GLOBAL MONITORING PLAN
FOR PERSISTENT ORGANIC POLLUTANTS

UNDER THE STOCKHOLM CONVENTION ARTICLE 16 ON EFFECTIVENESS EVALUATION

THIRD REGIONAL MONITORING REPORT

CENTRAL AND EASTERN EUROPEAN REGION

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PREFACE

Persistent organic pollutants (POPs) are a group of chemicals that have toxic properties, resist degradation in the environment, bioaccumulate through food chains and are transported long distances through moving air masses, water currents and migratory species, within and across international boundaries. POPs belong to three main groups, however some of the chemicals fit into more than one of these three general categories:

- pesticides used in agricultural applications[1]
- industrial chemicals used in various applications[2]
- chemicals generated unintentionally as a result of incomplete combustion and/or chemical reactions[3].

Twelve POPs were initially listed in the Stockholm Convention (shown in bold font in footnotes 1-3). In general, these 'legacy' POPs were first produced and/or used several decades ago, their persistence, bioaccumulative properties and potential for long-range transport are well studied, and they have been globally banned or restricted since 2004. Eighteen additional chemicals have been listed in the Annexes of the Convention since, bringing the total number of POPs to thirty as of January 2020 (the meetings of the Conference of the Parties at which the listing of the chemicals took place are indicated in parenthesis in footnotes 1-3).

Article 16 of the Stockholm Convention requires the Conference of the Parties to evaluate periodically whether the Convention is an effective tool in achieving the objective of protecting human health and the environment from persistent organic pollutants. This evaluation is based on comparable and consistent monitoring data on the presence of POPs in the environment and in humans, as well as information from the national reports under Article 15 and non-compliance information under Article 17. The global monitoring plan for POPs, which has been put in place under the Convention, is a key component of the effectiveness evaluation and provides a harmonized framework to identify changes in concentrations of POPs over time, as well as information on their regional and global environmental transport.

While monitoring activities are ongoing in the frame of the GMP, every six year the information generated is collected, compiled and analyzed in monitoring reports (regional and global). The first two phases of the GMP have been implemented during the period 2004-2017, with two sets of regional monitoring reports and global reports developed to date in the frame of the GMP and have informed the effectiveness evaluation under Article 16 of the

[1] **aldrin, chlordane**, chlordecone (COP-4, 2009), **dichlorodiphenyltrichloroethane (DDT),** dicofol (COP-9, 2019), **dieldrin,** endosulfan (COP-5, 2011), **endrin, heptachlor, hexachlorobenzene (HCB),** gamma-hexachlorocyclohexane (γ-HCH, lindane) and by-products of lindane [alpha-hexachlorocyclohexane (α -HCH) and beta-hexachlorocyclohexane (β -HCH)] (COP-4, 2009), pentachlorophenol, its salts and esters (COP-7, 2015) **mirex, toxaphene**.

[2] tetra- and pentabromodiphenyl ethers (PBDEs) (COP-4, 2009), hexa- and heptabromodiphenyl ethers (PBDEs) (COP-4, 2009), decabromodiphneyl ether (COP-8, 2017), hexabromocyclododecane (HBCD) (COP-6, 2013), hexabromobiphenyl (COP-4, 2009), hexachlorobutadiene (COP-7, 2015), perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F) (COP-4, 2009), perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds (COP-9, 2019), pentachlorobenzene (PeCB) (COP-4, 2009), **polychlorinated biphenyls (PCBs)**, polychlorinated naphthalenes (PCN) (COP-7, 2015), short-chain chlorinated paraffins (SCCPs) (COP-8, 2017).

[3] **hexachlorobenzene (HCB),** hexachlorobutadiene (COP-8, 2017), pentachlorobenzene (PeCB) (COP-4, 2009), polychlorinated naphthalenes (PCN) (COP-7, 2015), **polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs)**.

Convention. The GMP Data Warehouse has been made operational during the second GMP phase and continued to support the regional organization groups in the work for the collection, processing, storing and presentation of monitoring data during the third phase of implementation of the GMP.

The present (third) monitoring report is synthesizing information from the first, the second and the third phase of the Global Monitoring Plan and presents the most up-to-date findings on POPs concentrations in the Central and Eastern European Region. While the first and the second monitoring reports, presented at the fourth and seventh meeting of the Conference of the Parties respectively, provided information as to the changes in concentrations of the chemicals initially listed in the Convention, as well as baseline information on some of the newly listed POPs, this third report builds on the increasing information base of POPs monitoring data and provides a further in-depth assessment of the changes measured over time in POPs concentrations, including time trends where available, as well as recent baseline information on the more recently listed POPs.

ABBREVIATIONS AND ACRONYMS

ALRT	Atmospheric Long-Range Transport
AMAP	Arctic Monitoring and Assessment Programme
CEE	Central and Eastern Europe
CEP	Caspian Environment Programme
CRM	Certified Reference Material
CIS	Commonwealth of Independent States
COP	Conference of the Parties
CTD	Characteristic Travel Distance
CV	Coefficient of Variation
DDD /DDE	Metabolites of DDT
DDT	Dichlorodiphenyltrichloroethane
dl-PCBs	Dioxin-like PCBs
EDCs	Endocrine Disrupting Chemicals
EMAN	Ecological Monitoring and Assessment Network
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
FAO	Food and Agriculture Organisation of the United Nations
GAPS	Global Atmospheric Passive Sampling Survey
GEMS	Global Environment Monitoring System
GMP	Global Monitoring Plan
HCB	Hexachlorobenzene
HELCOM	Helsinki Commission/The Baltic Marine Environment Protection Commission
HCHs	Hexachlorocyclohexanes
HPLC	High Performance Liquid Chromatography
HRGC	High Resolution Gas Chromatography (capillary column)
HRMS	High Resolution Mass Spectrometer
HBB	Hexabromobiphenyl
HBM4EU	EU Initiative on Human Biomonitoring for Europe, EU framework project
I-TEQ	International Toxicity Equivalence
KAW	Air/Water Partition Coefficient
KOA	Octanol/Air Partition Coefficient
Kow	Octanol/Water Partition Coefficient
LC50	Median Lethal Concentration
LD50	Median Lethal Dose
LOAEL	Lowest Observable Adverse Effect Level
LOD	Limit of Detection
LOQ	Limit of Quantification
LRT	Long Range Transport
LRTAP	Long Range Transport Air Pollutants
LRTP	Long Range Transport Potential
MDL	Minimum Detectable Level
MSCE-East	Meteorological Synthesizing Centre-East
ND	Not detected
NGOs	Non-Governmental Organisations
NIS	Newly Independent States
NOAEL	No Observable Adverse Effect Level
NOEL	No Observable Effect Level
OCPs	Organochlorine Pesticides

OECD	Organisation for Economic Co-operation and Development
OPs	Organophosphates
OSPAR	Commission for the Protection of the Marine Environment of the North-East Atlantic
PAHs	Polycyclic aromatic hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo- p-dioxins
PCDFs	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
PFOS	Perfluorooctane sulfonate
POPs	Persistent Organic Pollutants (group of twelve as defined in the Stockholm Convention 2001)
PRTRs	Pollutant Release and Transfer Registers
PTS	Persistent Toxic Substances
PUF	Polyurethane Foam
PVC	Polyvinylchloride
QA/QC	Quality Assurance and Quality Control Regimes
RECETOX	Research Centre of Masaryk University, Czech Republic
ROGs	Regional Organization Groups for the Global Monitoring Plan
SAICM	Strategic Approach to International Chemicals Management
SCCPs	Short-chain chlorinated paraffins
SOP	Standard Operating Procedure
SPM	Suspended particulate matter
t	Tonnes
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxicity Equivalents
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
WFD	Water Framework Directive
WHO	World Health Organisation
WMO	World Meteorological Organization
XAD	Styrene/divinylbenzene-co-polymer Resin

GLOSSARY OF TERMS

Activity	Any programme or other activity or project that generates data or information on the levels of POPs in the environment or in humans that can contribute to the effectiveness evaluation under Article 16 of the Stockholm Convention
Core matrices	These are the matrices identified by the Conference of the Parties to the Stockholm Convention at its second meeting as core for the first evaluation: A = ambient air; M = (human) mother's milk and / or B = human blood
CTD	The characteristic travel distance– defined as the "half-distance" for a substance present in a mobile phase
Intercomparisons	Participation in national and international intercalibration activities such as proficiency ring-tests, laboratory performance testing schemes, etc
LOD	Limit of detection. Definition: The lowest concentration at which a compound can be detected; it is defined as that corresponding to a signal three times the noise.
<LOD	Result below the limit of detection
LOQ	Limit of quantification. Definition: The lowest concentration that can quantitatively be determined is three times higher than LOD.
<LOQ	Result below limit of quantification. Compounds found at levels between LOD and LOQ can be reported as present, or possibly as being present at an estimated concentration, but in the latter case the result has to be clearly marked as being below LOQ.
MDL	Method detection limit. The MDL considers the whole method including sampling, sample treatment and instrumental analysis. It is determined by the background amounts on field blanks.
Phase I	Activities to support the Article 16 effectiveness evaluation that were conducted by the Conference of the Parties at its fourth meeting, information collected between 2000 and 2008.
Phase II	Activities to support the Article 16 effectiveness evaluation that were conducted by the Conference of the Parties at its seventh meeting, information collected between 2009 and 2014.
Phase III	Activities to support the Article 16 effectiveness evaluation that were conducted by the Conference of the Parties at its tenth meeting, information collected between 2015 and 2018.

EXECUTIVE SUMMARY

This third monitoring report synthesizes information from the first, the second, and the third phase of the Global Monitoring Plan and presents the current findings on POPs concentrations in the Central and Eastern European Region (CEE). The UN region of the Central and Eastern Europe covers 23 countries of the Central and Eastern Europe. However, additional countries of the Central Asia (Kazakhstan and Kyrgyzstan) were also included to this regional report, as agreed in discussions between the relevant Regional Organization Groups of CEE and Asia Pacific due to similar pattern of production and use of POPs, geographical proximity and language issues in the CEE region. Thus, this regional report covers 25 countries and more details about the region are provided in chapter 2 and in Annex 1 comprising filled questionnaires about national POPs activities.

The third phase of the Global monitoring Plan focused on expanding the information base for assessing changes in POPs concentrations over time, covering all 30 substances or groups of substances listed as POPs in the Stockholm Convention (as of January 2020); the inclusion of the more recently listed POPs in ongoing monitoring activities represented a significant increase in the scope of the GMP. The work in the third phase was equally directed at further enhancing comparability within and across monitoring programmes through new intercalibration studies, harmonizing data handling, and continued to ensure support to the collection, processing, storing and presentation of monitoring data in regions through the GMP Data Warehouse.

This third report contains POPs data collected between 1996-2019 for air, 1987-2019 for breast milk and also comprises information from three rounds of the Joint Danube Surveys organized in 2007, 2013 and 2019 in the Danube River Basin including tributaries.

POPs data availability in the CEE region is a result of the strategic partnerships with long term established monitoring programs for ambient air and UNEP/WHO milk survey. The unique set of ambient air POPs concentration data, generated through integrated monitoring based on active air sampling over a period of almost 30 years represents the Central European background, and the MONET Europe and GAPS networks, based on passive air sampling, provide a comprehensive set of data since 2006 and 2004 respectively. In the western part of the CEE region available time series confirm the decreasing levels for legacy POPs and some new POPs and indicate downward tendencies for POPs added to the Stockholm Convention after 2015.

Human tissues data at the regional scale are available only through the WHO and UNEP/WHO surveys, with information gaps identified for South European, Eastern (Russian Federation) and Central Asian part of the region. Overall, 52% of countries in the region have participated in various rounds of the human milk survey to date and 11 out of 13 did so at least twice. While there were seven countries participating in the global milk survey in 2013-4, only two countries (8 % of the region) took part in the most recent round. Support will be needed to increase availability of human exposure data in Eastern, South European, Caucasus and Central Asian countries in next rounds of UNEP/WHO milk survey.

Despite partly limited geographical coverage, available results from milk survey show decreasing tendencies for majority of listed POPs (chlordane, DDT, HCB, heptachlor, hexachlorocyclohexanes, PBDEs, indicator PCB, dioxins and furans and toxaphene). Slightly increasing tendency was observed for alpha-HBCDD and increasing trend was shown for several dl-PCB congeners. Non-detects or levels below LOQ have been identified for aldrin, chlordecone, dieldrin, endosulfan, endrin, mirex, hexabromobiphenyl, HCBD and pentachlorobenzene. Levels of' POPs whose reporting is not yet obligatory, dicofol and PFHxS, were also below LOQ. Limited data are currently available for HBCDD and SCCPs, baseline exists for PFOA, SCCPs and PFOS. Analyses of PCN were not yet completed when finalizing this report.

Water data are available for some countries in the western part of the region through European Joint Surveys (i.e Joint Danube Survey). Results of analyses also indicate decreasing tendency in the PFOS and PFOA levels over time, but data gaps exist in northwestern and eastern part of the region and support will be needed to fill in these gaps. Information on POPs levels in the Russian Federation part of the region were also complemented by several research projects and activities of a limited time span to provide at least some baseline within the period 2014-2018.

In addition, questionnaires sent to the National Focal Points of the Stockholm Convention in 2019 revealed that many countries in the region perform national POPs monitoring in non-core media (soil, sediment, food) that provides for additional information on levels for legacy POPs in particular, but the collected information is very diverse.

The questionnaire on POPs monitoring capacities has also revealed an increase in capacities for POPs analyses in the region, but expertise and infrastructures to analyze dioxins/furans, PFOS and PBDEs remain limited in southern and eastern part of the region. Nevertheless partnerships with advanced infrastructures have so far allowed to compensate for the gaps in analytical capacities, efforts are needed to reestablish POPs monitoring in core media as priority for most countries in the region and technical assistance is needed to increase expert capacities.

The countries in the region also recognized the beneficial impact of the capacity building and training activities available for sampling, monitoring and analyses of the samples and hereby acknowledges support provided by the Stockholm Convention Secretariat and its partners to countries in the CEE region. The experts participating in the summer schools, specific training or inter-laboratory comparison strengthened their knowledge in undertaking monitoring activities for legacy POPs as well as gradually introduced new sampling techniques to cover newly listed POPs. These activities should also continue in the future as they contribute significantly to the abilities of countries to establish and run sustainable national monitoring or at least fully participate in regional monitoring activities.

Finally, the electronic GMP Data Warehouse supporting regional data storage, analyses, and presentation, was instrumental in preparation of the regional monitoring report and will be also very useful for subsequent dissemination of information on the POPs monitoring activities to all stakeholder groups.

1 INTRODUCTION

The present (third) regional monitoring report synthesizes information from the first, the second and the third phase of the Global Monitoring Plan and presents its findings on POPs concentrations in the Central and Eastern European Region (CEE). While UN region of the Central and Eastern Europe covers 23 countries of the Central and Eastern Europe, two additional countries of the Central Asia (Kazakhstan and Kyrgyzstan) were also included to this regional report, as agreed in discussions between the relevant Regional Organization Groups of CEE and Asia Pacific due to their similar pattern of production and use of POPs, geographical and language proximity to the CEE region. Thus, this regional report covers 25 countries and more details about the region are provided in chapter 2 and 4 as well as in Annex 1 comprising questionnaires about POPs activities and capacities.

The first phase of the GMP has been implemented during the period 2004-2009 and the second phase during 2010-2017, providing information on changes in concentrations of the 12 POPs initially listed in the Stockholm Convention and information on baseline concentrations of the 11 substances newly listed in the annexes to the Convention in 2009, 2011 and 2013. Two sets of regional monitoring reports and global reports have been developed to date in the frame of the GMP and have informed the effectiveness evaluation under Article 16 of the Convention.

The present (third) monitoring report synthesizes information from the first, the second, and the third phase of the global monitoring plan and presents the current findings on POPs concentrations in the CEE Region. While the first and second monitoring reports, presented at the fourth and seventh meeting of the Conference of the Parties respectively, provided information as to the changes in concentrations of the chemicals initially listed in the Convention, as well as baseline information on some of the newly listed POPs, this third report builds on the increasing information base of POPs monitoring data and provides a further in-depth assessment of the changes measured over time in POPs concentrations, including time trends where available, as well as recent baseline information on the more recently listed and or candidate POPs.

At its sixth meeting in May 2013, the Conference of the Parties, by decision SC-6/23 on the global monitoring plan for effectiveness evaluation, adopted the amended global monitoring plan for persistent organic pollutants (UNEP/POPS/COP.6/INF/31/Add.1) and the amended implementation plan for the GMP (UNEP/POPS/COP.6/INF/31/Add.2).

At its seventh meeting held in May 2015, the Conference of the Parties, by decision SC-7/25, welcomed the second regional monitoring reports, and, at its eighth meeting held in May 2017, by decision SC-8/19, it welcomed the second global monitoring report which marked the end of the second phase of implementation of the GMP. COP-8 requested the Secretariat to continue to support the work on the GMP to provide relevant input to the process of effectiveness evaluation under Article 16 of the Stockholm Convention and ensure sustainability of POPs monitoring toward the third GMP phase.

Monitoring activities have been ongoing in the five UN regions to support POPs monitoring data generation for the third GMP phase. The global coordination group met four times over the period 2015-2018 in order to oversee and guide implementation of the third phase of the global monitoring plan, with particular emphasis on addressing the sampling and analysis of the newly listed POPs, harmonizing data collection, storage and handling, addressing the needs for ensuring sustainability of ongoing monitoring activities and for further capacity strengthening to fill the existing data gaps, as well as improving data comparability within and across monitoring programmes.

Long term viability of existing monitoring programmes (air and human biomonitoring) is essential to ensure that changes in concentrations over time can be investigated. National air monitoring activities having contributed data to the first and second monitoring reports continued during the third phase, and new programmes have been identified to support the development of the third reports. Likewise, the continued operation of global and regional air monitoring programmes organized through strategic partnerships with the RECETOX (MONET programme), Environment and Climate Change (GAPS programme) and EMEP activities were a major pillar in the third phase. The implementation of the UNEP/WHO human milk survey is another important pillar of the global monitoring plan, providing useful long-term results showing how human exposure to POPs changed over time as measures are implemented to enforce the Convention.

Enhanced comparability within and across monitoring programmes to evaluate changes in levels over time and the regional and global transport of POPs were equally important milestones. QA/QC practices have been and continue to be essential for ensuring comparability, along with inter-laboratory exercises and intercalibration studies. Efforts continue to be directed at ensuring comparability within and across programmes, providing for evaluation of changes in concentrations of POPs over time and enabling regional comparisons.

The electronic database and visualization platform, GMP Data Warehouse has been made operational during the second GMP phase, supporting the regional organization groups in the work for the assembling, processing, storing and presentation of monitoring data. The global monitoring plan data warehouse also constitutes a publicly available repository of valuable information that can serve as a useful resource for policy makers and researchers worldwide. The data warehouse was further enhanced and kept up-to-date to provide on-line access to the GMP monitoring data and enable data collection and processing during the third GMP phase and support the development of the third monitoring reports.

Furthermore, the process for updating the GMP guidance document has continued; information relevant to the POPs listed more recently in annexes to the Convention and on the chemicals recommended for listing or in the process of review by the POPs Review Committee has been included in the guidance. The Guidance on the Global Monitoring Plan for Persistent Organic Pollutants has been streamlined and updated in 2019 (UNEP/POPS/COP.9/INF/36) and provided a useful basis as the reference document for POPs monitoring in the third phase of the GMP, as well as for harmonized data collection, storage and handling shown in this report.

2 DESCRIPTION OF THE REGION

The Central and Eastern Europe covers 23 countries of the Central and Eastern Europe, two additional countries of the Central Asia (Kazakhstan and Kyrgyzstan) were also included to this regional report, as agreed in discussions between the relevant Regional Organization Groups of CEE and Asia Pacific due to their similar pattern of production and use of POPs, geographical and language proximity to the CEE region. Thus, this regional report covers 25 countries.

2.1. Geography

The region under examination spreads over almost 23 500 000 km^2 is populated by 402 800 000 inhabitants. The boundaries of the studied territory are roughly defined by 12 °E (Czech Republic), Chukhotka (170 °W), North land (82 °N) and Armenia (38 °N). The territory covers 25 countries.

Wide lowlands as well as highlands and mountains can be found within the studied region. In the western part of the region, the Carpathians and mountains of the Balkan Peninsula are the most important mountain systems. Farther to the east, spacious East-European Plain is situated, which is by the north-to-south range of the Ural Mountains separated from equally wide West Siberian Plain extending up to the Yenisei River. Farther to the east, between Yenisei and Lena Rivers, the Central Siberian Plateau is spreading out. Eastern part of Siberia is mostly mountainous with several mountain ranges (e.g. Verkhoyansk Range) and some active volcanoes in the Kamchatka Peninsula (e.g. Klyuchevskaya volcano). Major part of Central Asia holds the Kazakh Steppe (or Kazakh Plain) and the Kara Kum and Kyzyl Kum Deserts. In the southern part of the region, there are the highest mountain systems - Caucasus (Mt. Elbrus 5 642 m), Pamir Mountains (Ismoil Somoni Peak 7 495 m asl), Tian Shan (Jengish Chokusu 7 439 m), Altai Mountains, Sayan Mountains and other mountain ranges in southern part of Siberia.

2.2. Hydrology

Western part of the studied region belongs to Atlantic Ocean drainage area with these main rivers: Danube and Dnieper Rivers flowing to the Mediterranean or Black Sea and Elbe, Oder and Vistula Rivers drifting towards the German Ocean or Baltic Sea. Great part of the region is drained away to the Arctic Ocean – major part of Siberia, where the south-to-north flow direction is typical (with large streams of Lena, Yenisei and Ob-Irtysh), and northern part of European Russia. Eastern part of the region belongs to the Pacific Ocean drainage area (Amur River).

A significant part of the region has no drainage to any ocean, especially area drained away by Volga River to the Caspian Sea and Central Asia from where water is led away by Amu Darya and Syr Darya Rivers to the Aral Sea (its drying-out is great ecological problem in this region, with significant economic consequences) and by some other rivers to the Lake Balkhash and Lake Yssyk Köl.

Last but not least, Lake Baikal – the world's deepest, purest and most capacious freshwater lake (it contains over one fifth of the world's fresh surface water) is crucially important; other European lakes, especially Lake Lagoda and Lake Onega, are also significant. Large water reservoirs in the region represented by dam system on Volga, Kama, Dnieper, and on upper streams of Siberian rivers are of major (economic) importance.

2.3. Climate

From climatic point of view, the studied region belongs to following climatic zones: arctic (the northernmost part along the Arctic Ocean), sub arctic (reaching c. 60 °N in European part and c. 55 °N at Lake Baikal), temperate and in the southernmost part rarely also subtropical (Mediterranean coast of the Balkan Peninsula, south of Caucasus and south of Central Asia). Along eastern Asian coast, subarctic zone stretches more to the south due to cooling effect of the cold Oyashio Current. Southern part of East-Asian coast (round about Amur River and Sakhalin Island) is under influence of monsoon of temperate zone, which is expressed especially in winter season as a dry airflow from land to ocean and is linked to the semi-permanent Siberian High. Concerning precipitation, most part of studied region is semi- humid to dry (the driest are Central Asia and Central and Eastern Siberia), only the westernmost part of temperate zone could be classified as prevalent humid. Due to great surface extent of Eurasian continent, for large part of the studied region continental character of climate with the wide annual temperature range (very cold winter and hot summer) and unbalanced annual course of precipitation with remarkable summer maximum is typical.

2.4. Soils

In the northernmost part alongshore the Arctic Ocean and in major part of the Kamchatka Peninsula, a range of arctic and tundra type soils (lithosols) is situated. More southwards, a zone with prevailing occurrence of podzolic character soils is spreading out to large areas – whole Central and Eastern Siberia, only to Amur River territory stretches belt of cambisols. Eastward from upper stream of Yenisei River, podzolic soils verge into a compact zone of chernozems which is stretching to east as far as to lower stream of Dnieper River and to Caucasus region and chernozems also can be found along Danube River (up to Hungary). In Central Asia and in Europe southwards from c. 50°N, cambisols and kastanozems are prevailing. In European part north from the Arctic Circle, in Western Siberia more southwards (c. to 65–60°N) and in whole Central and Eastern Siberia, deep permafrost is extended (in the coldest region of Yana River basin, permafrost reaches 1,493 m deep).

2.5. Vegetation (natural)

Natural vegetation (not affected by human activity) in the studied territory (CEE region) can be classified as follows: the northernmost parts are occupied by tundra which occurs also in the highest parts of Siberian and central-Asian mountain ranges (so-called mountain tundra). Major part of the studied region is occupied by a wide zone of taiga (boreal coniferous forest), whereas so-called mountain taiga could be found also in the highest locations of the Carpathian Mountains. In southern part of Western and Central Siberia, taiga verge into a belt of forest-steppe and steppe spreading westwards (southwestwards) up to the Caucasus and along northern coast of the Black Sea. In Central Asia and along the Caspian Sea, semi-deserts and especially in Aral Sea drainage basin spacious deserts (Kara Kum and Kyzyl Kum) are situated. Only around lower stream of Amur River (under influence of monsoon) alternately-moist leafy forests reach. In Europe, taiga verges directly into a belt of leafy forests of temperate zone. Alongshore the Mediterranean Sea and at the Black Sea in Caucasian area, subtropical forests and shrubbery represent natural vegetation.

3 ORGANIZATION OF REGIONAL IMPLEMENTATION

This chapter summarizes information on the preparation of the third regional report including **overarching organizational strategy** for implementation of the Global Monitoring Plan, responsible entities and also the regional strategy aiming at the generation of the arrangements to provide comparable monitoring information on the presence of the chemicals listed in Annexes A, B and C of the Convention, as well as their regional and global environmental transport.

This chapter also covers the full **review of POPs monitoring activities** at continental/regional and national levels as well as information gathering strategy (**regional strategy**) and criteria adopted by the CEE region.

3.1. Organizational Framework for POPs monitoring

The Global Monitoring Plan under the Stockholm Convention was adopted at COP2 in 2005 with the following objective implementing requirements of the Article 16 of the Convention:

Provide a harmonized organizational framework for the collection of comparable monitoring data on the presence of the POPs listed in Annexes A, B and C of the Convention in order to identify trends in levels over time as well as to provide information on their regional and global environmental transport.

The organizational framework consists of the following pillars:

Expert groups responsible for coordinating the activities at global and regional levels - Global Coordination Group (15 members, 3 per region, oversee global monitoring activities) and five Regional Organization Groups (ROG). Each UN region has one organization group consisting of 6 members that oversee and coordinate monitoring activities and are responsible for the preparation of regional monitoring reports including the present report.

The second pillar is **technical guidance document** that is continuously updated to gather current expert knowledge on POPs data collection including selection of core matrices, sampling, sample processing, chemical analyses, statistical considerations as well as storage of data on POPs and their reporting.

The third pillar is the frequency and scope of preparing the regional reports that has been set to six-year intervals (2008, 2014 and 2020, respectively) by the **GMP Implementation Plan**. The scope of the regional report is gradually expanding and covers all POPs listed in the Stockholm Convention Annexes, but the main focus should be on the core media - ambient air, human tissues (human breast milk or blood), and water for hydrophilic POPs.

The following experts are members of the **Regional Organization Group** in the CEE region who were responsible for preparing and finalizing of the present regional monitoring report:

Ms. Kateřina Šebková (Czech Republic) - regional coordinator
Ms. Anahit Aleksandryan (Armenia)
Mr. Trajce Stafilov (North Macedonia)
Ms. Anna Cumanova (Moldova)
Ms. Zarema Amirova (Russian Federation).
The replacing member (for Bulgaria) is to be identified from among the EU part of the region.

Global Coordination Group, GCG members from the CEE region: Ms. Kateřina Šebková (regional coordinator), Mr. Trajce Stafilov, Ms. Zarema Amirova

In 2018, the CEE ROG agreed that Czech Republic will continue to act as the regional coordinator, supported by the Stockholm Convention Regional Centre in the Czech Republic hosted at RECETOX.

ROG agreed on division of work in communication with the region:

Armenia	**Czech Republic**	**North Macedonia**	**Moldova**	**Russian Federation**	**new CEE-EU member replacing Bulgaria**
Armenia Georgia Kyrgyzstan	six CEE-EU countries out of the following: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia	Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia	Azerbaijan Belarus Moldova Ukraine	Russian Federation Kazakhstan	five CEE-EU countries (5)

Monitoring activities have been ongoing in the five UN regions to support POPs monitoring data generation for the third GMP phase and third report. The global coordination group met four times over the period 2015-2018 in order to oversee and guide implementation of the third phase of the global monitoring plan, with particular emphasis on addressing the sampling and analysis of the newly listed POPs, harmonizing data collection, storage and handling, addressing the needs for ensuring sustainability of ongoing monitoring activities and for further capacity strengthening to fill the existing data gaps, as well as improving data comparability within and across monitoring programmes.

3.2. Regional Strategy

On the basis of the arrangements leading to the first monitoring report and agreements stemming from the regional strategy described below, the CEE ROG and its consultants from the Stockholm Convention Regional Centre in the Czech Republic took steps to prepare this third report. The text below describes activities undertaken between end of 2015 and October 2020.

The CEE regional strategy on POPs monitoring activities was prepared in the joint meeting of the ROGs and GCG organized in Brno, Czech Republic 30 May - 1 June 2018. It included monitoring arrangements and timeline for completion of the third regional monitoring reports for submission at COP-10 (2021).

The strategy also comprises the division of responsibilities for communication with countries shown in section 3.1, organization and planning of coordination activities, the strategy on how the information should be received / used for the report, the arrangements for the drafting team and the sequence/timetable for preparing the report, and identification of the areas where financial support from the Secretariat will be needed during the report drafting.

CEE Regional Strategy as adopted in 2018:

- identify changes in existing POPs monitoring programme(s) and new activities in core media through SC NFPs via a letter and questionnaire; the region will also contact countries of Central Asia that were included in the previous CEE regional report - in particular Kazakhstan and Kyrgyzstan which cooperated with the regional group closely in the past.

- verify capacity of POPs laboratories in the region via questionnaire
- format for data submission: same as in the GMP DWH - data reporting templates, data should go to GMP DWH as soon as they are ready
- evaluation of readily available data criteria: in addition to established ongoing international POP monitoring program (MONET, GAPS, AQUA-GAPS, EMEP database, WHO-UNEP milk database + reports under the Water Framework Directive) - baseline available and time trends observed in some cases; national activities collecting POPs data will be evaluated and used with the aim to improve regional coverage, but without compromising data quality. Preference is given to those where is a potential to see time trends and where procedures of sampling and data analyses are known and traceable. ROG agreed with the collection of all relevant POPs including new ones, preference is given to core media (air, human tissues and water for PFOS). Data for other media should only be included for the most relevant POPs (with preference to new POPs).
- data handling: ROG agreed with the continuous use of the GMP data warehouse for data collection, handling, and management in the CEEs region, will add data from 2014-2019 where available and try to fill gaps in previous data.

There was no regional meeting during the third phase that would solely focus on the regional monitoring activities, apart from brief exchanges of information provided by the ROG coordinator in the CEE regional consultation meetings in spring 2017 and 2019 in preparation prior COP8 and COP9.

Information gathering strategy to prepare third report:

The following activities were performed by the ROG to inform countries in the region about the need to gather information and collection of additional data, where available:

1) Regional coordinator prepared an official letter in English with all relevant information concerning the GMP III (third round of POPs data gathering) to the responsible ministries and official contact and focal points including the two countries of the Central Asia and asked therein for the persons responsible for the reporting of national POPs data and other relevant information to be provide to CEE ROG as soon as possible. The letter was accompanied by a questionnaire that collected structured information (see point 2 below). Response to the letter was to be provided to ROG members by May 2019.

2) Regional coordinator prepared the questionnaire regarding ongoing POPs monitoring activities at the national level and on existence of POPs analyzing laboratories. Letter was discussed with ROG members in early 2019 and then sent to all countries in the region (both national focal points and official contact points). Responses were sought by May 2019.

3) On the basis of the questionnaire, the ROG contacted data providers in the region: necessary in 2019 until March 2020 (relevant ROG members and then RECETOX GMP DWH team) to ensure that all POPs data were transferred to GMP. The transfer was delayed, and some data were only received by end of 2020.

4) The region wished to have at least one face-to-face drafting meeting of ROG CEE in 2020 (either to finalize the draft or incorporate comments received from CEE countries), but the epidemiological situation did not allow that and all consultations were held online (July 2020, autumn 2020).

5) The ROG also confirmed the drafting team of experts beyond the Regional Organization Group, report modalities and timeline as follows:

Report modalities

Report will be based on previous reports, but structure to be used is to mirror the template prepared by the BRS secretariat as updated.

Region will use data outputs (visualization from GMP DWH - maps, charts, tables) to illustrate trends, data availability, baseline and/or summary information per matrix.

Report will be prepared in English only.

Timeline (as updated during 2020 due to the global epidemiological situation)

- June 2018 - letter by CEE ROG asking for new information and to collect data for updates
- until end 2019 - time for response by CEE Parties to ROG with new information and all data for updates
- until June 2020 - data transfer to GMP DWH console
- until October 2020 – drafting group develops first version of the CEE regional report
- November-December 2020 - input from ROG to the report and development of the draft for consultations by CEE countries
- January 2021 - report consulted with countries in the region (electronically).
- February 2021 - finalization of the report on the basis of comments received from the region
- March 2021 - submission of the report to the Stockholm Convention Secretariat.

