# THE RECYCLING MYTH 2.0

## THE TOXIC AFTER-EFFECTS OF IMPORTED PLASTIC WASTE IN MALAYSIA

**GREENPEACE MALAYSIA**
Level 6-12 , Menara Sentral Vista
150 . Jalan Sultan Abdul Samad, Brickfields ,50470 ,
Kuala Lumpur.

**PHOTOGRAPHER:**
Nandakumar S. Haridas / Greenpeace
Alex Stoneman / Greenpeace
Manfred Santen / Greenpeace

**GRAPHIC DESIGN:**
Amin Landak

**COVER PHOTO:**
Nandakumar S. Haridas / Greenpeace

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

Issues related to plastic waste were raised and highlighted in Malaysia following the release of 'The Recycling Myth' report by Greenpeace Malaysia in November 2018. Investigations into the issue began after China's ban on imports of plastic waste. Since then, there have been increasing news reports on pollution, landfills and plastic recycling factories affecting neighbourhoods relating to the imported plastic waste trade. By early 2019, the Malaysian government publicly announced the decision to send back imported waste intercepted at the Klang and Penang ports to the respective origin. However, what remains uncertain is the status of the discarded waste that remains within Malaysia.

To answer that pertinent question, a joint investigation was carried out in July and August 2019 by Greenpeace at several locations suspected to have onsite imported plastic waste. It is important to note that overall, the findings from these investigations have revealed that shredded plastic disposed at several dumpsites in Malaysia contain a range of metals, metalloids and organic chemicals, including persistent organic pollutants (POPs), which have likely been contaminating the surrounding environments during their storage or processing/recycling activities. The results of the chemical analysis have been published in a technical report based on analysis done by Greenpeace at the Greenpeace Research Laboratories (2019).

## Key Findings

- Investigations at the dumpsite in Pulau Indah (refer to Figure 1) where waste was burned, showed a number of post-burn residues that were found to contain several contaminants - some in forms that are likely more mobile compared to the source plastics, with additional chemicals or compounds generated during or as a result of the combustion process.
- Significant contaminantion with hazardous chemicals including heavy metals and the presence of brominated flame retardants were found at sites where plastic waste were burned.
- There is evidence that surface waters adjacent to, or downstream from, some of the plastic disposal or processing sites investigated in this study are contaminated with solid waste and chemicals, which may have originated from the plastics discarded at these sites or equivalent operations within the same area.
- Unregulated and now abandoned, dumpsite at Sri Cheeding has been filled and covered with shredded plastics as a layer of topsoil. This layer of topsoil is contaminated with high concentrations of heavy metals including cadmium and lead, relative to background environmental levels. Laboratory tests also revealed the presence of persistent organic compounds such as brominated flame retardants and phthalates at this site.

The detection of heavy metals like cadmium and lead are a matter of concern. Most of the pollutants identified in the tests conducted can potentially remain in the soil for a very long period of time. High levels of the heavy metals identified can also cause secondary pollution to nearby water sources. Such contamination has the potential of bearing hazardous impacts to flora, fauna including microorganisms and humans. Lead is known to cause

intellectual disabilities with no known safe levels in the blood. Exposure to lead could result in decreased intelligence in children, and may lead to behavioural difficulties and learning problems (CHEMtrust 2017).

Heavy metals, polycyclic aromatic hydrocarbons (PAHs), some of the volatile organic compounds (VOCs), and flame retardants (FR) detected in the samples are toxic chemicals, and have been identified in studies to potentially cause diseases resulting in the inhibition of mental growth in children, causing endocrine disruption, reproduction dysfunction, damage to organs (liver and kidney), cardiovascular and respiratory diseases, Alzheimer's disease, Parkinson's disease, as well as trigger various cancers.

## Recommendations

Based on the investigation, Greenpeace Malaysia recommends the following:

**For the Malaysian government:**

- **An inclusive rehabilitation action plan** that involves local communities for the clean-up and rehabilitation of the polluted sites, especially in areas used for open burning and illegal dumping of imported plastic waste:
  i) **The Ministry of Environment and Water** should conduct further environmental investigations into the affected areas, particularly on the risk of leakage of hazardous substances into air, soil and water sources.
  ii) **The Health Ministry** should conduct health impact studies and provide healthcare support to affected residents due to the pollution caused by imported plastic waste.
  iii) **The Malaysian Anti Corruption Commission** should reactivate its Environmental Corruption initiative with specific emphasis on plastic pollution and the corruption related to the management of plastic waste.

- **The need to revisit and enhance the Freedom of Information Act** will ensure waste trade transparency. Despite the government's commitment to shut down illegal facilities and send plastic waste back to the countries of origin, there is still an influx of complaints lodged by local communities regarding pollution by unregulated plastic waste facilities. In order to effectively curb these public health concerns, it is imperative that the right to full and frank disclosure must be codified, enabling stakeholders such as local communities, NGOs and the media to obtain crucial information relating to waste trade from local authorities and the Federal Government.

- **The need to amend or replace the Environmental Quality Act 1974 with an Environmental Protection Law** accompanied by more stringent and effective regulations and rules, accompanied by uncompromising enforcement, is imperative. Stricter policies, rules and regulations must be enforced and action must be taken against illegal operators. Efficiently regulating the industry ensures sustainability, curtails corruption, and eradicates illegal recalcitrant players. The punishment for environmental crimes must also be enhanced to ensure that it plays a pivotal role as a deterrent, and in driving compliance.

**For the global community (plastic waste importing and exporting countries):**

- **Investigate the plastic waste industry** with a focus on possible corrupt, fraudulent and illegal practices by exporting countries and local unlicensed operators. Immediate action must be taken against companies that export plastic waste to unlicensed operators.

- **Put in place legislation requiring local councils and recycling companies in countries exporting plastic waste to conduct due diligence on importers.** Impose hefty penalties on councils or companies that fail to carry out due diligence prior to importation and exportation.

- **Promote a global agreement to combat the flood of plastic.** The governments from plastic waste exporting countries in Europe, Australia, New Zealand, the United States should immediately work towards a binding international agreement to resolve the plastic waste problem. An alliance of German Civil Society Groups recently called on the German government to promote a global agreement to combat the flood of plastic (Greenpeace e.V. et al 2020). This should cover all aspects of the life cycle and must further the protection of the climate, the oceans and biodiversity. A first step would be for those states whose waste is proven to pollute the environment to contribute to the measures and costs of the proper disposal and clean up of unregulated landfills in Malaysia.

- **Prioritise a plastic pollution reduction plan** to reduce unnecessary single-use plastic in phases, to set up clear reduction targets of single-use plastic in accordance with an action plan that focused on developing alternatives based on systems of refill and reuse, while increasing the recycling rate.

- **Enforce Extended Producer Responsibility (EPR)** in the production of plastics by regulating corporations that produce unnecessary single-use packaging for products, requiring them to track products from cradle to grave in order to ensure and strengthen the transparency of plastic usage, disposal and recycling systems internationally.

# INTRODUCTION

In July and August 2019, Greenpeace Malaysia led a team of activists from Greenpeace offices globally, which includes Germany, Italy, and Hong Kong, conducted physical investigations on several identified dumpsites in Malaysia based on information associated with the dumping or the burning of imported plastic waste. The on-site investigations were carried out as a follow-up to the expose made in the Greenpeace Malaysia's report titled "The Recycling Myth" which was released in 2018.

Information was gathered and desk research was carried out in preparation for the field investigation. In these investigations, several previously identified sites were revisited, in addition to other newly discovered sites. Some revisited sites were found to be still in use as a dumpsite, while others were shut down and abandoned for some time. Among the dumpsites cleared, some were cleaned superficially rather than professionally, while the plastic piles and waste from other sites visited were removed and transported to other locations. One of the sites where plastics were disposed was covered with a layer of topsoil which contained a high-density layer of small pieces of shredded plastic.

