Plus was present at concentrations above LOQ in blood serum of 34 from 40 e-waste workers while only in 1 from 26 organic farm workers.

Environmental contamination can be a source of Dechlorane Plus in humans. Dechlorane Plus was present at concentrations above LOQ in 78 % of the environmental and food samples taken in e-waste recycling communities in Thailand, indicating the **wide presence of Dechlorane Plus in the environment of the concerned communities**. By contrast, samples from the reference areas contained concentrations above the LOQ only in 20 % of cases.

Ingestion of contaminated dust is considered one of the major pathways for human Dechlorane Plus exposure in e-waste recycling areas (Zheng et al., 2010). The results of this study confirm this. Exposed workers in the Thai e-waste recycling communities and the control group from organic farms share similar dietary habits, but their local food contained different Dechlorane Plus concentrations. Therefore, dietary exposures may partly explain the blood serum Dechlorane Plus concentration differences between e-waste workers and the control group. It should be noted that the environmental and food samples were only partly paired with human blood samples, which leads to some uncertainties. Still, **the results of our study clearly link Dechlorane Plus levels in Thai e-waste workers with recycling activities in their communities.**

The Dechlorane Plus concentrations in this study cannot be easily compared with studies from China as case studies from China usually cover much larger workshops. Chen et al. (2015) found serum concentrations ranging between 22 and 1400 ng/g lipid in e-waste workers from South China. The levels in this study (median 190 ng/g lipid) were lower than those found in occupational workers in a Dechlorane Plus manufacturing plant (median 860 ng/g lipid) and comparable to those found in non-occupationally exposed residents near the manufacturing plant (median 240 ng/g lipid) (Zhang et al., 2013). Similar concentrations as in Chen et al. (2015) were also found by Yan et al. (2012) in southern Chinese e-waste workers (ranging between 22–2200 ng/g lipid with median of 150 ng/g lipid). However, levels one order of magnitude lower were found by Dong and Li (2020) in e-waste workers in southeastern China (median 53 ng/g lipid). Yin et al. (2020) found median concentrations of 4 ng/g lipid in the serum of pregnant women living in the area, but not working in the local e-waste business, in Wenling, China.

A comparison of the Dechlorane Plus blood serum concentrations in Thai e-waste workers with data in scientific literature revealed that these ranged from similar to lower than in e-waste workers from China. Any conclusive comparison of the Dechlorane Plus concentrations with case studies from China is out of the scope of this report. Size, period of operation, waste management practices, or tonnages of processed waste would need to be assessed to draw conclusions on workshops comparison. **Nevertheless, e-waste and ELV recycling workshops are found to be significant sources of workers' exposures. The levels of Dechlorane Plus in workers blood from larger e-waste sites in China can exceed the elevated levels measured in Thailand.**

5. Implications for the Stockholm Convention: No room for toxic exemptions

Dechlorane Plus has been recommended by the POPs Review Committee (POPRC) to the 2023 Stockholm Convention Conference of the Parties for global elimination (Annex A listing). The POPRC has concluded that Dechlorane Plus is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and/or environmental effects, such that global action is warranted. That is, Dechlorane Plus is among the world´s most dangerous chemicals. However, the POPRC recommendations for Dechlorane Plus include a long list of proposed broad exemptions. Some of these exemptions are proposed to last until 2044 and would allow for continued production and use of Dechlorane Plus for certain purposes for two decades.

This study concludes that **there is a high risk of occupational exposures to workers engaged in e-waste and EVL management activities, therefore the exemptions will lead to continued occupational exposures.** This is especially concerning for the many exemptions related to the automotive industry, since this is where the highest concentrations of Dechlorane Plus are used. Moreover, **continued use of Dechlorane Plus is likely to lead to contamination of recycled materials such as recycled plastic pellets and consumer products, thus exemptions will lead to environmental contamination and continued exposures to consumers.**

The risk management evaluation of Dechlorane Plus (UNEP, 2022) identified several chemical and non-chemical alternatives to Dechlorane Plus. It also noted that historically, production is known to have occurred in the U.S. and in China, but that current production is assumed to only occur in China and that China has decided to ban production, use, import, and export from 1 January 2026. **Therefore, it is reasonable to conclude that no production will take place past January 2026 and that alternatives are readily available.**

Recognizing that viable alternatives exist and are in use, IPEN recommends that no exemptions be granted for Dechlorane Plus. If any exemptions are considered, we recommend that any exemptions are as narrow as possible and only allowed for a short period of time. This promotes the development of alternatives and ensures that the Convention fulfils its purpose of global elimination of POPs.
The proposed exemptions for Dechlorane Plus are very broad and lack detail of what specific products are exempted. The proposed exemptions are for "replacement

parts" and only a range of broad applications are listed, including "...motor vehicles (covering all land-based vehicles, such as cars, motorcycles, agricultural and construction vehicles and industrial trucks)." It is therefore important to both specify that the exemption only applies to legacy vehicles, since replacement parts could be used for newer vehicles, and provide more detail on the proposed exemptions. **This is especially important noting that the proposed exemptions allow for continued production of Dechlorane Plus for this purpose.**

Previously, in the listings for hexabromocyclodecane (HBCD) and pentachlorophenol, requirements for labeling were introduced to ensure that the product containing the listed chemical could be easily identified (e.g., and its salts and esters). Labeling should also be implemented for Dechlorane Plus to help countries separate dangerous products and wastes and to reduce exposures and environmental releases. This would also help Parties to comply with the Convention and not recycle articles containing Dechlorane Plus into new products, and to prevent on-going exposures in homes and workplaces, protecting health and promoting a non-toxic recycling system. **IPEN therefore recommends labeling of products that contain Dechlorane Plus so that Parties can identify these substances in products and wastes and fulfill requirements under Article 6. This would be similar to what was agreed upon when listing HBCD (SC-6/13).**

References

Chen K., Zheng J., Yan X., Yu L., Luo X., Peng X., Yu Y., Yang Z., Mai B. (2015). Dechlorane Plus in paired hair and serum samples from e-waste workers: Correlation and differences. Chemosphere 123, 43-47.