3.3. POPs Monitoring programs in the CEE region and responsible institutions

Historically, there are several POPs monitoring programs in the CEE region. The oldest one is POPs air monitoring established under the Protocol on POPs of the Long-Range Transboundary Air Pollution. Objective of the Convention/Protocol is to control, reduce or eliminate POPs discharge, emission and release into atmosphere. Monitoring activities are usually carried out by national/governmental authorities such as Hydrometeorological or Environmental institutes responsible also for reporting generated data, including the international reporting to European Environmental Agency or to EBAS database. For details see part 4.1.3, EMEP programme.

The establishment of the Global Monitoring Plan has prompted development of new research activities targeting POPs monitoring in ambient air by using passive sampling. MONET Network organized by the Masaryk University, Czech Republic and GAPS Network organized by the Environment and Climate Change Canada have been put in place. POPs monitoring activities are carried out in collaboration with local partners on sampling sites in the CEE countries, but except the sampler exposure and logistics, all other steps are carried out by the responsible institutions. Details of both programmes are provided in chapter 4.1.1.

Human biomonitoring is not organized regionally, but rather globally - in a UNEP/WHO coordinated human milk survey. Details on this important and fully harmonized POPs monitoring activity are provided in chapter 4.1.2.

National activities on POPs monitoring have also been established and research activities were carried out. The lead is the Czech Republic with the countrywide monitoring of various environmental compartments. Lot of research related to the human exposure has been also performed in the Slovak Republic, Poland, Croatia, Hungary, Slovenia and Estonia (Bipro, 2004). Other countries have limited their POPs monitoring activities to specific media and specific chemicals (i.e. soil and pesticides) - Soil is being monitored in Bulgaria, Czech Republic, Moldova, Montenegro, Poland, Serbia and Slovakia. Similarly, in many countries of the region, POPs are monitored in surface waters and sediments of the main water bodies (lakes, reservoirs, rivers), in Bulgaria and the Czech Republic also in ground water, some countries monitor POPs in precipitation (Czech Republic, Moldova). These monitoring programs are mainly focused on OCPs, PCBs, in some cases also on PAHs.

Further information is also revealed through questionnaires as shown in Annex 1 to this report.

In addition, new information was provided on activities in the Russian Federation, where an interdepartmental working group on coordination of SC implementation (IWG) was recently established by the Ministry of Natural Resources and Ecology. While there is no regular state network for POPs monitoring in Russia, a retrospective assessment of some 1995-2018 POPs data is available. Future activities will include: monitoring of POPs in the environment, Roshydromet (2021 - 2028), biomonitoring (human population), Regional goverments (2017-2020), Rospotrebnadzor / Ministry of Health (2021 - 2028), monitoring of PCB (UNIDO), the Rospotrebnadzor / FASO Russia (2017-2020) and local programs of POPs in biological tissues of urban populations: Perm (2006-2014), Ufa (1992-2015), Chapaevsk (2008), AMAP activities, and the federal program "Baikal" (2012-2020).

Moreover, additional/newer harmonized POPs monitoring activities in Europe have a potential to contribute data for next GMP phase. These include the Horizon 2020 ERA-Planet project supporting the,GOS4POPs Initiative of the GEO, passive monitoring of surface waters through the AQUA-GAPS network organized by RECETOX. biomonitoring data obtained through the Horizon 2020 HBM4EU project and numerous longitudinal cohort studies (e.g. CELSPAC, TNG, and HAPIEE).

3.4. Strategy for using information from existing programmes

The regional strategy defined in 2018 set that the regional report will use all data from previous reports that comply with data quality and are available in the format (concentration levels and metadata) that can be transferred to GMP DWH. Priority will be given to establishment of trends and thus adding new (2014-2019) data on POPs in core matrices. This includes reporting of new activities as well updating earlier datasets provided by the following programmes:

a) Existing international and regional programs and activities (MONET, GAPS, AQUA-GAPS, EMEP database, WHO-UNEP milk database + reports under the EU Water Framework Directive) - baselines are available and time trends observed for some POPs. ROG agreed to collect information on all POPs including new ones. It is expected that following programs will contribute data (on the basis of previous reports and known activities): MONET Europe (air), GAPS Network (air), EMEP (air), UNEP/WHO milk survey (human milk) and Joint Danube Survey, NORMAN association (water).

b) Existing national programs and activities - national activities collecting POPs data will be evaluated and available data used with the aim to improve regional coverage, but without compromising data quality. Preference is given to those where is a potential to see time trends and where procedures of sampling and data analyses are known and traceable. It is expected (on the basis of previous activities and POPs data reported in the first and second regional report) that the following national activities will contribute to this report: Integrated monitoring Košetice, Czech Republic (ambient air, active sampling), MONET CZ (ambient air, passive sampling) and national human bio monitoring survey, Czech Republic (human exposure).

c) National or regional arrangements and activities including research initiated to address regional data gaps.
d) The region will try to fill gaps (length of time series but also geographical coverage) in previous data by contacting individual data owners by responsible ROG members.
e) ROG agreed with the collection of all relevant POPs including new ones, preference is given to core media (air, human tissues and water for PFOS). Data for other media should only be included for the most relevant POPs (with preference to new POPs).
f) The region wishes also to screen relevant information from National Implementation Plans.

4 METHODS FOR SAMPLING, ANALYSIS AND HANDLING OF DATA

This chapter provides overview of POPs monitoring programmes delivering representative regional data from core matrices[4] to this report. Details of the programs - arrangements, sampling, analyses, data handling are described in greater detail in Chapters 4.1.1., 4.1.2. and 4.1.3. Results of monitoring activities - POP levels and trends - are provided in Chapter 5.

Sampling, analysis and data management procedures are instrumental arrangements to produce quality reports. Global analysis of the first regional reports[5] revealed that to allow maximum comparability, sampling, data handling and data analyses need to be undertaken in the uniform manner, structure and with globally agreed standards, both retrospectively (where possible), but most importantly towards the future. Any changes in the methodology need to capture also previous data. For the above, the CEE region therefore fully supported development and use of the global electronic data collection system with a strict coding of data format, and a range of metadata required. Moreover, the CEE region continues using standard/validated methodologies for sampling, analysis and data handling, so that maximum comparability of collected information is ensured.

All relevant available representative data for POPs levels in the CEE region are stored in the GMP Data Warehouse in the required format (annually aggregated), covering the maximum time span and diversity (range of chemicals) of available representative data. Though access to this instrument was restricted to experts only in the preparatory phase of this report, the information will be publicly available also in the electronic format (www.pops-gmp.org/visualization) once the report is finalized.

Nevertheless, the CEE region decided to share available monitoring information with its stakeholders continuously. More detailed and gradually updated information on levels of POPs collected in the CEE region is also publicly accessible and permanently available online through the GENASIS database (www.genasis.cz, the Global Environmental Assessment Information System) operated by the RECETOX Centre, a host of the Stockholm Convention Regional Centre in the Czech Republic.

4.1 Strategy for gathering new information

On the basis of the arrangements leading to the first and second regional monitoring report and agreements stemming from the regional strategy to collect information, the CEE ROG

[4] Considering the global dimension of the Global Monitoring Plan under the Stockholm Convention, the Conference of the Parties has chosen air, and human milk and/or blood as core matrices in 2007. They provide information on the sources and transport of POPs, and the levels of exposure in human populations. Water was added more recently due to specific properties of perfluorinated chemicals (PFOS) and their low levels in ambient air. More information is available in Global Monitoring Plan Guidance Document, 2013, chapters 2 and 4.

[5] Klánová J., Dušek L., Borůvková J., Hůlek R., Šebková K., Gregor J., Jarkovský J., Kohút L., Hřebíček J., Holoubek I., The initial analysis of the Global Monitoring Plan (GMP) reports and a detailed proposal to develop an interactive on-line data storage, handling, and presentation module for the GMP in the framework of the GENASIS database and risk assessment tool. Masaryk University, Brno, Czech Republic, 2012.

continues to use the support of the Stockholm Convention Regional Centre in the Czech Republic and its infrastructure for monitoring activities and data handling, in particular through the GENASIS database (www.genasis.cz).

In addition, since early 2009 the ROG members took steps to extend strategic partnerships in support of POPs monitoring in the CEE region. The steps were initiated by the RECETOX Centre and agreed by the European experts in April 2009 in Sankt Petersburg (EMEP Task Force meeting). The outcome of the meeting was agreement to establish a pan-European passive sampling network MONET Europe to support a continental collection of information (WEOG+CEE UN regions) in a harmonized monitoring network that started operating in January 2009 (based on the CEE pilot carried out since 2003). Details are provided in chapter 4.1.1 below.

It has embedded many sites of the former MONET-CEE network, and added new ones, in particular in the western part of the European continent. It is the only monitoring activity that is undertaken in Europe as a whole and this activity continuously produces harmonized, scientific, evidence based and comparable information in the whole continent.

Moreover, the CEE ROG has also taken steps to broaden cooperation with GAPS to get GAPS data from its sampling sites located in the Central and Eastern Europe into this report. In order to comprise EMEP activities taking place in the CEE region, the steps were taken to extract information and data collected through EMEP activities and place it in the EBAS database.

In terms of human tissues, the CEE ROG acknowledges work of the WHO and joint UNEP/WHO milk surveys as well as information that is provided through national biomonitoring programmes. Nevertheless, it is necessary to promote participation of countries in the region in the future UNEP/WHO surveys as data available for this region are relatively scarce. The ROG believes the Stockholm Convention Regional Centres in the CEE region may be used for supporting such measures/activities, in particularly through its longitudinal cohort studies taking place in the CEE countries.

For water, the CEE ROG agrees that it is necessary to adopt widely recognized methods and techniques as soon as practicable and introduce region-wide activities once a global decision is taken. In that regard, the RECETOX has been working on new passive samplers that could be used in water monitoring and MONET Acqua network was piloted in 2018 in several countries. However, the samplers used were not suitable for sampling perfluorinated chemicals. Further development is on-going and we hope that for the next phase we would have such tool and network available. In addition, it will be beneficial to investigate further activities of International Commissions for Protection of Danube, Oder, Elbe or other Rivers in case they organize further joint surveys and their scope. Moreover, NORMAN association that provides data generated in aquatic environment to GMP DWH is also very active and has a database of useful information.

In addition, the CEE ROG emphasizes it is necessary to bridge gaps in knowledge – call upon academia and researchers for support in development of new and cost-effective monitoring and analytical techniques. The Stockholm Convention Regional Centre in the Czech Republic is one of such hubs that helps covering regional gaps as described below in the capacity building part.

Last but not least, in terms of data analyses, it may be necessary to prepare for a retrospective analyses of some samples collected in the past and long-term stored for that purpose. Introduction of a specimen banking would be important also in the CEE region. The Stockholm Convention Regional Centre has initiated steps to establish such a specimen bank and a new bio banking facility will be available for the CEE region since 2020.

Furthermore, the CEE ROG has also pursued a regional agreement that all relevant regional and national POPs data should be provided to and stored in the GENASIS Warehouse. CEE ROG members would facilitate process of contacting the national focal points and create a network of national monitoring experts to consult on development and activities ongoing in national programs or join forces for further activities. One such activity might be harmonization currently occurring at the EU level in terms of the pan European Human Biomonitoring Initiative that is also organizing alignment studies collecting human samples and analyzes them for some relevant POPs. Furthermore, the EU will further harmonize its activities leading to the risk assessment and management of chemicals in the EU Partnership (PARC) in 2022-2028. It is expected that some relevant chemicals such as PFAS, flame retardants or some other candidate (potential candidate) POPs will be also studied.

4.1.1 Programs/activities related to air monitoring

Ambient air was chosen as core matrix for POPs monitoring under the Stockholm Convention because it has a very short response time to changes in atmospheric emissions. This well-mixed environmental medium is also an entry point into food chains and a global transport medium. In addition, air data are required to validate atmospheric POPs transport models.
In line with the Guidance on the Global Monitoring Plan, there are two ways of sampling ambient air[6] - active air sampling and passive air sampling. Within the CEE GMP region there are existing programs using both active sampling and passive sampling techniques described below in greater detail. Overview of existing programmes monitoring POPs in ambient air in the CEE GMP region is provided in Table A1.

Table 1 Overview of existing programmes monitoring POPs in ambient air in the CEE including the information on data availability

Monitoring network	Matrix	First year	Last year	Number of parameters	Number of sites
AMAP	Air	2002	2009	35	1
Department of the Environment, Moscow	Air	2018	2019	1	1
EMEP	Air	2009	2010	31	2
Europe Air PUF	Air	2006	2006	22	13
GAPS	Air	2004	2014	51	3
GMP 1	Air	1994	2001	5	2
grant RAS	Air	2012	2014	8	7
Kosetice	Air	1996	2021	22	1
MONET	Air	2003	2021	69	75

6 Assessing the POPs levels and trends in each UN/GMP region, the Global monitoring plan (GMP) (UNEP, 2007) should strive for at least: 1) Three to five stations with active high-volume sampling devices; 2) A network of (10 to 15) passive air sampling stations arranged in a grid with spacing of approximately 20° x 20° for an enhancement of the geographical resolution.

Rosgidromet monitoring	Air	2013	2016	14	4

It has to be noted that for ambient air monitoring a relatively small number of international/regional programmes cover the whole CEE GMP region such as EMEP, MONET, and GAPS. Some of the monitoring activities are lasting for decades (since 1980s), however they cover a limited scope of Stockholm Convention chemicals as shown in table A2. Other air monitoring activities were only initiated simultaneously with the first data collection campaign (from 2006 onwards) or by the very end of that period (post-2008). Nevertheless, the long-term sustainability of both long-term and most recently established programmes remains crucial for the production of representative and comparable data in the region in the future. This fact is also valid for any future effectiveness evaluation of the implementation of the Stockholm Convention.
For ambient air monitoring, both active sampling and passive sampling techniques organized in the pan-European or global monitoring networks are used to generate data under the global monitoring plan in the CEE region.

The time range (sampling window) for the first monitoring report aiming at establishment of the initial baseline of POP levels in ambient air was set to 1998-2008, in line with Global Monitoring Plan Guidance Document. The second monitoring report built on findings from the first regional report and added more recent monitoring data until 2014, where available. Majority of air samples collected in 2013 and 2014 were still processed in laboratories at the time of writing the second report.
The current regional monitoring report provides regional scale monitoring results in three core matrices out of four; regional data for POP levels in ambient air span over 1996-2020, for human breast milk 1987-2019 and in water data cover 2007-2019 period. Human blood data are scarce and were only available in the first regional monitoring report.

MONET

Background and key message

Aside from long-term active air monitoring of POPs at Košetice (Czech Republic) since 1996, (*Dvorska, 2008; Kalina, 2017*) monitoring data outside of the WEOG region were much more limited prior to the Stockholm Convention. The first significant passive air monitoring campaign for POPs in CEE countries was organized within the EU FP5 project APOPSBAL and coordinated by RECETOX (Masaryk University, CZ) with aim to investigate the extent to which residents of the former Yugoslavia were exposed to elevated atmospheric POP levels following the Balkan wars. From 2003–2004, active and passive air sampling campaigns of POPs occurred at 34 sampling sites across Bosnia and Herzegovina, Croatia, and Serbia, (*Klánová, 2007b, 2007a*), as well as at 18 reference passive air sampling sites across the Czech Republic. These 18 Czech sampling sites formed the basis for the establishment of the MONET passive air sampling network, which continues to monitor the long-term atmospheric burden of POPs across the Czech Republic to date (MONETCZ). (*Kalina, 2018*). Following the conclusion of the APOPSBAL campaign, routine MONETCZ passive sampling expanded into an additional 18 CEE countries in 2006–2008 (MONETCEEC), (*Pribylova et al., 2012*) and then expanded again into an additional 14 WEOG countries in 2009 (MONETEU) to generate consistent and comparable long-term air monitoring data for the entire continent.
It is the only monitoring activity that is undertaken in Europe as a whole and this activity continuously produces harmonized, scientific, evidence-based and comparable information in the whole continent. MONET is organized, financed, and operated by the RECETOX Centre in cooperation with a number of local staff at the sites.

The full network encompassed more than 50 sampling sites in 34 countries in 2009, since 2014 there were 31 sampling sites in 28 countries; and in 2018 there are 18 sites in CZ, and one in other 13 countries. The scope of the network also depends on the indispensable support and help provided by the local, site workers and institutions who are involved in sampling. Within CEE, these 14 countries are covered: Bulgaria, Croatia, Czech Republic (18), Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Russian Federation, Serbia, Slovakia, Slovenia, and Ukraine.

As of 2019, MONET is the largest POP monitoring network in Europe, with 32 long-term monitoring sites (all >7 years) in 27 countries across the continent (in addition to 18 other long-term monitoring sites just within the Czech Republic).

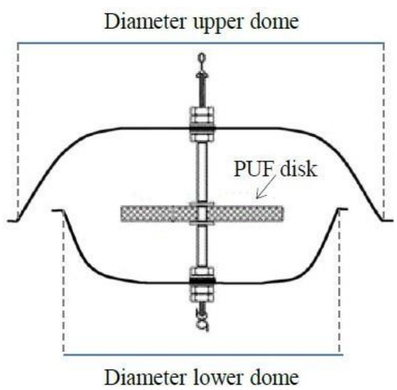
Aside from Fruška Gora (Serbia), Plateliai (Lithuania), and Zagreb (Croatia), all MONET sites included in the CEE region are located at EMEP air monitoring stations, including a station with long-term EMEP POP data (Košetice). As a result, the majority of sites are classified as background sites and are rural or remote (with the exception of the urban site in Zagreb and suburban site in Prague Libuš). For the Czech Republic only four sites located at Czech EMEP stations (Churáňov, Košetice, Prague Libuš, Svratouch) are used.

Sampling

MONET passive air samplers consist of polyurethane foam disks (15 cm diameter, 1.5 cm thick, density 0.030 g cm^{-3}, type N 3038; Gumotex Breclav, Czech Republic) housed in a protective chamber. The chamber is composed of two stainless steel bowls that protect the PUF disk from dry and wet deposition, as well as sunlight exposure, but still allow penetration of ambient air. MONET passive sampler design characteristics are listed in a table below.

Table 2: MONET passive sampler characteristics

PUF disk characteristics	
Volume (m^3)	2.64×10^{-4}
Effective film thickness (m)	5.67×10^{-3}
Density (g/m^3)	3.00×10^{4}
Surface area (m^2)	4.23×10^{-2}
Mass (g)	7.92
Sampler housing dimensions (cm)	
Diameter (upper dome)	28
Depth (upper dome)	8
Diameter (lower dome)	22
Depth (lower dome)	8



The sampling chambers were prewashed and solvent-rinsed with acetone prior to installation. All PUF disks were prewashed, cleaned (8 h extraction in acetone, followed by 8 h in dichloromethane, toluene or methanol; depending on the analytes), wrapped in two layers of aluminum foil, placed in zip-lock polyethylene bags and kept in a freezer prior to their deployment. Once installed at the sampling site, PUF disks were exposed for approximately 12 weeks (84 d). Field blanks were obtained by installing and then removing an additional PUF disk at all sampling sites. After sampling, the exposed PUF disks were again wrapped in two layers of aluminum foil, labeled, placed in zip-lock polyethylene bags and transported in a cooler (at 5 °C when possible) to the laboratory where they were kept in a freezer at –18 °C until analysis. All PUF disks were analyzed at the RECETOX Trace Analytical Laboratory in Brno, Czech Republic.

Samples were analyzed for the individual compounds and analytes outlined in Tables S3 and S4. The analytical methods described here are the current methods used for analysis of passive PUF samples collected under the MONET network since 2013. For analytical methods used in the initial MONET campaigns, refer to Klánová et al.[1] One notable change occurred, with the transition from GC-EI-MS/MS to GC-APCI-MS/MS for the analysis of the ‘other’ OCPs (Section 2.2.1d.) leading to significantly improved instrumental detection limits after 2012.

Chemicals

Across the MONET network, 16 of the currently listed Stockholm Convention POPs have been included in continuous routine monitoring 2008 or 2010 (depending on their listing: aldrin, chlordane, DDT, dieldrin, endrin, endosulfan, HBCDD, HCB, HCHs, heptachlor, mirex, PBDEs, PCBs, PCDDs, PCDFs, and PeCB.

Toxaphene, chlordecone, hexabromobiphenyl, PFOS, HCBD, pentachlorophenol are not monitored and PCNs and SCCPs were not yet implemented in this third phase.

Chemical analysis

After each exposure period (initially MONET passive samplers were deployed for 28 d intervals; as of 2010, they are instead deployed for 84 d), PUF disks were collected and shipped to RECETOX where they were analyzed in the Trace Analytical Laboratory and steps are described below:

Chemical extraction

All samples were spiked with surrogate internal standards before extraction: ^{13}Clabelled BDE 28, 47, 99, 100, 153, 154, 183 and 209 congeners; ^{13}CHxBB-153, ^{13}C-γ-HBCD, ^{13}Cdl-PCBs (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189), ^{13}CPCDD/F 17 homologues, ^{13}C8PFOA, and ^{13}C8PFOS. All ^{13}Clabelled standards were obtained from Wellington Laboratories Inc., Canada. For PCB and OCP analysis, the surrogate standards, PCB 30 and 185, were used (Absolute Standards Inc., USA). Three subsamples of each PUF disk were Soxhlet-extracted (Büchi B-811, Switzerland) in dichloromethane (DCM), toluene, and methanol, respectively. DCM extracts were split into two aliquots: 60% for the analysis of in-PCBs, ‘basic’ OCPs (DDT, HCB, HCH, PeCB), PBDEs, HBCD, and HxBB-153; 40% for the analysis of the ‘other’ OCPs (aldrin, chlordane, chlordecone, dieldrin, endosulfan, endrin, heptachlor, and mirex). Toluene extracts were used for the analysis of PCDD/Fs and dl-PCBs.

Clean-up of DCM extracts (in-PCBs, OCPs, PBDEs, HxBB153, and HBCD)

Each aliquot for in-PCB, ‘basic’ OCP, PBDE, HxBB-153, and HBCD analysis (60% of DCM extract) was cleaned on sulfuric acid modified silica columns eluted with 40 mL of a 1:1 mixture of *n*hexane:DCM. The eluate volume was reduced by a stream of nitrogen gas in a TurboVap II (Caliper LifeSciences, USA) concentrator unit and transferred into a vial, where

PCB 121 and ^{13}CBDE 77 and 138 were added as syringe standards prior to instrumental analysis.

Each aliquot for 'other' OCP analysis (40% of DCM extract) was cleaned on a silica column (5 g of silica, 0.063 – 0.200 mm, activated at 150°C for 12 hours, 10% deactivated with water) and 1 g Na_2SO_4. The sample was loaded and eluted with 5 mL *n*-hexane followed by 50 mL DCM. The eluate volume was reduced by a stream of nitrogen gas in a TurboVap II (Caliper LifeSciences, USA) concentrator unit and transferred into a vial, where PCB 121 was added as a syringe standard prior to instrumental analysis.

Clean-up and fractionation of toluene extracts (PCDD/Fs and dl-PCBs)
Each toluene extract for PCDD/F and dl-PCB analysis was cleaned on a sulfuric acid modified silica column (30% w/w), eluted with a 40 mL DCM/*n*-hexane mixture (1:1). Fractionation was achieved in a micro column (6 mm i.d) containing from bottom to top: 50 mg silica, 70 mg charcoal/silica (1:40), and 50 mg of silica gel. The column was prewashed with 5 mL of toluene, followed by 5 mL of a DCM/cyclohexane mixture (30%), then the sample was added and eluted with 9 mL of a DCM/cyclohexane mixture (30%) in Fraction #1 (mono-ortho dl-PCBs) and 40 mL of toluene in Fraction #2 (PCDD/Fs, non-ortho dl-PCBs). Each fraction was concentrated using stream of nitrogen gas in a TurboVap II (Caliper LifeSciences, USA) concentrator unit and transferred into a vial, where ^{13}C1,2,3,4TCDD and ^{13}CPCB 162 were added as syringe standards prior to instrumental analysis.

Instrumental Analysis in MONET
Indicator PCBs and 'basic' OCPs (DDT, HCB, HCH, PeCB)
Each DCM extract for in-PCBs, 'basic' OCPs, PBDEs, HxBB-153, and HBCDD was first analyzed for in-PCBs and 'basic' OCPs by gas chromatography tandem mass spectrometry (GCMS/MS) using an Agilent 7890A GC (Agilent, USA) equipped with a 60 m x 0.25 mm x 0.25 µm SGE-HT8 column (SGE, USA), coupled to an Agilent 7000B triple quadrupole MS operating in positive electron ionization (EI+) multiple reaction monitoring (MRM) mode. Samples were splitless injected at 280°C, with He as the carrier gas at a constant flow of 1.5 mL/min. The GC temperature program was 80 °C (1 min hold), ramp 15 °C/min to 180°C, and final ramp 5 °C/min to 300°C (5 min hold). Following analysis of the chlorinated compounds, the remaining extract was evaporated to dryness then reconstituted with 5 µL of acetone. The extract was vortexed and brought to a total volume of 250 µL with acetonitrile for further analysis of brominated compounds.

PBDEs and HxBB-153
Extracts were then analyzed for PBDEs and HxBB-153 by gas chromatography high-resolution mass spectrometry (GCHRMS) using an Agilent 7890A GC equipped with a 15 m x 0.25 mm x 0.10 µm RTX-1614 column (Restek, USA), coupled to a Waters AutoSpec Premier MS (Waters, UK) operating in EI+ selected ion monitoring (SIM) mode at a resolution of >10,000 and 35 eV electron energy; for BDE 209, the resolution was set to >5,000. Samples were splitless injected at 280 °C, with He as the carrier gas at a constant flow of 1 mL/min. The GC temperature program was 80 °C (1 min hold), ramp 20 °C/min to 250 °C, ramp 1.5 °C/min to 260 °C (2 min hold), and final ramp 25 °C/min to 320°C (4.5 min hold). Waters TargetLynx was used for data processing. After analysis of the chlorinated and brominated compounds, the remaining extract was solvent exchanged to acetonitrile, and the syringe standard ^{13}CγHBCD was added before final analysis.

HBCD

Extracts were finally analyzed for HBCD by high performance liquid chromatography mass spectrometry (HPLC-MS) using an Agilent 1100 HPLC equipped with a Phenomenex LUNA C18 end-capped column (100 × 2 mm, 3 µm particle size) maintained at 30 °C and a Phenomenex SecureGuard C18 pre-column, coupled to a tandem AB Sciex QTRAP 5500 MS (AB Sciex, Canada) operating in EI− MRM mode at 450°C, with N_2 as a nebulizer gas and an entrance potential of -4kV. The mobile phases for the gradient separation were a 1 mM solution of ammonium acetate in water at pH 4 (solution A) and a 1 mM solution of ammonium acetate in acetonitrile (solution B). The flow rate was 0.25 mL/min, and the injection volume was 10 µL. The linear gradient began at an initial A/B composition of 50:50 (v/v) and ran to 10:90 over 6 min, where it was held for 8 min.

'Other' OCPs (aldrin, chlordane, chlordecone, dieldrin, endosulfan, endrin, heptachlor, mirex)

Each DCM extract for 'other' OCPs was analysed by gas chromatography atmospheric pressure chemical ionization tandem mass spectrometry (GC-APCI-MS/MS) using an Agilent 7860A GC equipped with a 30 m x 0.25 mm x 0.25 µm Rxi-5Sil MS column (Restek, USA), coupled to a Waters Xevo TQ-S MS operating under dry source conditions (N_2 at 40 psi constant pressure) in MRM mode. Samples were splitless injected at 250°C, with He as the carrier gas at a constant flow of 1.5 mL/min. The GC temperature program was 90 °C (1 min hold), ramp 40 °C/min to 200 °C, ramp 2 °C/min to 240 °C, and final ramp 40 °C/min to 310 °C (5 min hold).

PCDD/Fs and dioxin-like PCBs (dl-PCBs)

Each toluene extract for PCDD/Fs and dl-PCBs was analyzed by 2xGC-HRMS using dual Thermo Scientific TRACE 1310 GCs (Thermo Fisher Scientific, USA) equipped with a 60 m × 0.25 mm × 0.25 µm Restek Rtx-Dioxin2 column (for PCDD/Fs) and a 60 m × 0.25 mm × 0.25 µm SGE HT8 column (for dl-PCBs), coupled to a Thermo Scientific DFS HRMS operating at a resolution of 10,000 (10% valley) and 45 eV electron energy. PCDD/F samples were splitless injected at 280 °C and dl-PCB samples were splitless injected at 260 °C, with He used as the carrier gas for both at a constant flow of 1.5 mL/min. The GC temperature program for PCDD/Fs was 120 °C (1.5 min hold), ramp 30 °C/min to 200 °C, ramp 3 °C/min to 300 °C (2.5 min hold), and final ramp 30 °C/min to 320 °C (20 min hold). The GC temperature program for dl-PCBs was 120 °C (1.5 min hold), ramp 30 °C/min to 200 °C, and final ramp 3 °C/min to 310 °C (10 min hold). Thermo Scientific TargetQuan 3 was used for data processing.

Analytical procedures (Derivation of air concentrations)

Concentrations of POPs in each PUF disk (pg/PUF) were converted to concentrations in air (pg/m3) using the standard GAPS template model for estimating effective air sampling volumes of passive PUF samplers. *Shoeib, 2002* Model input parameters specific to MONET samplers are listed above in the background part relative to this monitoring programme.

A more robust GAPS model for estimating effective passive air sampling volumes has recently been proposed, however, in its current state it could not be applied to all of the POPs included in this study. For now, the original GAPS model remains the standard global method for reporting passive air concentrations to the Stockholm Convention GMP.

Data Comparability: Quality Assurance / Quality Control

Unexposed PUF disks transported and processed alongside the other samples were used as field blanks. The concentrations in MONET–Africa field blanks were <5% for PBDEs (<20% for BDE 209), and below detection for all PCBs, OCPs, and PCDD/Fs. Field blanks were used to determine method detection limits (MDLs), based on the average + 3x the standard deviation of the field blanks. For compounds that were not detected in the field blanks, the instrument quantitation limits (LOQs) were determined as concentrations corresponding to a 9:1 signal to noise ratio. Laboratory method blanks were also analyzed with each sample set (one laboratory blank per 20 samples).
Method performance was tested prior to sample preparation and analysis using reference materials. Recoveries of in-PCBs and OCPs were monitored using PCB 30 and 185 recovery standards, with an average PCB 30 recovery of 70.0 ± 10.5% (min-max ranging 48.2–93.3%) and an average PCB 185 recovery of 87.4 ± 14.7% (min-max ranging 66.6–118.6%). PCB and OCP concentrations were not further adjusted for recoveries. Isotope dilution was used to quantify PBDEs, HxBB-153, HBCD, PCDD/Fs, dl-PCBs, PFOS and PFOA, thus the reported concentrations were inherently adjusted for recoveries.

Data storage
All MONET passive air sampling data are freely accessible online through the Genasis Database (Borůvková et al., 2015) hosted by RECETOX at Masaryk University in Brno, Czech Republic - www.genasis.cz Data managers transfer all information into the GMP DWH upon request of the CEE ROG.

Global Atmospheric Passive Sampling, GAPS
Background and key message
The Global Atmospheric Passive Sampling (GAPS) Network has been in operation since 2005 to address monitoring needs for listed POPs in air for the global monitoring plan (GMP) under the Stockholm Convention and to provide new information (surveillance) on emerging chemicals of interest to support domestic (Canadian) and international risk assessment. Passive air samplers (PAS), with polyurethane foam (PUF) disks as the sampling medium, are deployed for consecutive three-month periods at background, polar, rural, agricultural and urban sites, a total of 111 sites. Data for legacy POPs monitored under the GAPS network is available for the deployment years 2005, 2006, 2007, 2009, 2011 and 2014 in five United Nations Regional Groups[7].

Sampling
The methodology for the sample preparation, extraction and analysis are described in detail in previous publications *Pozo 2004, Pozo, 2006, Pozo, 2008*. In short, pre-cleaned polyurethane foam (PUF) disk samplers were deployed for three-month periods between the years 2005 – 2014 at 111 international sampling sites following the protocol of the GAPS network. The coefficient of variance for duplicate PUF-PAS field samples was previously determined and reported as <35% by *Gouin, 2005*.

Chemicals: Data is available for the deployment years 2005, 2006, 2007, 2009, 2011 and 2014 for PCB 28/52/101/118/138/153/180, Endosulfan I/II/SO4, α- /γ-HCH, cis-/trans-Chlordane, trans-Nonachlor, Heptachlor, Heptachlor epoxide and Dieldrin.

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[7] 46 sites are located in Western European and Others Group (WEOG), 28 sites in Latin American and Caribbean regional group (GRULAC), 25 sites in Asia-Pacific regional Group, 9 sites in African regional group and 3 sites in Eastern European regional group (CEE)

Analytical procedures

Samples were spiked with surrogate standard before extraction. Details on recoveries margins are reported elsewhere *Pozo 2008*, *Pozo 2006*, *Rauert 2018*. Samples for the years 2005-2007 were Soxhlet-extracted with petroleum ether *Pozo 2004, 2006, 2008*. Samples for the years 2009-2014 were extracted with petroleum ether / acetone using accelerated solvent extraction *Rauert, 2016 and Rauert 2018*. Extracts were concentrated using rotary evaporation and passed through an anhydrous sodium sulfate column. Extracts were analyzed for PCB 28/52/101/118/138/153/180, Endosulfan I/II/SO4, α- /γ-HCH, cis-/trans-Chlordane, trans-Nonachlor, Heptachlor, Heptachlor epoxide and Dieldrin using gas-chromatography – mass-spectrometry (GC-MS) for samples 2005-2007 and GC-MS-MS for samples 2009-2011. Details on the GC-MS programs are provided in *Pozo 2008, Pozo 2006, Rauert 2018*.