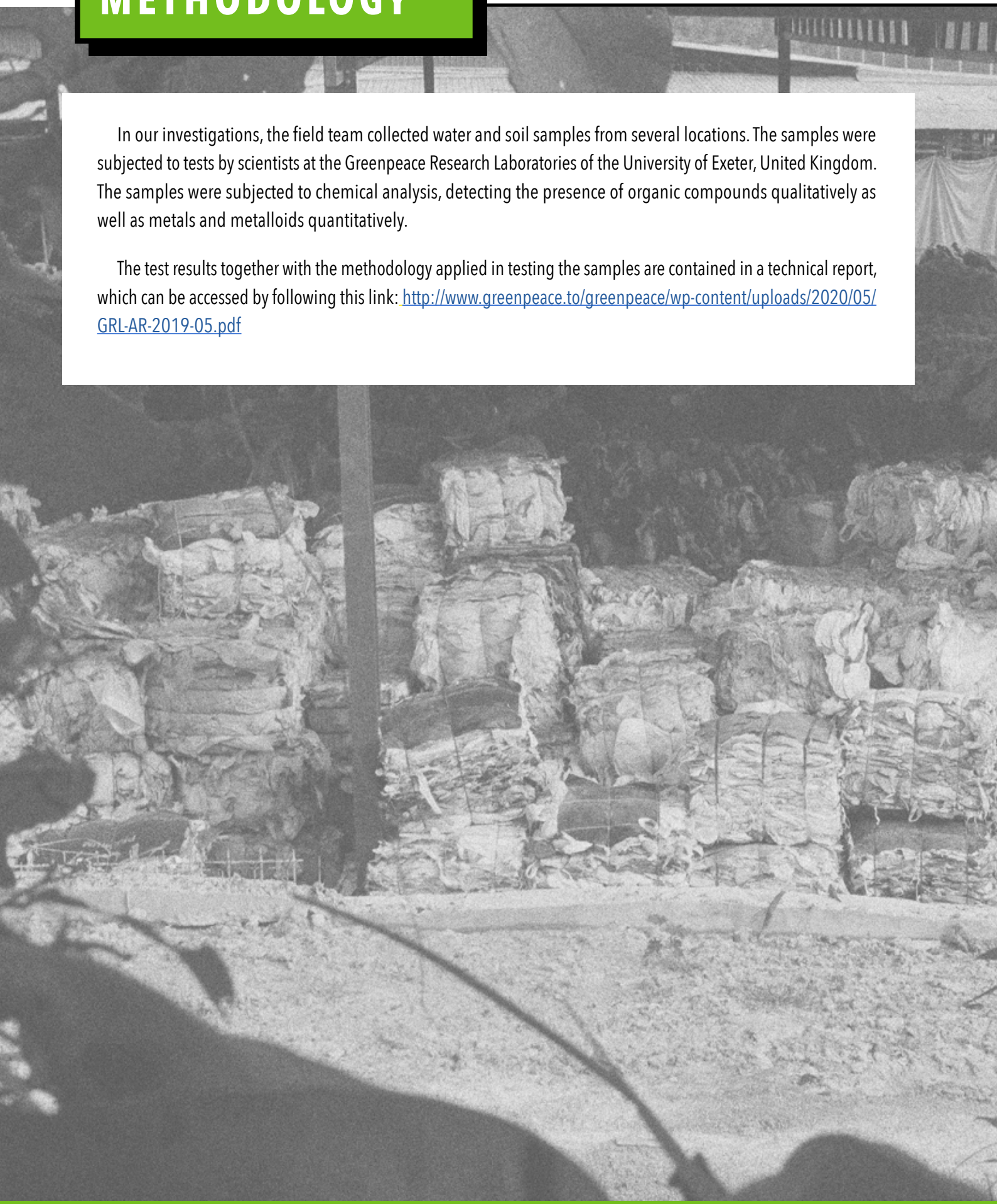
A report released recently by Ecoton, IPEN, Nexus3 and Arnika (2019), revealed that a huge amount of plastic dumped at unregulated sites poses a chemical threat to human health and the environment. The report revealed that toxic chemicals released from plastic waste had entered the food chain exposing the people residing in the vicinity of two plastic dumpsites in Indonesia to health risks. Tests have also, revealed that dioxins were found in free-range chicken eggs collected near a factory that produces tofu, in which plastic waste was burned as fuel, while significant levels of other hazardous chemicals like polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), perfluorooctane sulfonate (PFOS) and short-chain chlorinated paraffins (SCCPs) were also identified. The determined concentrations have posed a risk to residents as the level of toxicity from eating just one of those eggs collected in the vicinity of the tofu factory in Tropodo was equivalent to an individual consuming 70-fold of chlorinated dioxins, exceeding the European Food Safety Authority's (EFSA) published tolerable daily intake (TDI). Similarly, the consumption of an egg collected near the rural plastic waste dump site in Bangun would exceed the proposed EFSA tolerable weekly intake of PFOS. It is important to note that the levels of the mentioned chemicals are regulated globally under the Stockholm Convention.

These factors prompted a detailed study of water and soil samples at and around the two identified dumpsites. These investigations led by Greenpeace Malaysia revealed the presence of hazardous chemicals leached from the landfill dumpsites into the surrounding environment giving the potential to enter the food chain.

# METHODOLOGY

In our investigations, the field team collected water and soil samples from several locations. The samples were subjected to tests by scientists at the Greenpeace Research Laboratories of the University of Exeter, United Kingdom. The samples were subjected to chemical analysis, detecting the presence of organic compounds qualitatively as well as metals and metalloids quantitatively.

The test results together with the methodology applied in testing the samples are contained in a technical report, which can be accessed by following this link: http://www.greenpeace.to/greenpeace/wp-content/uploads/2020/05/GRL-AR-2019-05.pdf



# BACKGROUND AND FINDINGS RELATED TO SAMPLING AT THE INVESTIGATED LOCATIONS

The investigations by Greenpeace Malaysia were carried out one year after the release of the 'The Recycling Myth' report, in July / August 2019. The Greenpeace investigative team returned to a few of unregulated dumpsites in Malaysia where there was physical evidence of discarded plastic waste and other scrap materials. Some of these dumpsites are still active, whilst the others have been shut down. The dumpsites were however, selected because of the deplorable manner in which those particular dumpsites had been filled before being abandoned. The waste at the dumpsite has been superficially covered with a layer of topsoil which contravenes legal requirements and standard guidelines.

The investigations conducted involved sampling water bodies comprised of creeks, rivers, canals and a fish pond located in the vicinity of the dumpsite. These water bodies indicated uptake of rainwater washed out from the dumpsites and plastic storage units potentially carrying with it chemicals leached from plastic waste. Samplings of water and soil were collected during the field investigations and individually sealed and labelled before being sent to the Greenpeace Research Laboratories in the UK for analysis.

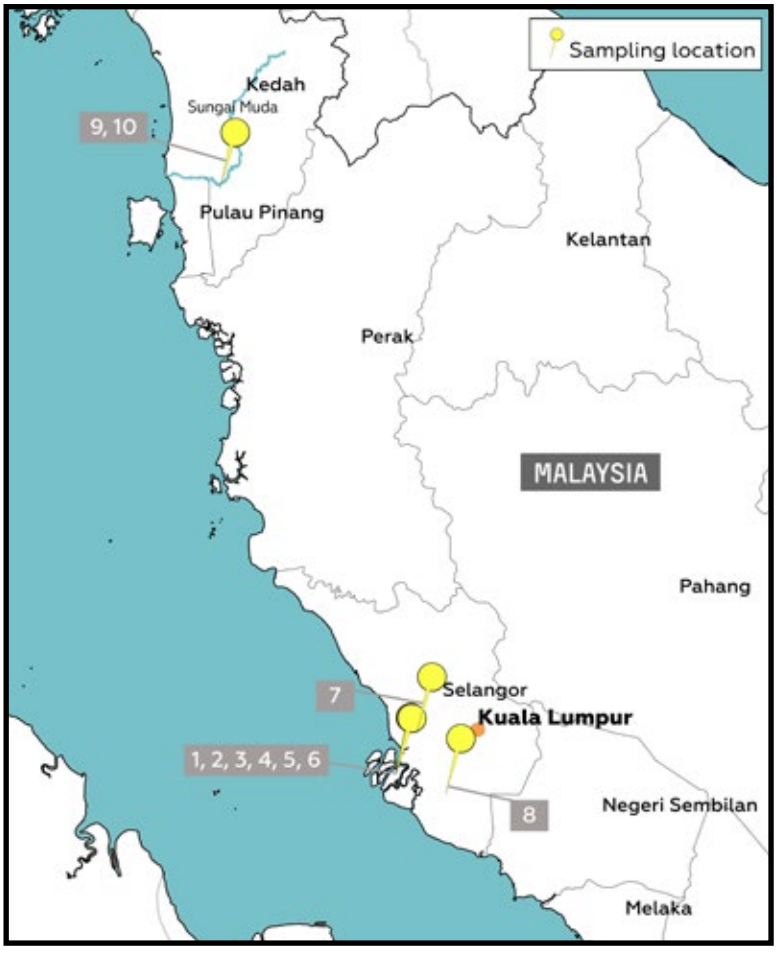



*Figure 1: Map of the overall sampling locations*

Table 1 shows the locations that were visited and a list of samples that have been collected with a summary of the results from analysis conducted by the Greenpeace Research Laboratories in Exeter, UK. Significant contamination by metals and metalloids as well as the presence of toxic organic chemicals have been found at several locations that were used as plastic waste dumpsites.

