Захист навколишнього середовища

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The Current State of the Issue of Persistent Organic Pollutants in Ukraine and Approaches for its Resolution

Persistent organic pollutants (POPs) relate to a group of toxicants, which is separated due to an extremely hazardous impact on human health and is regulated by a special international agreement — the Stockholm Convention on POPs. Each Party of the Convention should develop and consistently renew the National Implementation Plan to implement requirements under this Convention. Ukraine developed the National Implementation Plan in 2007, and the experts started works on its renewal in 2020.

The article contains results of expert analysis of changes in volumes and forms of accumulation of waste, consisting of containing or contaminated with POPs, in particular, unusable and prohibited plant protection chemicals (PPC). There are outcomes of expert analysis of changes in use of electrical equipment that contained synthetic dielectric liquids based on polychlorinated biphenyls (PCBs). Based on analysis, activities are proposed to the National Implementation Plan for development of effective infrastructure for thermal destruction of POP-containing waste.

In addition to storage sites of POPs-containing waste, so-called "unintentional production" is an essential source of POPs entering environment. For categories of sources that under the Stockholm Convention can potentially polluted environment with POPs volumes of annual emission into the air, water, and soil for six basic pollutants have been calculated.

Modern extensive monitoring system for POPs should be established to clear up a real state with environmental pollution by POPs in the country. Results of such monitoring together with strong regulatory support may motivate enterprises to an introduction of "best available techniques". *Bibl. 7, Tab. 3.*

Key words: persistent organic pollutants, hazardous waste, emission, destruction.

A system for preventing formation and environmentally safe removal of persistent organic pollutants (POPs) is an actual problem for Ukraine. The Stockholm Convention on Persistent Organic Pollutants requires establishment of that system, and in 2007, Ukraine develops the National Plan for its implementation. When developing the Plan, all POPs specified in the Convention were thoroughly inventoried, and in order to correct actions of the National Implementation Plan, an expert assessment regarding changes in volumes, forms of accumulation and storage of POPs was carried out in 2020.

As at March 31, 2006 21,615 tons of unusable or prohibited plant protection chemicals (PPC) were accumulated in Ukraine, 2,019 tons of them are pesticides classified as POPs, among which majority is DDT — 1,744 tons and hexachlorocyclohexane — 273 tons [1].

In recent years, inventory of unusable and prohibited pesticides has been taken at the regional level. Each regional State Administration Office annually makes an Environmental Passport of the region, which contains data on volume of accumulation and storage status of unusable and prohibited PPC. Please see the Summary on storage of prohibited and unsuitable pesticides by January 01, 2019 in Table 1.

Table 1. Storage status of prohibited and unusable pesticides by January 01, 2019

Region	Pesticides, stored in SH, tons	Number of storehouses	Condition of storehouses		
			Good	Satisfactory	Unsatisfactory
Vinnitsa Region	2964.0	116	1	26	89
Kherson Region (01.2017)	1921.804	–	–	–	0
Sumy Regiont	563.529	64	–	38	26
Odesa Region	532.818	66	0	11	55
Zhytomyr Region	392.186	137	11	36	94
Kyiv Region	298.355	22	–	3	19
Cherkasy Region	282.371	13	3	4	6
Chernigiv Region	277.900	52	0	1	51
Khmeltitskiy Region	253.518	11	–	9	2
Zaporizhzhya Region	252.714	49	3	8	38
Mykolaiv Region	166.87	6	–	3	3
Poltava Region	160.44	21		18	3
Rivne Region	46.815	13		12	1
Lugansk Region	36.5	4	2	1	1
Donetsk Region	25.660	–	–	–	0
Ternopil Region	17.814	7	–	1	6
Volyn Region	0	0	0	0	0
Dniepropetrovsk Region	0	0	0	0	0
Transcarpathian Region	0	0	0	0	0
Ivano-Frankivsk Region	0	0	0	0	0
Kropyvnytskiy Region	0	0	0	0	0
L'viv Region	0	0	0	0	0
Kharkiv Region	0	0	0	0	0
Chernivtsi Region	0	0	0	0	0

As of beginning of 2019, 8 regions completely disposed of accumulated unusable PPC, but in many cases, storehouses and surrounding sites were not cleaned of pesticide residues. Detailed inventory of waste and areas around storehouses contaminated with pesticides should be one of the main tasks of the updated National Implementation Plan.