Data Comparability: Quality Assurance / Quality Control

The chemical levels in the samples were transformed to concentrations in air by using sample and compound specific effective air volumes. Effective air volumes were calculated following the method described by *Shoeib, 2002* with site specific sampling rates estimated from the model by *Herkert, 2016 and Herkert 2018*.

Field blanks were deployed at all sites for all sampling years. Method detection limits (MDL) were estimated for each sampling year from the average of the field blanks plus 3 times the standard deviation of the field blanks. All samples were blank corrected.

Data storage

Data from GAPS Network are stored in an electronic database GAPS data browser that is for authorized users only. It is a sister database to GENASIS (www.genasis.cz).

European Monitoring and Evaluation Programme (EMEP)

Key message

The co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe (inofficially known as 'European Monitoring and Evaluation Programme' = EMEP) is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) for international co-operation to solve transboundary air pollution problems. EMEP provides scientific evidence-based information in relation to levels of chemicals in ambient air since 1988. It operates on multiple sampling sites and formerly covered chemicals causing eutrophication and acidification. Over the years, the range of chemicals covered broadened to ozone, volatile organic compounds, and since 1999 also to selected polyaromatic hydrocarbons, persistent organic pollutants, and heavy metals.

Background

This programme uses active sampling by high volume devices as described below. Figure 1 provides overview of relevant sampling sites used in EMEP programme in the CEE region.

Sampling

The EMEP programme uses active sampling by high volume devices. High volume ambient air samplers PS-1 (Graseby-Andersen, USA, flow: 12-18 m3 h-1, volume: 250-400 m3 per 24 h) and two types of adsorbents were used: a Whatmann quartz filter (QF) (fraction dae < 50μm) for collection of particles, and a polyurethane foam (PUF) disk (Gumotex Břeclav, density 0.03 gcm-3) for collection of the gaseous phase. PUF filters were cleaned before the campaign by extraction with acetone and dichloromethane in a Soxtec extractor (8 hours extraction in acetone and 8 hours in dichloromethane). The duration of sampling was 24 hours; quartz filter field blanks and PUF disks field blanks were collected each month (*Holoubek et al., 2007a*).

Chemicals

16 US EPA polycyclic aromatic hydrocarbons (PAHs), 7 indicator polychlorinated biphenyls (PCBs: IUPAC congeners number 28, 52, 101, 118, 153, 138, 180), organochlorine pesticides (OCPs) - p,p'- DDT, p,p'-DDD, and p,p'-DDE, α-, β-, γ-, δ-hexachlorocyclohexane (HCH), hexachlorobenzene (HCB), and pentachlorobenzene are analyzed on regular basis.

Data storage

All reported data to EMEP are stored in the EBAS database. EBAS is a database hosting observation data of atmospheric chemical composition and physical properties. EBAS hosts data submitted by data originators in support of a number of national and international programs ranging from monitoring activities to research projects. EBAS is developed and operated by the Norwegian Institute for Air Research (NILU).

4.1.2 Programs/activities related to human tissues (milk and blood)

4.1.2.1 Programs/activities related to human milk

WHO survey of Human Milk for Persistent Organic Pollutants

Background

Comprehensive human milk monitoring programmes have been initiated by WHO. Early WHO surveys performed mainly in Europe and North America in 1987-1989 and 1992-1993 exclusively focused on PCB, PCDD and PCDF. In 2001-2003, a larger global survey was implemented, covering the twelve POP compounds initially listed in the Stockholm Convention. Following the ratification of the Stockholm Convention, WHO and UNEP started their collaboration, and four additional global surveys were completed in 2004-2007, 2008-2011, 2012-2015, 2017-2019. These studies significantly enlarged the geographical scope providing representative results for all regions of the globe and currently cover all 30 POPs listed in the Stockholm Convention.

Guidance

Under WHO, a protocol has been developed for sampling and sample preparation methodology for exposure studies of Persistent Organic Pollutants (Malisch & Moy, 2006; WHO, 2007). This protocol forms the basis for the human milk component of the GMP (UNEP, 2017a). An online version of the protocol is available at http://www.who.int/foodsafety/chem/POPprotocol.pdf (see also Annex 3 in the GMP guidance).

The main objectives of these studies are: 1) to produce reliable and comparable data on concentrations of POPs in human milk for further improvement of health risk assessment in infants, 2) to provide an overview of exposure levels in various countries and geographical areas and to allow to draw conclusions on priorities for further follow-up in a country / region, 3) to determine trends in exposure levels.

Sampling

In order to promote reliability and comparability of results, samples are collected by the participating countries following a harmonized comprehensive protocol developed by WHO (WHO, 2007) and amended by UNEP (last amendment: see UNEP, 2017a). Participating countries are encouraged to adhere as closely as possible to the protocol, which provides guidance on the number and type of samples, selection of donors, collection, storage and pooling of samples, and shipping of samples to the reference laboratory. For all studies, the following criteria for selection of donating mothers are stringently applied:

- They should be first time mothers;
- They should be healthy;
- They should be exclusively breastfeeding one child (i.e., no twins).

In order to get statistically reliable data, an appropriate number of individual donors must be recruited to provide samples for the survey. As a first approximation, a minimum of 50 individual samples is recommended for each country. Equal aliquots of these individual samples are mixed to form a representative composite sample ("pooled sample"). The power of the survey can be increased by the inclusion of more than 50 individual samples and is encouraged. It is recommended to collect one representative individual sample per one million citizens. In particular, countries with populations greater than 50 million should include at least one additional participant per one million population over 50 million. Countries with populations well over 50 million (or with sufficient resources) are encouraged to prepare a second pooled sample (or more) if feasible.

QA/EC and data consistency / comparability

The representative pooled sample is analysed for the POPs listed in the Stockholm Convention by the reference laboratory. This approach has several advantages:

- The analysis of pooled human milk samples is far less expensive than the analysis of all individual samples;
- It is easier for each donor to provide the lower volume of milk required for pooled analyses. Therefore, in comparison to analysis of individual samples, much more sample amount is available allowing a more comprehensive analysis with lower limits of quantification;
- To ensure the reliability of exposure data and to improve comparability of analytical results from different laboratories, a reference laboratory was selected based on inter-laboratory quality assessment studies. To further ensure consistency in measurements, all pooled samples are analyzed by the WHO/UNEP reference laboratories using validated methods;
- Aliquots of the individual samples can be analysed for analytes of interest by laboratories selected by the National Coordinator.

This combination of selection of a statistically reliable number of individual samples, preparation of a representative composite sample and analysis of the pooled sample for the 28 POPs listed in the Stockholm Convention by the reference laboratory is a very cost-effective way to derive information on the relevance of certain POPs in certain regions in humans as end-point of releases of POPs and to follow time trends.

QA/QC and comparability of the data in the frame of the programme is ensured by centralized analysis of the pooled sample. The State Institute for Chemical and Veterinary Analysis of Food (Germany) has met all the criteria for analyses of lipophilic POPs in human milk and was selected as a reference laboratory for the WHO exposure studies (WHO 2000, Malisch and van Leeuwen 2002, 2003). It is also the EU Reference Laboratory for halogenated persistent organic pollutants (POPs) in feed and food (COMMISSION REGULATION (EU) 2018/192). Proteinophilic POPs (e.g., PFOS) are analyzed at the MTM laboratory at the University of Orebro, Sweden.

Analytical procedures
The procedures for the analysis of POPs in human milk are described in detail the GMP guidance document (UNEP/POPS/COP.9/INF/36), Chapter 5 Analytical methodology. Details regarding newly listed POPs can also be found in Chapter 4 Sampling and sampling preparation methodology, Section 4.2. addressing human milk as a sampling medium.

Benefit risk evaluation
Results of the WHO/UNEP Human Milk Survey for PCDDs, PCDFs, PCBs and DDTs were evaluated with particular focus on benefit–risk evaluation of breastfeeding (van den Berg, M. et al., 2017).

Data storage
Data are stored at the GMP data warehouse, available at www.pops-gmp.org.

4.1.3 Programs/activities related to water

PFOS in water is not currently monitored in any regional scale programme. A diverse and limited information exists from various sources (i.e. surface water, ground water) and through various activities (NORMAN Network of reference laboratories, research centres and related organizations for monitoring of emerging environmental substances) or Joint Danube Surveys (2009-2013 and 2019)undertaken by the Joint Research Centre of the European Commission in Ispra, Italy).
PFOS in water bodies of the CEE region are regularly monitored only in the EU countries of the region (it is required by the EU legislation since 2013, where Water Framework Directive amendment included PFOS to the priority substance list as priority hazardous substance[8]). Activities that focus on different range of water pollutants are carried through international commissions on protection of watercourses in Europe - Danube, Elbe, Oder, but data are not always available with the exception of the International Commission Protection of the Danube River.

Analytical Methods[9]
Solid-phase extraction (SPE) during the JDS
The water samples were extracted at the JRC by solid-phase extraction (SPE) with Oasis HLB (200 mg) cartridges. Most water samples contained particles (suspended particle material; SPM) which settled to the bottom of the plastic bottles. The water was not filtered, but decanted into a 500 mL glass bottle (Schott-Duran). Thus, only the dissolved (liquid) water phase was investigated. Before extraction, the samples (500 mL) were spiked with the internal standard (50 μL), which contained the labeled substances PFOA 13C4, PFOS 13C4, carbamazepine d10, simazine 13C3, atrazine 13C3, ibuprofen 13C3, and 4n- nonylphenol d8. The spiking level in the water samples was 10 ng/L for PFOA 13C4 and PFOS 13C4, and 100 ng/L for the other labeled compounds. The glass bottles were closed, and then the samples were mixed by shaking. The SPE procedure for the clean-up and concentration of water samples was

[8]Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy, entry 35 in the Annex I
[9]information reproduced from Loos, 2010

performed automatically using an AutoTrace© SPE workstation (Caliper Life Sciences). 200 mg (6 mL) Oasis® HLB columns (Waters, Milford, MA, USA) were used. The cartridges were activated and conditioned with 5 mL methanol and 5 mL water at a flow- rate of 5 mL min-1. The water samples (400 mL) were passed through the wet cartridges at a flowrate of 5 mL min-1, the columns rinsed with 2 mL water (flow 3 mL min- 1), and the cartridges dried for 30 min using nitrogen at 0.6 bars. Elution was performed with 6 mL methanol. Evaporation of the extracts with nitrogen to 500 µL was performed at a temperature of 35°C in a water bath using a TurboVap© II Concentration Workstation (Caliper Life Sciences).

Liquid chromatography tandem mass spectrometry (LC-MS2)
Analyses were performed by reversed-phase liquid chromatography (RP-LC) followed by electrospray ionization (ESI) mass spectrometry (MS) detection using atmospheric- pressure ionization (API) with a triple-quadrupole MS-MS system. Quantitative LC-MS2 analysis was performed in three separate LC-MS2 runs (methods 1-3) in the multiple reaction monitoring (MRM) mode. Method 1 comprised the compounds in the negative ionization mode, method 2 those in the positive ionization mode, and method 3 alkylphenolic compounds and estrogens which were analysed with a different HPLC mobile phase.
LC was performed with an Agilent 1100 Series LC systems consisting of a binary pump, vacuum degasser, autosampler and a thermostated column compartment. LC separations were performed with a Hypersil Gold column (Thermo Electron Corp., 100 x 2.1 mm, 3µm particles). Tandem mass spectrometry was performed on a bench-top triple- quadrupole quattro micro MS from Waters-Micromass (Manchester, UK) equipped with an electrospray probe and a Z-spray interface.

The eluants used for the separations of the target analytes were water and acetonitrile. The water phase used was acidified with 0.1 % acetic acid (pH 3.5) when analyzing PFCs, pharmaceuticals, and pesticides in the negative and positive ionization modes. The flowrate was 0.25 mL min-1. The gradient started with 90 % water and proceeded to 90 % acetonitrile over 25 min, conditions hold for 5 min, returned back to the starting conditions over 5 min, and followed by 5 min equilibration.

Instrument control, data acquisition and evaluation (integration and quantification) were done with MassLynx software. Nitrogen is used as the nebulizer gas and argon as the collision gas. Capillary voltage was operated at 3.2 kV, extractor lens at 1.0 V, and RF lens at 0.0 V. The source and desolvation temperatures were set to 120 and 350 °C under chromatographic HPLC conditions. Cone and desolvation gas flows were 50 and 600 L h-1, respectively. The applied analyser parameters for MRM analysis were: LM 1 and HM 1 resolution 11.0, ion energy 1 1.0, entrance –1 (negative mode), 2 (positive mode), exit 1, LM 2 and HM 2 resolution 11.0, ion energy 2 2.0, multiplier 600 V. The MRM inter-channel delay was 0.05 and the inter-scan delay 0.15.

Collision-induced dissociation (CID) was carried out using argon at approx. 3.5 x 10^{-3} mbar as collision gas at collision energies of 7 - 40 eV. The optimized characteristic MRM precursor → product ion pairs monitored for the quantification of the compounds together with the cone voltage and collision energy are given in Table 2.

Identification, quantification, QA/QC and LODs
The internal standards PFOS and PFOA 13C4 from Wellington Laboratories (Guelph, Canada) were used. The recoveries were determined with spike experiments in the concentration range of 10 and 100 ng L^{-1} using Milli-Q water (replication n = 6); they were in the range of 50 – 90 % Good performance of the developed analytical methods was demonstrated by successful participation in several interlaboratory exercises. All perfluorinated carboxylates were quantified with PFOA 13C4, and PFOS with PFOS 13C4. The compound-dependent method detection limits (MDLs or LODs) for the SPE- LC-MS2 procedure were calculated from the

mean concentrations of the blanks of the real water samples plus 3 times the standard deviation; 400 mL water was extracted and concentrated to 0.5 mL, which results in an enrichment factor of 800. LOD for per fluorinated chemicals was 1 ng L^{-1}

Uncertainty

Measurement uncertainties of analytical methods can be calculated by the analysis of certified reference materials (CRM), or from the Z-scores derived from interlaboratory studies. CRMs for polar organics in water samples do not exist. The JRC-IES laboratory participated in two interlaboratory studies on non-steroidal anti-inflammatory drugs NSAIDs (Farré et al.), the 3rd international interlaboratory study on PFCs (van Leeuwen et al.,2008), and a dedicated study on nonyl- and octylphenol (Loos et al., 2008b). Another possibility to calculate the uncertainty is from the single uncertainty sources in the laboratory, if known (standards, glass ware, balance, etc.). Examples how to calculate the uncertainty of a SPE-GC-MS method by this procedure can be found in (Quintana et al., 2001; Planas et al., 2006). These examples show that typical uncertainties for the analysis of water samples by SPE-GC-MS are around 25-50 %.

Statistical analyses

Frequency of positive detection (freq) in [%], average, median (med), and percentile 90% (Per90), were quantified with excel software (Microsoft).

Data storage

Data are only available through research publications and specialized survey reports. They became available online - see JDS1-4 in Reference chapter.

4.2 Strategy concerning analytical procedures

This report contains data from internationally recognized programmes in core media that have embedded strict quality control quality assurance measures as described in the chapters 4.1.1- 4.1.3.

In addition, the air chapter of the updated Guidance document also addresses the comparability of data and presents results of various QA/QC exercises and recent studies evaluating available data. It has been demonstrated that the uncertainty of data is largely given by the uncertainty of results provided by the participating laboratories. Such variability is greater than the one caused by various air sampling techniques. Based on these data it is strongly recommended to maintain several large-scale air monitoring programmes supported by central laboratories. Interlaboratory comparisons as well as comparisons of the results coming from various networks with their samplers co-employed at selected "super-sites" are recommended *Holt, 2017*.

Further, using the online tool of the Global Monitoring Plan that has also embedded multilevel checks, ensures spatial or temporal comparison of imported data, and implements a multilevel evaluation procedure based on the annually aggregated concentration values. This procedure guarantees comparability of the different samples, especially from the point of view of the type of site, matrix, sampling method, time span and sampling frequency. It also ensures linkage of new datasets for evaluation of temporal trend.

The Import procedure is as follows: Data providers uploaded data in batches using import templates and automatic validations were performed by the DMC system. In the case of primary data upload: GMP DWH Data manager performs a manual data harmonisation of imported data with the rest of the GMP database content – Data manager marks data import as "Validated by the Data Manager" if the batch is in conformity with GMP standards. In case of errors the Data Manager marks data import batch as "Invalid by the Data Manager". Data provider then needed correct the batch. Data from validated data imports were synchronized with GMP DWH Data Visualization module every 30 minutes. Both data providers and ROG members can see uploaded data to check the correctness. After the visualization check, data provider marks data as VERIFIED and that completes the data import process. All verified data are considered as approved by ROGs. Delete function is not supported in order to be able to track and audit all performed operations in the data management console (new data import and editing, modification or cancellation of the import batches).

The processing procedures in place also limit the impact of uncontrolled covariates and thus reduce the risk of false trend detection or neglecting truly significant changes. Details on statistical considerations and their implementation in the third phase GMP are available in the guidance document (UNEP/POPS/COP.9/INF/36).

In addition, laboratories providing data are accredited laboratories that are obliged to participate in a number of proficiency tests each year and also organized a survey among monitoring programmes to ensure comparability.

The third global monitoring campaign provides an opportunity to analyse temporal trends in available longitudinal air monitoring data. This is only possible for the original POPs which are being monitored for more than a decade now. As there are some overlaps between the active and passive air monitoring networks, a comparison of the trends based on two different sampling techniques is also possible. There is also an important question of sustainability of existing monitoring efforts, therefore we need to discuss regional representativeness of data coming from various sampling sites: *Kalina, 2017, Kalina, 2018 and Holt 2017.*

4.3 Strategy concerning participating laboratories

The CEE region collected information on the available POPs laboratories in the national questionnaires (see Annex 1 for details). There were a total of 235 laboratories reported, but laboratories are in different stages of development. Some of the CEE laboratories are also part of the POPs laboratory databank organized by UNEP[10].

The questionnaire collected information on the number of laboratories and their location, which POPs can these laboratories analyze and whether data quality management system was in place including standard operating procedures and participation in the national or international proficiency testing schemes or accreditation level. There was a full range of responses. Some laboratories from the regional questionnaires are fully EN/ISO accredited, with state-of-the-art equipment and capable of analyzing all listed POPs and beyond, while other countries have expressed they do not have any or a very limited capacity in analyzing certain POPs and need for technical support and training - namely in the field of developing methods of laboratory analysis and sampling (this support was requested by 7 countries of the region)[11].

As far as POPs data in this report are concerned, there were a limited number of laboratories involved in their analyses - either a central laboratory of the monitoring programme as shown in 4.1.1. for MONET CZ and MONET Europe, accredited dioxin laboratory located in the CEE region or in 4.1.2. the State Institute for Chemical and Veterinary Analysis of Food (Germany),

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[10] There are a total of 256 laboratories and 54 laboratories from the CEE region (13 countries: Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Montenegro, Poland, Russian Federation, Serbia, Slovakia and Ukraine). The UNEP databank was updated in 2018. POPs laboratory databank is available online.

[11]Slovakia, reported need for capacity building in existing laboratories. Ukraine, North Macedonia and partly Estonia stated that the biggest priority is the creation of a number of laboratories with modern equipment and reagents. Kazakhstan reported an absence of a laboratory for the determination of dioxins and furans.

a reference laboratory for the WHO exposure studies and MTM laboratory at the University of Orebro, Sweden - both laboratories are located in the WEOG region.

All the above mentioned laboratories contributing data from POPs monitoring programmes regularly participate in the inter-laboratory proficiency tests with good results. In addition, some laboratories also participated in the last two rounds of the UNEP organized POPs inter laboratory assessment (2015 and 2018).

4.4 Data handling and preparation for the regional monitoring report

ROG CEE decided that it will use such data from POPs monitoring activities that allow for trend evaluation or for establishment of baseline (at a minimum, and report that one only if no other information is available). Thus, the CEE ROG approached CEE data providers and requested them to provide data in the format compatible with that of the GMP Data warehouse so that important metadata including information covered above in chapters 4.1.1-4.1.4 is available. GMP Data warehouse is described below.

The correct definition of data is a prerequisite for the subsequent statistical analysis. Only reliably reported concentration values can be accepted for any spatial or temporal comparison. Protocols showing standardized formats for data acquisition/import are available in GMP DWH Data management console. There are 8 different templates – one for each combination of core sampling media (Air, Water, Blood, human breast Milk) and type of data (primary, aggregated). GMP DWH does not allow to combine different core sampling media into a single data import template. For each core medium and datatype must a relevant import template must be used.

To ensure spatial or temporal comparison of imported data, a multilevel evaluation procedure based on the annually aggregated concentration values is implemented in the GMP DWH in order to maintain a high predictive value of the GMP records while avoiding bias in the concentration values.

The Import procedure is as follows: Data providers uploaded data in batches using import templates and automatic validations were performed by the DMC system. In the case of primary data upload: GMP DWH Data manager performs a manual data harmonisation of imported data with the rest of the GMP database content – Data manager marks data import as “Validated by the Data Manager” if the batch is in conformity with GMP standards. In case of errors the Data Manager marks data import batch as “Invalid by the Data Manager”. Data provider then needed correct the batch. Data from validated data imports were synchronized with GMP DWH Data Visualization module every 30 minutes. Both data providers and ROG members can see uploaded data to check the correctness. After the visualization check, data provider marks data as VERIFIED and that completes the data import process. All verified data are considered as approved by ROGs. Delete function is not supported in order to be able to track and audit all performed operations in the data management console (new data import and editing, modification or cancellation of the import batches).

The data evaluation procedure in place in the third phase GMP guarantees comparability of the different samples, especially from the point of view of the type of site, matrix, sampling method, time span and sampling frequency. Heterogeneity in these factors might dramatically increase the uncertainty in the final outcomes. The processing procedures in place also limit the impact of uncontrolled covariates and thus reduce the risk of false trend detection or neglecting truly significant changes. Details on statistical considerations and their implementation in the third phase GMP are available in the guidance document (UNEP/POPS/COP.9/INF/36).

Data for the monitoring report

All CEE POPs data shown in this report have been imported to the electronic tool of the Global Monitoring Plan. The GMP Data Warehouse (www.pops-gmp.org) has been made operational during the second GMP phase, supporting the regional organization groups in the work for the collection, processing, storing and presentation of monitoring data. The data warehouse was further enhanced and kept up-to-date to provide on-line access to the GMP monitoring data and enable data collection and processing during the third GMP phase and support the development of the third monitoring reports.

The GMP DWH also comprises a publicly available repository of valuable information that can serve as a useful resource for policy makers and researchers worldwide. It is available at www.pops-gmp.org and public access is available once the regional reports are released.

4.5 Preparation of the monitoring reports

The CEE ROG decided in 2018 (see chapter 3 above) to closely cooperate with the Stockholm Convention Regional Centre in the Czech Republic (RECETOX) and its experts to prepare the present regional report, and also to collect additional information from the countries via specific questionnaire. The questionnaire comprised information on ongoing POPs monitoring activities, range and time span, but also sought information on available laboratory capacities and infrastructures, ongoing POPs research and also collected inputs regarding country needs for support. The questionnaires were collected in 2019 and evaluated in 2020 and information is incorporated in 3.3., 4.1., 4.3. and provide input to chapters 5 and 6. Filled questionnaires are reproduced in their entirety in Annex 1.

The present report was drafted in 2020, with the support from the Small-Scale Funding Agreement BRS-SSC-SSFA-2002. The ROG wanted to have one face to face meeting, but the epidemiological situation did not allow for this and all communication was carried out electronically. A specific discussion on the available data was organized on 7 July 2020 for the whole ROG with data analysts and GMP DWH team - Jana Borůvková, Jakub Gregor and Richard Hůlek.

Subsequently, drafting of the report was carried out by the RECETOX team led by Kateřina Šebková (CEE ROG coordinator) and the following experts contributed to the chapters:

- Air chapter: Kevin White, Jiří Kalina, Jana Klánová and Kateřina Šebková
- Milk survey: Kateřina Šebková
- Water: Jaromír Sobotka, Branislav Vrana, Foppe Smedes
- Other media: Petra Přibylová and Kateřina Šebková
- Long range transport: MSC-East (Alexey Gusev)
- Analyses of capacities and country needs and update of information on the CEE countries: Lukáš Pokorný, Kateřina Šebková

CEE ROG was responsible for further developing and finalizing the Results and Conclusions and Recommendations chapter on the basis of drafts prepared by the RECETOX team and consultations were held in October 2020 and January 2021. Countries in the region were consulted electronically and the report was finalized in March 2021 incorporating comments raised.

5 RESULTS

This chapter describes data provided by the monitoring programmes and activities described in section 3.4 and 4.1. of this report. It also provides information on sources of POPs, comments on changes in concentrations of studied POPs over time from regional perspective and provides other relevant information on trends reported elsewhere.

POPs monitoring has progressed a lot over since the establishment of the Global monitoring plan under the Stockholm Convention. While the first regional report in 2008 focused on the twelve POP substances listed in the Annexes of the Stockholm Convention and on collection of available information on some new POPs (hexachlorocyclohexanes, pentachlorobenzene), it also comprised other toxic substances data - polycyclic aromatic hydrocarbons (PAHs) - that are not subject to the Stockholm Convention, but are regulated by the UN ECE Convention on Long-Range Transboundary Air Pollution (CRLTAP) and its POPs Protocol. PAHs were not included in the regional report since then. The second regional report provided trend data on majority of the original twelve POPs and first baselines for POPs listed in 2009 as the short time series (two to three years long) were not sufficient for establishing statistically significant trends yet.

Attention of this report is focused on providing more information on new POPs and their trends and to provide baseline for other POPs recently listed in the Stockholm Convention (SCCPs, PCN, dicofol, pentachlorophenol, PFOA, PFHxS), but it still covers all listed POPs. If needed, a more detailed information for concentration changes and other details for some chemical parameters would be provided in Annex 2. In some cases, levels of the original 12 POPs are very low or below limit of quantification of analytical methods used.

Part 5.1. provides overview of results organized per matrix in the context of the POPs use in the CEE region complemented by charts, tables and maps generated from the GMP DWH including summary tables on trends and baseline levels.

Part 5.2. provides a more detailed discussion related to the trends or tendencies in changes in POPs levels over time observed.

Part 5.3. invites the readers to consult additional information sources

Due to limited space available in this report, full reprint of all available data is not provided. Detailed information for each site, compound or concentration levels are available in yearly aggregated form online in the GMP Data warehouse in its data visualization with data up to 2020 (www.pops-gmp.org).

5.1 The results in context

This chapter is organized in three parts - POPs levels on the basis of historical and current sources of POPs, regional considerations and other information.

Part 5.1.1. discusses results on the basis of available information on historical and current sources of POPs in the CEE region. This region has produced a number of legacy and some newly listed POPs as is provided in chapter below, but in many instances, the production and or use has been phased out or banned.

Part 5.1.2. looks at data produced by region regarding the coverage, data gaps and capacity development needs and finally part 5.1.3. points out the reader to other sources of information on POP levels and trends reported elsewhere.

5.1.1. Historical and current sources of POPs

This chapter further comments on the production and use of POPs in the CEE region. The text builds on the information made available in the first regional report and is organized in the same manner as monitoring data in the core matrices in chapters 5.2.1. and 5.2.2. below; at first it covers seven organochlorine pesticides from Annex A followed by HCB, PCBs, DDTs, and dioxins and furans. New POPs are described in the following order HCHs, chlordecone, endosulfan, PBDEs, hexabromobiphenyl, pentachlorobenzene, PFOS and hexabromocyclododecane.

5.1.1.1 Cyclodiene Insecticides/ Organochlorine Pesticides

This chapter covers production and use of aldrin, chlordane, dieldrin, endrin, heptachlor, chlordecone, mirex, and toxaphene in the CEE region.

Aldrin

The use was banned in 1980 in the Czechoslovakia, in the former Soviet Union before 1987 and in Ukraine since 1997. It has never been registered and applied in the Russian Federation.

Chlordane
use banned in Ukraine since 1997 and it has never been registered and applied in the Russian Federation.

Dieldrin
used for pesticide production in Poland, use banned in Ukraine since 1997. Never used in the Czech Republic (former Czechoslovakia) and it has also I never been registered and applied in the Russian Federation.

Endrin
The use was banned in the Czechoslovakia in 1984, in the former Soviet Union before 1987, and in Ukraine since 1997. In addition, it has never been registered and applied in the Russian Federation.

Heptachlor

The agricultural use was banned in the Czechoslovakia in 1989, in the former Soviet Union before 1987 and in Ukraine since 1997. In addition, it has never been registered and applied in the Russian Federation.

Chlordecone
never produced in the region nor registered

Mirex
It was used in Kazakhstan for protection of cotton crops and in Poland, but it was never registered/used in the former Soviet Union or in the Russian Federation.

Toxaphene
use banned in the former Soviet Union before 1987, in the Czechoslovakia in 1986. In addition, it has never been registered and applied in the Russian Federation. Plant protection products containing toxaphene were imported to the Czechoslovakia between 1963-1986.

5.1.2. Hexachlorobenzene (HCB)
Intentional production in the Czech Republic ceased in 1968. Use as pesticide banned in the Czechoslovakia in 1977, in Ukraine since 1997.
Used for pesticide production in Poland; HCB is still unintentionally produced in the production of perchlorinated ethylene in the Czech Republic, but it is in the closed system and it is disposed of as waste /by incineration under controlled conditions/.

5.1.3. Polychlorinated biphenyls (PCBs)

As described in detail in the first monitoring report, several countries of the CEE region produced PCB technical mixtures (former Czechoslovakia, Poland, and former Soviet Union). PCBs were manufactured between 1959 and 1984 in Eastern Slovakia (Chemko Strážske, about 22500 tons) and used extensively in production of capacitors, paints and varnishes in the former Czechoslovakia and former East Germany. Amount of PCB containing products sold during this period represents 2% of the estimated world PCB production. Other significant PCB production, in Dzerzhinsk in the region of Nizhni Novgorod and in Novomoskovsk in Tula Region (300 km east from Moscow and 200 km south of Moscow respectively), was in operation between 1939 and 1993, producing about 180 000 tons of PCBs for paints, varnishes, lubricants, transformers and capacitors. The equipment produced was extensively used in the countries of the former Soviet Union. Small quantities of PCBs were also produced in Poland. PCBs were never produced in the former Yugoslavia, but the country manufactured transformers and capacitors in Slovenia, Serbia and in Croatia.

Both the previous and present industrial use of PCBs is responsible for current PCB emissions. The major sources of atmospheric contamination are due to evaporation from the old open systems (paint and wood protecting layers, softeners etc.), from landfills, dumping sites and waste incinerators, and from transformers, condensers, hydraulic systems and other PCB containing devices that are either in use or waiting to be disposed of and from soil that is around them.

While the situation has significantly improved over the last two decades, the results of the milk survey still reveal PCB human exposure in the countries that produced large amounts of PCB are still among the highest in the world (even if the former amount has been reduced to 14% of the original amount in 1990s).

5.1.4. DDT

There is no current production of POPs pesticides in the CEE region. Historically, several POPs pesticides (DDT, HCH, lindane) were produced in the territory of the former Czechoslovakia. Other pesticides were never produced in the country but they were imported to the Czech Republic and Slovakia, and used to formulate plant protection preparations. Similarly, DDT and toxaphene were produced in Poland while the others (dieldrin, hexachlorobenzene and toxaphene) were imported to produce pesticide preparations.

It was used quite extensively until 1970s/1984 in the region (i.e. phased out in Poland in 1975, CZ:1975, import and use banned in 1982 in former Yugoslavia, end of use in the Soviet Union in 1986 (used since 1946), and the use was banned in Ukraine since 1997.

For Poland, no listed POPs containing pesticides have been used since 1980s.

5.1.5. PCDDs and PCDFs

These compounds are unintentionally produced by combustion in the whole region.

5.1.6. New POPs

This chapter covers all remaining POPs listed in the Stockholm Convention after 2009 and their situation in the region. It looks first at new POPs containing chlorine (hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene (PeCB), endosulfan, pentachlorophenol (PeCP/PCA), PCN, hexachlorobutadiene, SCCPs), brominated POPs (PBDEs, Hexabrombiphenyl-HBB, HBCDD), PFOS and POPs whose reporting is not yet obligatory (dicofol, PFOA and PFHxS).

Hexachlorocyclohexanes (HCHs)

Hexachlorocyclohexanes (technical mixture) were extensively produced in the region since

1950s, in particular in the Czech Republic, Poland, Romania, Azerbaijan, and former Soviet Union. Obsolete stocks still remain in many countries on landfills and dumping sites throughout the region or in the former production facilities that ceased their operation. Although some hazardous pesticides are not used anymore, and obsolete stocks have been largely disposed of through technical assistance projects and with support of the official development assistance, in some cases certain stocks still remain in the countries. Recent relevant data on the POPs pesticide stocks are provided in individual National Implementation Plans of the Stockholm Convention on POPs. Via concerted efforts of the technical assistance and official development assistance a number of projects to remediate contaminated sites, old warehouses or to upgrade landfills and establish sound environmental disposal of obsolete pesticide stockpiles improved situation in Armenia, Moldova, Serbia and other countries of the region and further activities take place in North Macedonia, Russian Federation, Ukraine and other countries.

Endosulfan
used in agriculture (past use) or as wood preservative in some countries of the region.