| NO | LOCATION | GPS OF THE LOCATION | SAMPLE LAB-ID, TYPE | SAMPLING DATE | KEY CHEMICALS FOUND | KEY EFFECTS/IMPACTS |
|---|---|---|---|---|---|---|
| 1 | Unregulated dumpsite at the abandoned shop lots in **Pulau Indah, Klang** | 2.98419, 101.34565 | MY19007 sample of soil that partially consists of burned plastic | 8/6/2019 | - **metals and metalloids**: antimony, cadmium, zinc, lead, tin,<br>- **22 organic compounds**: long-chain aliphatic hydrocarbons<br>- **trace levels of 8 polycyclic aromatic hydrocarbons (PAH)** | - **heavy metals, metalloids and polycyclic aromatic hydrocarbons (PAHs)**: toxic chemicals that are carcinogenic and can lead to chronic diseases<br><br>- **Cadmium**: can accumulate in the body over time, with long-term exposure causing damage to the kidneys and bones<br><br>- **Lead**: can accumulate in the body over time. Irreversible damage to the nervous system, including its development in children, also affects the blood system, kidneys and reproduction<br><br>- **Antimony**: can cause gastrointestinal effects, and when inhaled potentially cause myocardial effects<br><br>- **PAH**: can cause neurodegenerative diseases (Alzheimer's disease and Parkinson's disease); lung cancer; cardiovascular disease risk and hypertension; disruption of reproductive cycles and interference with cardiac conduction of marine life |
| 2 | Small ditch in front of the unregulated dumpsite at the abandoned shop lots in **Pulau Indah, Klang** | 2.98400, 101.34690 | MY19015 water | 8/6/2019 | - **metals and metalloids**: no notable concentrations<br>- **flame retardants (FRs)**: TPPO | - **TPPO**: the degradation products of the compound could be toxic to aquatic organisms; TPPO is a neurotoxin to golden apple snails |

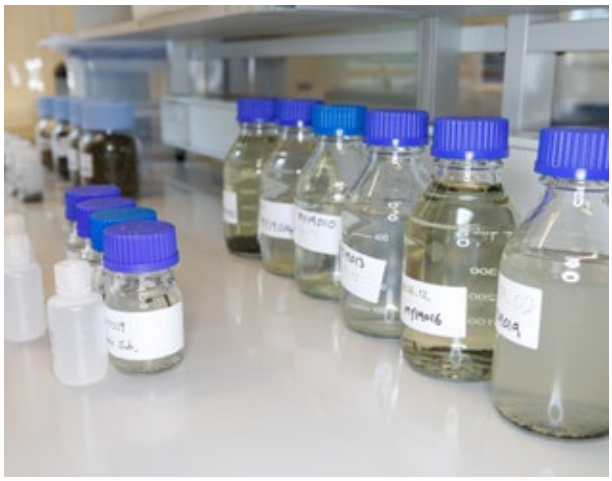
| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Fishing pond close to the unregulated plastic waste dumpsite and plastic waste recycling factories in **Pulau Indah, Klang** | 2.98510, 101.34610 | MY19008 sediment | 8/6/2019 | - **metals and metalloids**: antimony, copper, nickel<br>- **5 polycyclic aromatic hydrocarbons (PAH) & 1,1'-(1,3-propanediyl) bis-benzene** | - **nickel**: gastrointestinal and cardiac effects.<br>- **antimony**: can cause gastro-intestinal effects, and when inhaled potentially cause myocardial effects<br>- **PAH**: can cause neurodegenera-tive diseases (Alzheimer's disease and Parkinson's disease); lung cancer; cardiovascular disease risk and hypertension; disruption of reproductive cycles and interfer-ence with cardiac conduction on marine life |
| 4 | | | MY19009 water | 8/6/2019 | - **metals and metalloids**: antimony, nickel, copper, strontium<br>- **flame retardants (FRs)**: TPPO, triphenylphosphine sulphide | - **antimony**: can cause gastro-intestinal effects, and when inhaled potentially cause myocardial effects<br><br>- **nickel**: can cause gastrointesti-nal and cardiac effects<br><br>- **TPPO**: the degradation products of the compound could be toxic to aquatic organisms; TPPO is a neurotoxin to golden apple snails |
| 5 | Channel flowing into the fishing pond and downstream of several plastic waste recycling factories in **Pulau Indah, Klang** | 2.98427, 101.34664 | MY19012 water | 8/6/2019 | - **metals and metalloids**: antimony, nickel, copper, manganese<br>- **volatile organic compounds**: cyclohexane, chlorinated alkenes, benzene, toluene, o-xylene and p-xylene (BTEX) | - **nickel**: can cause gastrointesti-nal and cardiac effects<br><br>- **antimony:** can cause gastro-intestinal effects, and when inhaled potentially cause myocardial effects<br><br>- **VOC**: some VOC are carcinogen-ic (benzene) |
| 6 | Ditch near unregulat-ed plastic wastes burning site in **Pulau Indah, Klang** | 2.98111, 101.35111 | MY19018 water | 8/7/2019 | - **metals and metalloids**: Molybdenum<br>- **organic compound**: 7,9-di-tert-butyl-1-oxaspiro (4,5) deca-6,9-diene-2,8-dione | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Creek at a plastic recycling facility in **Kapar, Klang** | 3.16195, 101.43837 | MY 19001 water | 7/29/2019 | - **metals and metalloids**: No notable concentrations | |
| 8a / 8b | Unregulated dumpsite in **Kampung Sri Cheeding, Kuala Langat** | 2.89250, 101.56389 | MY 19020 & MY 19021 sample 1 & 2 of shredded plastic (topsoil layer) | 8/7/2019 | - **metals and metalloids**: Copper, lead, zinc; lower concentration: cadmium,, antimony, tin, molybdenum, arsenic<br>- **flame retardants (FRs)**: polybrominated diphenyl ethers (PBDEs) from hepta- to decabrominated congeners, chlorinated FR dechlorane, 1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPE) and decabromodiphenyl ethane (DBDPE)<br>- **plasticizers**: 2 phthalate esters (DEHP and DUP), and 1 terephthalate (di(2-ethylhexyl) 1,4-benzenedicarboxylate)<br>- **others**: long chain aliphatic hydrocarbons and PAH | - **lead**: can accumulate in the body over time. Irreversible damage to the nervous system, including its development in children, also affects the blood system, kidneys and reproduction<br><br>- **zinc**: high levels of exposure can lead to accumulation with possible toxic effects, including pancreatic damage anaemia and gastrointestinal distress<br><br>- **copper**: high levels of exposure can lead to gastrointestinal effects, also aquatic organisms in surface water are very sensitive to copper & toxic effects can occur at very low levels<br><br>- **PBDEs**: can cause developmental neurotoxicity, reproductive system toxicity, and endocrine system toxicity<br><br>- **phthalates**: can affect endocrine system; link to cancer and reproductive problems |
| 9 | **Sungai Muda** river at the edge of dumpsite, Kedah | 5.54277, 100.58487 | MY 19003 water | 7/31/2019 | - **metals and metalloids**: no notable concentrations<br>- **flame retardants (RFs)**: TPPO<br>- **others**: dibutyl sebacate | - **TPPO**: the degradation products of the compound could be toxic to aquatic organisms; TPPO is neurotoxin to golden apple snails |
| 10 | **Sungai Muda** riverbank at the edge of dumpsite, Kedah | | MY 19006 soil | 7/31/2019 | - **metals and metalloids**: No notable concentrations | |

*Table 1: Water and soil samples collected in July to August 2019 during investigations of imported plastic waste related locations in Malaysia.*

## Lab analysis by Greenpeace Research Laboratories in Exeter, UK

Water and soil samples collected from Malaysian plastic dumpsites and sent for lab analysis to the Greenpeace Research Laboratories, Exeter, UK.