It is also necessary to make significant adjustments to planned actions of the National Plan according to current state of accumulation of polychlorinated biphenyls (PCBs) in Ukraine. In 2003, according to specially developed forms of statistical reporting, a nationwide inventory of electrical equipment, containing PCB, was completed [2]. According to obtained inventory results, the National Registry of PCBs was developed, and actions for environmentally sound disposal of PCBs were planned in the 1st edition of the National Implementation Plan.

Table 2. Number of equipment with concentrated PCBs in the regions in 2003 and 2018

Region	Number of enterprises, confirmed PCB presence		Transformers		Capacitors	
	in 2003	in 2018	in 2003	in 2018	in 2003	in 2018
Donetsk Region	no inf.*	no inf.	250	no inf.	5,727	no inf.
Dniepropetrovsk Region	no inf.	30	114	126	7,322	21,577
Kyiv Region	65	no inf.	114	no inf.	1874	no inf.
Poltava Region	no inf.	9	67	38	5,694	38
Lugansk Region	39	no inf.	58	no inf.	6,281	no inf.
Kyiv City	no inf.	no inf.	41	no inf.	1,402	no inf.
Volyn Region	no inf.	5	39	0	4,109	284
Zhytomyr Region	20	4	39	0	1067	172
Ivano-Frankivsk Region	39	7	28	4	1,125	105
Cherkasy Region	20	18	28	7	1,172	835
Kirovograd Region	54	18	27	15	2,704	280
Kharkiv Region	30	15	25	8	6,532	1,016
Odesa Region	60	no inf.	22	no inf.	1,667	no inf.
Mykolaiv Region	no inf.	6	17	73	4,265	594
Vinnitsa Region	23	28	16	16	1,971	1,913
Zaporizhzhya Region	32	no inf.	16	no inf.	18,021	no inf.
Kherson Region	no inf.	no inf.	13	no inf.	1,125	no inf.
Transcarpathian Region	no inf.	no inf.	9	no inf.	1,403	no inf.
Sumy Region	no inf.	5	9	2	7,253	1,218
Rivne Region	17	no inf.	8	no inf.	2,110	no inf.
Ternopil Region	no inf.	7	8	0	1,944	258
Khmeltitskiy Region	23	2	8	0	1,516	35
L'viv O Region	51	no inf.	6	no inf.	2,318	no inf.
Chernivtsi Region	no inf.	1	5	33	1,129	0
Chernigiv Region	10	7	3	0	2,259	295
Total	26	no inf.	970	322	91,990	29,502

* no inf. — No information.

Total number of concentrated PCBs in 2003 was estimated to be 4,240 tons. Similar to the case of pesticides, there have been significant changes in situation with PCBs in the time ahead.

Clarification of the data of the National Register on concentrated PCBs was conducted in period of 2017–2018 within framework of the EF/UNIDO Project "Environmentally sound management and final removal of polychlorinated biphenyls (PCBs)" by surveying enterprises (see Table 2). Since participation in the survey was freely, results obtained do not reflect the state of the issue for whole country.

Many enterprises, which showed PCBs in 2003, did not confirm presence of equipment with PCBs in 2018, or even they were closed down. There are also enterprises that were not covered by inventory in 2003, but showed a significant number of capacitors in 2017.

Clarification of this data with a direct check of enterprises, on which previously equipment with PCBs was discovered, should be one of the directions in the updated National Action Implementation Plan.

In accordance with requirements of the Stockholm Convention on POPs, inventory should be covered all objects where the PCB pollution exceeds 50 ppm. Therefore, in 2017, a research for possible PCB contamination of transformers filled with mineral oil was started. In 2017–2018, 5,000 screening tests of mineral oil samples were analyzed. An updated National Implementation Plan should provide a wider investigation.

Another persistent organic pollutant — *hexachlorobenzene* — plays an important role in origin of environmental risks for Ukraine. Reportedly, 11,352.5 tons of hexachlorobenzene waste were stored at the Kalush Chemical and Metallurgical Plant in 2001. According to the Environmental Passport of the Ivano-Frankivsk Region, 29,431 tons of waste, containing hexachlorobenzene and soils from sites around a landfill, were taken for disposal during 2010–2013. However, recultivation of landfill was not completed. Within updating the National Implementation Plan, it is necessary to examine of areas surrounded landfill in order to assess extent of pollution with

hexachlorobenzene and to define measures on removal of residual contamination.