Pentachlorobenzene
unintentionally produced, releases/transfer as waste reported in the Czech Republic - similarly to hexachlorobenzene.

New POPs containing bromine

Brominated POPs are not produced in the region, but they are released to the environment from use of products. In particular textiles, electric and electronic equipment, insulation construction materials especially upon becoming waste and during the waste disposal, primarily in landfills or unsound waste management.

PBDEs
not produced in the region, but used (in articles)

Hexabrombiphenyl
never produced or used in the region

HBCD (hexabromocyclododekan)
Not produced in the region but it was imported and used in the Czech Republic in the manufacture of the construction material for insulation of houses until 2014. Nowadays, all use in the EU is prohibited

PFOS
Perfluorinated POPs are not produced in the region either, but they were detected and used in firefighting foam, textiles, car upholstery and packaging.

5.1.2. Regional considerations

Some parts of the CEE region are well monitored through existing air monitoring networks pertaining to international monitoring programmes EMEP, GAPS and MONET, in particular western part of the CEE region. The monitoring combines active and passive sampling and up to 30 years long time series are available for chlorinated POPs and about 15 years long series exist from passive sampling.

The air monitoring activities currently cover 21 countries out of 25 described in this report (no information is available for Albania, Azerbaijan, Bosnia and Herzegovina, Georgia and a limited information is available for the Russian Federation). Air monitoring also cavers majority of listed POPs and data are available until 2019.

On the other hand, Central Asian countries have a limited availability of information that only covers several organochlorine POPs (alpha-, beta-, gamma-HCH, HCB, PCB, and DDT in 2008-2010). To restart such activities would require both policy and technical support for a sustainable solution for POPs data collection in that sub-region.

Data availability for human tissues is more limited. Information generated through WHO and UNEP/WHO surveys covers only 13 countries out of 25 in the CEE region and 11 countries participated in the surveys more than once. Support in participation of non-EU CEE countries in the milk surveys need to be significantly strengthened in particular for South European countries, and for Central Asia and Caucasus countries. On the other hand, the UNEP WHO surveys are a perfectly adequate source of information on POP levels and useful for effectiveness evaluation.

Data on water are even more limited for PFAS. At present, there is no regional scale program for monitoring PFOS/PFOA in water except surveys (research projects) undertaken by the European Commission (JRC). Nevertheless, this activity only covers western part of the CEE region and the Southern, Central Asian and Caucasus countries are not involved.

For all the above, table 4 provides an overview of identified POP levels and availability of trends in the CEE region in core matrices.

Table 4 *Changes over time in POPs concentrations measured in air, human matrices and water in the CEE region. Listed POPs are organized alphabetically. Substances written in grey do not yet require to be reported, grey chemicals marked in italics are candidate chemicals for listing (PFHxS). Shadings indicate: green – generally decreasing trends; red – increasing trends; blue – cannot establish trend; white – no trend data; dark grey - not considered as core matrix for this chemical, # - warning to indicate limited data*

Chemical	Air	Human matrices	Water
aldrin	Mostly declining trends and tendencies, 24 sites	Below LOQ for 10 countries over 2001-2019	
chlordane	Mostly declining trends and tendencies, 23 sites	Decreasing tendencies observed for 5 countries in western part of the region (oxychlordane)	
chlordecone	no data available	Below LOQ for 2 countries in 2019 #	
DDT	Decrease observed for 5 countries, individual analytes increase (o,p-DDT) at 4 sites, but overall decreasing trend for sum parameters in 6 countries	Decreasing tendencies observed for 5 countriesn for all analyses	
dicofol	*no data*	Below LOQ for 2 countries in 2019 #	
dieldrin	Mostly declining trends and tendencies, 23 sites	Decrease observed for 5 countries otherwise no trend data (partly green)	

Chemical	Air	Human matrices	Water
endosulfan	declidning trends for alpha endosulfan in9 sites for 7 countries, beta end-sultan and end-sultan sulfate data available only for 3 sites	Below LOQ for 10 countries	
endrin	Mostly declining trends and tendencies, 21 sites	analyzed in 2001-2019, all samples below LOQ	
HBB	no data available	Below LOQ 2009-2019, 6 countries	
HBCDD (hexabromcyclododecan)	data from 1 site, a baseline but below LOQ #	for alpha HBCDD an increasing tendency observed for 3 countries # - short time series (2 rounds)	
HCB (hexachlorobenzene)	Mostly declining trends and tendencies, in other sites a baseline	Decreasing tendencies observed for five countries in the region #	
HCBD (hexachlorobutadiene)	no data available	Below LOQ for 2 countries in 2019 #	
α-HCH	Decreasing at 12 sites	Decreasing tendencies or below LOQ observed for 10 countries	
β-HCH	Decreasing at 6 sites	Significantly decreasing tendencies observed for 10 countries	
γ-HCH	Decreasing at 20 sites	Decreasing tendencies confirmed or decrease to below LOQ observed for 10 countries	
heptachlor	Decreasing trend at 4 sites, but downward tendencies at other 18 sites	Below LOD for heptachlor and trans-heptachlorepoxide; decrease for cis-heptachlor observed for 5 out of 10 countries #	
mirex	information from 2 sites only, limited time span #	analyzed in 2006-2019, all samples below LOQ	
PBDEs (c-penta, c-octa)	Decreasing trend at 4 sites, but downward tendencies at other 18 sites	Declining concentrations over time observed in human milk (with a peak in cases)	
PBDE: decaBDE	no data available now	samples for 2019 not yet analyzed	
PCB	Declining at 14 sites, baseline well established	Statistically significant trend + decreasing tendencies observed for 10 countries in the region	

Chemical	Air	Human matrices	Water
PCDD/PCDF	Declining trends confirmed at 4 sites, but overall decreasing tendency at additional 15 sites	Statistically significant trend + decreasing tendencies observed for 10 countries in the region	
PCN	no data available now	no data available when preparing the report	
pentachlorophenol (PeCP)	no data currently available	Below LOQ for 2 countries in 2019 #	
PFHxS	*no data available*	*Below LOQ for 2 countries in samples of 2019* #	
PFOA	*no data available now*	*Baseline available for 2 countries in samples of 2019* #	Baseline data available for Danube River Basin 2007-2019 and decreasing tendencies are observed #
PFOS	Baseline data available at 1 site	Baseline data available for four countries in the region - two in 2009 and two in 2019 #	Baseline data available for Danube River Basin 2007-2019 and overall decreasing tendencies are observed #
PeCBz (pentachlorobenzene)	Decreasing at 10 sites with a trend, on additional 20 statistically non significant	analyzed in 2009-2019, all samples below LOQ	
SCCPs	no data available from existing monitoring programs	First data available for 2 countries in 2019 #	
toxaphene	no data	analyzed in 2001-2019, Parlar 62 predominantly below LOQ, Parlar 26 and 50 decreased to below LOQ over time. #	

5.2 Review of concentrations and their changes over time in the region

This chapter presents each listed chemical or group of substances and showcases observed changes over time and availability of trend data. Results are shown in the same order for each core media - ambient air, maternal milk and water. If too much information was available, further data are shown in Annex 2.

5.2.1 Ambient air

Both active and passive sampling networks and programmes contributed data to this chapter. It covers maximum span of data available – i.e. 1996 onwards for DDT, HCB, PCBs, pentachlorobenzene, and all HCHs. Other POPs were added gradually as listed, depending on monitoring programme, sites and analytical equipment (and expertise) available. The longest time series are available for chemicals collected by active sampling at the Košetice EMEP station. The most recent data also show levels for 2019, but only for selected chemicals.

Data in this chapter are organized in the following order: cyclodiene insecticides (aldrin, chlordane, dieldrin, endrin, heptachlor, mirex and toxaphene), DDT, hexachlorobenzene (HCB), PCB, PCDD and PCDF, new POPs (new POPs containing chlorine (hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene (PeCB), endosulfan, pentachlorophenol (PeCP/PCA), PCN, hexachlorobutadiene, SCCPs), brominated POPs (PBDEs, Hexabrombiphenyl-HBB, HBCDD) PFOS and POPs whose reporting is not yet obligatory (dicofol, PFOA and PFHxS).

5.2.1.1. Cyclodiene insecticides

This chapter covers aldrin, chlordane, dieldrin, endrin, heptachlor, chlordecone, mirex and toxaphene.

<u>Aldrin</u>

Data coverage increased significantly (two sites at previous report). Now they are available for 24 sites (EMEP, MONET, GAPS) in 11 countries. Statistically significant decreasing trends are detected for 8 sites in 5 countries as shown in Figure 1. Data are available for 2004-2010 (GAPS sites), 2011-2019 MONET sites.

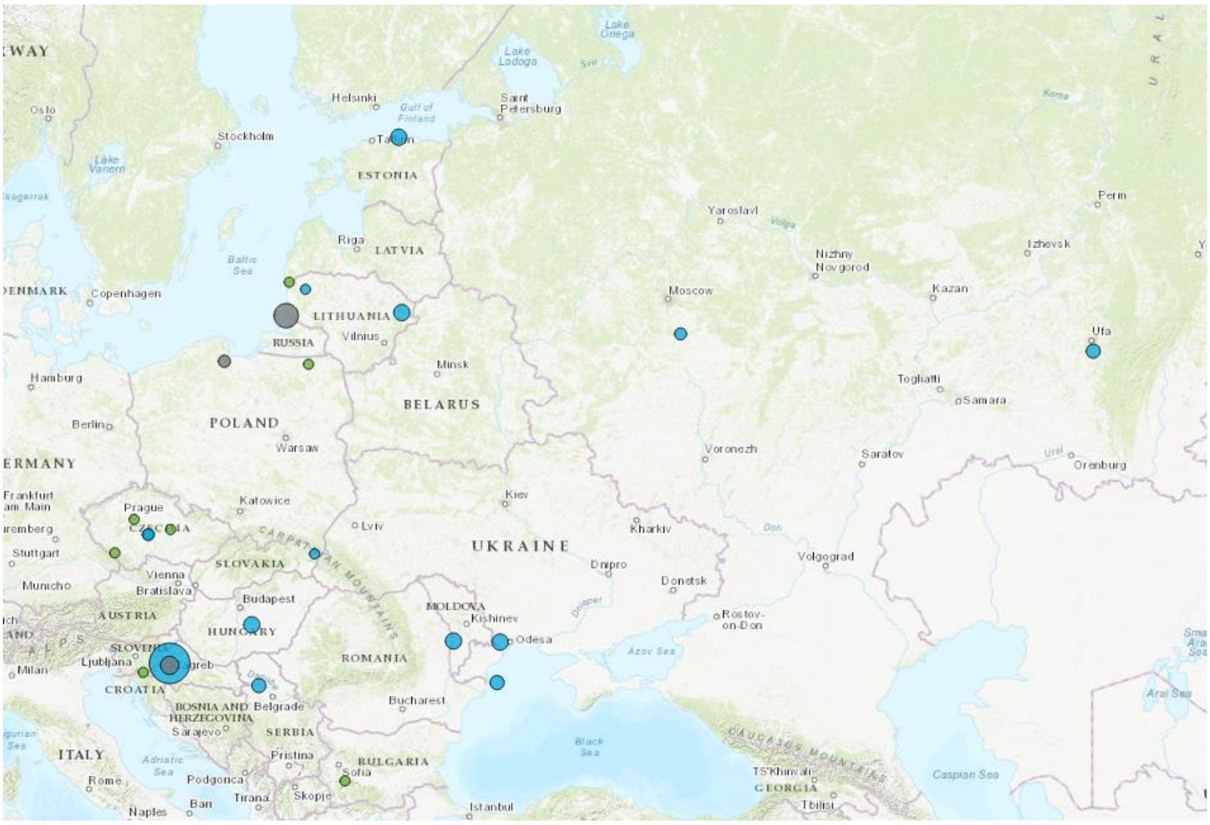


Figure 1: Trends observed in the CEE region for changes in levels of aldrin in ambient air between 2007-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Chlordane

Data availability and coverage increased significantly since the second regional monitoring report. Currently, data are available for 24 sites (EMEP, MONET, GAPS) and statistically significant decreasing trends are detected for 8 sites in 5 countries as shown in Figure 2.

Data are available for 2007-2010 (GAPS sites), 2011-2019 MONET sites. Additional figures for trends of other chlordane parameters (4 additional maps) are available in Annex 2 to this report.

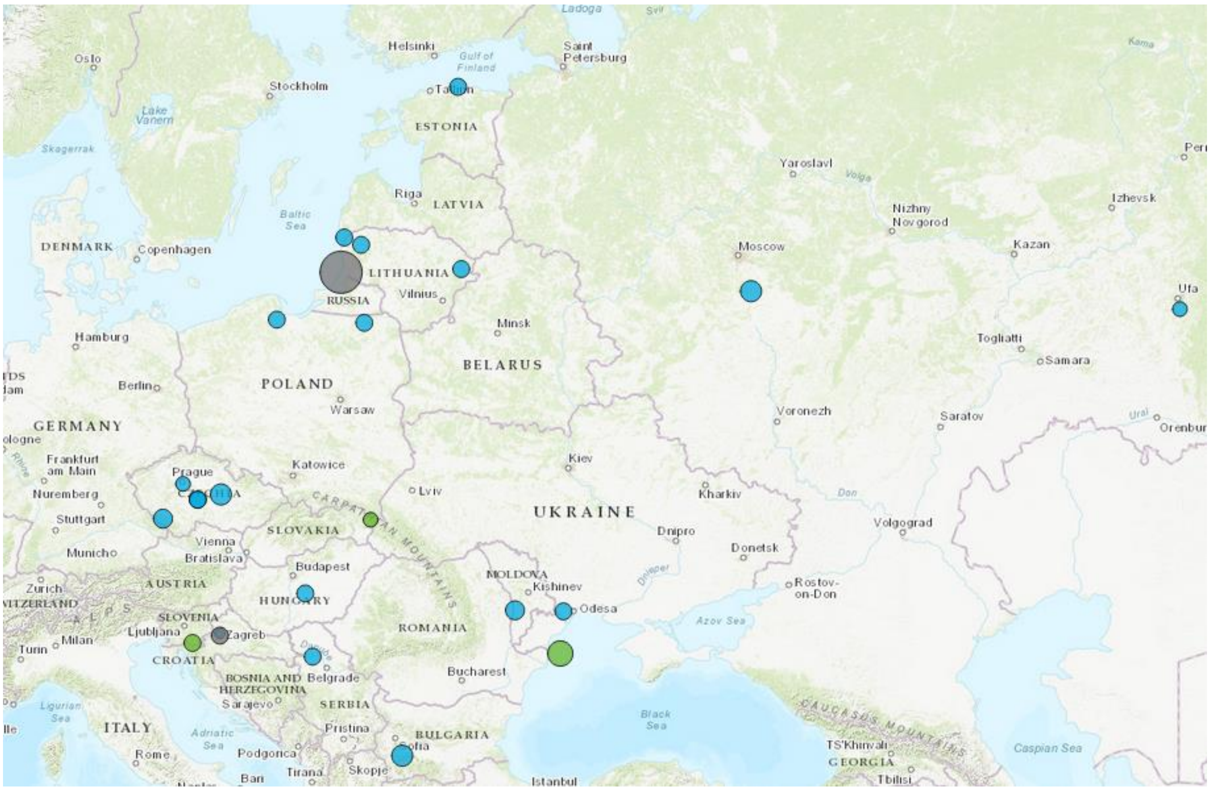


Figure 2: Trends observed in the CEE region for changes in levels of cis-chlordane in ambient air between 2007-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Dieldrin

More data became available over time. Nowadays, CEE region has 23 sites (EMEP, MONET, GAPS) in 11 countries and statistically significant decreasing trends are detected for 6 sites in 3 countries as shown in Figure 3. Data are available for 2004-2010 (GAPS sites), 2011-2019 MONET sites.

Endrin

Further information became available over time. Endrin data are available for 21 sites now and statistically significant decreasing trends are detected for 8 sites in 6 countries as shown in Figures 4. Data are available for 2011-2019 MONET sites.

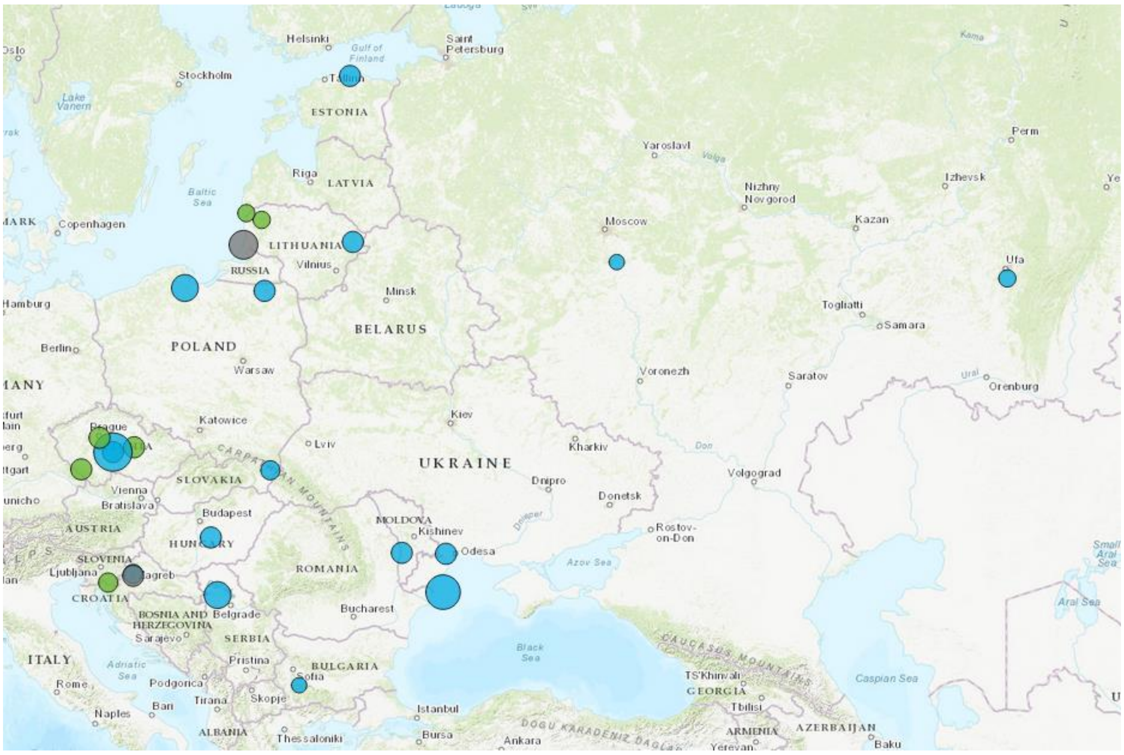


Figure 3: Trends observed in the CEE region for changes in levels of dieldrin in ambient air between 2007-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

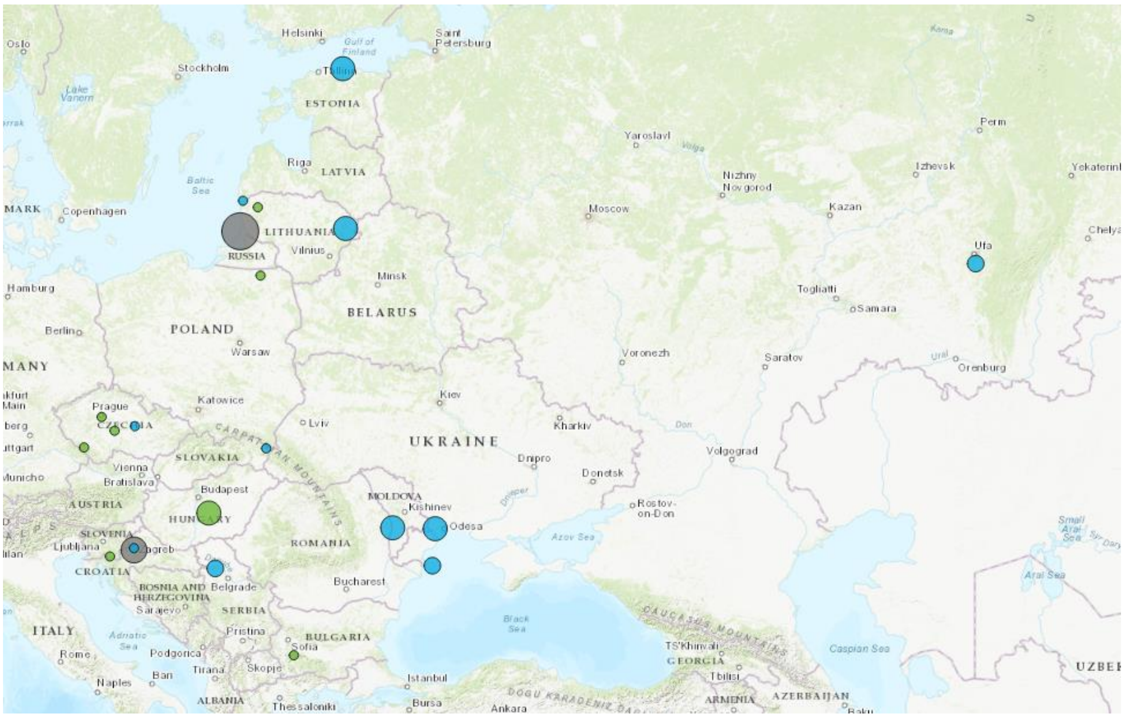


Figure 4: Trends observed in the CEE region for changes in levels of endrin in ambient air between 2011-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Heptachlor

Data availability and coverage for heptachlor increased significantly since the second regional monitoring report. Currently, data are available for 24 sites (MONET, GAPS) and statistically significant decreasing trends are detected for 4 sites in 3 countries as shown in Figure 5. Data are available for 2004-2010 (GAPS sites), 2011-2019 MONET sites.

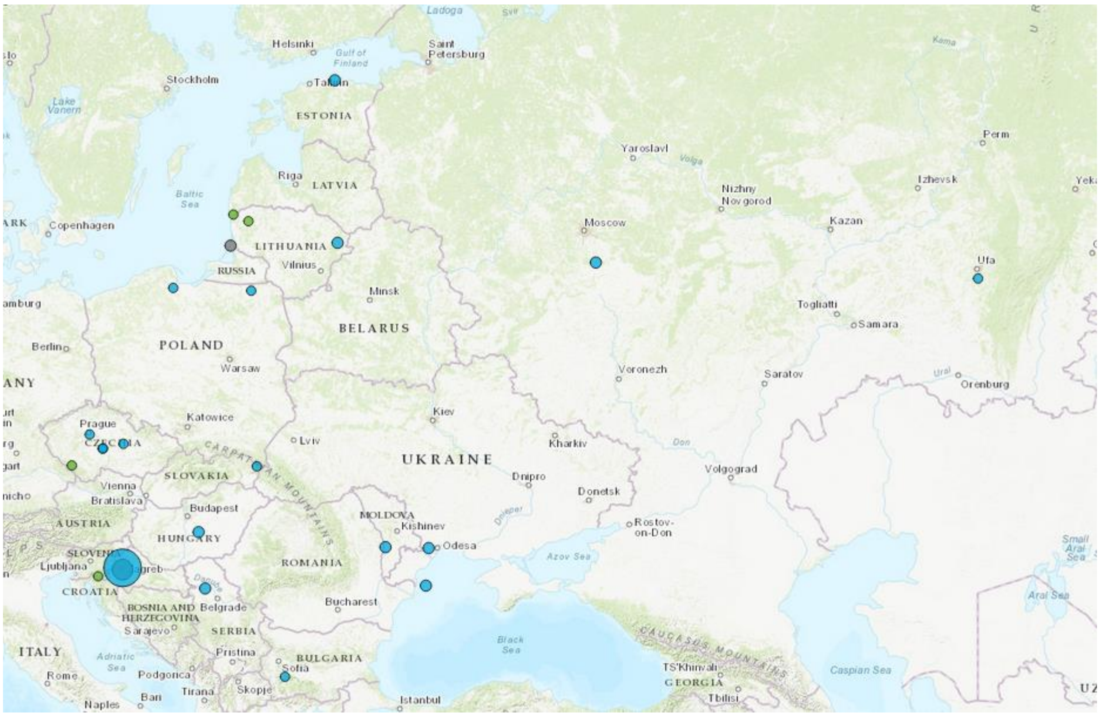


Figure 5: Trends observed in the CEE region for changes in levels of heptachlor in ambient air between 2004-2019. Statistically significant decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Chlordecone

Chlordecon was monitored by active sampling in Košetice EMEP station, Czech Republic 2011-2013, but all levels observed were below LOQ.

Mirex

No data are available through long term monitoring programs. Some data are available from a project by Roshydromet in around Baikal Lake for 2014 and 2016.

Toxaphene

No relevant data were identified for this compound.

5.2.1.2. DDT

DDT is another POPs extensively studied in the region. It was monitored on 79 sampling sites of 17 countries in the CEE region by both passive and active sampling. However, the total duration of time series varies considerably between 1 year - grey sites in figures 6-8 till 26 years. Baseline for this chemical was established in the previous phase of the GMP.

Trend data show that for some congeners increasing trends were observed as shown in Figure 6, but when we review summary parameters, the increasing trend is overrides by higher share of another p,p congener present in higher amount.

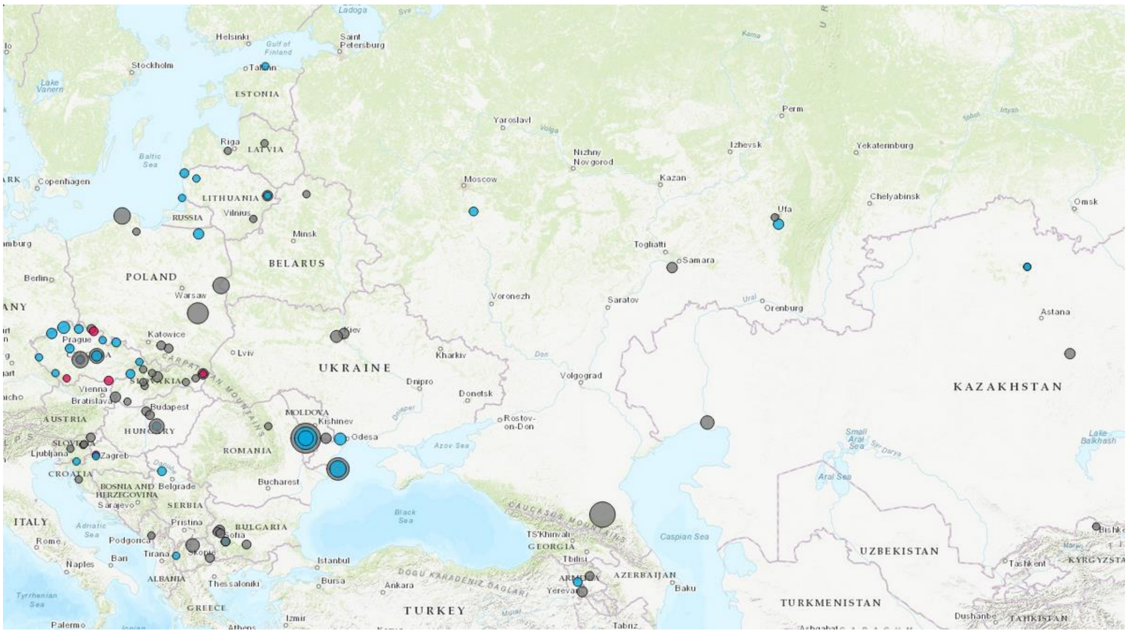


Figure 6: Trends observed in the CEE region for changes in levels of o,p-DDT in ambient air between 2004-2019. Increasing trend is marked in red, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Figure 7 shows a higher incidence of statistically significant decreasing trends for p, p DDE which are available for the following countries: 9 sites in the Czech Republic, Serbia, Hungary, Lithuania, Kazakhstan, Estonia and 9 sites in the Czech Republic. Decreasing tendencies are shown for Ukraine, Russia, Armenia, Romania.

Similar picture provides Figure 8 describing the sum 3 p,p DDTs and summary trends.

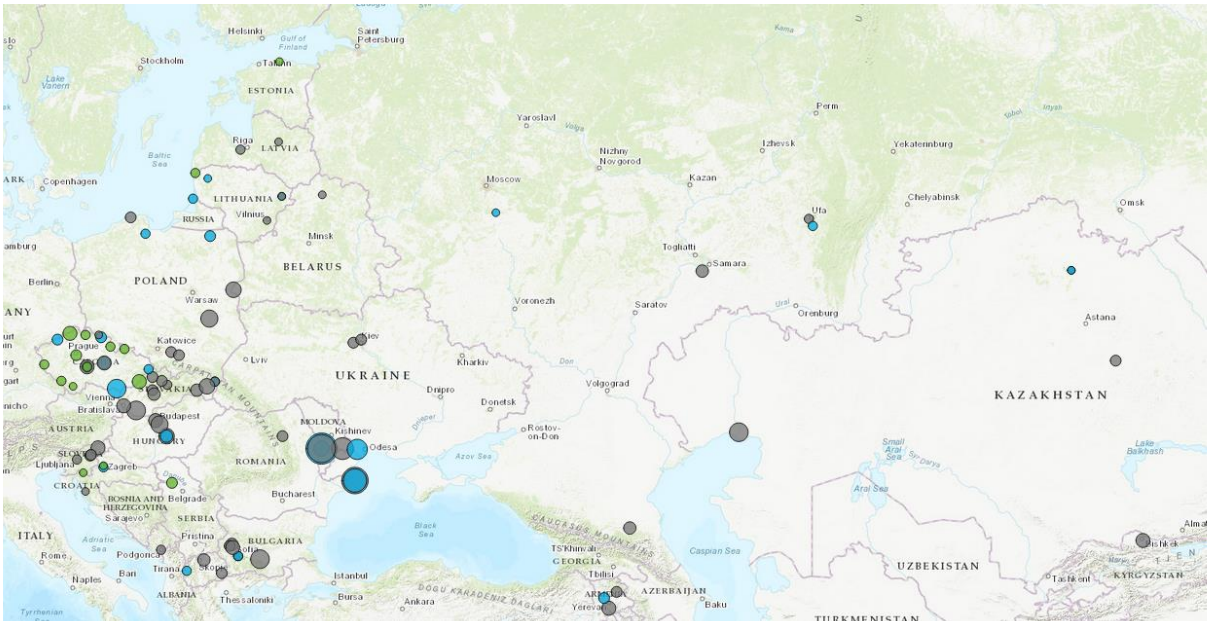
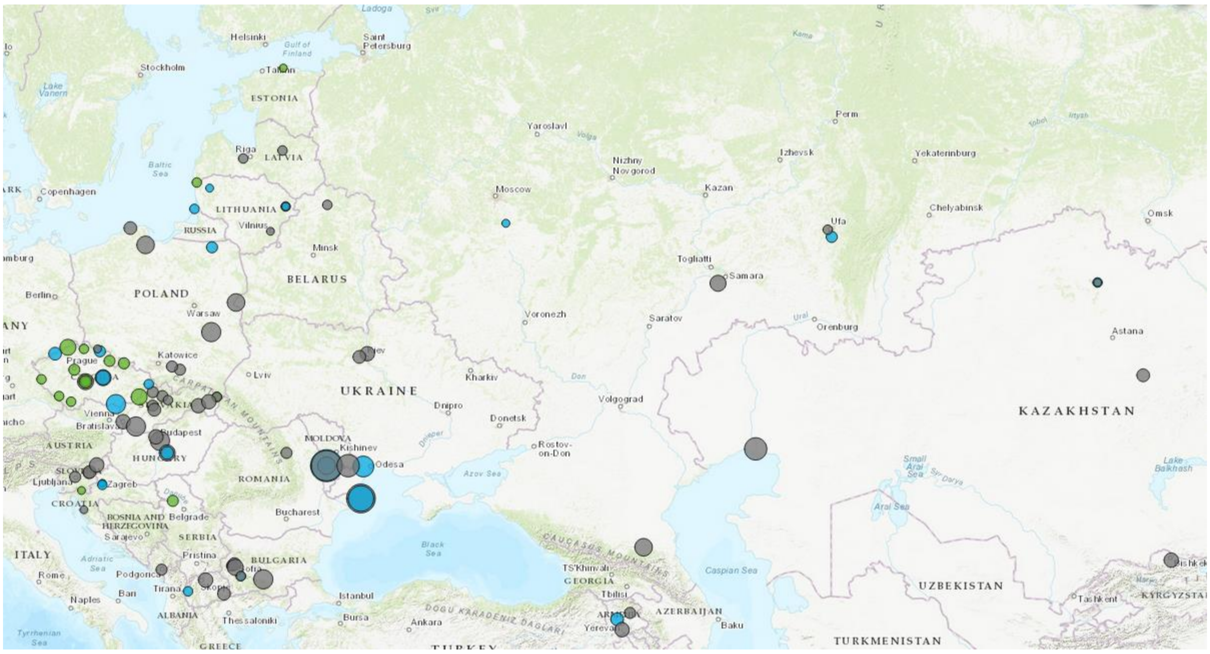


Figure 7: Trends observed in the CEE region for changes in levels of p,p-DDE in ambient air between 2004-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the



concentrations. (source: GMP DWH)

Figure 8: Trends observed in the CEE region for changes in levels of sum 3 p,p-DDE in ambient air between 2004-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

5.2.1.3. Hexachlorobenzene (HCB)

Hexachlorobenzene is/was monitored quite extensively on 77 sampling sites of 17 countries in the CEE region however, the total duration of time series ranges from one year up to thirty years. Baseline for this chemical was established in the first phase of the GMP data collection already and now the range of statistically significant trends increased from two to 12 sites in 6 countries of the region. Grey sites provide a baseline level as shown in Figure 9.