*Dr. Iryna Labunska and Dr. Kevin Brigden, Senior Scientists at Greenpeace Research Laboratories in Exeter, UK, explain the analysis results to Manfred Santen, campaigner with Greenpeace Germany*

## Sampling Locations : July and August 2019


*Location 1: Unregulated dumpsite at the abandoned shop lots in Pulau Indah , sample No.1 and No.2*

Pulau Indah, with its literal translation being 'beautiful island', was formerly known as Pulau Lumut. It is an island situated within the district of Klang in the state of Selangor, Malaysia. Located within the Pulau Indah administrative area is Westport, one of the main ports in Malaysia, the Pulau Indah Industrial Park (including Selangor Halal Hub), the local villages of Kg. Perigi Nenas, Kg. Sungai Pinang, Kg. Sungai Kembong, Kg. Teluk Nipah, the seaside park known as Laguna Park, a housing estate known as Bandar Armada Putra and the Malaysian Navy's National Hydrographic Centre. Pulau Indah was once home to a large area of natural mangrove swamps, which has been systematically lost until 1999, peaking with the development of West Port and the industrial estates.

The Pulau Indah landfill dumpsite involved in the study is situated within an area of abandoned industrial lots along Jalan Sungai Chandong in Bandar Armada Putra near to Boustead Cruise Centre (Star Cruise Terminal) and the National Hydrographic Centre. The landfill dumpsite was discovered and made the subject of the report by Greenpeace Malaysia in the report titled 'The Recycling Myth'. Imported plastic waste originating from several countries including, waste from Australia, the United States of America, the United Kingdom, Germany, France, Spain, Scandinavian countries and Japan have found their way to this landfill dumpsite. There were a number of unregulated plastic recyclers operating in the area prior to a crackdown on the operation of these factories by the local Selangor state council.

The dumpsite has been visited several times by a number of teams from Greenpeace, and journalists from around the world. It has since been partially cleaned up over the past few months. However large amounts of plastic waste piles from numerous countries can still be found at the dumpsite, including waste from European countries like Germany, Spain and the Scandinavian countries. An examination of the waste revealed that it consists mainly of a mix of non-recyclable plastic, in addition to other scraps which includes e-waste (e.g. plastic cases or circuit boards from electronic devices) that continue to be stored in abandoned buildings. Signs of previous fires in the area indicate that there have been attempts to dispose of evidence of the type of wastes discarded at the dumpsite by burning them.

*Unregulated dumpsite at Pulau Indah, Klang. Sample No.1 (MY19007) was collected in this area. On the right: location where sample No. 1 was collected.*

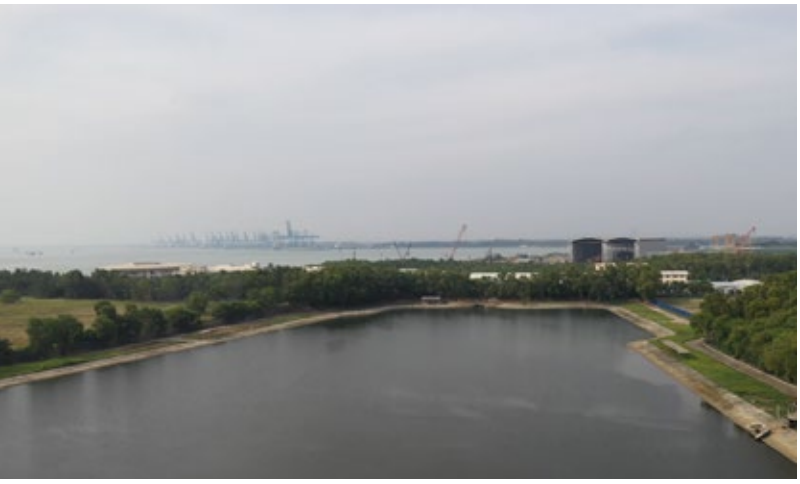
On our visit, the team from Greenpeace managed to gather samples that were collected from a pile of plastic waste which included partly burnt plastic materials. Subsequent tests revealed that the samples contained chemicals that could be released by thermal decomposition or the pyrolysis of plastics. The samples contained toxic metals such as cadmium and lead, and the metalloid antimony in a concentration similar to those found in the shredded plastic from the location in Sri Cheeding. Lead and tin were 3-5 times lower than median shredded plastic sample concentrations. Concentrations of copper and molybdenum were above typical levels in uncontaminated environmental matrices such as soil (Bahaa-Eldin, 2008). Burning of these plastic waste exposes metals and metalloids, bound within the plastic, to environmental weathering. It also converts the metals and metalloids into different chemical forms, which can be more mobile in the environment. The analysis also detected a variety of organic chemicals, which includes trace levels of long-chain aliphatic hydrocarbons and eight polycyclic aromatic hydrocarbons (PAH), including benzo[a]pyrene which are common byproducts of plastic thermal decomposition and are known to be carcinogenic in humans.

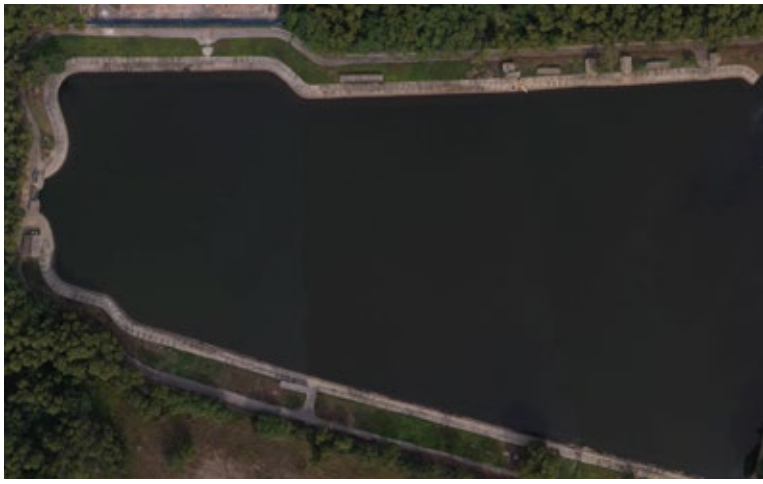
As for water samples collected from a small ditch located at the front of the dumpsite, there was no notable concentration of metal and metalloids detected by the analysis done. However the analysis did reveal a flame retardant compound known as triphenylphosphine oxide (TPPO), which is a by-product in the production of acrylonitrile styrene plastic. Isomers of styrene acrylonitrile trimer, were also found in the water samples taken. These chemicals are known as potential nervous system toxicants.

Further, investigations into the extent of pollution in this area are necessary for suitable remedial measures to be implemented in an attempt to halt, and if possible, mitigate the environmental contamination. Professional cleaning and remediation of the site are needed to avoid the spread of hazardous materials and toxic chemicals, by leaching through rainwater runoff or the mobilisation of contaminated fine dust particles by wind.

## Location 2: Fishing pond in Pulau Indah, samples No.3 , No.4 and No.5

The fishing pond is located about 50 metres (m) from the dumpsite and is still in active operation. It is one of the largest brackish water ponds in the state of Selangor, covering an area approximately the size of 5 to 6 football fields. Its water levels change with the tides from Straits of Malacca. Members from the Greenpeace team interviewed the owner of the fishing pond who claimed that there was a large amount of fish, which had died on the 6$^{th}$ of September, 2019 due to pollutants in the water. The actual cause of the pollution or its source has not been determined.



