Chapter 7

Persistent Organic Pollutants (POPs) in Indonesia

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A. Persistent Organic Pollutants (POPs) in General Understanding

1. Definition and Types

Hazardous organic compounds are persistent, bioaccumulated, susceptible to long-range transboundary airborne movement and deposition, and are likely to have significant harmful public health or ecological effects both close and far from their source persistent organic pollutants (POPs) (Ballschmiter et al., 2002). They infect far-flung locations where they have never been used or produced, posing a global threat. They build up throughout the food web, reaching peak levels in the top species, and pose risks to health and wild animals (EC, 2017).

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Many POPs were formerly applied to crops, medical management, industry, and industrial operations, among other things. However, due to their resistance and poor management of decommissioned products, such as old electrical equipment containing polychlorinated biphenyls (PCBs), even forbidden POPs can linger in the environment for years. Furthermore, surely POPs are still being directly discharged into the atmosphere: polycyclic aromatic hydrocarbons (PAHs) are released by combustion, mainly from automobile exhaust emissions (EC, 2017).

However, some newly discovered, emerging POPs, such as perfluoroalkylated substances (PFASs), a class of industrial chemicals, and polybrominated diphenyl ethers (PBDEs) (also known as brominated flame retardants), have recently been controlled, are scheduled to be regulated, or are being considered for rules. Although there is less data on these newer pollutants than on heritage POPs, it is known that some (such as PFASs) operate differently in humans and animals than older POPs, attaching predominantly to protein and, to a lesser extent, fat (EC, 2017).

The primary sources of air pollution that contribute to the accumulation of POPs are (1) the use of specific pesticides, (2) the fabrication and use of specific chemicals, and (3) the unintentional formation of certain substances in burning waste, combustion, metal production, and vehicles, according to the POP protocol of the Convention on Long-Range Transboundary Air Pollution (LRTAP) (Ballschmiter et al., 2002).

In December 2000, diplomats from 122 countries signed a treaty in Johannesburg, South Africa, to restrict the manufacturing, importing, exporting, dumping, and using hazardous chemicals that can last for decades in the environment. In May 2001, the Agreement was finally signed during a summit in Stockholm, Sweden. Like previous multilateral environmental treaties, the Stockholm Convention on Persistent Organic Pollutants relies on the scientific expertise of its 179 parties. The Agreement aims to protect human health and the environment from POPs by decreasing and eliminating their environmental contamination and subsequent human exposure. In addition, it knows the significance of monitoring data in the efficient application of standards. It encourages parties to engage in global monitoring arrangements to obtain comparable monitoring data on the presence of POPs, identify changes in their concentrations over time, and provide data on their regional and global environmental transport (Magulova & Priceputu, 2016).

Magulova and Priceputu (2016) discuss the Stockholm Convention's Global Monitoring Plan's (GMP) implementation. The Plan provides a single global platform for generating and exchanging data on POP levels in three "core media": atmospheric air, human samples (blood or milk), and water. Although the manufacturing and use of many POPs were outlawed by the United Nations Stockholm Convention in 2004, they continue to be a health danger worldwide due to multiple sources of continued exposure. POPs are still manufactured and used in countries that have not ratified the Stockholm Convention, such as India and other South Asian countries. In India, PCBs will not be phased out until 2025. Despite being outlawed in some countries, the organochlorine pesticide dichlorodiphenyltrichloroethane (DDT) is widely used to control disease vectors worldwide. DDT was only recently made illegal in Mexico, and it is still widely used in Africa and Asia. India is the world's leading producer and consumer of DDT (La Merrill et al., 2019).

All chlorinated substances, such as aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, and toxaphene, have accidentally generated by-products or chemical products, such as hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-p-dibenzo-p-dibenzo-p-d (PCDFs). HCB has also been used to make fungicides. Aldrin, dieldrin, endrin, heptachlor, mirex, and hexachlorobenzene are the only single compounds; the remainder are complex combinations of isomers and congeners (PCBs, PCDDs, PCDFs, toxaphene). PCBs are made up of a total of 209 congeners, with about 120–140 of them occurring in the environment. Two semivolatile halogenated chemicals were discovered that are most likely of natural sources and showed all of the characteristics of a human, persistent pollutant: persistence, bioaccumulation, and local to world dispersion (Ballschmiter et al., 2002; Trojanowicz, 2020).