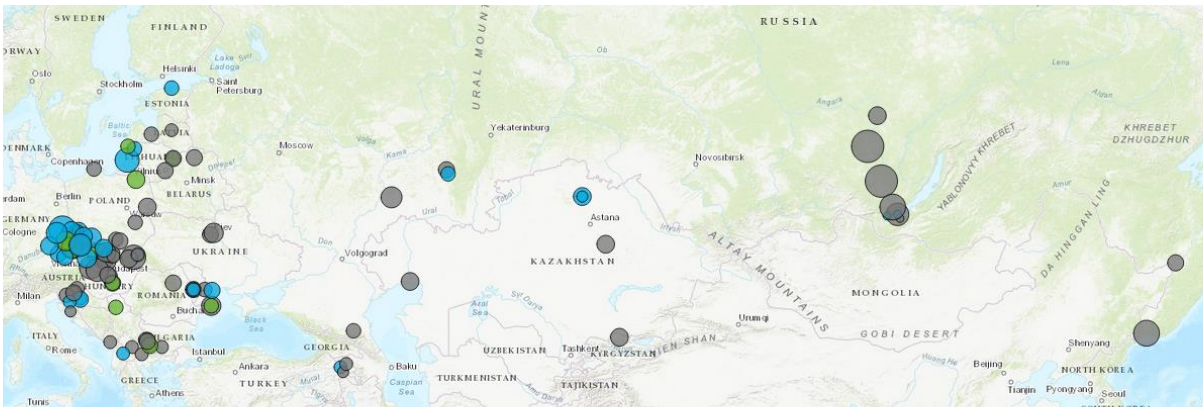


Figure 9: Changes over time and trends observed in the CEE region for changes in levels of hexachlorobenezene in ambient air between 2004-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

5.2.1.4. Polychlorinated biphenyls (PCB)

PCBs in air were monitored by passive sampling on 80 sampling sites of 17 countries in the CEE region quite broadly. However, the total duration of time series differs significantly; it ranges from one year up to thirty three years. Baseline for this chemical was established in the first phase of the GMP data collection.

This chapter discusses not only indicator PCB congeners, but also dioxin-like PCBs. Levels of the latter would also be expressed as toxic equivalents (TEQ) and are shown in Figure 11.

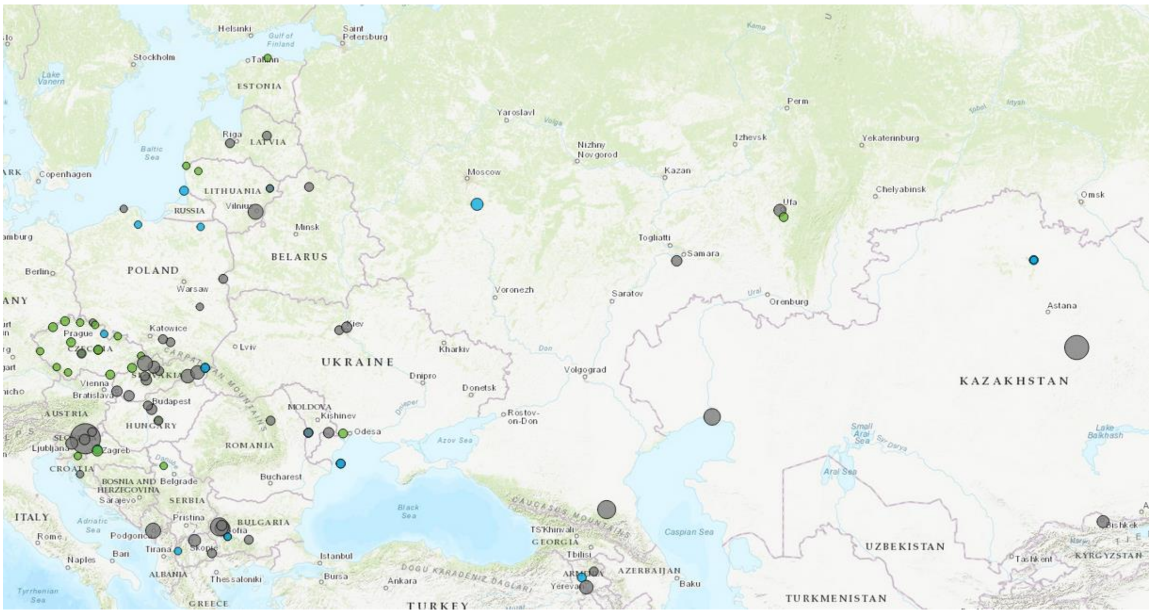


Figure 10: Trends observed in the CEE region for changes in levels of indicator PCB (sum 6) in ambient air between 2007-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

As shown in the regional map in Figure 10, several passive sampling sites detected statistically significant decreasing trends. They were observed in the remote site Lahemaa in Estonia (2006-2019), sub-urban site in Zagreb Siget, Croatia (2007-2016) and on twelve sites in the Czech Republic, where eight out of twelve are located in the border mountains (remote), one is urban site in Prague, and three remaining sampling sites are rural sites (Svratouch, Plaňavy, Mikulov-Sedlec) in Moravia.A decreasing trend has a median annual change of −10.5% corresponding to a halving time (t1/2) of 6.0 yr.

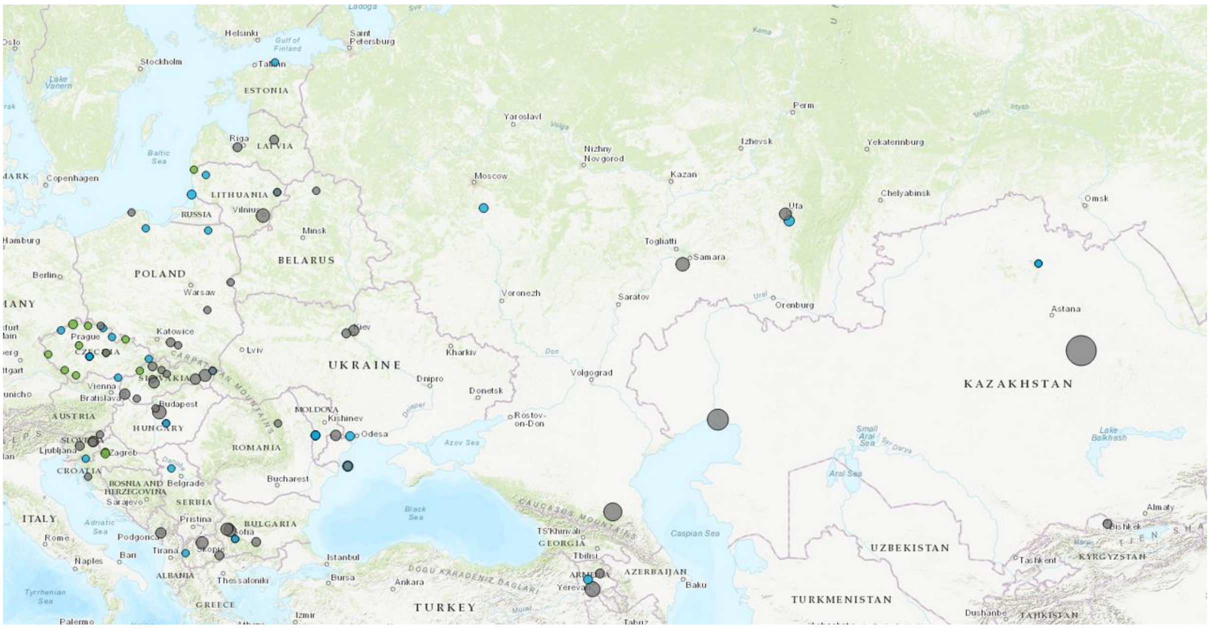


Figure 11: Trends observed in the CEE region for changes in levels of PCB118 in ambient air between 2007-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

5.2.1.5. Dioxins and Furans (PCDD and PCDF)

This chapter contains not only concentration levels and trends for dioxins and furans, but data are also expressed as toxic equivalents (TEQ).

Dioxins and furans (all 17 parameters) were originally monitored by active sampling only in Košetice EMEP station, Czech Republic 2011-2013 and that activity continues to date.

In addition, MONET network has initiated PCDD and PCDF analyses at its sites in 2011 and data are available until 2019 for 17 sites as shown in Figure 12.

As it is seen for in Figure 12, statistically significant decreasing trends are detected at 5 sites in 4 countries and on for other trends decreasing tendencies are seen (see more in Annex 2). A decreasing trend was observed in atmospheric ∑17PCDD/F concentrations at sites with long-term monitoring data (5 statistically significant), with a median annual change of −8.0% (t1/2 = 8.4 yr).

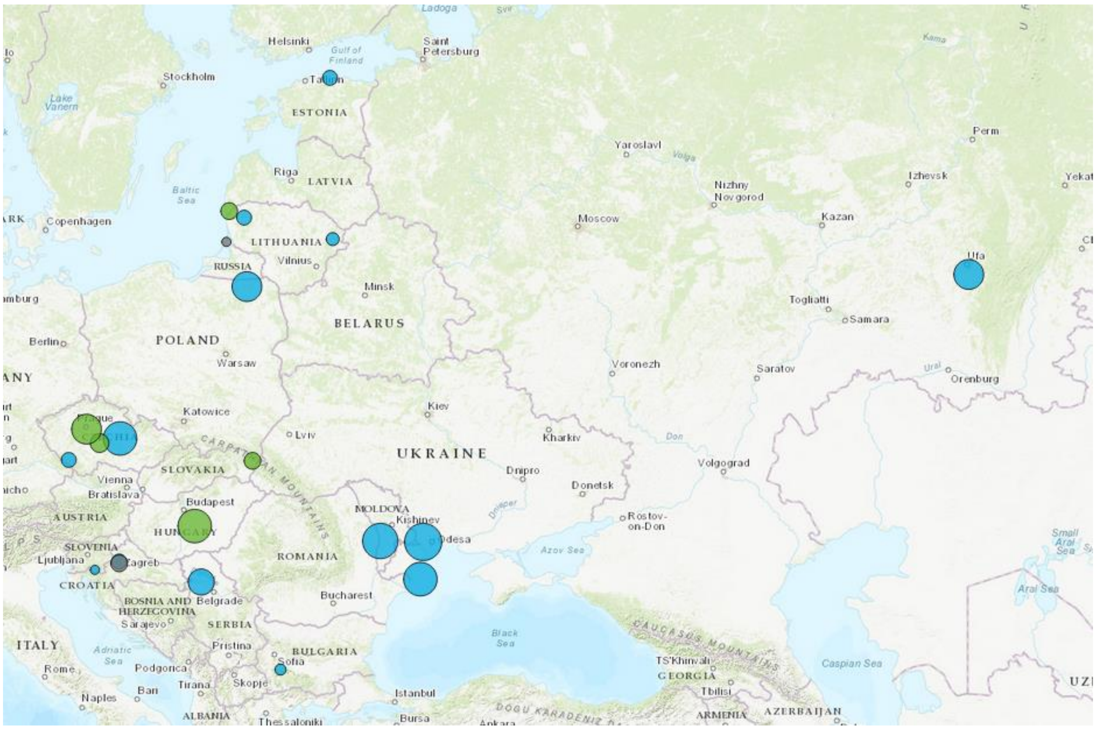


Figure 12: Trends observed in the CEE region for changes in levels of sum PCDD/F in ambient air between 2011-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

More data are available in Annex 2.

5.2.1.6. New POPs

New POPs are described in the following order: POPs containing chlorine (hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene, endosulfan, pentachlorophenol,PCN, hexachlorobutadiene, SCCPs), Brominated POPs (polybrominated diphenylethers PBDEs (tetra, penta, hexa, hepta, octa and deca), hexabromobiphenyl, hexabromocyclododecane), PFOS and voluntary/candidate POPs (PFOA, PFHxS, dicofol).

5.2.1.6.a New POPs containing chlorine

This text covers hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene, endosulfan, pentachlorophenol, PCN, hexachlorobutadiene and SCCPs.

HCH

Hexachlorcyclohexanes (three isomers: alpha-, beta- and gamma- lindane, HCHs) are another well studied chemical in the CEE region.

Individual isomers were analyzed/detected in air collected by passive sampling at 80 sampling sites of 17 countries in the CEE region. However, the duration of time series differs significantly; it ranges from one year up to 33 years (by active sampling) and statistically significant trends are available for more than 20 sites and decreasing tendencies are seen in others. Trends visible for gamma HCH are shown in Figure 13, alpha and beta HCH are shown in Annex 2.

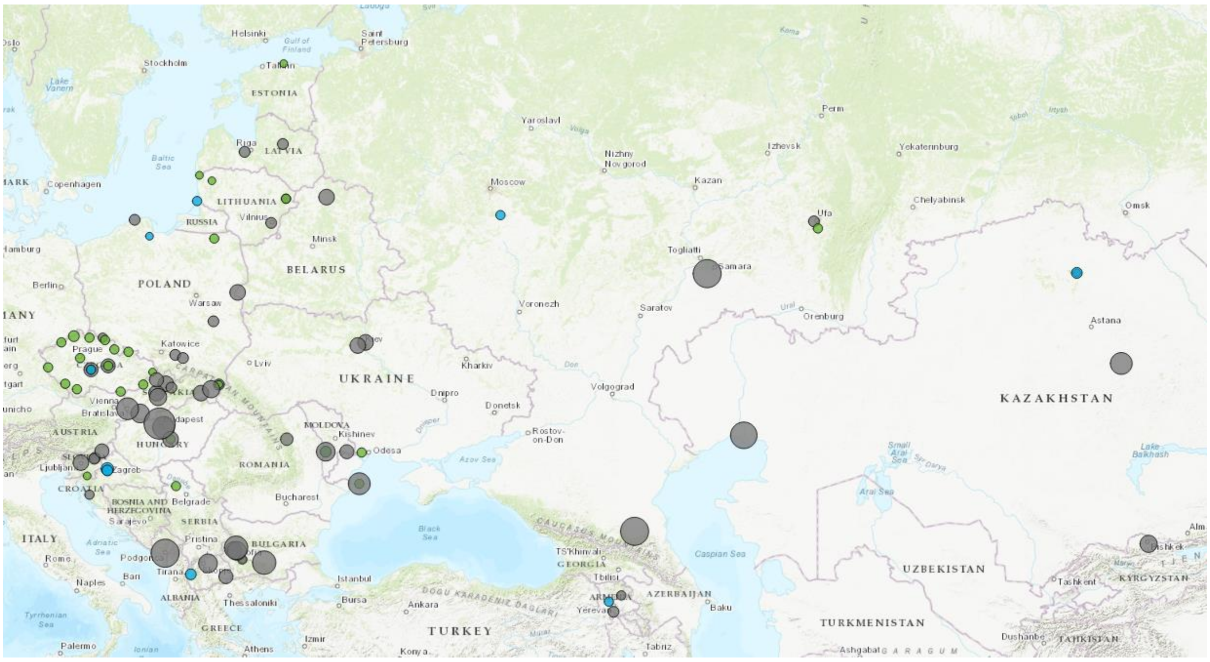


Figure 13: Trends observed in the CEE region for changes in levels of sum gammaHCH in ambient air between 2004-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Chlordecone

No data were available.

Pentachlorobenzene

This chemical is included in the monitoring by active samplers at the Košetice EMEP station since 2001 and levels from MONET network exist from 2004-2019. Baseline and one statistically significant trend were identified in the second report, now the statistically significant decreasing trends are expanded to other sites and countries as shown in Figure 14.

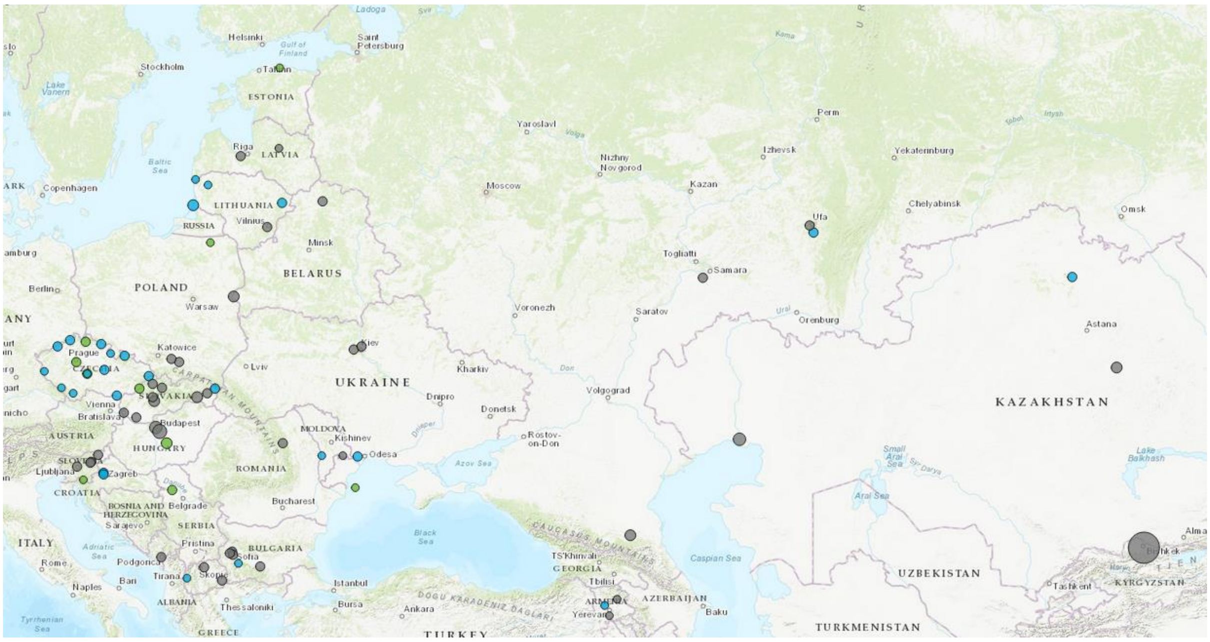


Figure 14: Trends observed in the CEE region for changes in levels of PeCB in ambient air between 2004-2019. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Endosulfan

Monitoring of endosulfan isomers and transformation products originally took place at four sampling sites in the CEE region - Danki (2005-2009), Košetice (2004-2010) and Pomlewo (2004-2006) by passive sampling.

Monitoring was expanded also to MONET sites in 2011 and statistically significant decreasing trend has been identified for alpha endosulfan at 9 sites in 7 countries in the region as shown in Figure 15.

Data available for beta endosulfan and endosulfan sulphate in the CEE region are shown in Figures 17 and 18, as their time series are not sufficiently long to establish statistically significant trends as shown in figure 16 for beta endosulfan (and the same is true for endosulfan sulphate). Data for these isomers/transformation products are only available from GAPS network activities for 2004-2014 period.

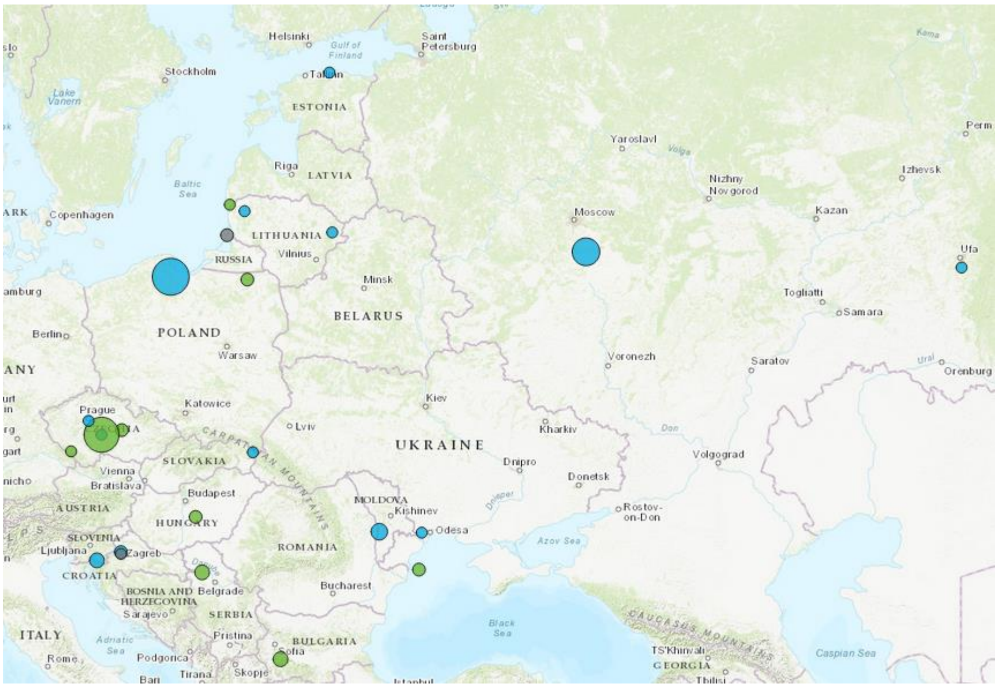


Figure 15: Trends observed in the CEE region for changes in levels of alpha endosulfan in ambient air between 2004-2019 for MONET and GAPS networks. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

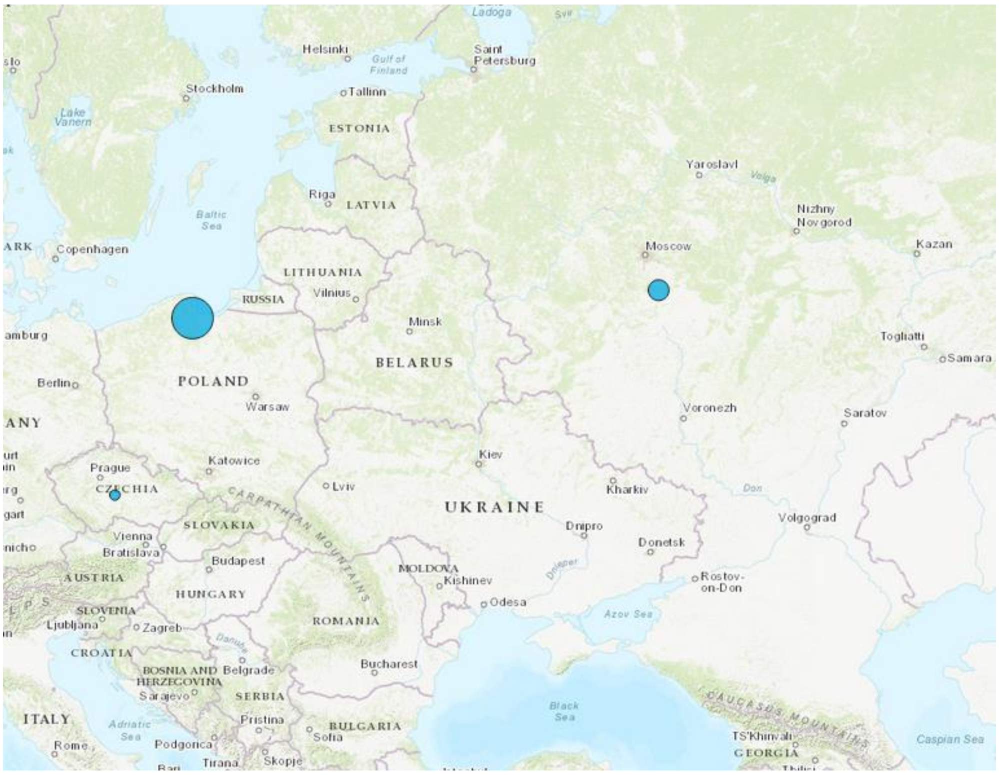


Figure 16: Trends observed in the CEE region for changes in levels of beta endosulfan in ambient air between 2004-2014 for GAPS networks at Danki, Pomlewo and Košetice sites. Statistically non-significant trend in blue, size of the circle represents the median of the concentrations. (source: GMP DWH)

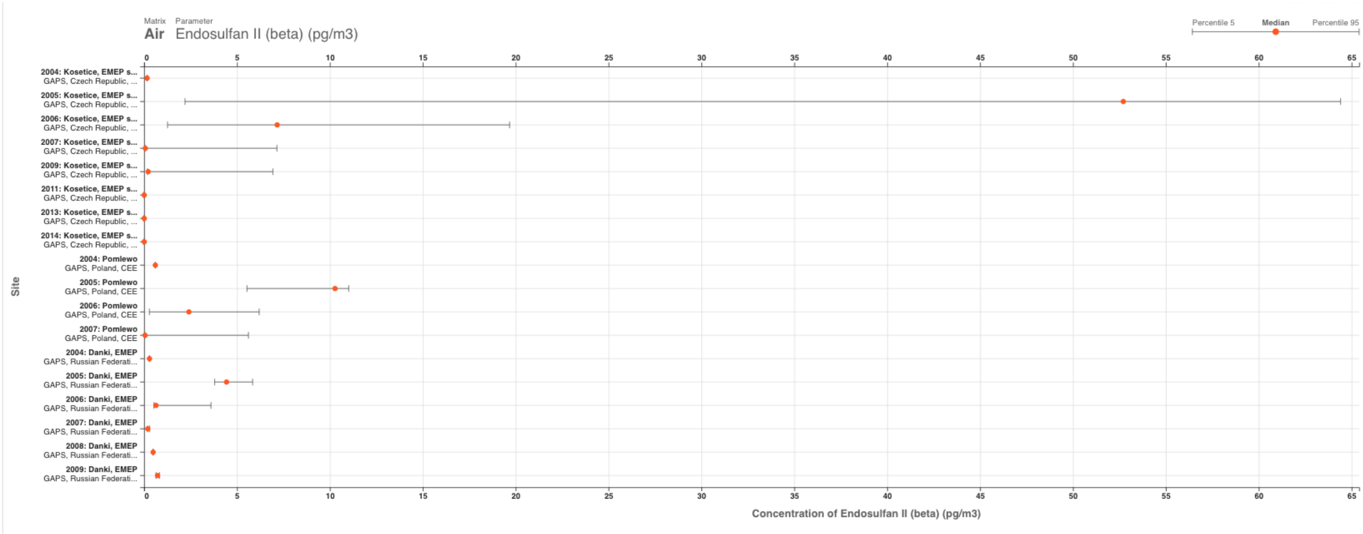


Figure 17: Observed beta endosulfan levels (pg/m^3) in ambient air at Košetice, Pomlewo and Danki sites between 2004-2014 for GAPS networks. (source: GMP DWH)

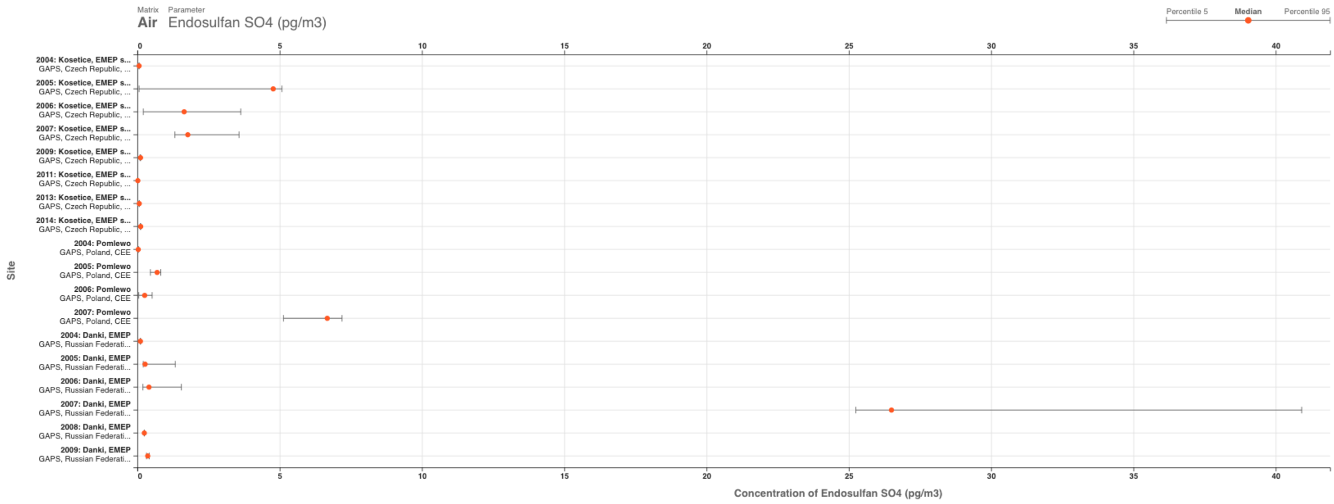


Figure 18: Observed endosulfan sulphate levels (pg/m^3) in ambient air at Košetice, Pomlewo and Danki sites between 2004-2014 for GAPS networks. (source: GMP DWH)

Pentachlorophenol

no data are currently available - neither for pentachlorophenol nor for pentachloroanisole, PCA (analyses of this parameter not yet adopted by monitoring networks).

SCCPs

no data were identified (analyses of this parameter not yet adopted by monitoring networks)

5.2.1.6.b New POPs containing bromine

PBDEs

Decreasing trends are observed in atmospheric PBDE concentrations at sites with long-term monitoring data (18 statistically significant), with a median annual change of −11.5% ($t_{1/2}$ = 5.2 yr).

For BDE 100 time series are available at 19 MONET sites in 13 countries. Length of the time series varies between 4 and 8 years, but statistically significant trend for BDE 100 is only available at one site. For all other sites decreasing tendencies were identified. Relevant table showing changes in BDE 100 levels (pg/m^3) is available in Annex 2.

Similar situation exists for other BDE congeners which is illustrated here by Figure 20 for BDE 47. Full datasets are available online in GMP DWH.

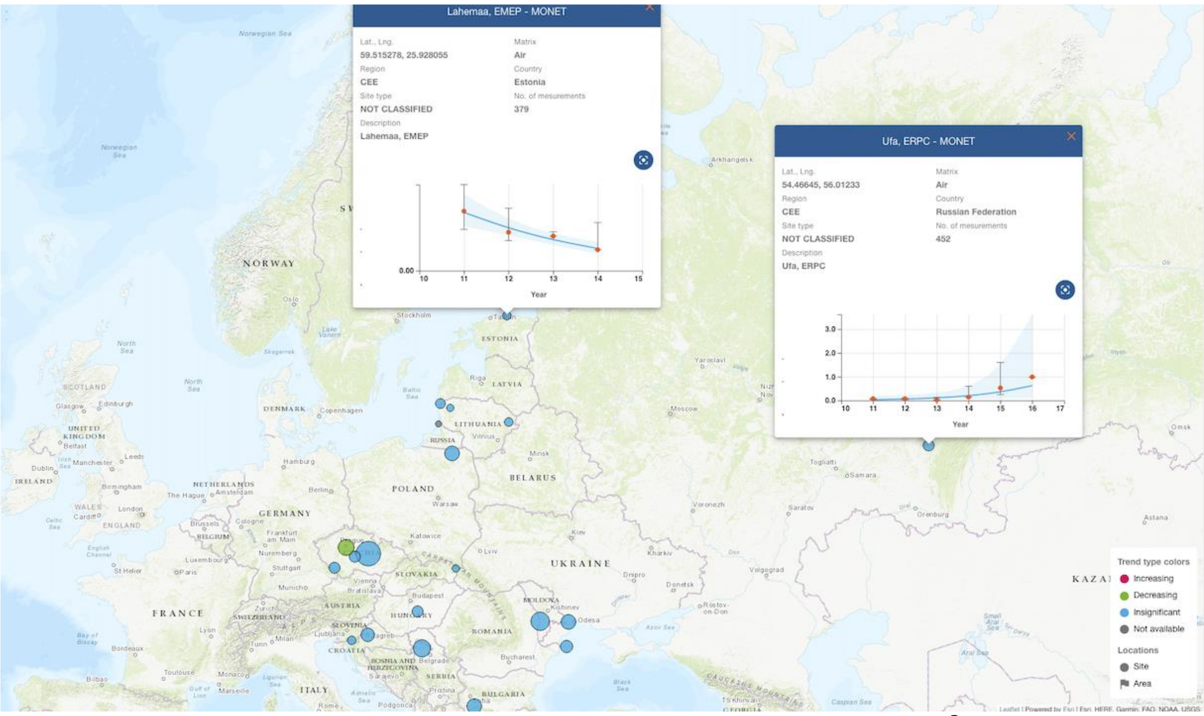


Figure 19: Trends observed in the CEE region for changes in levels (pg/m^3) of BDE100 in ambient air in MONET sites between 2011-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

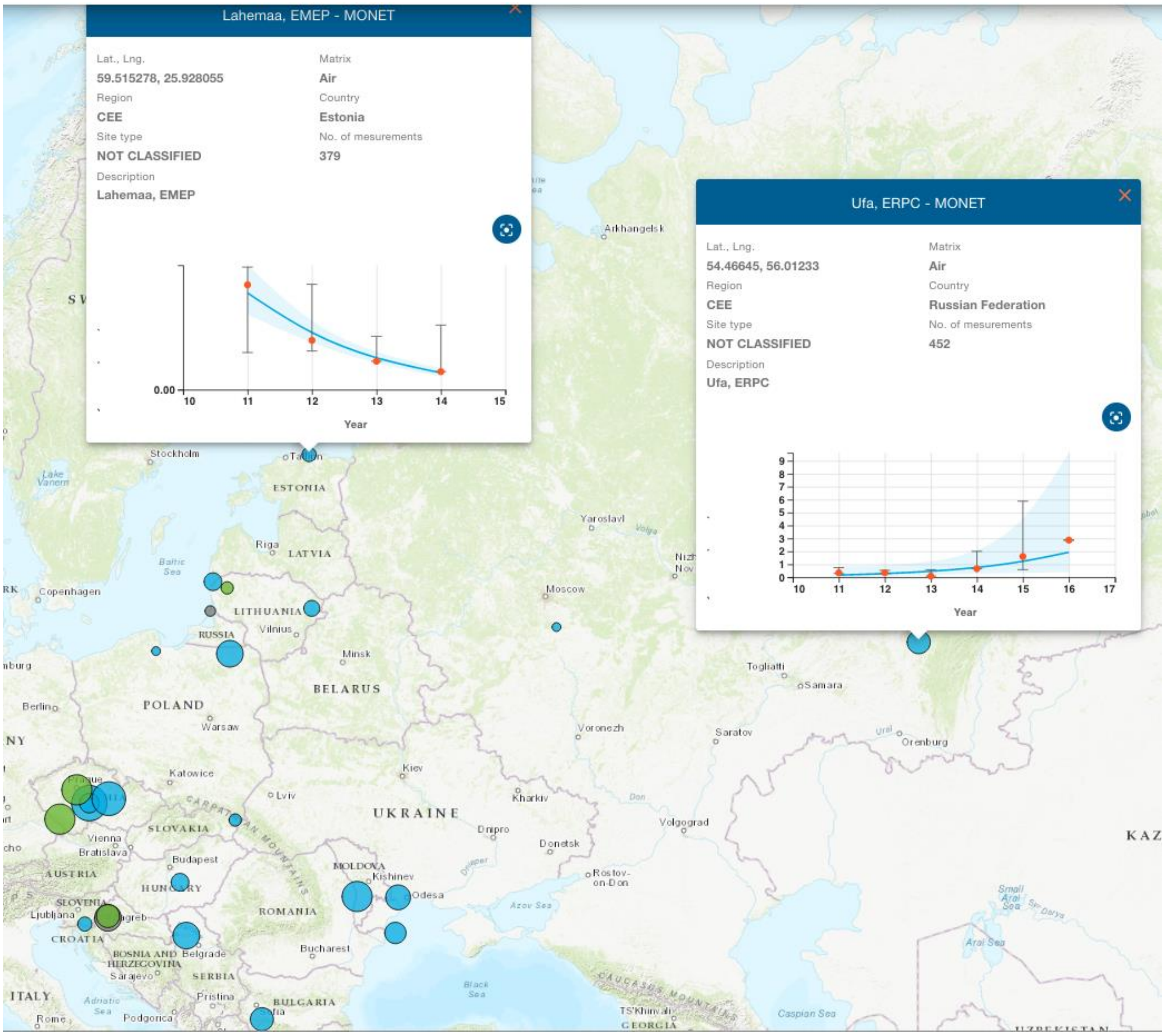


Figure 20: Trends observed in the CEE region for changes in levels of BDE 47 (pg/m^3) in ambient air at 19 MONET sites between 2011-2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. Size of the circle represents the median of the concentrations. (source: GMP DWH)

Hexabrombiphenyl-HBB

For this chemical no data are available through POPs monitoring activities in ambient air.