To define measures regarding development of POP treatment infrastructure, it is important to know not only total scale of accumulation of certain types of POPs, but also amount and forms of waste generation during decommissioning of equipment, cleaning storehouses, and recultivation of landfills, etc.

In addition to creation of an infrastructure for disposal of accumulated POPs, the National Implementation Plan should be aimed at preventing or reducing the so-called "*unintentional production*" of POPs.

The Stockholm Convention on POPs requires the Parties:

— develop an action plan for identification, determination of properties and resolution of issues related to chemical emissions, in appendix C: hexachlorobenzene (HCB); hexachlorobutadiene; pentachlorobenzene ((PeCBz); polychlorinated biphenyls (PCBs) polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) and polychlorinated naphthalenes;

— contribute to application of existing, necessary and practical measures that could promptly ensure elimination of the source, or a real and substantial reduction in emissions.

Emissions assessment is carried out according to generally accepted method by multiplication production volumes of a particular product by emission factor [3]. Emission factor is established based on specific features of the technological process, requirement for raw materials, and configuration of equipment. This coefficient also shows how application of "best available techniques will reduce emissions into environment of certain POPs".

As of 2018, on the base of statistics [4, 5] regarding volumes of activity and with use of spreadsheets proposed by UNEP for POP emission the following PCDD/PCDF, PCB, HCB and PCB releases were calculated (please see Table 3).

At present, for many origins of pollution there are no well-based emissions factor into different environments. Therefore, one of the tasks of the updated National Implementation Plan should be also to determine emission factors for both existing equipment configuration and for options for its possible modernization.

Objective of the Stockholm Convention is to protect human health and environment from persistent organic pollutants by reducing or eliminating their releases into environment. NIP of every country has to have part concerning to monitoring of SC chemicals based on global and regional monitoring activities and plans. Key aspect of this monitoring programs is to evaluate effectiveness of the SC measures in this case on the territory of every country.

A risk of irreversible changes in terrestrial and aquatic ecosystems requires a coordinated monitoring effort based on broad international cooperation. It means that every monitoring system is long-term process with the basic focus on determination of trends in time and space.

It has been recognized that an important step in establishment of effective control measures is the inventory of current POP concentrations in various environmental compartments, and assessment of their time trends. Determination of POP concentrations in the atmosphere, wet and dry deposition, surface water, sediment, soil, and vegetation are desirable under various geographic and climatic conditions. Such information improves our understanding of the pathways and potential effects of chemical substances, and defines specific parameters for exposure assessment. At the same time, new data sets valuable for validation of regional and global models of atmospheric transport and environmental fate are generated. A number of sites where POPs are continuously monitored over extended time periods in several environmental compartments is, however, very limited.

The Stockholm Convention Global Monitoring Plan (GMP) [6] evaluates whether the POPs (and their levels observed in the environment) were reduced or eliminated as requested in Articles 3 and 5 of the Convention which means that information on environmental levels of the chemicals listed in the Annexes to the Convention should enable detection of trends over time. Therefore, focus is upon monitoring of background levels of POPs at locations not influenced by local sources.

But national monitoring has to be focused on the most relevant POPs sources in the country, contaminated sites, potential transboundary transport. Design of this national monitoring program, development of the national network and long-term realization is very complicated and expensive process. There is a basic difference between development of the long-term monitoring program and shorter pilot phase or study projects.