Existing monitoring procedures (air and human bio-monitoring) must be long-term sustainable to analyze fluctuations in concentrations over time. National air monitoring operations that provided data for the first monitoring reports continued in the second phase, and additional projects to aid the development of the second reports were found. For the new air monitoring activities, collaboration with key partners has guaranteed expense data collection and the deployment of standard POPs monitoring protocols. As measures to enforce the Convention have been accepted, the continuing United Nations Environmental Programme/World Health Organization (UNEP/WHO) human milk survey has continued to provide valid long-term results revealing how human exposure to POPs has evolved (Magulova & Priceputu, 2016).

2. Impact for Environment and Human Health

The Stockholm Convention defines POPs as carbon-based compounds that stay in the environment for a long time and are widely dispersed. They gather in the fatty tissues of living creatures, posing a threat to humans and wildlife (Trojanowicz, 2020). Most POPs known to date have been prohibited or regulated worldwide due to concerns about their harm to ecosystems and human health (EC, 2017).

POPs may cause several developmental, metabolic, neurodegenerative, and neoplastic problems in humans. There are reasonable concerns about such consequences; these concerns can be integrated with the fact that humans commonly contain combinations of POPs at low and high concentrations (Pumarega et al., 2016). According to many pieces of research, POP exposure has been associated with several health impacts, including hormone-dependent cancers, reproductive health issues, metabolic problems (including type-2 diabetes), obesity, and increased susceptibility to viral diseases (Bonefeld-Jorgensen et al., 2011; Ghosh et al., 2014; Skakkebaek et al., 2016; Weihe et al., 2016; Yu et al., 2000). In addition, POPs and their neurological consequences, such as IQ deficits or autism, are becoming more concerned (Mitchell et al., 2012; Stewart et al., 2008). However, because of the long period between exposure and the beginning of health problems, as well as the influence of a range of other environmental factors, establishing definitive links between POP exposure and any health effects remains a significant challenge (Antignac et al., 2016).

Water pollution is commonly connected with a large amount of wastewater being dumped into the environment from various sources. Furthermore, due to the wide range of pollution sources, such as dwellings, hospitals, industries, veterinary services, and agriculture, and their various application procedures, effluents' composition and characterization are wholly different and very complex. According to the Stockholm Convention, persistent Organic Pollutants (POPs are one type of substance found in wastewaters and are challenging to eradicate (Titchou et al., 2021). These pollutants are stable organic compounds resistant to photolytic, chemical, and physical destruction (El-Shahawi et al., 2010).

The Agreement acknowledges the existence of scientific and technological data on emissions, atmospheric processes, the effects of persistent organic pollutants on human health and the environment, and the importance of continuing scientific and technical collaboration to understand these concerns better. Analyzing the convoluted geographical and temporal picture of a compound's environmental destiny at the global trace level, a classic difficulty requiring expertise in global environmental chemistry, necessitates problem-oriented, highly sensitive, and accurate analytical measurements (Ballschmiter et al., 2002).

Understanding the long-range distribution and origins of these hazardous chemicals requires detecting and monitoring POPs in the environment. Long-term studies can also be used to examine the success of international control efforts by identifying patterns in levels (EC, 2017).

B. Source and Distribution of POPs

POPs produced and used in industries, urban, and agricultural areas are the primary sources released to the environment. Based on their production POPs were divided into intentionally and unintentionally produced chemicals (UPOPs) (Stockholm Convention, 2021). Intentional POPs are currently used in manufacturing, industrial processes, agriculture. For example, mentioned in Kodavanti and Loganathan (2014) study, PCBs are used in various industrial applications (such as electrical transformers and large capacitors). Another example was dDDT, an insecticide used in agriculture. DDT is still used in some countries to control malaria as a mosquito insecticide (US EPA, 2021a). Though DDT has been banned worldwide, its traces are still found in any level of the environmental compartment (Hofmann et al., 2012; Ueno et al., 2003).