Dong M., Li X. (2020). The concentrations and temporal trend of Dechlorane Plus in human serum collected from a typical e-waste recycling area in China. Environmental Chemistry 39, 2035-2043.

Ghelli E., Cariou R., Dervilly G., Pagliuca G., Gazzotti T. (2021). Dechlorane Plus and Related Compounds in Food—A Review. International Journal of Environmental Research and Public Health 18, 690-706.

Haarr A., Nipen M., Mwakalapa E. B., Borgen A. R., Mmochi A. J., Borga K. (2023). Chlorinated paraffins and Dechloranes in free-range chicken eggs and soil around waste disposal sites in Tanzania. Chemosphere 329, 138646.

Li N., Chen X. W., Deng W. J., Giesy J. P., Zheng H. L. (2018). PBDEs and Dechlorane Plus in the environment of Guiyu, Southeast China: A historical location for E-waste recycling (2004, 2014). Chemosphere 199, 603-611.

Mach V., Petrlik J., Teebthaisong A., Ritthichat A. (2017). POPs at Four Thai Hot-spots: Map Ta Phut, Samut Sakhon, Tha Tum, and Khon Kaen. Arnika, EARTH, and IPEN report available at https://arnika.org/en/publications/pops-at-four-thai-hot-spots-map-ta-phut-samut-sakhon-tha-tum-and-khon-kaen. 71 p..

Petrlik J., Bell L., DiGangi J., Molly Allo'o Allo'o S., Kuepouo G., Ochieng Ochola G., Grechko V., Jelinek N., Strakova J., Skalsky M., Ismawati Drwiega Y., Hogarh J. N., Akortia E., Adu-Kumi S., Teebthaisong A., Carcamo M., Beeler B., Behnisch P., Baitinger C., Herold C., Weber R. (2022). Monitoring dioxins and PCBs in eggs as sensitive indicators for environmental pollution and global contaminated sites and recommendations for reducing and controlling releases and exposure. Emerging Contaminants 8, 254-279.

Rauert C., Schuster J. K., Eng A., Harner T. (2018). Global Atmospheric Concentrations of Brominated and Chlorinated Flame Retardants and Organophosphate Esters. Environmental Science & Technology 52, 2777–2789.

SC (2021). Draft risk profile: Dechlorane Plus. Stockholm Convention on Persistent Organic Pollutants, Persistent Organic Pollutants Review Committee Seventeenth meeting, Geneva, 24–28 January 2022. UNEP/POPS/POPRC.17/3.

UNEP (2022). Risk management evaluation for Dechlorane Plus. Stockholm Convention on Persistent Organic Pollutants, Persistent Organic Pollutants Review Committee Eighteenth meeting, Rome, 26–30 September 2022. UNEP/POPS/POPRC.18/2/Add.1.

Wang J., Tian M., Chen S. J., Zheng J., Luo X. J., An T. C., Mai B. X. (2011). Dechlorane Plus in house dust from e-waste recycling and urban areas in South China: Sources, degradation, and human exposure. Environmental Toxicology and Chemistry 30, 1965–1972.

Wang P., Zhang Q., Zhang H., Wang T., Sun H., Zheng S., Li Y., Liang Y., Jiang G. (2016). Sources and environmental behaviors of Dechlorane Plus and related compounds — A review. Environment International 88, 206–220.

Yan X., Zheng J., Chen K. H., Yang J., Luo X. J., Yu L. H., Chen S. J., Mai B. X., Yang Z. Y. (2012). Dechlorane Plus in serum from e-waste recycling workers: Influence of gender and potential isomer-specific metabolism. Environment International 49, 31–37.

Yin J. F., Li J. F. T., Li X. H., Yang Y. L., Qin Z. F. (2020). Bioaccumulation and transfer characteristics of Dechlorane Plus in human adipose tissue and blood stream and the underlying mechanisms. Science of the Total Environment 700, 134391.

Zhang, H. D., Wang, P., Li, Y. M., Shang, H. T., Wang, Y. W., Wang, T., Zhang, Q. H., Jiang, G. B. (2013). Assessment on the occupational exposure of manufacturing workers to Dechlorane Plus through blood and hair analysis. Environmental Science & Technology 47, 10567–10573.

Zheng J., Wang J., Luo X. J., Tian M., He L. Y., Yuan J. G., Mai B. X., Yang Z. Y. (2010). Dechlorane Plus in Human Hair from an E-Waste Recycling Area in South China: Comparison with Dust. Environmental Science & Technology 44, 9298–9303.

Zheng X. B., Wu J. P., Luo X. J., Zeng Y. H., She Y. Z., Mai B. X. (2012). Halogenated flame retardants in home-produced eggs from an electronic waste recycling region in South China: Levels, composition profiles, and human dietary exposure assessment. Environment International 45, 122–128.

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