Table 3. PCDD/PCDF, PCBs, HCB, PeCBz emissions in 2018

Group	Origin	Annual Releases (g/a)				
		Air	Water	Land	Products	Residues
1	Waste Incineration	180.2	0.0	0.0	0.0	932.2
2	Ferrous and Non-Ferrous Metal Production	747.0	72.0	0.0	0.0	733.8
3	Heat and Power Generation	144.6	0.0	0.0	0.0	10.2
4	Production of Mineral Products	0.8	0.0	0.0	0.0	0.8
5	Transportation	0.5	0.0	0.0	0.0	0.0
6	Open Burning Processes	1.0	0.0	0.3	0.0	0.0
7	Production of Chemicals and Consumer Goods	0.0	0.0	0.0	0.0	0.0
8	Miscellaneous	0.0	0.0	0.0	0.0	0.0
9	Disposal	0.0	85.1	0.0	0.0	8512.0
10	Contaminated Sites and Hot-Spots	–	–	–	0.0	0.0
1–10	**Total**	**1074.2**	**157.2**	**0.3**	**0.0**	**10189.0**
	Grand Total	**11421**				
PCBs emission						
1	Waste Incineration	7.9	0.0	0.0	0.0	0.0
2	Ferrous and Non-Ferrous Metal Production	10.8	0.0	0.0	0.0	0.0
3	Heat and Power Generation	116.1	0.0	0.0	0.0	0.0
4	Production of Mineral Products	0.1	0.0	0.0	0.0	0.0
5	Transportation	0.1	0.0	0.0	0.0	0.0
6	Open Burning Processes	0.1	0.0	0.0	0.0	0.0
7	Production of Chemicals and Consumer Goods	0.0	0.0	0.0	0.0	0.0
8	Miscellaneous	0.0	0.0	0.0	0.0	0.0
9	Disposal	0.0	0.0	0.0	0.0	0.0
10	Contaminated Sites and Hot-Spots	–	–	–	0.0	0.0
1–10	**Total**	**135.2**	**0.0**	**0.0**	**0.0**	**0.0**
	Grand Total	**135.2**				
HCB emission						
1	Waste Incineration	268.8	0.0	0.0	0.0	0.0
2	Ferrous and Non-Ferrous Metal Production	26580.8	0.0	0.0	0.0	0.0
3	Heat and Power Generation	3703.5	0.0	0.0	0.0	0.0
4	Production of Mineral Products	2.0	0.0	0.0	0.1	0.0
5	Transportation	357.0	0.0	0.0	0.0	0.0
6	Open Burning Processes	10.0	0.0	0.0	0.0	0.0
7	Production of Chemicals and Consumer Goods	2.1	0.0	0.0	0.0	0.0
8	Miscellaneous	0.0	0.0	0.0	0.0	0.0
9	Disposal	0.0	0.0	0.0	0.0	0.0
10	Contaminated Sites and Hot-Spots	–	–	–	0.0	0.20
1–10	**Total**	**30924.1**	**0.0**	**0.0**	**0.1**	**0.0**
	Grand Total	**30924**				
PeCBz emission						
1	Waste Incineration	0.0	0.0	0.0	0.0	0.0
2	Ferrous and Non-Ferrous Metal Production	53140.1	0.0	0.0	0.0	0.0
3	Heat and Power Generation	12.4	0.0	0.0	0.0	0.0
4	Production of Mineral Products	11.1	0.0	0.0	0.0	0.0
5	Transportation	0.0	0.0	0.0	0.0	0.0
6	Open Burning Processes	0.0	0.0	0.0	0.0	0.0
7	Production of Chemicals and Consumer Goods	0.0	0.0	0.0	0.0	0.0
8	Miscellaneous	0.0	0.0	0.0	0.0	0.0
9	Disposal	0.0	0.0	0.0	0.0	0.0
10	Contaminated Sites and Hot-Spots	–	–	–	0.0	0.0
1–10	**Total**	**53163.6**	**0.0**	**0.0**	**0.0**	**0.0**
	Grand Total	**53164**				

A lot of activities including long term measurements was discussed in the NIP from 2007. There is a summary of programmes which were focused on the long-term measurements of organochlorinated pesticides mainly in water, soil and human samples.

In this time a relatively sufficient number of laboratories, which were able to determine the

OCPs existed. Now is only fully supports the considerations of the Stockholm Convention on POPs — the L. Medved Institute of Ecological Hygiene and Toxicology, Kyiv city) that has been accredited for the right of carrying out of measurements of PCDDs/PCDFs content (in emitted substances, fish, waste products, and soils).

According to the data rendered by the State hydrometeorological service two OCPs belonging to the POPs group are being monitored regularly. These are DDT (including p,p'-DDE, p,p'-DDT, and p,p'-DDD) and HCB in the waters and DDT only (including p,p'-DDE, p,p'-DDT, and p,p'-DDD) in the soils at the territory of Ukraine.

One of the goals of the National implementation plan upgrade development is to prepare and establish a modern extensive network for monitoring of POPs presence in environment which should be a control tool to assess an effectiveness and adequacy of measures developed in frames of the National Implementation Plan of POPs. But key element will be sufficient financial support for development of really long-term monitoring network.