HBCDD

Here we only have a very limited information from GAPS network. Data are currently available for two years, 2013 and 2014, for alpha-, beta- and gamma- HBCDD at the Košetice GAPS site. Levels of all three congeners are very low/close to LOQ and no establishment of trends is possible due to insufficient length o the available time series.

5.2.1.6 c PFOS

A set of parent chemical, isomers and transformation products were analyzed from samples gathered by active sampling at the Košetice EMEP station in 2012 and 2013 as shown in Table 5. Baseline levels are thereby established. Since the time series only consists of two time points, a trend could not be observed. Moreover, levels observed for transformation products are very low and majority of them is below LOQ.

Table 5 Overview of concentrations of PFOS and its transformation products in the CEE region at Košetice site (active air sampling) in 2012 and 2013. (source 2nd CEE monitoring report)

Parameter/Compound	Time series start Year	Time series end Year	Length (Years)	Minimum concentration (mean) (pg m-3)	Maximum concentration (mean) (pg m-3)	Total amount of measurements	Concentration values below LOQ observed N times	Values below LOQ
PFOS				0,145471	0,337174	52	0	0%
PFOSA				0,0065801	0,0286688	52	26	50%
NEtFOSA	2012	2013	2	0,00461729	0,0278416	52	46	88%
NEtFOSE				0,0263281	0,0370864	52	31	60%
NMeFOSA				0,00695871	0,0260219	52	40	77%
NMeFOSE				0,0222207	0,0804179	52	22	42%

5.2.1.6 d New POPs whose reporting is not yet obligatory

This section covers dicofol, PFOA and PFHxS - but for all these chemical parameters no data are available through POPs monitoring activities in ambient air organized to date in the CEE region.

5.2.2 Human tissues (milk and/or blood)

This chapter shows data collected in the WHO human milk monitoring studies on PCBs and dioxins and furans conducted in 1987-1989 and 1992-1993 (WHO/EURO-coordinated exposure study on concentrations of PCB, PCDD and PCDF in human milk) and the participating countries reported results for PCDD and PCDF and also PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, and PCB 180 (WHO, 1989) and then subsequent studies organized by WHO in collaboration with UNEP between 2000 and 2019 reflecting the scope of the Stockholm Convention. The scope of the global WHO survey between 2001- 2003 comprised twelve POPs initially listed in the Stockholm Convention. Two additional UNEP/WHO global surveys (round 4 and 5) were conducted in 2005-2007 and 2008-2012. The scope for round 5 study (2008-2012) was extended to all POP parameters including new POPs and then round covering 2014-15 and 2018-2019 covers the full scope of the convention (some chemicals were analyzed on a voluntary basis).

Participation of the CEE region in the milk surveys is changeable and partly limited. The details are shown in the Figure 21 below. There were 13 countries and 11 participated repeatedly (with the exception of Albania and Poland). One country participated five times (Czech Republic), three countries (Croatia, Hungary and Slovakia) four times, Lithuania three times and six countries two times (Bulgaria, Georgia, Moldova, Romania, Russian Federation and Ukraine). In two rounds eight and seven countries participated (in 1992-3 and 2013/2014), otherwise the participation is low with only three or two participating countries from the region.

Figure 21: Countries from the CEE region participating in the WHO Euro and WHO-UNEP milk survey focussing on persistent organic pollutants between 1987-2019, source GMP DWH

In line with the survey protocol, multiple samples per country were submitted in the early studies (1987-1989 and 1992-1993) and then in the third round 2000-2003 *WHO, 1989; WHO, 1991, WHO, 1996*. In all subsequent studies only one pooled sample per country was submitted *WHO, 1996*.

Data in this chapter are organized in the following order: cyclodiene insecticides (aldrin, chlordane, dieldrin, endrin, heptachlor, mirex and toxaphene), DDT, hexachlorobenzene (HCB), PCB, PCDD and PCDF, new POPs (new POPs containing chlorine (hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene (PeCB), endosulfan, pentachlorophenol (PeCP/PCA), PCN, hexachlorobutadiene, SCCPs), brominated POPs (PBDEs, Hexabrombiphenyl-HBB, HBCDD) PFOS and POPs whose reporting is not yet obligatory (dicofol, PFOA and PFHxS).

5.2.2.1 Cyclodiene insecticides and toxaphene

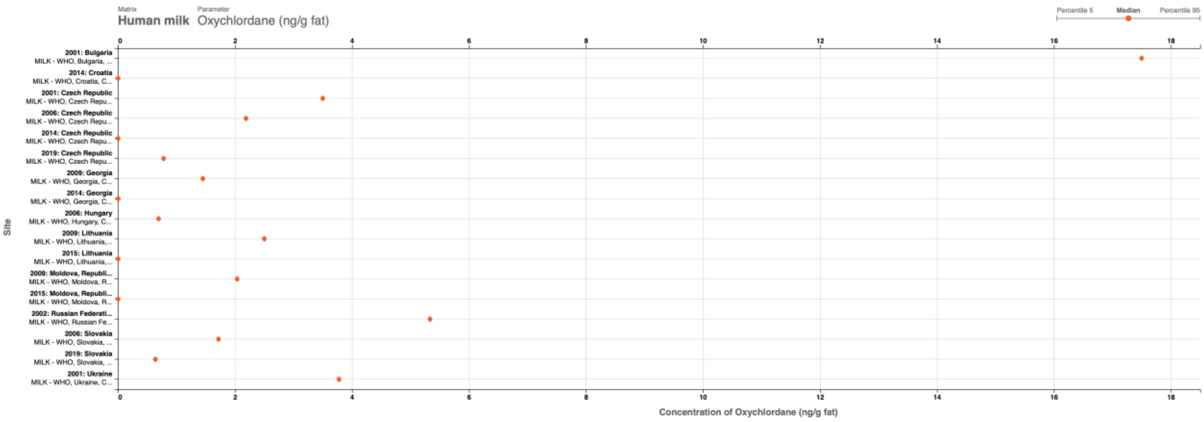
This chapter covers results of analyses for aldrin, chlordane, dieldrin, endrin, heptachlor, chlordecone, mirex and toxaphene in human milk.

<u>Aldrin</u>

Levels were analyzed for the first time in 2006 and over the years, results are available for seven CEE countries (Croatia, Czech Republic, Hungary, Slovakia, Georgia, Lithuania and, Moldova). Five countries have this chemical analyzed repeatedly - Czech Republic (4 times), Georgia, Lithuania, Moldova and Slovakia 2 times. Aldrin levels in all participating countries between 2006-2019 were lower than limit of quantification (0,5 ng/$g_{\text{lipid weight}}$) due to its rapid metabolization to dieldrin. It can be concluded that aldrin is not present in the analyzed pooled milk samples.

Chlordane

Chlordane is analyzed in three congeners - cis-, trans-chlordane and oxychlordane. Data are available 2001-2019 for 10 countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation, Slovakia, Ukraine) where five countries participated repeatedly (Czech Republic four surveys; Georgia, Lithuania, Moldova and Slovakia - two



surveys).

Figure 22: Observed oxychlordane levels in breast milk in the CEE region between 2001- 2019 (ng/$g_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Observed levels of cis-chlordane and trans-chlordane in all participating CEE countries showed the same pattern - levels were lower than limit of quantification 0,5 ng/$g_{\text{lipid weight}}$.

Values for oxychlordane differ more significantly and are shown in Figure 22 above. The highest level observed was 17,5 ng/$g_{\text{lipid weight}}$ in 2001, while the most recent levels observed in 2014 span between 1- and 2 ng/$g_{\text{lipid weight}}$ and for 2019 are 0.779 ng/$g_{\text{lipid weight}}$ representing 20 % of originally observed level.

As seen in Figure 22, the levels are decreasing, but the trend analysis shown in Figure 23 reveals that the current series length shows trends that are not statistically significant for 5 countries and no trends are available (not enough data) for the remaining five of participating CEE countries.

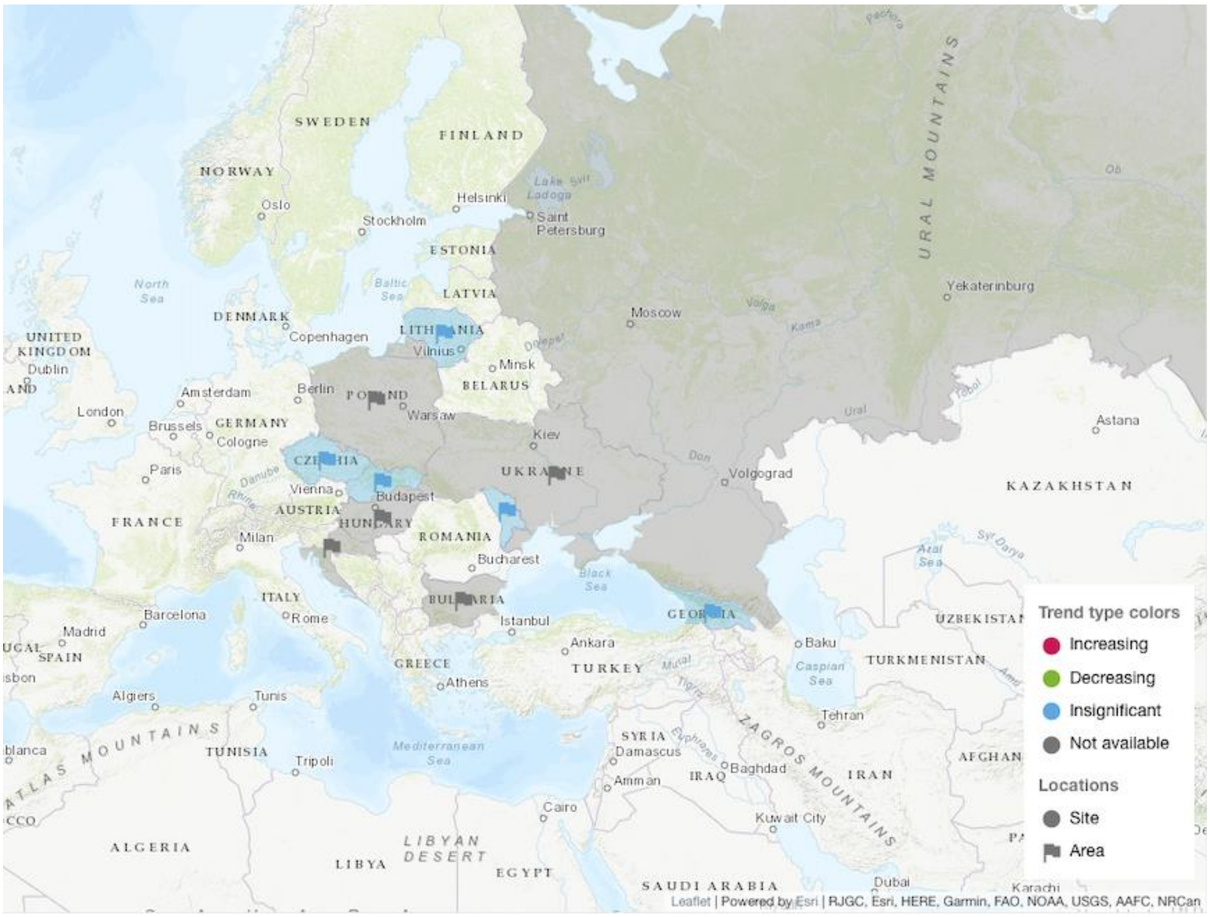


Figure 23: Trends observed in the CEE region for changes in levels of oxychlordane in human milk pooled samples between 2001-2019, UNEP/WHO milk survey. Decreasing trend is marked in green, statistically non-signifcant trend in blue, and no trend/not available trend in grey. (source: GMP DWH)

<u>Dieldrin</u>

Dieldrin levels are available for ten CEE countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation, Slovakia, Ukraine) participating in surveys between 2001 and 2019. Five countries have this chemical analyzed repeatedly - Czech Republic (4 times), Georgia, Lithuania, Moldova and Slovakia 2 times.

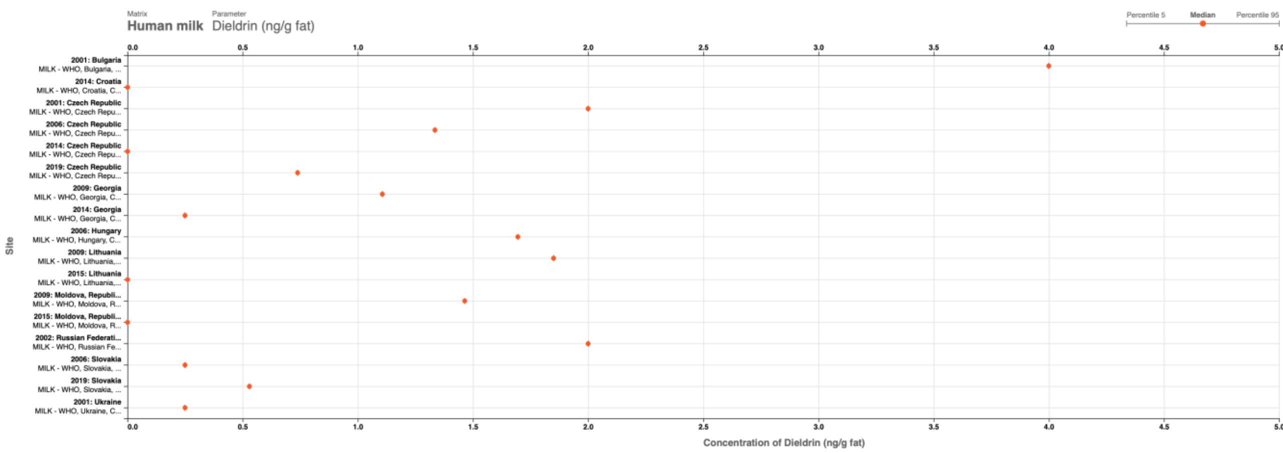


Figure 24: Observed dieldrin levels in breast milk in the CEE region between 2001- 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Observed levels decreased from 2 ng/g to close to quantification limit (0,5 ng/g$_{lipid\ weight}$) over time. Due to insufficiently long time series, no statistically significant trend could be identified. Nevertheless, decreasing levels (declining tendencies) are observed for the Czech Republic, Georgia, Lithuania and Moldova. Changes in dieldrin levels over the period 2001-2019 are shown in Figure 24.

Endrin

Endrin levels were analyzed for the first time in 2001, but it was never detected in any analyzed samples of the CEE region (10 countries - Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation, Slovakia, Ukraine) until present. All reported values were below limit of quantification (0,5 ng/g$_{lipid\ weight}$). It can be concluded the chemical is not present in the pooled milk samples analyzed for the CEE region.

Heptachlor

Heptachlor is usually analyzed as heptachlor, trans-heptachlorepoxide and cis-heptachlorepoxide. Unfortunately, heptachlor analyses were not the same for all years. The cis-heptachlorepoxide was the only heptachlor parameter analyzed in 2001, but subsequent surveys comprised all parameters of the heptachlor group. Data for cis-heptachlorepoxide are available for 10 countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation, Slovakia, Ukraine) and five of them participated in multiple surveys.

The highest level observed was 12,5 ng/g$_{lipid\ weight}$ in 2001 was about 10 times higher than values observed for the Czech Republic in the same period. More recent levels observed in 2014 span between 0,5- and 1 ng/g$_{lipid\ weight}$ and for 2019 are 0.741 ng/g$_{lipid\ weight}$ (Czech Republic) representing 50 % of originally observed level and 0.635 ng/g$_{lipid\ weight}$ (Slovakia).

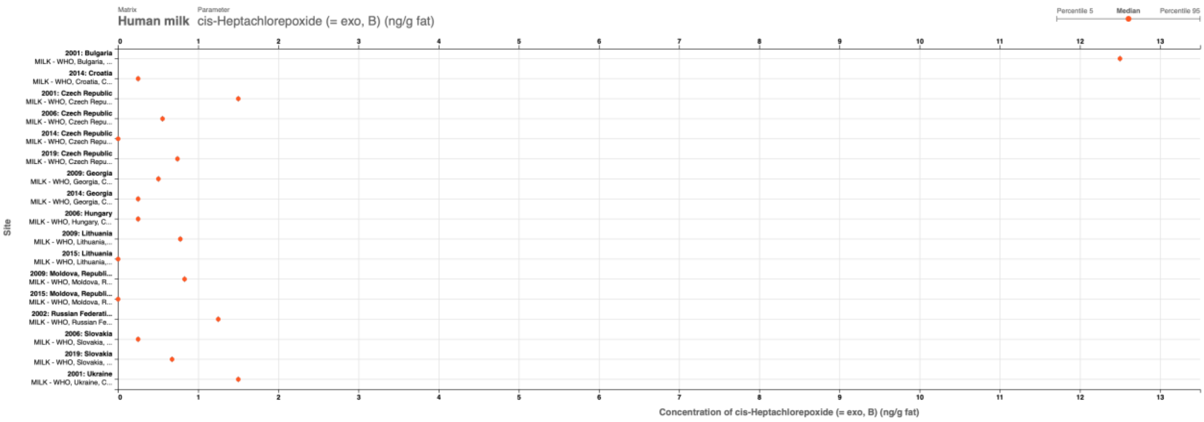


Figure 25: Observed cis-heptachlorepoxide levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

No statistically significant trend could be identified as of yet (see Figure 26), but there is a decreasing tendency observed for all countries with multiple participation - the Czech Republic, Georgia, Lithuania, Moldova and Slovakia as shown in Figure 25.

Heptachlor and trans-heptachlorepoxide levels were analyzed in 7 countries (Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Slovakia) between 2006-2019 are below limit of quantification (0,5 $ng/g_{lipid\ weight}$) for all samples, most likely because heptachlor is rapidly metabolized to cis-heptachlorepoxide.

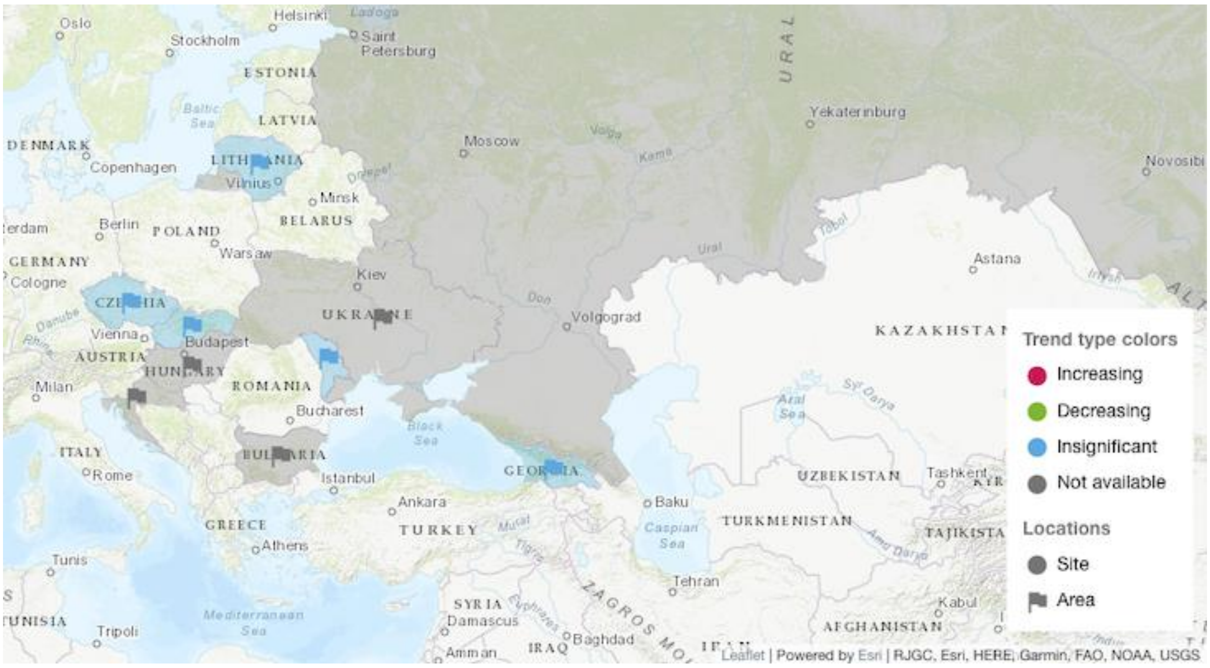


Figure 26: Observed cis-heptachlorepoxide trends in breast milk in 10 countries of the CEE region between 2001- 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. (source: GMP DWH)

Mirex

Mirex levels were analyzed in CEE pooled samples for the first time in 2006. There were analyses performed in samples from seven countries (Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Slovakia) and five countries repeated analyses in subsequent survey rounds. Five countries have this chemical analyzed repeatedly - Czech Republic (4 times), Georgia, Lithuania, Moldova and Slovakia 2 times. All mirex values reported were below limit of quantification (0,5 $ng/g_{lipid\ weight}$) in all analyzed samples until present. Thus, it can be concluded the chemical is not present in the pooled milk samples in the CEE region.

Toxaphene

Monitoring for toxaphene is based on the congeners Parlar 26 (P26), Parlar 50 (P50) and Parlar 62 (P62). Analyses in CEE region are available for ten countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation Slovakia and Ukraine) in the period 2001-2019. The Czech Republic participated in the survey round four times, Georgia, Lithuania, Moldova and Slovakia have two time points.

With the exception of a sample from Lithuania in 2009, no Parlar 62 was detected in the remaining nine CEE countries between 2001 and 2019.

For Parlar 26 and Parlar 50, levels observed below limit of quantification 0,5 $ng/g_{lipid\ weight}$) were reported for samples from Bulgaria, Croatia, the Czech Republic, Hungary and Slovakia. In other countries, Parlar 26 was found in ranges between 1-3 $ng/g_{lipid\ weight}$ and Parlar 50 in ranges 0,8 - 4 $ng/g_{lipid\ weight}$ as shown in Figures 27 and 28 below.

In cases of identified toxaphene/Parlar 26 and Parlar 50 concentrations above the limit of quantification, participation of the country in subsequent rounds and analyses for both analyses have shown a decrease in both analyses to levels below limit of quantification. Trends could not be quantified, but decreasing tendency was observed for all countries.

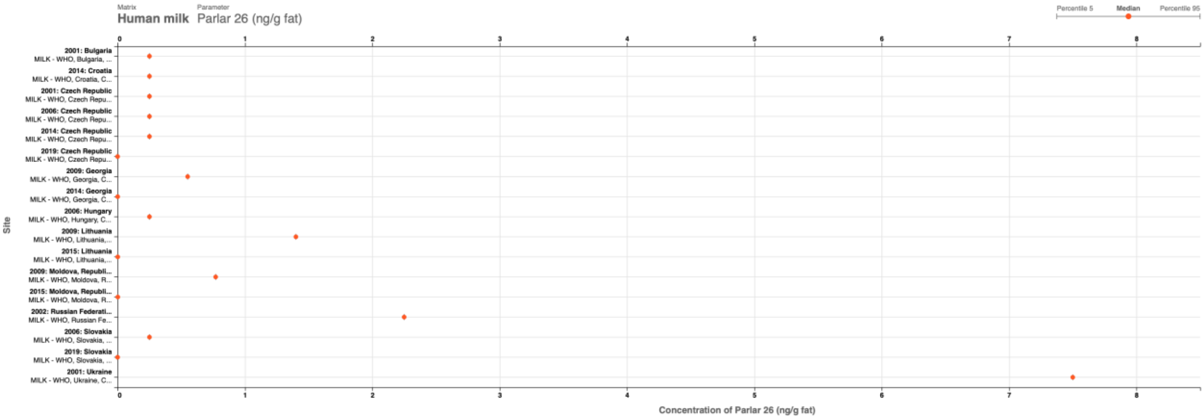


Figure 27: Observed Parlar 26 levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

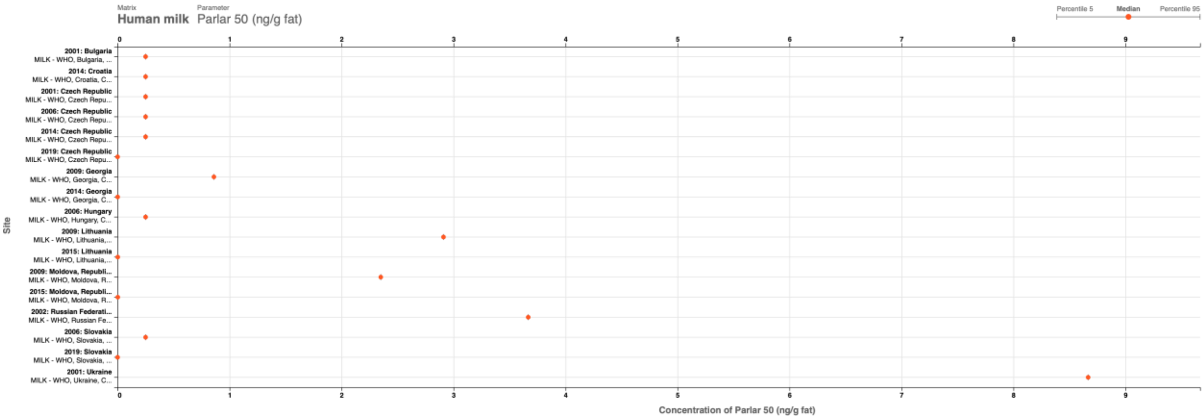


Figure 28: Observed Parlar 50 levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

5.2.2.2 DDT

DDT analyses were performed for ten CEE countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation Slovakia and Ukraine) covering period 2001-2019. Five countries participated repeatedly, the Czech Republic participated four times, Georgia, Lithuania, Moldova and Slovakia have two time points as shown in Figures 29-32.

The most important parameter controlling the total concentration levels is p,p-DDE that ranged between 54-1560 ng/g$_{\text{lipid weight}}$ representing up to 95% share in the summary parameter. Overall picture for the change of overall DDT levels provides Figure 29 providing information on summary of 6 DDT congeners. Repeated participation has shown a decrease in levels of all analyses as shown in figures 30-32 for p,p-DDD, p,p-DDT, and p,p-DDE respectively. Trends could not be quantified as statistically significant due to not sufficient length of the time series, but decreasing tendencies are clearly visible as shown in the figures 29-32.

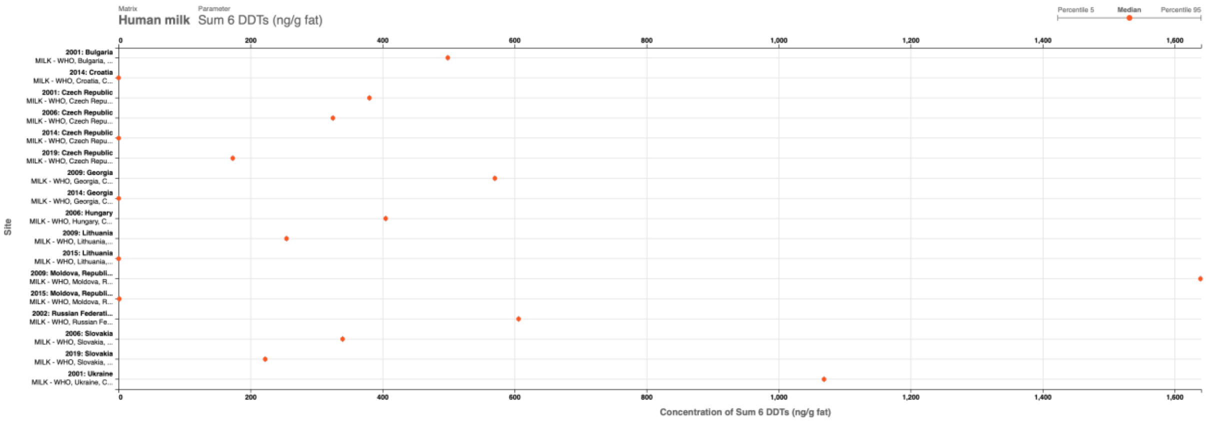


Figure 29: Observed 6 DDT levels in breast milk in the CEE region between 2001- 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

While levels of o,p DDE and o,p-DDD were almost all below level of quantification (i.e. below 0,5 $ng/g_{lipid\ weight}$), p,p-DDD levels ranged below LOQ in some countries (Bulgaria, Croatia, Russian Federation, Ukraine) while in all others the first sample was in the range of 0,7-3,5 $ng/g_{lipid\ weight}$ (see Figure 30).

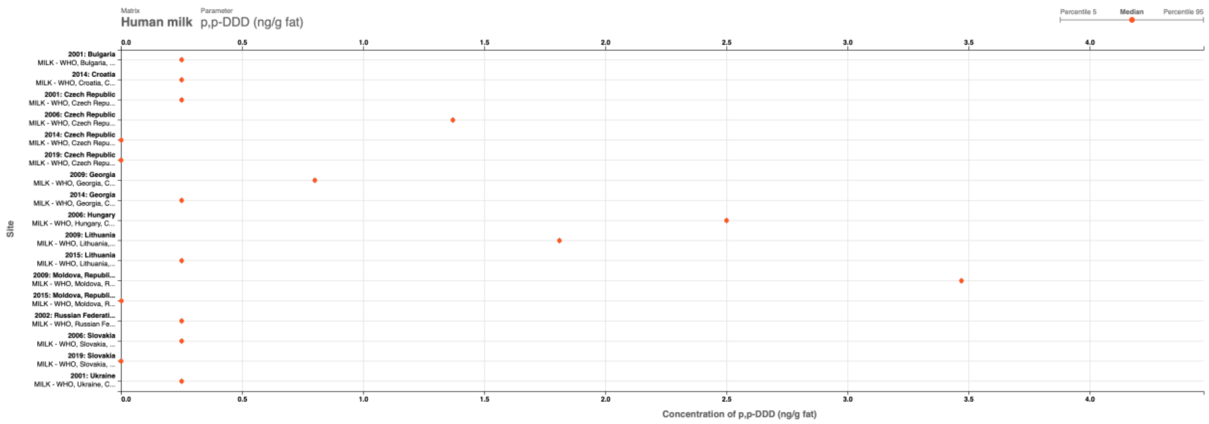


Figure 30: Observed p,p-DDD levels in breast milk in the CEE region between 2001- 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Levels of the DDT (o,p-DDT) were more variable. While below LOQ for Croatia, Czech Republic, Lithuania (2015) and Slovakia, ranges of 0,6-6 $ng/g_{lipid\ weight}$ were shown for other countries (Bulgaria, Hungary, Georgia, Lithuania, Moldova, Russian Federation and Ukraine) and levels of p,p-DDT ranged between 5-80 $ng/g_{lipid\ weight}$ as shown in Figure 31. Neverthless, repeated participation has shown a decrease in levels and o,p-DDT and p,p-DDT decreased with the exception of Slovakia for p,p-DDT where the levels remained similar.