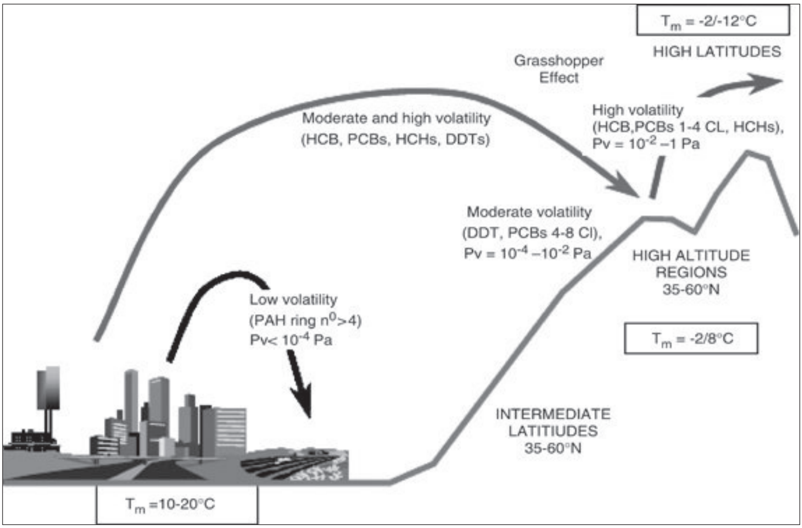
On the other hand, UPOPs are chemicals produced by industrial processes and combustion. For example, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-p-furans (PCDD/Fs) are by-products of incomplete combustion in municipal and medical waste incineration and backyard burning of trash (Stockholm Convention, 2021). Due to their persistent characteristics when released into the environment, these chemicals have two pathways. First, they persisted in the background environment through favorability. Second, they are transported from the source into another world through the atmosphere and surface water. Atmospheric long-range transport of POPs supported by the dust cloud from the Pacific Ocean to North America (US EPA, 2021b). Research on founding POPs concentration in a pristine location such as the Arctic proved the long-range transport of POPs (Hofmann et al., 2012; Jia et al., 2014).

1. Stationary

   Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are two POPs categorized as unintentional produced during incomplete combustion at certain conditions. PCDD/Fs can prove POPs from stationary sources through many monitoring studies. The combustion process that possibly produced these chemicals were waste incineration (Bie et al., 2007; Liu et al., 2012; McKay, 2002; Peng et al., 2020), medical waste incinerator (Du et al., 2013), smelting (Cagnetta et al., 2016; Mei et al., 2015), and burning coal for power production (Tian et al., 2021; Yu et al., 2021).

2. *Atmosphere*

POPs distribution in the atmosphere pathway was through global atmospheric circulation. Polycyclic aromatic hydrocarbons (PAHs), as one of the POPs produced during incomplete combustion, were predicted to be transported to the Pacific Ocean by the northeast monsoon from rich East Asian region with the most significant impact on the coal-burning area (Sato et al., 2009). In another study by Gong et al. (2019) about the Himalayan POPs transport mechanism, POPs emitted in Himalaya lowland were



Source: Lioy (2006)

Figure 7.1 Grasshopper Effect of Persistent Organic Pollutants Atmospheric Movement Illustration Surface Water transported to high altitudes. Through modeling, 90% of POPs are trapped along the way through high altitudes due to gaseous deposition to soil/foliage and rainfall scavenging across the Himalayas. Lioy (2006) demonstrates the process of PAHs long-range transport from lower altitudes to higher altitudes named as grasshopper effect. Different POPs undergo the grasshopper effect and scatter through different volatility characteristics in different altitudes.

POPs that disperse in the environment through different sources of pollution can stay in all ecosystem components due to their persistent and cumulative properties. Surface water is the primary pathway to enhancing human exposure through drinking and water usage (Nguyen et al., 2017). Han and Currell (2017) studied POPs transport processes in the water bodies. Figure 7.2. describes the POPs cycle in surface water. POPs experience an