The next step in establishment of an environmentally sound management system for POPs is accepting the outcomes of inventory on volumes of POPs accumulation and monitoring their releases into environments, and development of ecologically effective and economically optimal infrastructure for POPs disposal. According to forms of accumulation, POP-containing wastes with similar physicochemical properties should be divided into separate groups, and optimal treatment technology should be determined for each group.

If some country has powerful (with a capacity of several tons per hour) installations built on universal rotary kilns, then question of technology selection for any type of wastes is not so acute. Modern technological complex based on a rotary kiln with a multi-stage gas cleaning system is universal tool that provide high environmental and economic efficiency in destruction a wide range of waste. Content of chlorine in the loading (mixture of waste) in such installations is allowed up to 10 %. However, capital costs for establishment of such complexes are very high. There are no private companies in Ukraine that could be able to invest in development of such installations at existing level of risks in hazardous waste disposal activities, and state programs do not include their construction in the near future. The more realistic strategy is when for each group of POP-containing waste with relatively small amounts of accumulation its own optimal technology and acceptable means of its implementation are determined.

The most significant in volume is group of solid waste, with a relatively low content of POPs. This group includes almost all prohibited and unusable plant protection chemicals (PPC).

Inventories of the late 90's showed that among stored chemicals were: 1) the granules and powders — about 50 %, 2) liquid preparations, suspensions, emulsions — 35 %, and 3) pastes — 15 %.

Over 20 years of storage, because of mixing and repackaging, all mixtures have acquired a solid state with an unknown variable chlorine content. Overall majority of solid DDT mixtures consists of 50–70 % of mineral inert matrix. That is, if POPs share in total number of unusable pesticides is ~ 10 %, amount of chlorine in total volume of unusable pesticides is estimated at approximately 2–3 %.

To destroy active ingredient of such substances, effective measures are needed for desorption and transfer it to the gas phase. As practical experience proved, rotary kilns perform this most effectively. Today in Ukraine there are small technological complexes (with capacity of 500–800 kg/hour) built based on a rotary kiln with a gas cleaning system; they are designed for 2–3 % chlorine in loading. Such installations can also be used for treating soils with a high content of pesticides from land near abandoned pesticide storehouses. Sites of soil with high contamination of HCB are also at the Kalush's landfill of HCB waste.

Use of plasma destructive technique may be acceptable for concentrated organochlorine toxic substances, in particular, synthetic oils based on PCB [7]. Composition of synthetic oils usually includes 2–3 chlorinated organic compounds that during thermal destruction in chemically inert plasma with an addition of water vapor allow getting simple products: CO_2, H_2O, and HCl. In addition, simple products formed after destruction reduce investment and operational costs of gaseous products cleaning system compared to other technologies based on using of rotary kiln. However, plasma technology has its own disadvantages. To ensure a high resource of continuous operation of arc plasmatron or stable discharge in radio frequency plasmatron, argon is used, which significantly reduces the economic effect of a simple system for gas cleaning. Usually, the installations with a capacity of up to 150 kWt are used for destruction of POPs and ODS. Thus, two installations with a produc-

tivity of 70 kg/hour could be able to process all concentrated PCBs, which were accumulated in Ukraine, in four years.

Another option for concentrated PCBs is export abroad for processing in available large incinerators. It is important, that in case of POP waste removal the disposal cost increases in 2–2.5 times.

Previous experience of other countries demonstrates that replacement of mineral oils in transformers may lead to their contamination with PCB. Share of transformers with contamination up to 50 ppm could reach 20 %. In aim to detect such contamination, transformers in Ukraine have been started to inspect. Previous screening tests of mineral oils for possible contamination with PCBs proved that such pollution is not high (up to 200 ppm) and possible volumes of contaminated mineral oils may reach 24,000 tons. At such level of contamination, use of these oils as fuel in specialized rotary kilns, in particular in pesticides' processing, may be quite acceptable on environmental and economic indicators. However, in order to resolve finally the issue of possibility of burning oils contaminated with POPs, it is necessary to analyze possibility of synthesis of dioxins/furans.

Ukraine is developing its own technologies for thermal destruction of concentrated toxic organochlorine waste. The most promising among them are:

— technology for treatment of organochlorine waste in the melt of alkaline metal salts;

— technology of steam-plasma gasification of hazardous waste.

Unfortunately, to date, these technologies have not been sufficiently tested so that they can be recommended for wide implementation.