*Fish pond with brackish water and its feeding canals. Samples No.3 (MY19008) , No.4 (MY19009) and No.5 (MY19012) were taken in this area*

Water from the pond (sample No.4) and sediment (sample No.3) at the bottom of the pond were collected and analysed. The sample of sediment from the bottom of the pond revealed heavy metal contamination, reflecting their high concentrations in the fish pond water. Antimony and copper were found to be 50 times the backgrorund levels whilst the composition of nickel was 10 times higher than in background ranges for freshwater sediments (ATSDR 2004a, 2005a, 2019; Filella et al 2002; Salomons & Forstner 1984), background concentrations for metals in brackish water are usually lower than in freshwater. In addition to the high levels of heavy metals found, chemicals known to be used industrially as slip agents, lubricants or corrosion inhibitors were detected in water from the pond while several PAHs including benzo[a]pyrene (BaP) and phenanthrene, were identified in the sediment. PAHs are known to occur from incomplete plastic burning processes.

The site investigations also revealed that heavy metals, which include nickel, antimony and copper were found at elevated concentrations in a canal that flows into the fishpond. The sample from this canal also revealed elevated amounts of manganese which were found in concentrations of 10 times higher than typically found in non-contaminated fresh water.

In the water samples from the fish pond and in the water from the pond feeding channel, there were chemicals found which, can be linked to plastics, including by-products related to styrene polymers and chemicals used as additives with specific properties like flame retardants, slip agents, lubricants, and corrosion inhibitors. Toxic metals and chemicals were also detected in the sediment and suspended in the pond water. Most of the metals and plastic-related chemicals were also found in the canal which feeds into the pond, some of which were in higher concentrations than in the pond.

Due to the alarming quantities of the heavy metals and chemicals found in the fish pond, which is used for food production, it is imperative that further investigations are immediately conducted by the authorities to determine the necessary measures to contain the release of hazardous chemicals and high concentrations of heavy metals into the waterways, thus ensuring that the food chain is not contaminated. The first step towards successfully ensuring this, is to determine the source of the contamination and then to address it effectively. Undoubtedly though, effective measures must necessarily include the cleaning of the water and sediment in the fish pond and the canal leading to it to avoid further mobilisation of the heavy metals and chemicals.

*Samples from water (sample No. 4, MY19009) and sediment (sample No.3, MY19008) at fish pond in Pulau Indah*


*Water sampling at a fish pond in Pulau Indah*

## Location 3: Unregulated plastic waste burning site in Pulau Indah, Klang, sample No.6

The unregulated plastic waste burning site is located by the roadside near Jalan Sungai Chandong 12, as reported in "The Recycling Myth". It was actively being used as a dumpsite for waste and burning of plastic waste in 2018 and in early 2019. Some signs of small scale sporadic burning can still be seen along the road leading to the site compared to the past when huge amounts of plastic waste including municipal waste were observed being transported to the location and set on fire especially under the cover of the dark. This practice has since stopped as at the end of 2019.

*Burn site at Pulau Indah, formerly an illegal dumpsite for imported and domestic plastic waste. Sample No. 6 (MY19018) has been collected from a ditch close to the dumpsite*

The burning of plastics carries a risk of being mobilised spreading heavy metals and other toxic chemicals which, includes polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), which can form as a result of uncontrolled combustion processes of chlorine-containing plastic, such as PVC. When plastic products containing brominated flame retardants are burned, these chemicals can be converted to brominated dioxins and furans (PBDD/Fs), which is a group of highly toxic chemicals similar to chlorinated dioxins.

However, no notable contaminants were found in the water and sediment samples taken from the canal water that was visibly polluted with plastics, the lab analysis showed that there was no evidence of contamination with hazardous organic chemicals, which could be released by plastic products.


## Location 4: Unregulated dumpsite in Kampung Sri Cheeding, samples No.8a and No.8b

Kampung Sri Cheeding (Sri Cheeding Village) is situated in Kuala Langat district, Selangor at around 80 hectares (ha) in size. A tea plantation famous for its lowland tea plantations is situated within the area. Kampung Sri Cheeding is situated about 8 km away from Jenjarom, a town previously affected by pollution from the illegal plastic waste facilities and dumpsites. The unregulated dumpsite was situated beside a palm oil plantation. The material used as a form of topsoil to fill and cover the dumpsite mainly consists of shredded plastic particles. Smoke was visible from a smouldering fire the size of a few square meters (sqm) at one edge of the site when our investigative team visited the site. There was also a fire which previously occurred at the same site as reported by HuffPost in 2019.

*Shredded plastic particles were dumped in a palm oil plantation area at Kampung Sri Cheeding, Jenjarom. Samples No.8a (MY 19020) and No.8b (MY 19021) were collected in this area.*

Two samples were collected from the topsoil covering the dumpsite. Both contained hazardous substances like heavy metals including cadmium, lead and mercury, as well as chemicals such as brominated and chlorinated flame retardants (PBDEs and dechlorane) and plasticisers like DEHP and DUP that are potentially hazardous to the environment and also to human health.

Toxic metals like cadmium (13.8-16.7 mg/kg) and lead (2940-3780 mg/kg) were found to be at higher concentrations than usually found in soils from Malaysia. Cadmium is commonly found in a concentration below 1 mg/kg in soils, lead below 2 mg/kg (Khairiah, J 2009). For comparison, the State Environmental-Protection Administration in China (SEPA 1995) set a maximum allowable limit for cadmium of MAL 1.5 mg/kg, or lead a MAL 350 mg/kg for soils. The Malaysian Department of the Environment published SSL (Site Screening Levels) for residential soil as 71 mg/kg for cadmium and 400 mg/kg for lead (DOE 2015). The acceptable condition for the discharge of leachate in the Environmental Quality Act 1974 has been set 0.01mg/L for cadmium and to 0.1mg/L for lead (DOE 2009).

Other metals including copper, tin, antimony, molybdenum and zinc were also detected at elevated concentrations. From the samples tested mercury was also detected in notable amounts in the soil sample. Mercury is a highly toxic metal, typically found in the environment at very low concentrations. The source of metals found in the soil sample can either be remnants from the plastic itself or introduced as additives intentionally incorporated into plastic formulations such as fillers, stabilisers, pigments or flame retardants.

Both samples from this location also contained various highly brominated and chlorinated flame retardants (FR) like brominated diphenyl ethers (PBDEs). One of the samples had a range of PBDEs, from hepta- to decabrominated

congeners, while another sample had a range from octa- to decabrominated congeners. A chlorinated flame retardant, dechlorane, was identified in both samples. While two brominated flame retardants, 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE) and decabromodiphenyl ethane (DBDPE, a substitute for the banned DecaBDE), were detected in one of the two samples collected at the site.

The most common members of the PBDE family were banned by the Stockholm Convention including commercial mixtures of PentaBDE (2009), OctaBDE (2009) and DecaBDE (2017). Brominated flame retardants such as polybrominated diphenyl ethers (PBDEs) are known as endocrine-disrupting chemicals (EDCs) and adversely impact the development of the nervous system and children's intelligence (POP RC 2006, 2007, 2014, 2015, 2016). Plasticisers from the phthalates chemical group, detected in the samples, were DEHP and DUP. These substances are widely used as additives in the manufacturing of plastic products to make them more flexible. Some phthalates are toxic to the reproductive system (Swan 2008, Lyche et al 2009), increases the risk of allergies and asthma, and have an adverse impact on children's neurodevelopment (Jurewicz 2011). In addition to that, one sample was found to contain a polycyclic aromatic hydrocarbon (PAH), 1,6-dimethyl-4-(1-methylethyl) naphthalene. The formation of PAH is most likely from the burning of plastic waste. Some representatives of PAHs are known to be carcinogenic.

Therefore, there is an urgent need for immediate investigations at the site to determine the full extent of contamination of hazardous metals and chemicals at the site, both in-depth and breadth of the Sri Cheeding dumpsite. Urgent measures must be taken to remove all materials that contain toxic chemicals or have the potential to release toxic chemicals by leaching through rain or burning, while the dumpsite itself has to be decontaminated. Professional remediation of the surface and layers of contaminated soil layers must be carried out. Prompt action and mitigating measures may be able to ensure the contamination does not mobilise.