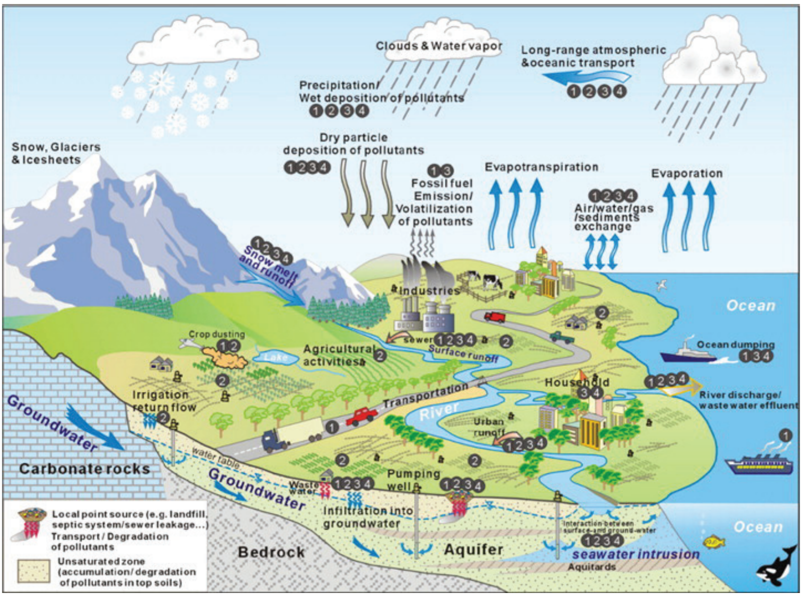


Figure 7.2 Persistent Organic Pollutants

air-soil-water exchange expected from their persistent characteristics and might be done by a long-range transport system that is connected with the atmospheric system. The cycle of POPs was a complex system of exchange and transformation processes that occur between air, soil, sediment, water, and biota. Evaporation of these chemicals dominates as the primary process in low latitudes regions while deposition plays in higher altitudes. While in mid-latitude areas, seasonal cycling of deposition and evaporation happens. Another way POPs are transported in the water cycle is through exchange and interaction between surface water and groundwater aquifers (karst and fractured aquifers).

C. Source: Han & Currell (2017) Control Technologies for POPs

Effective control of POPs contamination can be carried out, especially on sources of incomplete combustion (diesel engines, incinerators, coal industry, motor vehicles, etc.), which are the primary sources of POPs contamination in the atmosphere, water, and environment. The control of POPs contamination includes (Guo et al., 2020): (1) optimization of the combustion conditions of the incinerator process, one of which is the strategy for controlling temperature, time, turbulence, and oxygen demand parameters; (2) physisorption method through injection of active carbon into the exhaust gas and through fabric filter (FF); (3) Using chemical inhibition by injection of inhibitors into the exhaust gas (example: addition of nitrogen components, alkali (Qian, 2018), sulfur (Ogawa et al., 1996), ammonia injection, etc.); and (4) catalyzed destruction. Catalytic destruction can be carried out using Catalytic Filter (CR) and Selective Catalytic Reduction (SCR) technologies which have been proven to effectively reduce PCDDs/Fs contamination levels and have already been used in incinerator systems and powerful engines.

It is determining incredibly small amounts of essential contaminants that used to be a difficult and time-consuming task, particularly in industrial waste incineration, cement manufacture, metallurgical operations, and the refining and petrochemical sector. On the other hand, it is measuring emissions of minimal quantities of critical pollutants used to be a complex and time-consuming process–especially in applications like the aforementioned sectors. Therefore, it needs a technology that is available to periodically monitor the environment named Control Architecture for Dioxin Monitoring System.

The Dioxin Monitoring System is made up of three primary components, all of which may be customized to meet the demands of specific applications: filters, sample units, and controller units. Its modular design and controller architecture place emphasis on ease of use. When the automated sampling procedure is finished, the operator replaces a filter cartridge and sends the cartridge with the accumulated pollutant sample to the laboratory, where analysis may be completed considerably more effectively than on-site. In addition, all features are accessible through remote access. This, along with the Dioxin Monitoring System's integrated architecture, makes it incredibly less expensive to run than mobile measuring stations that need time-consuming installation and de-installation, and it also simplifies laboratory studies.

On the other hand, an automatic dioxin sampling system is ideal for long-term isokinetic sampling of hazardous organic chemicals in municipal and industrial waste incineration plants. Aside from dioxins, the system may collect furans and other POPs) such as PCBs and PAHs. The automated dioxin sampling system may be configured with the ParTrace option, which allows for heavy metal and fine particle collection to get the most out of the system.