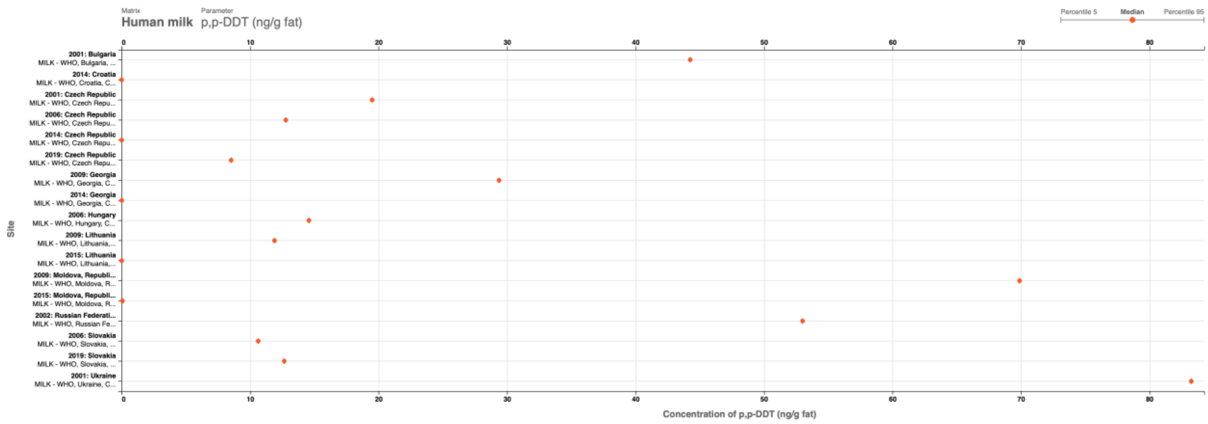


Figure 31: Observed p,p-DDT levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

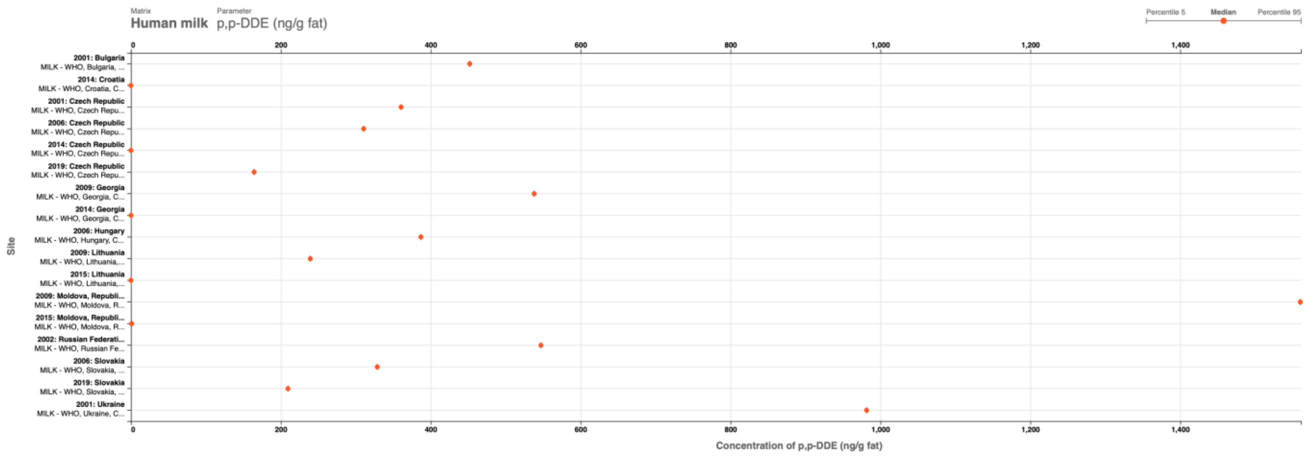


Figure 32: Observed p,p-DDE levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

5.2.2.3 Hexachlorobenzene (HCB)

Concentration values for hexachlorobenzene are available for ten CEE countries (Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Russian Federation Slovakia and Ukraine) covering period 2001-2019 for as shown in Figure HCB. Observed values vary significantly, minimum levels were found in ranges 7,6 - 12 ng/g$_{lipid\ weight}$ in Bulgaria and Croatia, while maximum observed was 154 ng/g$_{lipid\ weight}$ as shown in Figure 33. For five countries with repeated participation, the subsequent sample shows a significant decrease (of 50-75% of the original value). Levels observed between 2014 and 2019 range between 7 - 13 ng/g$_{lipid\ weight}$.

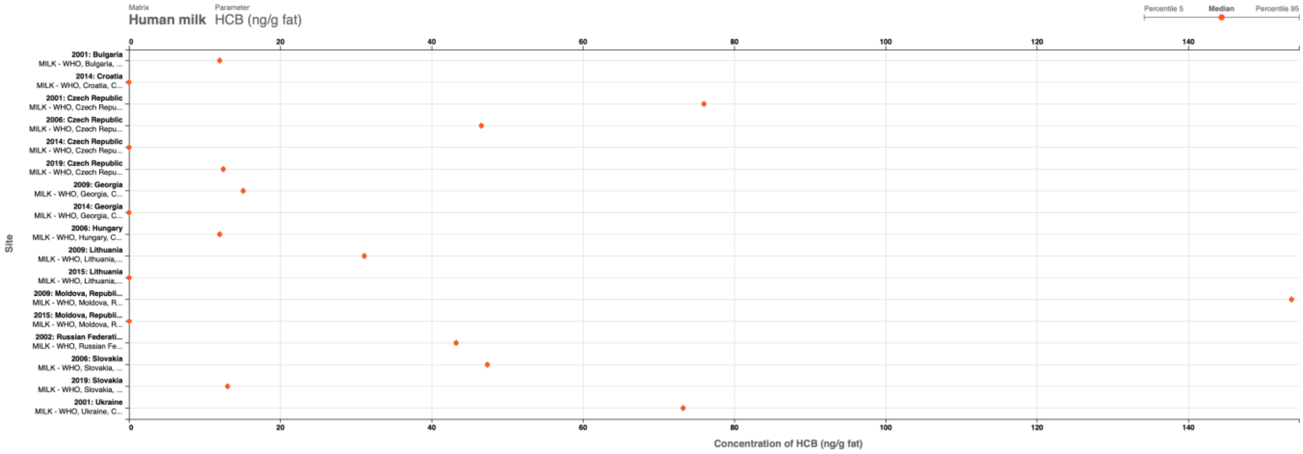


Figure 33: Observed HCB levels in breast milk in the CEE region between 2001- 2019 (ng/$g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

5.2.2.4 Polychlorinated biphenyls (PCB)

For the estimation of time trends for polychlorinated biphenyls (PCB), polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), this evaluation uses the five rounds of WHO / UNEP-coordinated exposure studies from 2000-2019 as well as two WHO-coordinated exposure studies carried out in 1987-1988 and 1992-1993.

Data and analyses are available for 13 CEE countries (Albania, Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Romania, Russian Federation, Slovakia, and Ukraine).

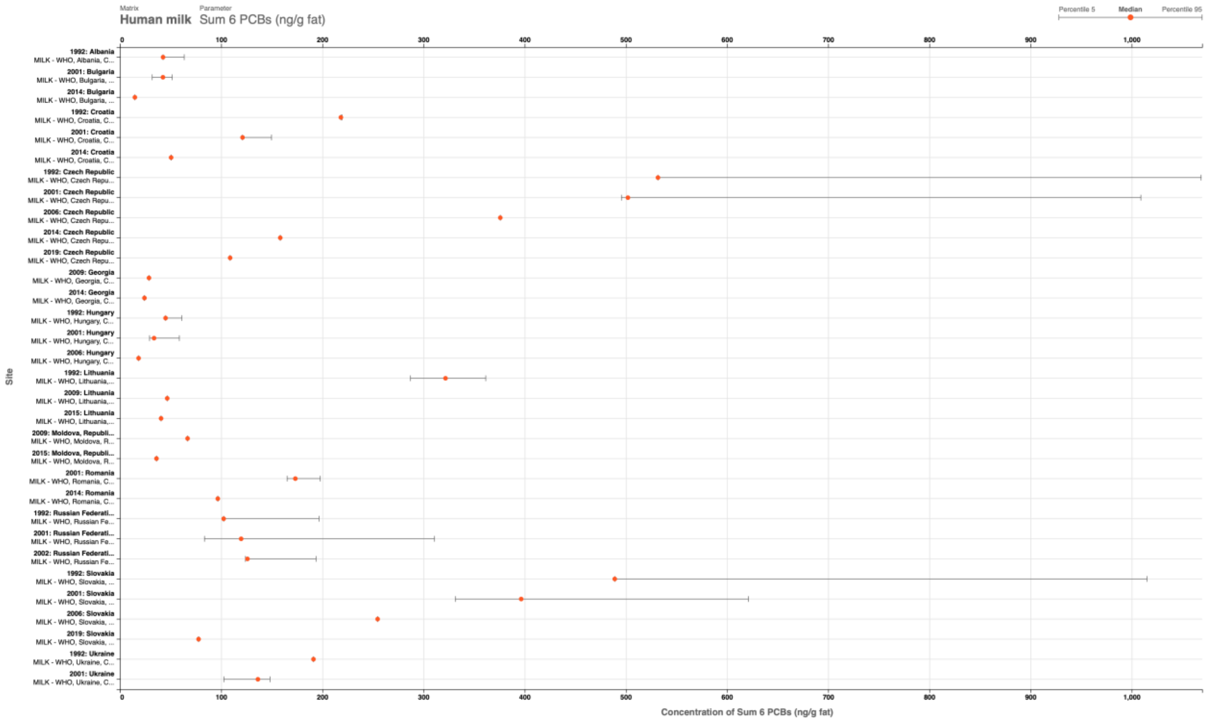
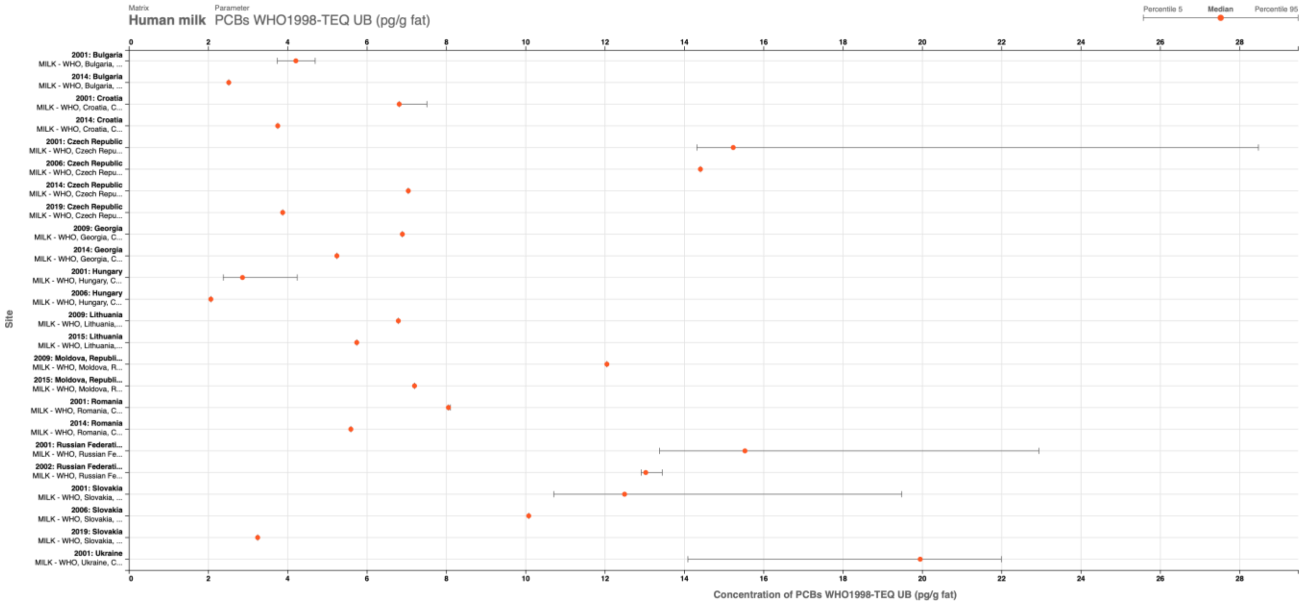


Figure 34: Observed indicator PCB levels in breast milk in the CEE region between 2001-2019 (ng/$g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Figure 34 shows that for all countries with repeated participation in WHO surveys levels decrease over time (Bulgaria, Croatia, Czech Republic, Hungary, Lithuania, Romania, Russian Federation, Slovakia and Ukraine). Decrease in Croatia, Czech Republic, Slovakia, and Lithuania exhibit a steeper slope than that of Hungary, Russia and Ukraine. The more significant decrease is seen in countries that have not produced PCB in their territory.

This chapter discusses not only indicator PCB congeners, but also dioxin-like PCBs and



shows.PCB levels expressed in toxic equivalents (TEQ) as shon in figure 35.

Figure 35 : Observed PCBs levels expressed as WHO1998 TEQ UB levels in breast milk in the CEE region between 2001- 2019 (pg/g$_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

5.2.2.5 Dioxins and Furans (PCDD and PCDF)

Polychlorinated dibenzo dioxins (PCDDs) and furans (PCDFs) were the most studied compounds in the milk surveys. This chapter contains not only concentration levels and trends for dioxins and furans, but data are also expressed as toxic equivalents (TEQ). For the estimation of time trends the evaluation uses the five rounds of WHO / UNEP-coordinated exposure studies from 2000-2019 as well as two WHO-coordinated exposure studies carried out in 1987-1988 and 1992-1993.

Some congener levels are available for 12 CEE countries (Albania, Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova, Poland Russian Federation, Slovakia and Ukraine). 10 countries participated repeatedly and statistically significant trend was available for one country, but decreasing tendencies are seen for all countries.

There is a repeated participation and trends Four countries participated in three consecutive surveys (Czech Republic, Hungary, Russian Federation and Slovakia), other countries (Croatia, Lithuania and Ukraine).

Figure 36 shows sum PCDD/Fs concentrations and reveal that for the majority of countries with repeated participation in WHO surveys levels decrease over time. A decrease observed for Croatia, Czech Republic, Hungary, Slovakia, and Lithuania exhibit a steeper slope than that for Russia and Ukraine. When testing for trends, the statistical tests do not prove a statistically significant trends as of yet. Longer time series would be necessary.

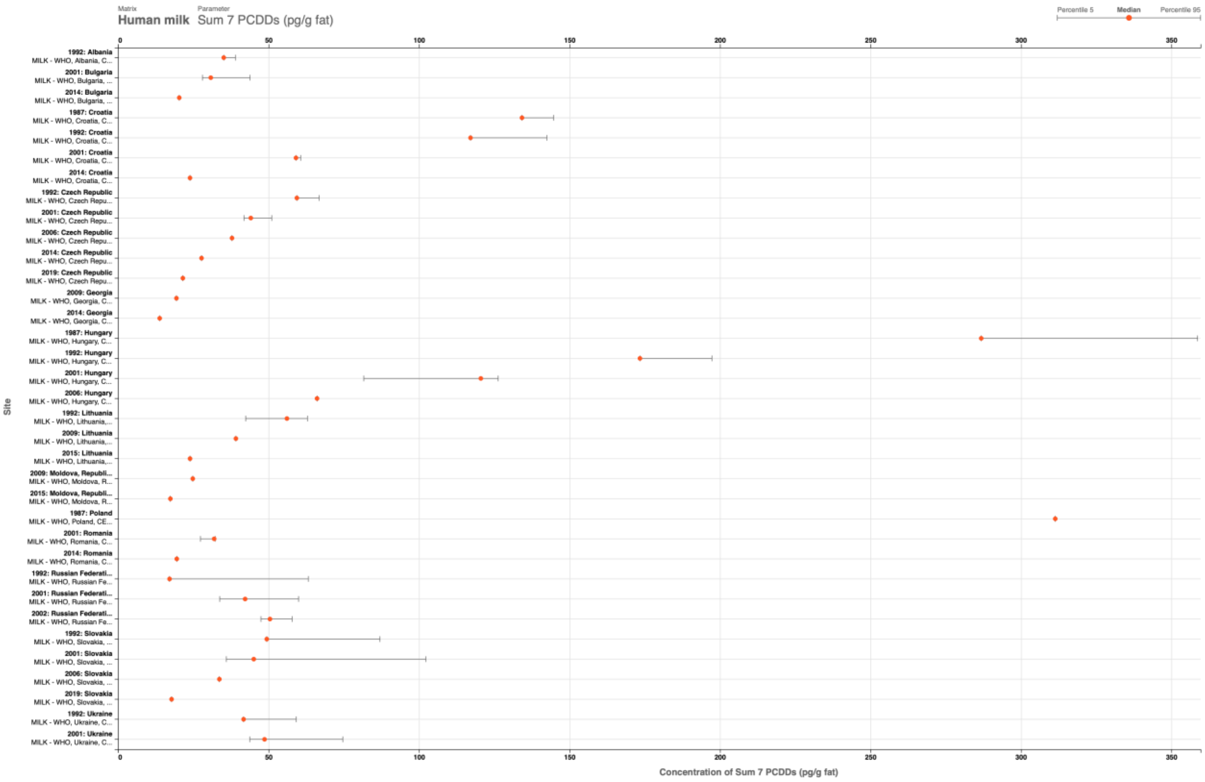


Figure 36: Observed changes in the summary parameter for polychlorinated dibenzo dioxins (PCDDs) levels in breast milk in countries of the CEE region between 2001- 2019 ($pg/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

5.2.2.6 New POPs

New POPs in the milk survey are described in four groups in the following order: **POPs containing chlorine** (hexachlorocyclohexane (HCHs), chlordecone, pentachlorobenzene, endosulfan, pentachlorophenol,PCN, hexachlorobutadiene, SCCPs), **Brominated POPs** (polybrominated diphenylethers PBDEs (tetra, penta, hexa, hepta, octa and deca), hexabromobiphenyl, hexabromocyclododecane), **PFOS** and **voluntary/candidate POPs** (PFOA, PFHxS, dicofol)

New POPs containing chlorine

Hexachlorocyclohexane (HCH)

Hexachlorocyclohexane[12] isomers were listed to the Stockholm Convention in 2009 but analyses were performed in the CEE region since milk survey round 3 in 2001. Data for 10 CEE countries are available over time.

Alpha HCH levels above limit of quantification were detected in 2001 in Bulgaria, Russian Federation and Ukraine, and Georgia and Moldova in 2009, but analyses in subsequent survey rounds have shown a decrease and the observed levels are below limit of

[12] Hexachlorocyclohexane(s) (HCH) were produced in a technical a mixture of isomers comprising about 65-70 % alpha-HCH, 7–20 % beta-HCH and 14-15 % gamma-HCH. Only gamma-HCH has insecticide properties (“lindane”: >99 % gamma-HCH). Accumulation in humans occurs for beta HCH (Fürst, 2021).

quantification (0.5 ng/g$_{lipid\ weight}$) as shown in Figure 37 for alpha HCH for 10 countries of the region.

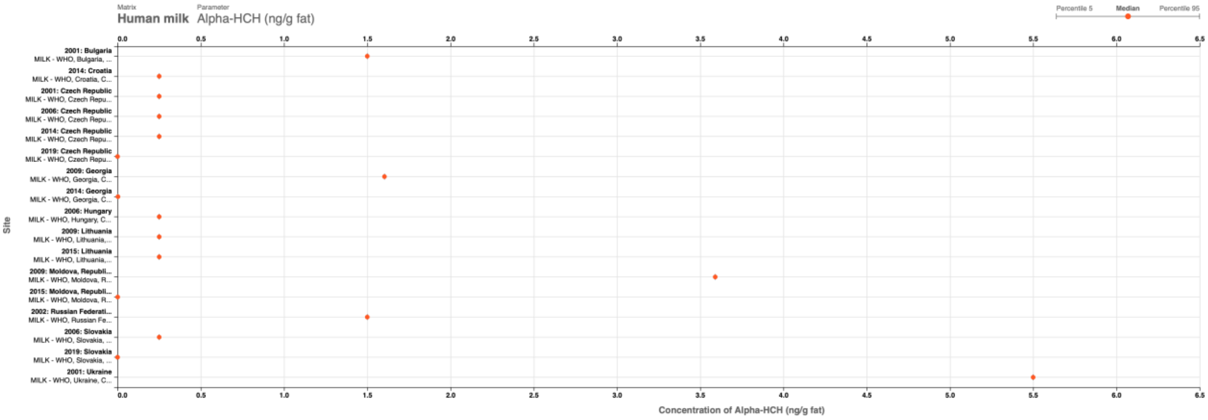


Figure 37: Observed alpha-HCH levels in breast milk in the CEE region between 2001-2019 (ng/g$_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

<u>Gamma- HCH/Lindane</u> levels were analyzed for the same period 2001-2019 show detection above limit of quantification in the samples of 2001 for Bulgaria, Czech Republic, Russian Federation and Ukraine in the range between 1 and 12 ng/g$_{lipid\ weight}$, Slovakia and Hungary in 2006 and Lithuania and Moldova in 2009. Repetition of analyses in further survey rounds provided levels below limit of quantification for the Czech Republic, Georgia, Lithuania, Moldova and Slovakia as shown in figure 38 for gamma-HCH.

Two studies in the Russian Federation outside the UNEP WHO milk survey have detected lindane and alpha HCH in 2017 and 2018 in the ranges between 1-10 ng/g$_{lipid\ weight}$. (see data in GMP DWH).

The levels observed for beta-hexachlorocyclohexane are of one to two orders of magnitude higher as shown in figure 39. In 2001 the levels ranged mostly between 26 and 279 ng/g$_{lipid\ weight}$, with median of 104,4 ng/g$_{lipid\ weight}$ in 2001. Subsequent participation in later surveys have shown a significant decrease in beta-HCH for all countries. More recent levels (over 2014-2019 participation) show a median of 7,9 ng/g$_{lipid\ weight}$ in 2014 and 2,37 ng/g$_{lipid\ weight}$ in 2019.

Trends for beta-HCH could not be quantified as statistically significant, four countries out of 10 have participated twice (usually 2009-2014) and only one country collected four samples over the period 2001-2019, nevertheless, decreasing tendency is clearly visible as shown in figure 39.

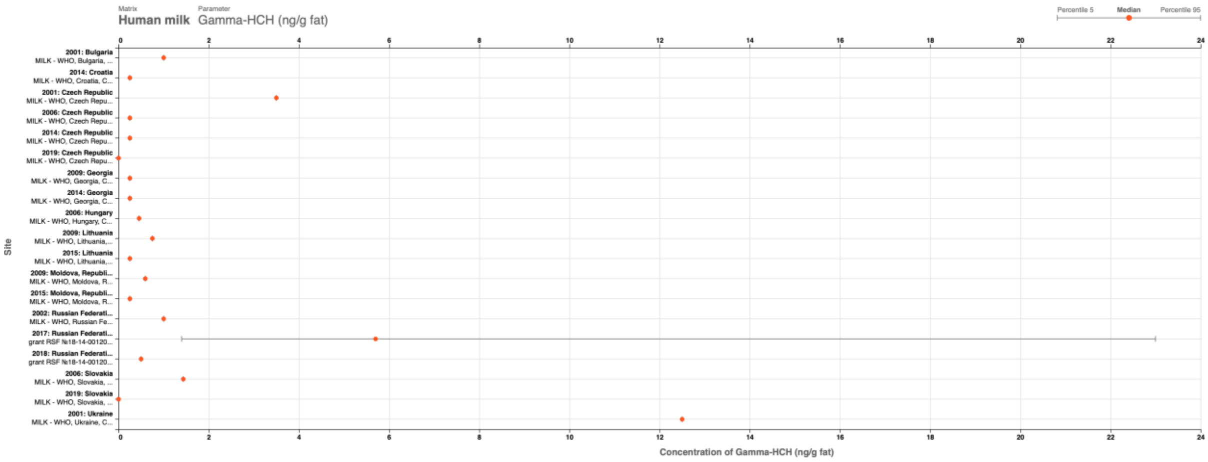
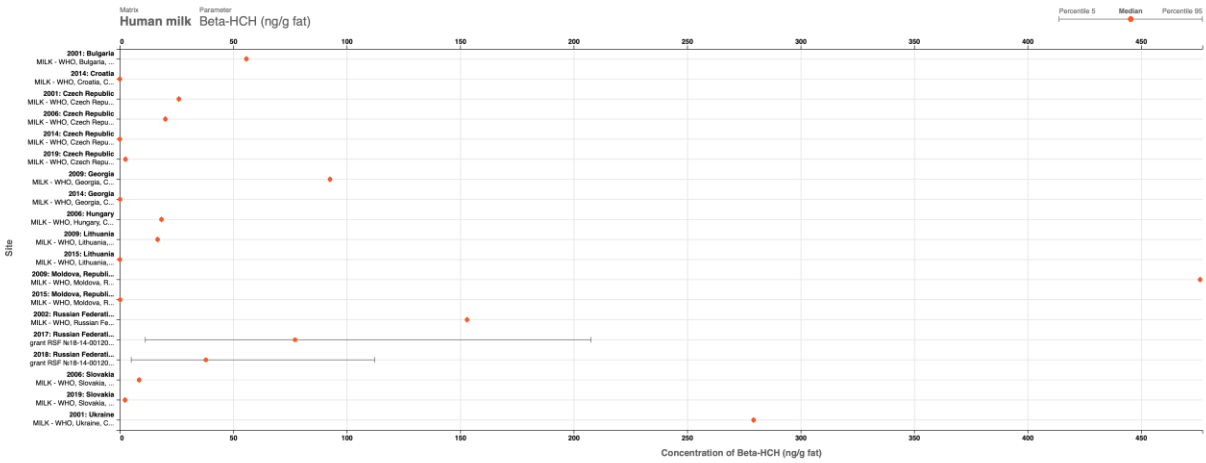


Figure 38: Observed lindane/gamma-HCH levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled



samples. (source: GMP DWH)

Figure 39: Observed beta-HCH levels in breast milk in the CEE region between 2001- 2019 (ng/g$_{\text{lipid weight}}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Chlordecone

While chlordecone was added to the Stockholm Convention in 2009, chlordecone levels were only analyzed in the most recent milk survey round in 2019. The levels were below the limit of quantification 0.5 ng/g$_{\text{lipid weight}}$ in the two participating countries.

Pentachlorobenzene

Analyses for pentachlorobenzene were performed for six countries between 2009 and 2019. Three countries analyzed the chemical in two rounds, but for all analyzed samples the levels were below the limit of quantification 0.5 ng/g$_{\text{lipid weight}}$. Thus, it can be concluded pentachlorobenzene was not present in the pooled milk samples in the CEE region between 2009 and 2019.

Endosulfan

Endosulfan was added to the Stockholm Convention in 2009. Analysis for endosulfan comprises the determination of endosulfan I (alpha), endosulfan II (beta) and endosulfan sulfate.

No levels were reported for neither of the three analyses for 10 countries in the region in samples collected between 2001-2019. One country analyzed for the analyses in four rounds, four other countries in two rounds. All reported values were below limit of quantification (0,5 $ng/g_{lipid\ weight}$). Thus, it can be concluded endosulfan is not present in the pooled milk samples in the CEE region.

Pentachlorophenol

Pentachlorophenol was listed in the Convention in 2015 and should be analyzed/reported as of 2018. Two parameters should be analyzed - pentachlorphenol (PCP) and its metabolite pentachloroanisol (PCA). PCP does not bioaccumulate in humans, but the metabolite could be found if PCP had been used. Analyses for PCP and PCA were only performed in the most recent milk survey round in 2019. The reported levels for both PCP and PCA were below the limit of quantification 0.5 $ng/g_{lipid\ weight}$ in the two participating countries.

Polychlorinated naphthalenes

Data for these POPs in CEE region were not available at the moment of preparation of this report. Polychlorinated naphthalenes were listed in the Convention in 2015 and should be analyzed/reported as of 2018, but there is a challenge for determination of concentration levels in the sample.

Hexachlorobutadiene

The hexachlorobutadiene (HCBD) was listed to the Stockholm Convention in 2015 and its levels should be reported to GMP since end of 2018. Thus, HCBD analyses were only performed in the most recent milk survey round in 2019. The levels observed were below the limit of quantification 0.5 $ng/g_{lipid\ weight}$ in the two participating countries.

Short-chained chlorinated paraffins

The group of short-chained chlorinated paraffins was listed to the Stockholm Convention in 2017 and levels should be reported to GMP since end of 2020. First analyses were only performed in the most recent milk survey round in 2019. The SCCP levels observed are shown in Figure 40 in the two participating countries.

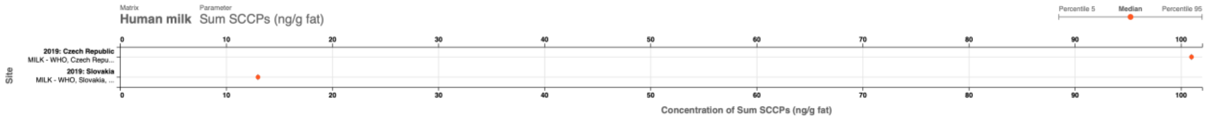


Figure 40: Observed SCCP levels in breast milk in the CEE region between in 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Brominated POPs

This section covers POPs listed in the Stockholm Convention between 2009 and 2019: polybrominated diphenyl ethers PBDEs (tetra-, penta-, hexa-, hepta-, octa- bromodiphenyl ethers (all listed in 2009)) and decabromodiphenyl ether (2019), hexabromobiphenyl (2009), hexabromocyclododecane (2013)

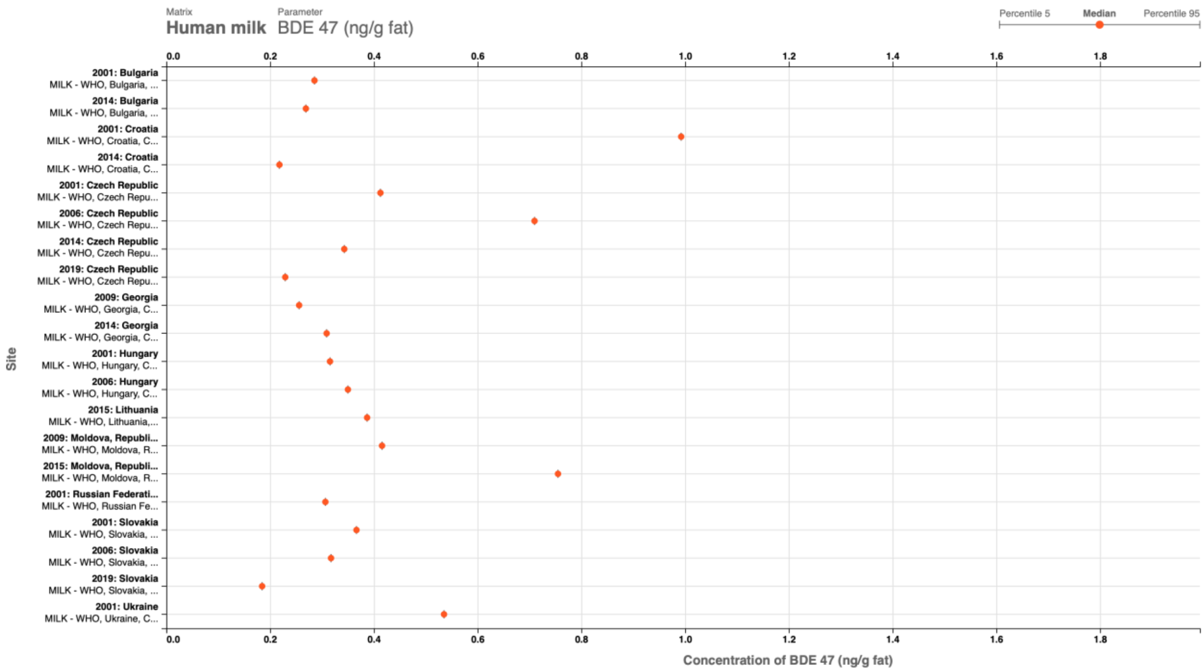


Figure 41: Observed BDE47 levels in breast milk in the CEE region between in 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

PBDE listed in 2009 (c-penta- and c-octa BDE)

Levels for polybrominatediphenylethers were analysed in samples collected between 2001 and 2019 for Bulgaria, Croatia, Czech Republic, Georgia, Hungary, Moldova, Romania, Russian Federation, Slovakia, and Ukraine. Five countries Bulgaria, Czech Republic, Hungary, Romania, and Slovakia have results from multiple rounds.