## Location 5: Sungai Muda, Kedah, samples No. 9 and No. 10

Sungai Muda (Muda River) is the longest river in the state of Kedah, Malaysia. It flows westward, passing through the southern suburbs of Kedah's second-largest city Sungai Petani, and forms a natural boundary with the Penang state. The Muda River then empties into the Straits of Malacca at Kota Kuala Muda. The Beris Dam is used to regulate the flow of water along the Muda River basin to augment water for the irrigation of paddy or upland crops, as well as for domestic and industrial water supply and other uses.

The illegal dumpsite was reported to be 2ha in size and was located on the bank of the Muda River near Sidam Kiri in a village called Kampung Kemumbung. It is believed to have been operational since 2008 and residents in the vicinity have made complaints related to the dumpsite's operations since 2016. Villagers in the area claimed that at one point in time, at least 30 lorries entered the site to dump waste on a daily basis. Imported plastic waste was found on-site and the local authorities sealed off the site in late July 2019.

*Unregulated dump site near a village, Kampung Kemumbung at Sungai Muda, Kedah*




*German plastic wastes were found at unregulated dumpsite at Sungai Muda*

*Riverbank at the dumpsite in Sungai Muda*

Water and soil samples from the embankment surface were collected for analysis. Rainwater was seen washing out parts of the dumpsite, flowing into the river, from which we collected the samples. The water samples collected at the Muda River contained TPPO, a flame retardant and dibutyl sebacate, a plasticiser found in plastic production. Rainwater can potentially assist in the leaching of chemical compounds from plastics and other contaminants. None of the organic compounds were identified in the soils sample while concentrations of metals and metalloids were well within the broad 'typical' ranges reported for uncontaminated soils globally.


*Water samples from the river Sungai Muda, among them is sample No. 9 (MY 19003)*

## Location 6: Recycling factory in Kapar, Klang, sample No. 7

In Kampung Bukit Kapar, Klang, there are residential areas, schools, factories and an oil palm plantation situated within and in the near vicinity. The recycling company operating within the vicinity, which sits amidst an oil palm plantation was discovered to be importing waste from foreign countries. Our investigations revealed that there was waste found which can be traced back to Italy. Plastics and other forms of waste were also found indiscriminately dumped in the oil palm plantation beyond the boundaries of the factory. While conducting our fieldwork we witnessed some of the waste being set on fire which was captured in Photo 11 where the fire and the smoke billowing from it can be seen at the bottom of the photo.

*Plastic recycling facility in Kapar, Klang. The picture shows smoke from burning mixed waste, which includes plastics.*


*Location of plastic recycling facility in Kapar, Klang , sample No. 7 (MY 19001)was collected.*

*Plastic bales, workers and machines at the plastics recycling factory in Kapar, Klang*

*Fence of the plastics recycling factory*

*Sample No. 7 (MY 19001) is from the creek situated approximately two to three metres from the plastics recycling facility's boundary fence.*

*Dumped waste including packaging from European countries close to the fence of the plastics recycling factory.*


*Plastic waste from Italy was found close to the fence of the plastics recycling factory.*

Water samples were collected at the creek located approximately two to three metres from the boundary fence of the factory processing waste plastics. Large quantities of waste plastics and waste and raw materials were clearly visible. Laboratory analysis conducted by Greenpeace however did not indicate that the water was contaminated with heavy metals or organic chemicals, known to be used in the production of plastic.

# POTENTIAL HEALTH / ENVIRONMENTAL IMPACTS RELATED TO THE FINDINGS

The primary concern associated with discarding and recycling plastic waste haphazardly is the environmental impact from the release of chemicals additives introduced in the manufacturing of plastics in order to give it certain properties - for instance, brightly red, yellow and orange plastics often contain cadmium. While heavy metals like tin, lead, cadmium or a combination of these heavy metals are introduced as heat stabilisers (Verma et al 2016; Vivek 2014). Heavy metals, polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs) are toxic chemicals that can be released by plastic waste, which are potentially known to cause carcinogenic and chronic diseases, e.g. for metals and metalloids and PBDEs bound within a plastic, burning of the plastic can expose them to environmental weathering, and convert the metals and metalloids into different chemical forms which can be more mobile in the environment. PAHs are formed during incomplete combustion processes, e.g. when plastic waste is incinerated openly. They are released with the smoke and are particularly concentrated in the fire residues. If plastic waste containing chlorinated or brominated compounds is incinerated, the particularly toxic polychlorinated dibenzodioxins or dibenzofurans may be formed. Such plastic wastes can be PVC containing products and textiles or motherboards and other parts from electronic devices. There are long-term effects resulting from plastic waste due to fragmentation and shredding, e.g. by weathering and UV from sunlight. Microplastic particles and hazardous chemicals will be released and contaminate the soil. In case these pollutants are persistent and they potentially will be absorbed for a very long time. It can also result in secondary pollution of the nearby water sources. These pollutants, especially toxic metals, could not only have hazardous impacts on humans but also on flora, fauna and even microorganisms, eventually affecting the surrounding ecosystem.

Several studies have also revealed that improper plastics and e-waste handling can have a severe environmental impact. A comprehensive investigation on e-waste sites in China has estimated human exposure to polybrominated diphenyl ethers (PBDEs) and to other key contaminants via consumption of locally produced animal-derived foods (Labunska 2017). The earlier mentioned study from Indonesia has shown that communities living close to unregulated plastic waste dump sites also can be exposed to toxic chemicals that entered the food chain (Arnika, Ecoton, IPEN, Nexus3 2019).

Exposure to heavy metals can threaten the health and livelihood of humans, both in adults and in particular children, the harm can occur through incidental ingestion, breathing and dermal contact of the contaminated soil. Plants and crops can bioaccumulate various heavy metals if grown near industrial areas and polluted soil. Additionally, contaminants can enter the human body through ingestion of these crops. Individuals exposed to heavy metals risk developing health issues such as the inhibition of mental growth in children, endocrine disruption, reproduction dysfunction, damage to organs (liver and kidney), cardiovascular and respiratory diseases, as well as various cancers. Some of these metals have been classified as non-essential to the human body and are included in the top 20 'dangerous substances' list by the United States Environmental Protection Agency and the Agency for Toxic Substances and Disease Registry (ATSDR) (Wu et al 2018; Khan et al 2016; Rai et al 2019). PAHs are highly carcinogenic, mutagenic, and teratogenic, and have been associated with neurodegenerative diseases (Alzheimer's disease and Parkinson's disease), cardiovascular diseases and hypertension, as well as lung cancer. PAHs were also found to disrupt reproductive cycles and interfere with the cardiac conduction of aquatic lives (Coxon et al 2018; Dsikowitzky 2011).

The combustion of plastic waste can produce smoke and solid residue ash, which have a high potential to damage health and environmental components, such as volatile organic compounds (VOCs), semi-VOCs, smoke including particulate matter, particulate bound heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzofurans (PCDFs) and dioxins (PCDDs). Some of these compounds are potentially carcinogenic and may enter our food chain. A flame retardant (FR) like triphenylphosphine oxide (TPPO) is one of the pollutants that can be detected in aquatic environments. TPPO degradation products are known to be toxic and neurotoxic e.g. to golden apple snails. The polybrominated diphenyl ethers (PBDEs) are a group of other known prohibited hazardous FRs that, once released to the environment, are able to accumulate in soil and sediments, thus, become available for uptake by both aquatic and terrestrial organisms. Finally, PBDEs may enter the food chain and can potentially cause a range of toxic effects to humans (Labunska et al 2014, 2015 & 2017; Verma et al 2016; Emery et al 2005; Dsikowitzky 2011; Chea & An 2018; Christale et al 2018; Lai et al 2019).

# CONCLUSION AND RECOMMENDATIONS

Overall, our investigations demonstrate that shredded plastic and plastic waste disposed of at several dumpsites in Malaysia contain a range of metals, metalloids and organic chemicals, including persistent organic pollutants (POPs). These pose a potential risk to likely contaminating the surrounding environment with hazardous chemicals resulting from plastics storage, processing and/or recycling. As seen in the report by Ecoton, IPEN, Nexus3 and Arnika (IPEN 2019), chicken eggs collected near plastic dumpsites in Indonesia contain plastic pollutants that could be dangerous to the health and livelihood of people. Results from their report have shown the possibility that contamination from dumpsites could spread, polluting water and soil resources.