Based on the explanation above, the steps taken by the Indonesian government in implementing POPs regulations are reasonable and can be appreciated. The initial step is in the way of government awareness and concern for PCB contamination. PCBs contamination is hazardous and can potentially pollute the environment, one of which can contaminate one of the components in the food chain. As time goes by, the Indonesian government already has several capabilities and technology and research collaboration networks in monitoring dioxins in the country. Hence, the state hopes that it will be able to prevent and overcome the dangers of POPs in Indonesia.

Consequently, all stakeholders should be able to follow and adapt to the development of dioxin regulation in the country. This is a common consequence that needs to be faced by all stakeholders, especially in the industrial business sector, in this case, manufacturing entrepreneurs. The entrepreneurs need to work hard in planning and implementing business so that their business activities can be free from dioxin contamination. In this case, they must prepare careful planning, including budgets, management plans, monitoring plans, and other supporting systems that support the prevention of dioxin hazards. These are not easy and require awareness and cooperation from various parties.

Academics and consultants are also crucial in this POPs circle (instead of the Indonesian government). In this case, they need to update their knowledge and experience to monitor and analyze POPs in Indonesia. Because POPs are still a new thing and different from other regulatory gases, the development and sustainability of POPs must be improved through networking and training for people, especially those who work as practitioners.

D. POPs Regulations in Indonesia

The Indonesian government's concern and vigilance towards the dangers of POPs contamination have been shown through the government's attention and participation in the Stockholm Convention on 23 May 2001, and the effort of the Convention showed into force in 2004. Delegations of Indonesian government representatives also joined and thus Indonesian government became one of the 152 countries that signed the International Agreement about POPs contamination. As one of the supporting countries for the Stockholm Convention, the Indonesian government is following up on its support efforts through the establishment of Law No. 19 the Year 2009 concerning the Ratification of the Stockholm Convention on Persistent Organic (Stockholm Convention Persistent Organic Pollutants). The regulation shows the state's efforts to support and contribute to the Stockholm Convention. The Indonesian government is obliged to implement the international agreement provisions such as the prohibition of production, restriction of use, destruction of materials or waste containing POPs, and restoring the environment contaminated by POPs. One of the POPs congeners which are already regulated in the Stockholm Convention and became the initial attention of the Ministry of the Environment is PCBs, among various other types of POPs PCDDs/Fs, PCDEs, PBDDFs, PBBs, and PBDEs.

The Indonesian government, prior to the implementation of the Stockholm Convention and Law No. 19 the Year 2009, has had PP No. 74 the Year 2001 concerning the B3 Management (Toxic and Hazardous Substances) along with Government Regulation (PP) No. 18 the Year 1999 concerning Management of Hazardous and Toxic Materials which was later changed to PP No. 85 the Year 1999. Hazardous and Toxic Materials (PB3) are materials that, due to their nature and/or concentration and/or concentration and/or amounts either directly or indirectly, can damage the environment, human health, and the survival of humans and other living creatures. Moreover, B3 management is activities including production, transportation, distribution, storage, and or disposing of hazardous and toxic materials.

Table 7.1 National Regulations Regarding POPs

No.	Regulations	Descriptions
1	Kep. Ka. BAPEDAL Nomor KEP-68/BAPEDAL/05/1994	Procedures for Obtaining a Permit for Storage, Collection, Operation of Processing, Processing, and Final Landfilling of Hazardous and Toxic Waste
2	Kep. Ka. BAPEDAL Nomor KEP-01/BAPEDAL/09/1995	Procedures and Technical Requirements for Storage and Collection of Hazardous and Toxic Waste
3	Kep. Ka. BAPEDAL Nomor KEP-02/BAPEDAL/09/1995	Hazardous and Toxic Waste Documents
4	Kep. Ka. BAPEDAL Nomor KEP-03/BAPEDAL/09/1995	Technical Requirements for the Treatment of Hazardous and Toxic Waste