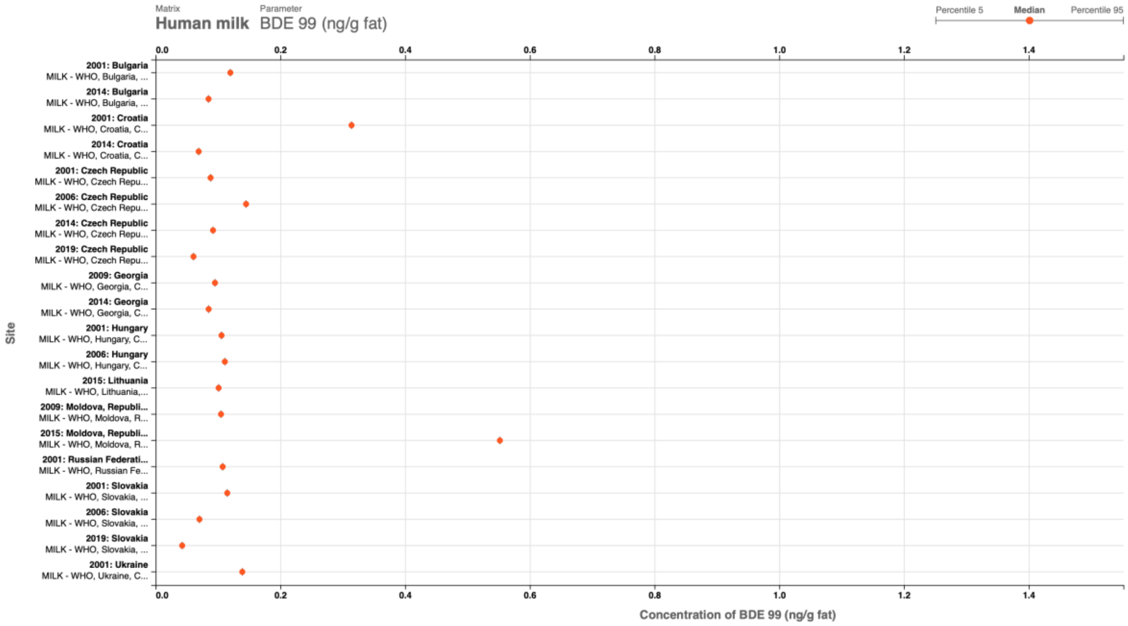


Figure 42: Observed BDE99 levels in breast milk in the CEE region between 2001-2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

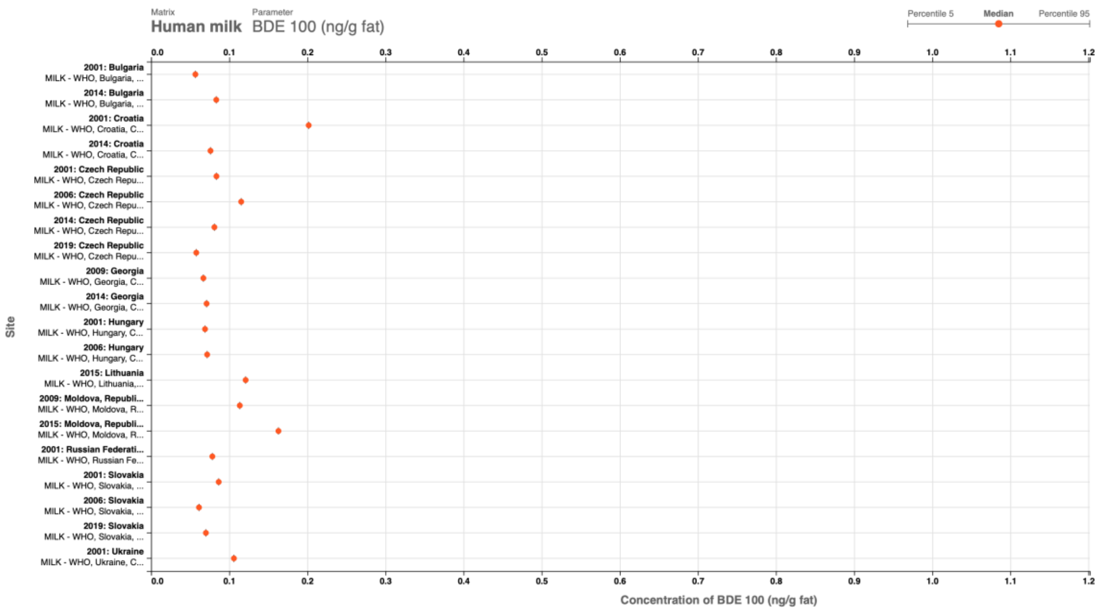


Figure 43: Observed BDE100 levels in breast milk in the CEE region between 2001-2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Results for BDE 47, 99, and 100 are shown in Figures 41-43 respectively. All other BDE isomers (BDE 17, BDE 28, BDE 153, BDE154) were detected in all countries, though for BDE 17 the median values seen were predominantly below LOQ (0.002 $ng/g_{lipid\ weight}$), for BDE28 a range of 0.017-0.059 $ng/g_{lipid\ weight}$, BDE 153 0.09-0.33 $ng/g_{lipid\ weight}$, and BDE154 0.003-0.05 $ng/g_{lipid\ weight}$ and for BDE 175/173 ranges of 0,02-0,044 $ng/g_{lipid\ weight}$ were obtained.

BDE listed in 2017 (deca-BDE)

Deca-BDE was listed in the Convention in 2017 and should be analyzed/reported as of end 2020. Data for this BDE congener expressed by the parameter BDE 209 were not available at the moment of preparation of this report - the results were not yet available for the pooled samples collected in 2019.

Hexabromobiphenyl

Hexabromobiphenyl was listed in 2009 and the first analyses for had been already performed in the 5th round of the milk survey in 2009. Data are expressed as congener PBB153 and are available for 6 countries - Croatia, Czech Republic (2 rounds), Georgia (2 rounds), Lithuania (2 rounds), Moldova and Slovakia. Observed levels were identical for in all samples for all survey rounds - below the limit of quantification 0.5 $ng/g_{lipid\ weight}$.

Hexabromocyclododecane

Hexabromocyclododecane was listed in the Stockholm Convention in 2013 and should be reported to GMP since 2016. The but the first data were already provided in the round 4 between 2006-2009 and then subsequently until 2019. Data are available for seven countries (Croatia, Czech Republic, Georgia, Hungary, Lithuania, Moldova and Slovakia) and multiple datapoints (two) are available for Czech Republic, Georgia, Moldova and Slovakia.

For alpha HBCD with the exception of hte Czech Republic, levels of the congener increased over time and were detected in ranges 1-8 $ng/g_{lipid\ weight}$ with the following medians 2 $ng/g_{lipid\ weight}$ (2006), 2,05 $ng/g_{lipid\ weight}$ (2009), 3 $ng/g_{lipid\ weight}$ (2014) and 2 $ng/g_{lipid\ weight}$ in 2019 patterns are shown in Figure 44.

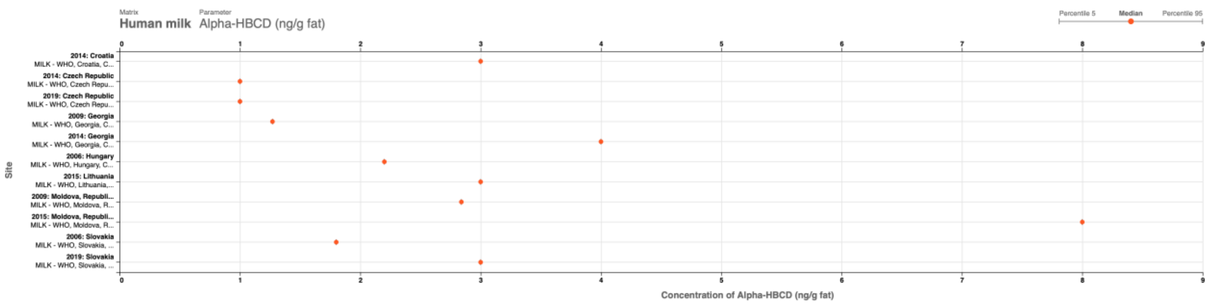


Figure 44: Observed alpha HBCDD levels in breast milk in the CEE region between 2006 and 2019 ($ng/g_{lipid\ weight}$). Data generated through WHO and UNEP/WHO surveys, pooled samples. (source: GMP DWH)

Levels observed for beta-HBCDD in Croatia, Czech Republic, Georgia Moldova and Slovakia were below LOQ (0.1 $ng/g_{lipid\ weight}$) with the exception of a sample for Hungary 2006 = 0.2

ng/g $_{\text{lipid weight}}$ and Lithuania 2015 = 0.3 ng/g $_{\text{lipid weight}}$. Similar pattern was observed for gamma-HBCDD and the only above LO1 levels were sample for Hungary 2006 = 0.2 ng/g $_{\text{lipid weight}}$ and Moldova 2015 = 0.2 ng/g $_{\text{lipid weight}}$. Other samples were below LOQ (0.1 ng/g $_{\text{lipid weight}}$).

Perfluorooctane sulfonic acid (PFOS)

PFOS analyses on milk samples in CEE region were performed for the first time in 2009, but data were not made available. The observed levels were 28 ng/l for Georgia (2009) and 65 ng/l for Moldova (2009). There were 7 additional samples analyzed in 2014, but data are not yet available. Subsequently, in the 7th round, two additional samples were analyzed and their levels are shown in Figure 45.

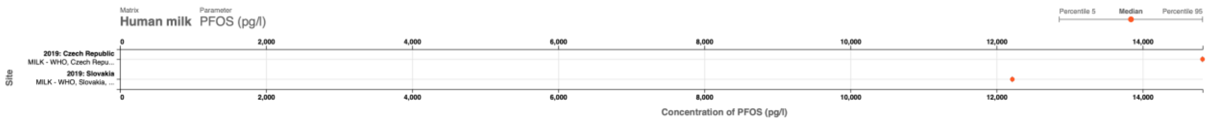


Figure 45: Observed PFOA levels in breast milk in the CEE region in samples collected in 2019 (pg/l). Data generated through WHO and UNEP/WHO survey, pooled samples. (source: GMP DWH).

voluntary/candidate POPs (PFOA, PFHxS, dicofol)

<u>Dicofol</u>

Dicofol was listed to the Stockholm Convention in 2019 and its levels should be reported to GMP since end of 2021. Nevertheless, first analyses performed in the most recent milk survey round in 2019. The levels observed were below the limit of quantification 0.5 ng/g$_{\text{lipid weight}}$ in the two participating countries.

<u>Perfluorooctanoic acid (PFOA)</u>

PFOA was listed in 2019 and the first data in GMP will be required since 2022. On a voluntary basis, first analyses were performed in the most recent milk survey round in 2019. The levels observed are shown in Figure 46 in the two participating countries. The PFOA levels are two times higher than those observed for PFOS.

Figure 46: Observed PFOA levels in breast milk in the CEE region in 2019 (pg/l). Data generated through WHO and UNEP/WHO survey, pooled samples. (source: GMP DWH).

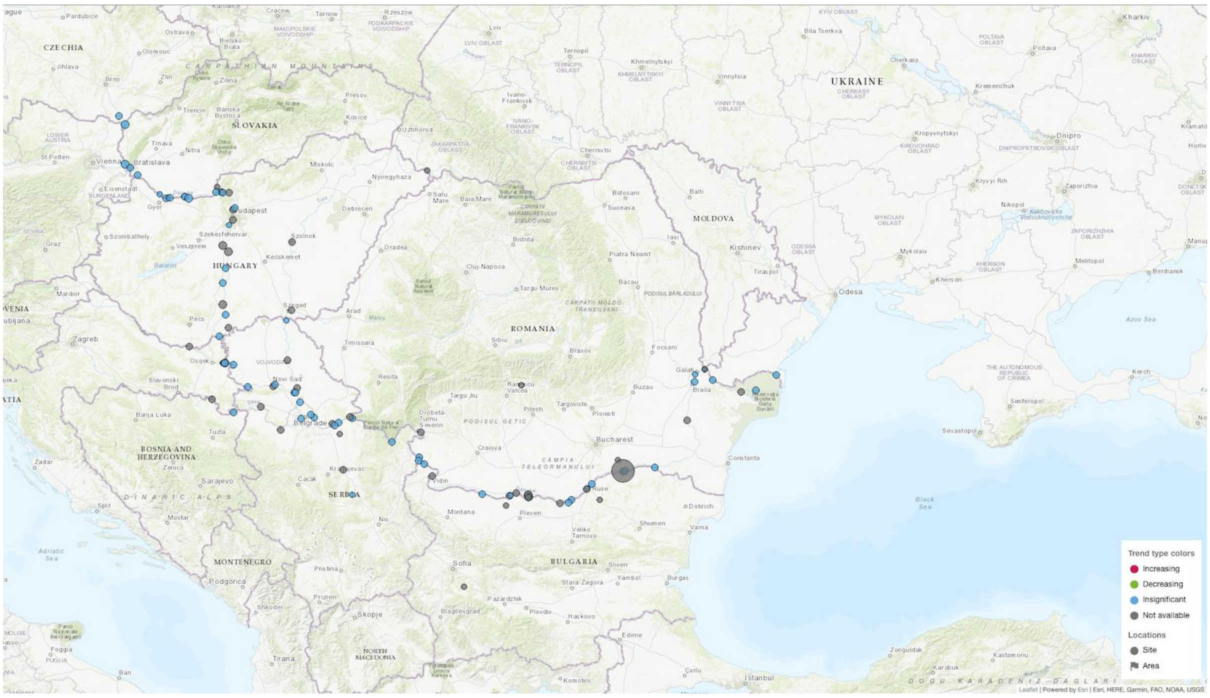
<u>Perfluorohexane sulfonic acid (PFHxS)</u>

PFHxS is a candidate chemical and the first data in GMP will be required approximately three years after it is successfully listed in annexes of the Stockholm Convention. On a voluntary basis, first PFHxS analyses were performed in the most recent milk survey round in 2019.

Observed levels were identical for both participating countries - below the limit of quantification 5,5 ng/litre.

5.2.3. Water

A limited information is available in relation to PFOS levels in the CEE region. There are no systematic regional nor national monitoring programme related to PFOS/PFOA in water, however the PFOS was included among priority substances under the EU Water Framework Directive in 2013 and thus should be monitored by all EU countries since 2013. Nevertheless, a research survey was organized by the International Committee on Protection of Danube, European Commission and Joint Research Centre that provides a key data in the western part of the CEE region. It started as a research project in 23 countries along Danube river including its tributaries and investigated occurrence of 34 polar organic contaminants including PFOS and PFOA in major European rivers and their tributaries. Data for PFOS and PFOA in surface water are available from joint Danube survey performed in 2007, 2013/2014 and 2019 as



shown in Figure 47.

Figure 47: Sampling sites and tendencies observed for PFOS levels changing over time within the Joint Danube Survey rounds between 2007 and 2019. Decreasing trend is marked in green, statistically non-significant trend in blue, and no trend/not available trend in grey. (source: GMP DWH)

The results show that identification of both target Stockholm Convention chemicals reached 94 and 97% cases/samples respectively in 2007. In addition to PFOS and PFOA the survey also covered occurrence of some other POPs (organochlorine pesticides, brominated flame retardants, PCB and DDT), but data for those POPs do only provide some baseline, there are not enough data points to identify tendencies.

The short duration of time series do not allow to identify statistically significant trends, but decreasing tendencies were seen for many sampling sites of Danube tributaries as seen in Figures 48 and 49. Full set of data for all used JDS sampling sites is available in GMP DWH.

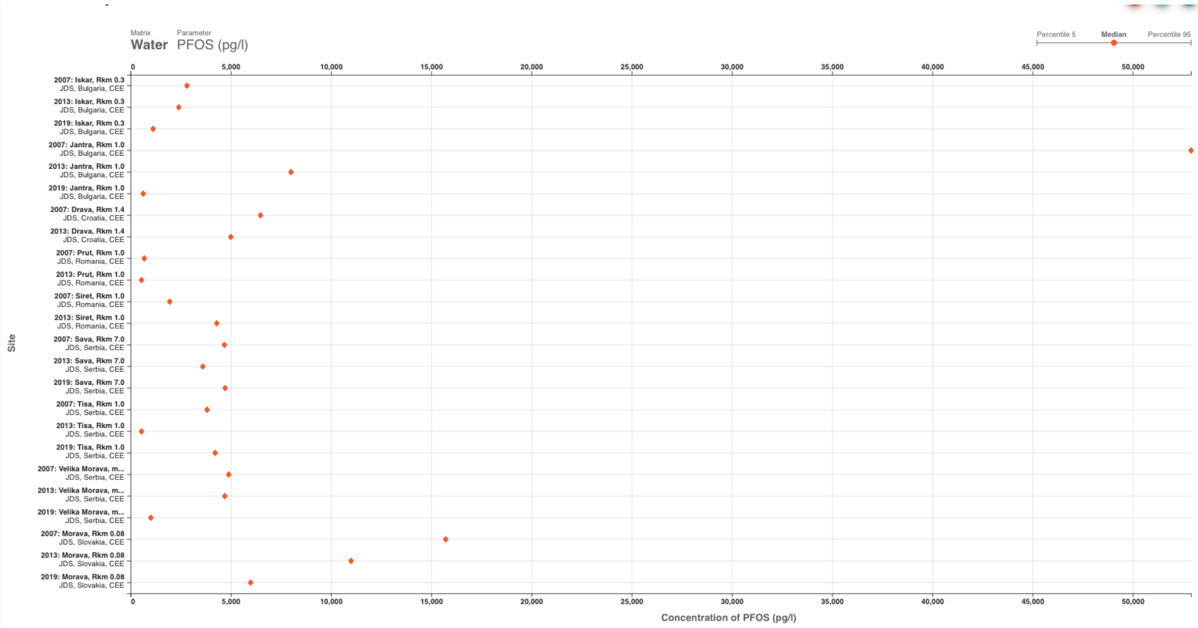


Figure 48: Observed PFOS levels surface water of the Danube tributaries in the CEE region (pg/l). Data generated through the Joint Danube Survey rounds between 2007 and 2019. (source: GMP DWH)

Levels of PFOS ranged from 5-10 ng/l in 2007 (and exceeding maxima at Jantra 0 Rkm 55 ng/l and Morava Rkm 0,08 15,7 ng/l) and decreased to 0,5-1,5 ng/l in 2019. Larger rivers Sava, Tisza and Morava ranged 4-6 ng/l near their mouth in 2019.

PFOA levels showed a different pattern. While Danube sites have shown PFOA levels between 10.8-33 ng/l in 2007 (maximum in Bratislava 46 ng/l), majority of sites decreased to 3-7 ng/l in 2013-4 and further decreased to a range of 1-4 ng/l in 2019, tributaries did have 1ow levels of 1-2,3 ng/l in 2007 and they remained similar for two subsequent survey rounds and reached 0.7-2.7 ng/l for Sava, Tisza and Morava in 2019.

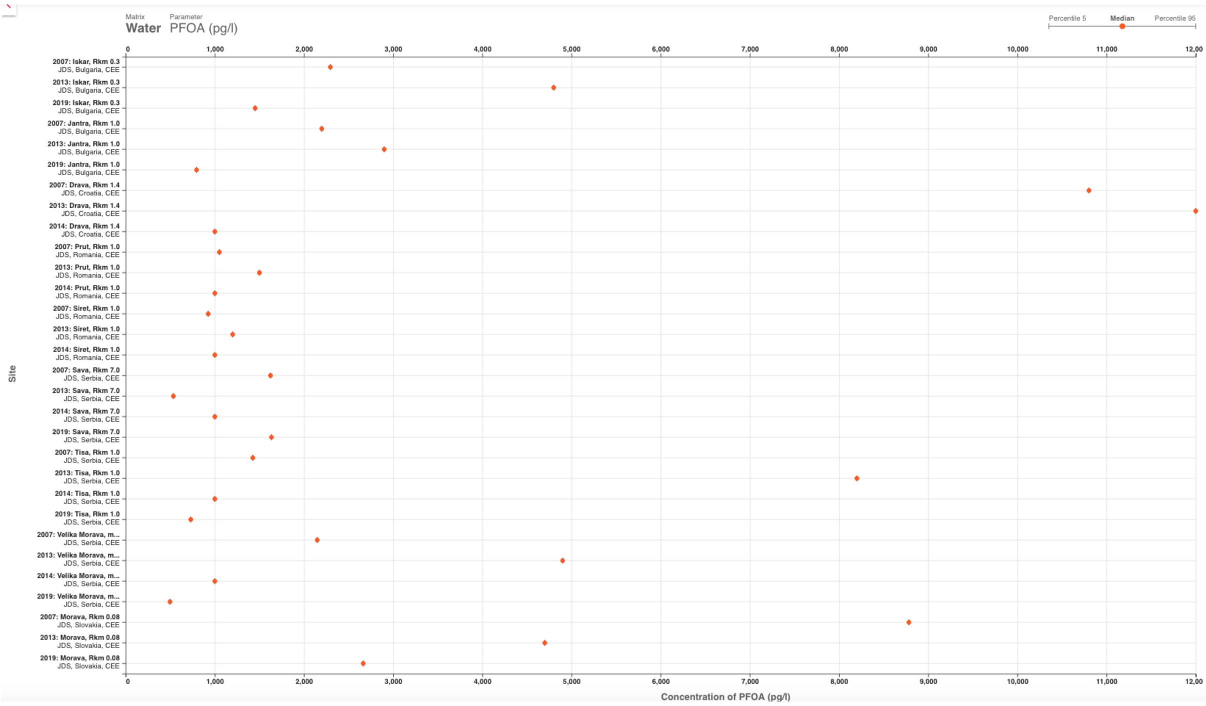


Figure 49: Observed PFOA levels in the surface water in the tributaries of the Danube CEE region (pg/l). Data generated through the Joint Danube Survey rounds between 2007 and 2019. (source: GMP DWH)

5.2.4 Other media

Monitoring activities related to other media exist in some countries in the CEE region. These include soil, sediments and biota (fish). However, the information from other media does not describe regional situation but provide information relevant locally/at a country level.

With support of the NORMAN association the CEE Regional Organization Group was able to review data related to other POPs from the Joint Danube Survey in a number of sites across Danube. Results on other POPs are presented in chapter 32 of the JDS4 scientific report[13] and in a limited number of water sampling sites cover 15 Stockholm Convention Chemicals (organochlorine pesticides, PCB, DDT, HCB, PeCB, endosulfan, HCHs, and some PBDE) in addition to PFOS and PFOA that are shown in 5.2.3 above.
Earlier JDS surveys also looked at other matrices such as sediments and mussels and their contamination by PCB and DDT and more detailed information is provided in scientific reports of each Danube survey[14].

Further, HELCOM Balthazar Project (2011) also targeted contamination of the Neva River and Bay of Finland and additional pollutants were considered.

Moreover, research activities organized by the Federal government at Baikal Lake in 2014-2016 to explore pollution by DDT, in 2018 and 2019 in Karelia and White Sea and assessed levels of DDT, HCB, HCHs, pentachlorophenol (analyzed as PCA) and toxaphene (Parlar 50).

[13] link to Scientific Report JDS4, (accessed December 2020)
[14] JDS1 http://icpdr.org/main/activities-projects/joint-danube-survey-1 (consulted 12/2020)
JDS2 http://www.danubesurvey.org/jds2/ (consulted 12/2020)

Finally, a research cruise EMBLAS in summer of 2016 focused on the contamination of the Black Sea by DDT, HCB, PeCB and BDE, subsequent cruises EMBLAS II (2017) and EMBLAS Plus (2019) took place, but the scope of addressed chemicals remained unchanged. The GMP DWH currently contains data for EMBLAS 2016.

The CEE ROG decided not to use information generated from these non-core media activities further in this report as the sources are too variable, measurement is episodic and the information generated reflects rather a national or local situation then a regional perspective.

5.3 Long-range transport

Long range transport within the CEE region was assessed in the NILU-MSC-EAST reports for HCB, PCBs and PCDD/PCDFs and text here is present only as a summary. Details are provided in Annex 3 to this report. Model simulations indicate decrease in total emissions, changes in relative proportion of contributions to transboundary fluxes from anthropogenic emission sources to non-EMEP emissions as well as to a more significant secondary emission sources (re-volatilization from the environmental media). The MSC-E report holds that levels and emissions of all studied POPs have decreased significantly between 1990 and 2020 (i.e. HCB by 90%, PCBs by up to 80%, PCDD/Fs by 40-75%). Decrease in emissions is usually attributed to significant national reductions of emissions (in some countries) as well as to a decrease in anthropogenic EMEP emissions.

6 CONCLUSIONS AND RECOMMENDATIONS

The third phase of the global monitoring plan was undertaken in the period 2014-2019 to further investigate trends in concentration of persistent organic pollutant in humans and in the environment, and to focus on data on the persistent organic pollutants that have been listed in the Convention after the year 2009.

This regional monitoring report provides regional scale monitoring results in three core matrices out of four; regional data for POP levels in ambient air span over 1996-2020, for human breast milk 1987-2019 and in water data cover 2007-2019 period from three rounds of the Joint Danube Surveys organized in 2007, 2013 and 2019 in the Danube River Basin including tributaries.

Human blood data are scarce and were only available in the first regional monitoring report.

Summary of the baseline concentrations

POPs monitoring has progressed a lot over since the establishment of the Global monitoring plan under the Stockholm Convention. The unique set of ambient air POPs concentrations data, generated through integrated monitoring based on active air sampling over a period of almost 30 years represents the Central European background, and the MONET Europe and GAPS networks, based on passive air sampling, provide a comprehensive set of data since 2006 and 2004 respectively. The longest time series are for OCPs - 6indicator PCB, and PCB118, DDTs, HCHs, HCB and PeCB - that range over 25 years (1996-2019). Air monitoring also included some of new POPs - PBDEs, HCBDD, and also includes PCDD/Fs. More volatile chemicals are not yet covered by passive sampling.

At least some POPs data in air currently exist in 21 countries out of 25 described in this report (no information is available for Albania, Azerbaijan, Bosnia and Herzegovina, Georgia and a limited information is available for the Russian Federation).

We would like to underline that a long-term sustainability of both long-term and most recently established programmes remains crucial for the production of representative and comparable data in the region in the future. This fact is also valid for any future effectiveness evaluation of the implementation of the Stockholm Convention.

POPs monitoring activities in human milk have produced baseline concentrations for all newly/recently listed POPs with the exception of BDE 209 and HBB and PCN that were not available at the moment of preparation of this report. Voluntary analyses in human milk allowed for establishing levels of dicofol, PFOA, PFHxS in human milk. On the other hand, some chemicals have very low levels (beyond LOQ).
Data for PFOS and PFOA in surface water are available from joint Danube survey performed in 2007, 2013/2014 and 2019. The levels observed do not allow to identify statistically significant trends, but decreasing tendencies were observed in many sites. Levels of PFOS ranged from 5-10 ng/l in 2007 (and exceeding maxima at Jantra 0.1 Rkm 55 ng/l and Morava Rkm 0,08 15,7 ng/l) and decreased to 0,5-1,5 ng/l in 2019. Larger rivers Sava, Tisza and Morava ranged 4-6 ng/l near their mouth in 2019.

PFOA levels showed different behavior. While Danube sites have shown PFOA levels between 10.8-33 ng/l in 2007 (maximum in Bratislava 46 ng/l), majority of sites decreased to 3-7 ng/l in 2013-4 and further decreased to a range of 1-4 ng/l in 2019, tributaries did have 1ow levels of 1-2,3 ng/l in 2007 and they remained similar for two subsequent survey rounds and reached 0.7-2.7 ng/l for Sava, Tisza and Morava in 2019.

Evidence of temporal trends

It can be concluded that POPs GMP data availability and comparability in the CEE region slightly increased since the second GMP phase.

POPs data availability in the CEE region is a result of the strategic partnerships with long-term monitoring programs. The unique set of ambient air POPs concentrations data, generated through integrated monitoring based on active air sampling over a period of almost 30 years represents the Central European background, and the MONET Europe and GAPS networks, based on passive air sampling, provide a comprehensive set of data since 2006 and 2004 respectively. Air data are currently available for 21 chemicals. Available time series long up to16 years confirm the decrease for legacy POPs and several POPs listed in 2009 and series of 5-7 years long exists for some new POPs. Otherwise, data also indicate downward tendencies for many more recently listed brominated POPs. Where statistically significant trends could be observed, they are predominantly decreasing, with the exception of two dl-PCB congeners where increasing trends occur. On the other hand, some of sampling sites decided to discontinue monitoring activities.

Human tissues data in human breast milk are made available only through the UNEP/WHO milk surveys. So far 13 countries in the CEE region have participated in different rounds of the survey at least once. One country participated five times, three countries four times, one country three times and 6 countries twice. Limited participation brings certain information gaps identified for South European, Eastern and Central Asian part of the region and for Russian Federation’s participation beyond 2003.

Due to limited amount of available data points, establishment of statistically significant trends for POPs in human milk was not possible, however decreasing tendencies for majority of listed POPs were observed.

Water data are available in the western part of the region and indicate decreasing tendency in the PFOS and PFOA levels over time.

Summary of evidence of long-range transport

Long range transport within the CEE region was assessed in the NILU-MSC-EAST reports for HCB, PCBs and PCDD/PCDFs. Model simulations indicate decrease in total emissions, changes in relative proportion of contributions to transboundary fluxes from anthropogenic emission sources to non-EMEP emissions as well as to a more significant secondary emission sources (re-volatilization from the environmental media). The MSC-E report holds that levels and emissions of all studied POPs have decreased significantly between 1990 and 2020 (i.e. HCB by 90%, PCBs by up to 80%, PCDD/Fs by 40-75%).

Summary of gaps in data coverage and the resources needed to overcome the gaps or establish/strengthen the capacity within the region

Some parts of the CEE region are well monitored through existing air monitoring networks pertaining to international monitoring programmes EMEP, GAPS and MONET, in particular western part of the CEE region. The monitoring combines active and passive sampling and up to 30 years long time series are available for chlorinated POPs and about 15 years long series exist from passive sampling.

Over the years at least some POPs data exist for 21 countries out of 25 described in this report (no information is available for Albania, Azerbaijan, Bosnia and Herzegovina, Georgia and a limited information is available for the Russian Federation). Air monitoring also covers majority of listed POPs and data are available until 2019.

On the other hand, Central Asian countries have a limited availability of information that only covers several organochlorine POPs (alpha-,beta-,gamma-HCH, HCB, PCB, and DDT in 2008-2010). To restart such activities would require both policy and technical support for a sustainable solution of POPs data collection in that sub-region.

Data availability for human tissues is even more limited. Information generated through WHO and UNEP/WHO surveys covers only 13 countries out of 25 in the CEE region and 11 countries participated in the surveys more than once. Support in participation of non-EU CEE countries in the milk surveys need to be significantly strengthened in particular for South European countries, and for Central Asia and Caucasus countries. On the other hand, the UNEP WHO surveys are a perfectly adequate source of information on POP levels and useful for effectiveness evaluation.

Water data are available for some countries in the western part of the region through European Joint Surveys (i.e Joint Danube Survey). Data gaps exist in southern and eastern part of the region and support will be needed to fill in these gaps in particular in the non-EU part of the region and in the Russian Federation.

In addition, countries in the region perform national POPs monitoring in non-core media (soil, sediment, food, water) that provides additional information on levels for legacy POPs in particular. Information on POPs levels in eastern part of the region were also complemented by several research projects of a limited time span.

Information related to POP levels in human blood is not available neither through regional nor through national programmes.

Monitoring data on occurrence of dioxins and furans and brominated and fluorinated chemicals are scarce, in particular due to lacking analytical capacities in non-EU part of the region and due to high costs of analyses. Nevertheless, capacity to analyze these chemicals exists in the region, in the RECETOX who has state of the art facility and instrumentation as well as trained personnel; however, this capacity needs to be enhanced in the region. Plans for the future include continuing the strategic partnerships for air monitoring with MONET Europe, GAPS and EMEP, support the operation of the 2nd active sampling station in Leova, Moldova, and further support the information collection from Southern Europe, Central Asia and promote greater involvement of the Russian Federation institutions into established networks while catering for the national legal requirements, but also keeping up to the programme QA/QC.

Comment on the adequacy of monitoring arrangements for the purpose of effectiveness evaluation

The electronic GMP Data Warehouse supporting regional data storage, analyses, and presentation, was instrumental in preparation of the regional monitoring report and will be also very useful for subsequent dissemination of information on the POPs monitoring activities to all stakeholder groups as well as very useful for a wider evaluation of effectiveness in the next round.

Recommendations for the future

The questionnaire on POPs monitoring capacities has revealed an increase in overall capacities for POPs analyses in the region, but expertise and infrastructures to analyze dioxins/furans, PFOS and PBDEs are limited in southern and eastern part of the region. Nevertheless partnerships with advanced infrastructures and strategic partners performing monitoring activities have so far allowed to compensate for the gaps, national efforts are needed to reestablish POPs monitoring in core media as priority for most countries in the region and technical assistance is needed to increase expert capacities.

To strengthen the evidence and identification of trends, repeated participation of countries in milk survey should be encouraged and, where appropriate, also supported.

The experts and members of the CEE ROG propose the following list as priority issues for the next GMP phase in the CEE region:

Establish closer contacts with relevant institutions in the Russian Federation and involve them in ongoing POPs monitoring programs.

Increase availability of data in relation to human exposure – POP levels in breast milk – and provide support to participation of South European countries + ECCA (Caucasus and Central Asian countries) countries in next rounds of UNEP/WHO surveys.

Ensure availability of human exposure data from general population in the CEE region for reference purposes, as some of undertaken human biomonitoring activities focused only on highly exposed populations and existing information on concentrations of POPs in the region may not be fully accurate.

Secure data from existing national biomonitoring programmes, national cohorts or the European projects (such as alignment studies under HBM4EU, EHEN project cluster on human exposome).

Explore additional/newer harmonized POPs monitoring activities in Europe as they have the potential to contribute data for next GMP phase. These include, for instance, the ERA-Planet project supporting the GOS4POPs initiative of GEO for air data, passive sampling of surface water through the AQUA-GAPS network organized by RECETOX and many others. The EU will further harmonize its approaches to the risk assessment and management of chemicals within the Horizon Europe Partnership (PARC) in 2022-2028. It is expected that relevant chemicals such as PFAS, flame retardants or some other candidate (potential candidate) POPs will be also studied. This will be an important source of information for the following GMP campaign.

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