As such, findings from our investigation underlines the urgent need for remediation and clean up measures at the aforementioned sites and locations of plastic waste dumpsites to prevent the escape of hazardous chemicals or the formation of even more toxic substances resulting from the unregulated burning of plastics.

Based on the investigation, Greenpeace Malaysia recommends the following:

**For the Malaysian government:**

- **An inclusive rehabilitation action plan** that involves local communities for the clean-up and rehabilitation of the polluted sites, especially in areas used for open burning and illegal dumping of imported plastic waste:
  i) **The Ministry of Environment and Water** should conduct further environmental investigations into the affected areas, particularly on the risk of leakage of hazardous substances into air, soil and water sources.
  ii) **The Health Ministry** should conduct health impact studies and provide healthcare support to affected residents due to the pollution caused by imported plastic waste.
  iii) **The Malaysian Anti Corruption Commission** should reactivate its Environmental Corruption initiative with specific emphasis on plastic pollution and the corruption related to the management of plastic waste.

- **The Need to Revisit and Enhance the Freedom of Information Act** will ensure waste trade transparency. Despite the government's commitment to shut down illegal facilities and sending plastic waste back to the countries of origin, there is still an influx of complaints lodged by local communities regarding pollution by unregulated plastic waste facilities. In order to effectively curb this public health concern, it is imperative that the right to full and frank disclosure must be codified enabling Stakeholders such as local communities, NGOs and the media to provide crucial information relating to waste trade from local authorities and the Federal Government.

- **The need to amend or replace the Environmental Quality Act 1974 with an Environmental Protection Law** accompanied by more stringent and effective regulations and rules accompanied by uncompromising enforcement is imperative. Stricter policies, rules and regulations must be enforced and action must be taken against illegal operators. Efficiently regulating the industry ensures sustainability,

curtails corruption and eradicates illegal recalcitrant players. The punishment for environmental crimes must also be enhanced to ensure that it plays a pivotal role as a deterrent driving compliance.

**For the global community (plastic waste importing and exporting countries):**

- **Investigate the plastic waste industry** with a focus on possible corrupt, fraudulent and illegal practices by exporting countries and local unlicensed operators. Immediate action must be taken against companies that export plastic waste to unlicensed operators.

- **Put in place legislation requiring local councils and recycling companies in countries exporting plastic waste to conduct due diligence on importers.** Impose hefty penalties on councils or companies that fail to carry out due diligence prior to importation and exportation.

- **Promote a global agreement to combat the flood of plastic.** The governments from plastic waste exporting countries in Europe, Australia, New Zealand, the United States should immediately work towards a binding international agreement to resolve the plastic waste problem. An alliance of German Civil Society Groups recently called on the German government to promote a global agreement to combat the flood of plastic (Greenpeace e.V. et al 2020). This should cover all aspects of the life cycle and must further the protection of the climate, the oceans and biodiversity. A first step would be for those states whose waste is proven to pollute the environment to contribute to the measures and costs of the proper disposal and clean up of unregulated landfills in Malaysia.

- **Prioritise a plastic pollution reduction plan** to reduce unnecessary single-use plastic in phases, to set up clear reduction targets of single-use plastic in accordance with an action plan that focuses on developing alternatives, based on systems of refill and reuse, while increasing the recycling rate.

- **Enforce Extended Producer Responsibility (EPR)** in the production of plastics by regulating corporations that produce unnecessary single-use packaging for products, requiring them to track products from cradle to grave in order to ensure and strengthen the transparency of plastic usage, disposal and recycling systems internationally.

# REFERENCES


Alloway, B.J. (1990). Heavy metals in soils. John Wiley and Sons, Inc. New York, ISBN 0470215984

Arnika, Ecoton, IPEN, Nexus3 (2019): Plastic waste flooding Indonesia leads to toxic chemical contamination of the food chain. https://ipen.org/sites/default/files/documents/indonesia-egg-report-v1_9-web.pdf

ATSDR (2004a) Toxicological Profile for copper. Agency for Toxic Substances and Disease Registry (ATSDR), United States Public Health Service, September 2004

ATSDR (2004b) Toxicological Profile for Strontium. The United States Public Health Service, Agency for Toxic Substances and Disease Registry, April 2004

ATSDR (2005a) Toxicological Profile for nickel. Agency for Toxic Substances and Disease Registry (ATSDR), The United States Public Health Service, August 2005

ATSDR (2005b) Toxicological Profile for zinc. Agency for Toxic Substances and Disease Registry (ATSDR), The United States Public Health Service, August 2005

ATSDR (2007) Toxicological Profile for Arsenic. The United States Public Health Service, Agency for Toxic Substances and Disease Registry, August 2007

ATSDR (2012) Toxicological Profile for Cadmium. The United States Public Health Service, Agency for Toxic Substances and Disease Registry, September 2012

ATSDR (2019) Toxicological Profile for antimony. The United States Public Health Service, Agency for Toxic Substances and Disease Registry, October 2019

Bahaa-Eldin, E. A. R., Yusoff, I., Rahim, S. Abdul, Wan Zuhairi, W.Y. and Abdul Ghani, M.R.(2008): Heavy Metal Contamination of Soil Beneath a Waste Disposal Site at Dengkil, Selangor, Malaysia,Soil and Sediment Contamination,17:5,449-466 DOI: 10.1080/15320380802304342; URL: http://dx.doi.org/10.1080/15320380802304342

Behl M, Elmore SA, Malarkey DE, et al. (2013) Perinatal toxicity and carcinogenicity studies of the styrene-acrylonitrile trimer, a groundwater contaminant. Toxicology. 314(1):84-94. DOI: 10.1016/j.tox.2013.09.006. https://europepmc.org/article/med/24060431

Chae, Y., & An, Y.-J. (2018). Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review. Environmental Pollution, 240, 387–395. doi:10.1016/j.envpol.2018.05.008 https://www.sciencedirect.com/science/article/pii/S0269749117348637/

CHEM Trust (2017): No Brainer - The impact of chemicals on children's brain development: a cause for concern and a need for action https://www.chemtrust.org/wp-content/uploads/chemtrust-nobrainer-mar17.pdf

Cooper RG, Harrison AP. The exposure to and health effects of antimony. Indian J Occup Environ Med. 2009;13(1):3–10. doi:10.4103/0019-5278.50716 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2822166/

Coxon, T., Goldstein, L., & Odhiambo, B. K. (2018). Analysis of the spatial distribution of trace metals, PCB, and PAH and their potential impact on human health in Virginian Counties and independent cities, USA. Environmental Geochemistry and Health. doi:10.1007/s10653-018-0172-2 https://link.springer.com/article/10.1007/s10653-018-0172-2

Cristale, J., Belé, T. G. A., Lacorte, S., & de Marchi, M. R. R. (2018). The occurrence of flame retardants in landfills: a case study in Brazil. Environmental Research. doi:10.1016/j.envres.2018.10.010 https://www.sciencedirect.com/science/article/abs/pii/S0013935118305449

Department of the Environment (DOE) Malaysia (2009). Environmental Quality (Control of Pollution From Solid Waste Transfer Station And Landfill) Regulations 2009 https://www.doe.gov.my/portalv1/wp-content/uploads/2015/01/Environmental_Quality_Control_of_Pollution_From_Solid_Waste_Transfer_Station_And_Landfill_Regulations_2009_-_P.U.A_433-2009.pdf

Department of the Environment (DOE) Malaysia (2015). Contaminated Land Management and Control Guidelines No. 1: Malaysian Recommended Site Screening Levels for Contaminated Land. Department of Environment, Ministry of Natural Resources and Environment Malaysia. https://doe.gov.my/portalv1/wp-content/uploads/2015/11/Contaminated-Land-Management-and-Control-Guidelines-No-1_Malaysian-Recommended-Site-Screening-Levels-for-Contaminated-Land.pdf

Dsikowitzky, L., Nordhaus, I., Jennerjahn, T. C., Khrycheva, P., Sivatharshan, Y., Yuwono, E., & Schwarzbauer, J. (2011). Anthropogenic organic contaminants in water, sediments and benthic organisms of the mangrove-fringed Segara Anakan Lagoon, Java, Indonesia. Marine Pollution Bulletin, 62(4), 851–862. doi:10.1016/j.marpolbul.2011.02.023 https://www.sciencedirect.com/science/article/abs/pii/S0025326X11000828