Conclusions

1. There are large-scale environmental risks in Ukraine now caused by the following factors:

— large volumes of use of POPs in electrical equipment;

— large volumes of POPs-containing waste (pesticides, hexachlorobenzene) stored in inappropriate conditions;

— releases of POPs into the environment (air, water, soil) due to imperfect production processes.

2. Optimal comprehensive solution to the problem of decontamination of POPs-waste in Ukraine is use of rotary kilns for waste with low concentration of POPs and use of plasma reactors for highly concentrated POPs.

3. To reduce the emission of POPs into environment because of their unintentional formation, it is necessary to develop a system of monitoring of POPs and to promote an implementation of the "best available methods", taking into account the monitoring results.

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Текущее состояние проблемы стойких органических загрязнителей в Украине и подходы к ее разрешению

Стойкие органические загрязнители (СОЗ) относятся к группе токсичных веществ, которая выделена из-за чрезвычайно опасного воздействия на здоровье человека и регулируется специальным международным соглашением — Стокгольмской конвенцией о СОЗ. Каждая Сторона Конвенции должна разработать и последовательно обновлять Национальный план выполнения требований настоящей Конвенции. Украина разработала Национальный план реализации в 2007 г., эксперты приступили к его обновлению в 2020 г.

В статье представлены результаты экспертного анализа изменения объемов и форм накопления отходов, состоящих из СОЗ, содержащих или загрязненных ими, в частности, непригодных и запрещенных химических средств защиты растений. Приведены результаты экспертного анализа изменений в использовании электрооборудования, содержащего синтетические диэлектрические жидкости на основе полихлорированных дифенилов. На основе анализа в Национальный план выполнения предлагаются мероприятия по развитию эффективной инфраструктуры термического обезвреживания СОЗ-содержащих отходов.

Помимо мест хранения отходов, содержащих СОЗ, важным источником попадания СОЗ в окружающую среду является так называемое «непреднамеренное производство». Для категорий источников, которые в соответствии со Стокгольмской конвенцией могут потенциально загрязнять окружающую среду СОЗ, рассчитаны объемы ежегодных выбросов в воздух, воду и почву для шести основных загрязнителей.

Необходимо создать современную обширную систему мониторинга СОЗ, чтобы прояснить реальное состояние загрязнения окружающей среды СОЗ в стране. Результаты такого мониторинга вместе с сильной нормативной поддержкой могут побудить предприятия к внедрению «наилучших доступных технологий». *Библ. 7, табл. 3.*

Ключевые слова: стойкие органические загрязнители, опасные отходы, выбросы, обезвреживание.

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Сучасний стан проблеми стійких органічних забруднювачів в Україні та підходи до її вирішення

Стійкі органічні забруднювачі (СОЗ) належать до групи токсичних речовин, яка відокремлюється внаслідок надзвичайно небезпечного впливу на здоров'я людей та регулюється спеціальною міжнародною угодою — Стокгольмською конвенцією про СОЗ. Кожна Сторона Конвенції повинна розробляти та послідовно оновлювати Національний план виконання вимог цієї Конвенції. Україна розробила Національний план реалізації у 2007 р., експерти розпочали роботи з його оновлення у 2020 р.

Стаття містить результати експертного аналізу змін обсягів та форм накопичення відходів, що складаються, містять або забруднені СОЗ, зокрема непридатних або заборонених хімічних засобів захисту рослин. Наведено результати експертного аналізу змін у використанні електричного обладнання, що містить синтетичні діелектричні рідини на основі поліхлорованих дифенілів. На основі аналізу до Національного плану реалізації пропонуються заходи щодо розвитку ефективної інфраструктури для термічного знешкодження СОЗ-вмісних відходів.

Окрім місць зберігання СОЗ-вміщуючих відходів, важливим джерелом потрапляння СОЗ у навколишнє середовище є так зване «ненавмисне виробництво». Для категорій джерел, які згідно Стокгольмської конвенції можуть потенційно забруднювати навколишнє середовище СОЗ, були підраховані обсяги річних викидів у повітря, воду та ґрунт для шести основних забруднювачів.

Слід створити сучасну розгалужену систему моніторингу СОЗ, щоб з'ясувати реальний стан із забрудненням навколишнього середовища СОЗ у країні. Результати такого моніторингу разом із потужною нормативною підтримкою можуть спонукати підприємства до впровадження «найкращих доступних технологій». *Бібл. 7, табл. 3.*

Ключові слова: стійкі органічні забруднювачі, шкідливі відходи, викиди, знешкодження.

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