No.	Regulations	Descriptions
5	Kep. Ka. BAPEDAL Nomor KEP-04/BAPEDAL/09/1995	Procedure for Requirements for Stockpiling of Processed Results, Requirements for Locations of Former Processing, and Locations for Former Landfills of Hazardous and Toxic Waste
6	Kep. Ka. BAPEDAL Nomor KEP-05/BAPEDAL/09/1995	Hazardous and Toxic Waste Symbols and Labels
7	Kep. Ka. BAPEDAL No. KEP-02/BAPEDAL/02/1998	Procedure for Supervision of Hazardous and Toxic Waste Management in the Regions
8	Kep. Ka. BAPEDAL No. KEP-03/BAPEDAL/03/1998	Partnership Program on Hazardous and Toxic Waste Management in Regions
9	Kep. Ka. BAPEDAL No. KEP-04/BAPEDAL/04/1998	Determination of Level I of Priority Provinces for Partnership Programs in the Management of Hazardous and Toxic Waste in the Regions
10	UU No. 19 Tahun 2009	Ratification of the Stockholm Convention on Persistent Organic Pollutants
11	UU No. 32 Tahun 2009	Protection and Management of the Environment
12	PP No. 18 Tahun 1999	Management of Hazardous Wastes and Toxic
13	PP No. 85 Tahun 1999	Amendment to PP No. 18 of 1999 concerning the Management of Hazardous and Toxic Waste
14	PP No. 74 Tahun 2001	Management of Hazardous and Toxic Materials (appendix)
15	PP No. 26 Tahun 2002	Radioactive Substance Transport Safety
16	PP No. 27 Tahun 2002	Radioactive Waste Management
17	Permen LH. No. 30 Tahun 2009	Management of Licensing and Supervision of Hazardous and Toxic Waste Management and Supervision of Recovery Due to Pollution of Hazardous and Toxic Waste by Regional Governments
18	National Implementation Plan on Elimination and Reduction of Persistent Organic Pollutants in Indonesia (July 2008)	
19	Peraturan Menteri Pertanian No. 24/Permentan/SR.140/2011	Requirements and Procedures for Pesticide Registration Terms

Source: (Dit.PB3., 2015) https://sib3pop.menlhk.go.id

The United Nations Industrial Development Organization (UNIDO) directly provided support to Indonesia regarding the participation of the Stockholm Convention by organizing a workshop in June 2003 on the Dissemination in Inventory Results of POPs Chemicals in Indonesia which produced outputs, one of which was the recommendation **not** to using organochlorine-based pesticides which are the source of POPs. Other prohibited POP chemicals are aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene, and hexachlorobenzene. The inventory results involved several relevant government institutions, including the Ministry of Environment, Ministry of Agriculture, Ministry of Transportation, Ministry of Manpower, Ministry of Health, Ministry of Home Affairs, and Ministry of Trade. In conclusion, the Indonesian government at that time does not explicitly have laws governing the quality standards of POPs as stated in the Stockholm Convention. The Indonesian government, in addition, also requires an integrated institutional approach from upstream to downstream regarding formulating national policies especially POPs in the environmental sector.

UNIDO, on the most recent occasion, also contributed by providing a grant in the presence of a gas chromatography (GC) and electron capture detector (ECD) test machine in 2019 to the Indonesian government, accepted and represented by the Deputy for Natural Resources Development Technology, Agency for the Assessment and Application of Technology (BPPT) together with Ministry of Environment and Forestry (KLHK) which will be placed in the Environmental Laboratory (PTL). The initial GC-ED application will be utilized to measure PCBs in transformer oil samples in the polluted area survey program, international collaboration between the KLHK and UNIDO. Recently, there has not been a single laboratory in Indonesia that can analyze the content of dioxins or POPs in mobile and stationary sources. Therefore, this is the right step and a beginning for the progress of POPs research in Indonesia.

Several findings related to dioxins, one of which was shown by collaborative research from the International Pollutant Elimination

Network (IPEN) in 2019 in collaboration with the NEXUS3 Foundation, Arnika, and Ecoton found that the concentration of dioxin in chicken eggs from a village in Sidoarjo, East Java, was one of the highest in Asia. Those findings were the first, and there had never been a research result like this before in Indonesia. Dioxin contamination inside poultry, eggs, and meat products was also found in other countries. After being traced, the cause was animal feed contaminated with PCB-based industrial waste that was illegally disposed of. PCB contamination in livestock products generally starts from animal feed contaminated by PCBs. Especially livestock whose feed is not controlled or loose chickens left to find their feed. IPEN researchers focused their studies on villages near an industry in Mojokerto, which imports about 40% of paper waste for its production. The paper containers ordered by this factory contain low-quality plastic waste, which is then sold to rural communities that depend on garbage for their livelihoods. The Statistics Indonesia (BPS) shows that Indonesia's plastic waste import figure increased by 141% in 2018 to 283,000 tons, mainly imported waste from Australia, Canada, Ireland, Italy, New Zealand, the UK, and the United States. The import increased after China closed its country from importing waste in early 2017. This might be a factor that led to the finding of PCBs in eggs.