Emery, R. J., Papadaki, M., Freitas dos Santos, L. M., & Mantzavinos, D. (2005). Extent of sonochemical degradation and change of toxicity of a pharmaceutical precursor (triphenylphosphine oxide) in water as a function of treatment conditions. Environment International, 31(2), 207–211. doi:10.1016/j.envint.2004.09.017 https://www.sciencedirect.com/science/article/pii/S0160412004001680

Filella, M., Belzile, N., Chen, Y.W. (2002). Antimony in the environment: a review focused on natural waters II. Relevant solution chemistry. Earth-Science Reviews 59: 265-285

Greenpeace e.V., Friends of the Earth Germany (BUND), Heinrich Boell Foundation, Bundesverband Meeresmuelle.V., Deutsche Umwelthilfe DUH, German Ocean Foundation, food & water Europe, Hej-support health environment justice, Green Bauhaus Foundation, Surfrider Foundation Europe, Women Engage for a Common Future WECF, (2020). Ways Out Of The Plastic Crisis, Demands From German Civil Society. https://www.greenpeace.de/sites/www.greenpeace.de/files/leporello_wege-aus-der-plastikkrise_009_eng_webversion.pdf

Greenpeace Malaysia. (2018). The Recycling Myth, Malaysia and the broken global recycling system. https://storage.googleapis.com/planet4-southeastasia-stateless/2019/04/7c9f822c-7c9f822c-the-recycling-myth-malaysia-and-the-broken-global-recycling-system.pdf

Greenpeace Research Laboratories. (2019). Greenpeace Research Laboratories Analytical Results 2019-05: Organic contaminants and metals in samples of water, soil, sediment and plastic from waste dumpsites in Malaysia : http://www.greenpeace.to/greenpeace/wp-content/uploads/2020/05/GRL-AR-2019-05.pdf

Heng, K. C. (2019). After 'The Recycling Myth' Report: Updates from the Field. Greenpeace Malaysia. https://www.greenpeace.org/malaysia/story/1272/after-the-recycling-myth-report-updates-from-the-field/

Jurewicz, J. and W. Hanke (2011). "Exposure to phthalates: Reproductive outcome and children's health. A review of epidemiological studies." International Journal of Occupational Medicine and Environmental Health 24(2): 115-141

Khairiah, J., Habibah, J., Ahmad Mahir, R., Maimon, A., Aminah, A. and Ismail, B.S.: Studies on Heavy Metal Deposits in Soils from Selected Agricultural Areas of Malaysia: Adv. Environ. Biol., 3(3): 329-336, 2009

Khan, S., Munir, S., Sajjad, M., & Li, G. (2016). Urban park soil contamination by potentially harmful elements and human health risk in Peshawar City, Khyber Pakhtunkhwa, Pakistan. Journal of Geochemical Exploration, 165, 102–110. doi:10.1016/j.gexplo.2016.03.007 https://www.sciencedirect.com/science/article/pii/S0375674216300668

Labunska, I, Harrad, S., Wang, M., Santillo, D., Johnston, P. (2014) Human Dietary Exposure to PBDEs Around E-Waste Recycling Sites in Eastern China, Environmental Science Technologie 48 (10)

Labunska, I, Abdallah, MAE, Eulaers, I, Covaci, A, Tao, F, Wang, M, Santillo, D, Johnston, P & Harrad, S 2015, 'Human dietary intake of organohalogen contaminants at e-waste recycling sites in Eastern China', Environment International, 74, 209-220. https://doi.org/10.1016/j.envint.2014.10.020

Labunska, Iryna (2017). Environmental contamination and human exposure to PBDEs and other hazardous chemicals arising from informal e-waste handling. University of Birmingham. Ph.D.

Lyche, J. L., A. C. Gutleb, A. Bergman, G. S. Eriksen, A. J. Murk, E. Ropstad, M. Saunders and J. U. Skaare (2009). "Reproductive and developmental toxicity of phthalates." J Toxicol Environ Health B Crit Rev, 12(4), 225-249.

Mosbergen, D. (2019). She Wanted Her Town To Breathe Clean Air. She Got Death Threats Instead. HuffPost. https://www.huffpost.com/entry/malaysia-jenjarom-activists-plastic-recycling_n_5c99e86ce4b0d42ce3606110?fbclid=IwAR3lw2k6FPiB8yO3lPpac6YdbzkNFzviMWmHJK39nxIfmcBgmQCwpaqpKuE

Nambiar, P. (2019). Kedah govt seals off huge illegal dumpsite along Sungai Muda. FMT News. https://www.freemalaysiatoday.com/category/nation/2019/07/28/kedah-govt-seals-off-huge-illegal-dumpsite-along-sungai-muda/

Nelson L.S. Lai, Karen Y. Kwok, Xin-hong Wang, Nobuyoshi Yamashita, Guijian Liu, Kenneth M.Y. Leung, Paul K.S. Lam, James C.W. Lam. (2019). Assessment of organophosphorus flame retardants and plasticizers in aquatic environments of China (Pearl River Delta, South China Sea, Yellow River Estuary) and Japan (Tokyo Bay). Journal of Hazardous Materials, 371, 288-294. doi:10.1016/j.jhazmat.2019.03.029. http://www.sciencedirect.com/science/article/pii/S0304389419302845

POP RC (2006). Risk profile on commercial pentabromodiphenyl ether, UNEP/POPS/POPRC.2/17/Add.1, Stockholm Convention POPs Review Committee. POP RC (2006a). Risk profile on perfluorooctane sulfonate, UNEP/POPS/POPRC.2/17/Add.5, Stockholm Convention POPs Review Committee: 34.

POP RC (2007). Risk profile on commercial octabromodiphenyl ether, UNEP/POPS/POPRC.3/20/Add.6, Stockholm Convention POPs Review Committee.

POP RC (2014). Risk profile on decabromodiphenyl ether (commercial mixture, c-decaBDE), UNEP/POPS/POPRC.10/10/Add.2, Stockholm Convention POPs Review Committee: 58

POP RC (2015). Risk profile on short-chained chlorinated paraffins, UNEP/POPS/POPRC.11/10/Add.2, Stockholm Convention POPs Review Committee: 47.

POP RC (2016). Risk profile on pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds, Stockholm Convention POPs Review Committee, UNEP/POPS/ POPRC.12/11/Add.2, Stockholm Convention POPs Review Committee: 34

Rai, P. K., Lee, S. S., Zhang, M., Tsang, Y. F., & Kim, K.-H. (2019). Heavy metals in food crops: Health risks, fate, mechanisms, and management. Environment International, 125, 365–385. doi:10.1016/j.envint.2019.01.067 https://www.sciencedirect.com/science/article/pii/S0160412018327971

Salomons, W. and Forstner, U. (1984). Metals in the hydrocycle. Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, ISBN 3540127550

State Environmental Protection Administration (SEPA). (1995). Environmental Quality Standards for Soils. China. GB. 15618–1995.

Swan, S. H. (2008). Environmental phthalate exposure in relation to reproductive outcomes and other health endpoints in humans. Environ Res, 108(2), 177-184.

Verma, R., Vinoda, K. S., Papireddy, M., & Gowda, A. N. S. (2016). Toxic Pollutants from Plastic Waste- A Review. Procedia Environmental Sciences, 35, 701–708. doi:10.1016/j.proenv.2016.07.069 https://www.sciencedirect.com/science/article/pii/S187802961630158X

Vivek P.P. 2014. Sustainable model of plastic waste management. International Journal of Chem Tech Res. 07(01), pp 440-458. http://sphinxsai.com/2015/ch_vol7_no1/6/(440-459)%20014.pdf

Wu, S., Zhou, S., Bao, H., Chen, D., Wang, C., Li, B., … Xu, B. (2018). Improving risk management by using the spatial interaction relationship of heavy metals and PAHs in urban soil. Journal of Hazardous Materials. doi:10.1016/j.jhazmat.2018.09.094 https://www.sciencedirect.com/science/article/abs/pii/S0304389418308884