Researcher from Ecoton (Ecological Observation and Wetlands Conservation) explains that the results of research exhibited 16 congeners of toxins from plastic waste found in chicken eggs belonging to villagers. Sampling activities were conducted in some villages, including three egg samples from Bangun Village, three egg samples from Tropodo Village, and six egg samples purchased at a supermarket. Eggs from Bangun Village and Tropodo Village contained dioxin levels of 200 picograms per fat gram, while the standard set by the Drug and Food Control Agency (BPOM) only 2.5 picograms per gram of egg. The results showed that the content of POPs contaminants, including dioxin in eggs content from Tropodo, far exceeded the content in control eggs purchased from supermarkets. Most supermarket are below the detection limit of laboratory equipment. Meanwhile, those in Tropodo and Bangun's egg samples exceeded the average standard limit, especially for the dioxin in Tropodo was 70 times higher than the dioxin safety standard in food controlled by the BPOM .

KLHK has also designed and developed a B3 information system regarding persistent organic pollutants called Toxic and Hazardous Substances and Persistent Organic Pollutants Information System (SIB3&POPs), which aims to provide education to the public about the integrated results of studies and research on POPs from various institutions into the official website of the Indonesian government regarding the handling of POPs in Indonesia. The goal of this program is to establish an information site/portal on POPs that can provide information on the problem of handling POPs in Indonesia for the Indonesian people and the international community.

The expected output from the collaboration is to complement the current SIB3&POPs content, especially the data and results of activities that cooperation partners have carried out in handling POPs so far. The following are some outputs that are expected to be displayed in SIB3 & POPs with data sources from cooperation partners.

1. A complete, clear, and easy-to-understand description of the 21 POPs materials that have been banned by the Stockholm convention (12 dirty dozen and 9 new POPs). It is necessary to include data on the study results of its effect on the health of the environment and living things. (BPPT, KLHK, Ministry of Agriculture, and UNIDO).
2. Analysis of research data on POPs pollution in Indonesia that has so far been carried out and published by relevant agencies, especially for government cooperation partners (BPPT, KLHK, and Ministry of Agriculture) including a GIS map of pollution distribution.
3. The public needs to know the industry data of products containing POPs materials so that the general public can wisely switch to the products that are environmentally friendly (Ministry of Industry, UNIDO).

4. Simple technological ways to detect POPs contamination in our environment that can be easily carried out by the public (KLHK, Ministry of Agriculture, BPPT).
5. Simple technology packages for the waste management or treatment caused by the use of POPs materials so that they can be applied by the community and industry (BPPT).
6. Information on research laboratories capable of conducting research, analysis, and scientific investigations on cases of B3 and POPs pollution by industry in Indonesia (KLHK, BPPT).
7. Information on substitutes for POPs for the development of similar industries that use materials that are safer for the environment and human health (BPPT, KLHK, Ministry of Agriculture).
8. Educational information for the public that is easy to understand in written documents, caricature images, slide shows, video clips, and others in Indonesian (BPPT, KLHK, Ministry of Agriculture, Ministry of Industry, UNIDO).
9. Information on existing regulations, both nationally and internationally, in Indonesian to make it easier for the community and industry to use POPs materials (KLHK)
10. Information about experts from various circles who understand POPs issues deeply are able to be used as a keynote resource for future activities in handling POPs in Indonesia (BPPT, KLHK, Ministry of Agriculture, UNIDO)

E. Conclusion

Persistent Organic Pollutants (POPs) produced and used in industries, urban, and agricultural areas are the primary sources released to the environment. Based on their production, POPs were divided into intentionally and unintentionally produced chemicals (UPOPs). POPs may cause several developmental, metabolic, neurodegenerative, and neoplastic problems in humans. Analysis of research data on POPs pollution in Indonesia that has so far been carried out and published by relevant agencies, especially for government cooperation partners.

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