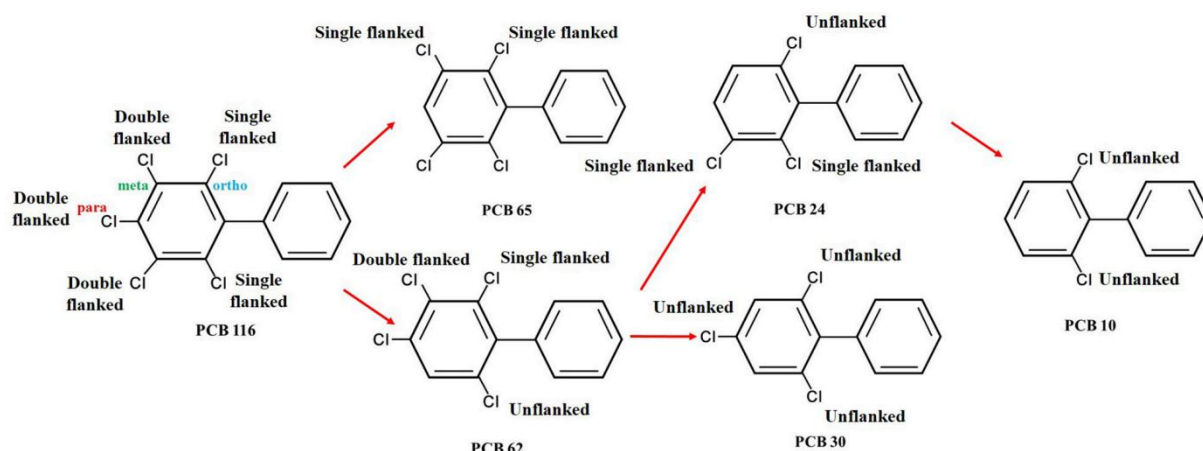




POPs Risk Management in the Transition to a Sustainable Bioeconomy (acronym: POPs_RISKMANbase)

Annex WP1 D1.6

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Introduction

The project implemented at the Technical University of Košice – Faculty of Aeronautics focuses on the research and management of environmental risks associated with persistent organic pollutants (POPs), particularly polychlorinated biphenyls (PCBs). The aim of the project is to establish a methodological and analytical basis for improved management of environmental burdens in the context of the transition to a sustainable bioeconomy and for strengthening society's resilience to environmental risks.

Work package WP1 (KPB1) focused on the analysis of existing environmental burdens, the identification of contamination sources, and the design of a methodological framework for assessing PCB-related risks. The outcome of this stage is a proposed risk assessment model that integrates information on contamination sources, environmental transport pathways, exposure scenarios, and potential impacts on humans and ecosystems.

As part of the work, available data on historical environmental burdens were analyzed, particularly in areas affected by long-term PCB contamination. The work also included a synthesis of knowledge on contaminant transport processes in the environment, including transport in sediments, water, and food chains.

Based on these analyses, a concept referred to as the “contamination source case history” was developed, enabling the systematic recording of the basic characteristics of the source, environmental conditions, and possible contaminant transport scenarios. This approach provides a basis for estimating and assessing the probability of hazard occurrence and for the subsequent prioritization of sites from the perspective of environmental management.

An important component of the work package was also the integration of analytical tools with the needs of public administration and regional institutions. The project therefore supports the development of a knowledge base that will facilitate better cooperation among research institutions, public authorities, and other stakeholders in addressing environmental burdens and protecting public health.

The results of work package WP1 provide a basis for subsequent stages of the project, which will focus on modelling risk dynamics, environmental monitoring, and designing measures to reduce the impacts of environmental contamination.

1. Work Package Objective

The objective of work package KPB1 was to establish the analytical and methodological prerequisites for the subsequent design of comprehensive and holistic support for POPs/PCB risk management. The work package focused on identifying PCB sources, describing transport pathways, determining vulnerable receptors, and establishing a basic framework for assessing the probability, consequences, and chronicity of environmental risks. The KPB1 deliverables provide the basis for the subsequent project work packages, particularly for further development of the C&HMS methodology (Comprehensive and Holistic Methodological Support).

2. Activities Carried Out

The activities of work package KPB1 focused on collecting, classifying, and professionally evaluating the knowledge required to design a POPs/PCB risk assessment methodology. Their objective was to prepare input data and information for the assessment of sources, transport pathways, receptors, and critical scenarios.

The following activities in particular were carried out within the work package:

- analysis of available scientific, technical, and strategic knowledge on the occurrence, behaviour, and effects of persistent organic pollutants, particularly PCBs, in the environment,
- identification and categorisation of typical primary and secondary sources of PCB contamination, including their links to industrial sites, sediments, watercourses, soil, biota, and the food chain,
- analysis of environmental PCB transport pathways within the source–pathway–receptor system, with a focus on the spread of contamination through water, sediments, soil, air, and biological components of the environment,
- processing of available data on historical environmental burdens and potentially high-risk sites, particularly in areas with confirmed or presumed long-term PCB contamination,
- assessment of hazards, effects, and vulnerability of selected receptors using screening and semi-quantitative approaches, particularly the S-P-R model and the H&V index,
- identification of environmental and climatic factors that may influence the mobilisation, transport, and persistence of PCBs in the environment, particularly floods, droughts, sediment resuspension, and changes in hydrological conditions,
- design of a methodology for the systematic recording and assessment of contamination source characteristics in the form of a “PCB source case history”,
- design of an analytical framework for estimating and assessing the probability of hazard occurrence, source chronicity, and potential consequences for health, the environment, and socio-economic activities,
- identification of priority sites and critical scenarios from the perspective of environmental management, monitoring, and future decision-making on measures.

The work employed interdisciplinary approaches integrating knowledge from environmental engineering, risk management, environmental monitoring, territorial vulnerability assessment, contaminant transport modelling, and decision support. The resulting framework provides a basis for the subsequent project work packages, particularly for further development of the comprehensive and holistic C&HMS methodological support.

3. Results Achieved

Within work package KPB1, expert analytical deliverables were prepared, establishing a knowledge, methodological, and data base for the further development of POPs/PCB risk management. The work package focused primarily on identifying contamination sources, analyzing existing knowledge, designing risk assessment criteria, assessing environmental and health impacts, and establishing a basic modelling framework for subsequent stages of the project.

Deliverable D1.1 – Report on the Analysis of the State of POPs Risk Management established a basic knowledge base on the status of PCB monitoring, assessment, and risk management in the Slovak Republic and abroad. The literature review confirmed that the available PCB contamination data are extensive but often inconsistent, outdated, and methodologically fragmented. A significant finding was that, despite several previous studies, there is no unified systemic framework linking contamination sources, transport pathways, receptors, and impacts on health, the environment, and the socio-economic development of the affected areas.

Deliverable D1.2 – Report on the Analysis of Specific Requirements for POPs Detection and Boundary Conditions elaborated the basic requirements for the identification and assessment of PCB sources. Source categories were proposed, particularly industrial sources, natural/environmental sources, and food-related or secondary exposure sources. At the same time, an initial modelling framework was developed for estimating and assessing the probability of PCB occurrence and spread, taking into account not only the nature of the source but also the availability and extent of monitoring. This deliverable provided a basis for further assessment of data uncertainty and the need for up-to-date monitoring.

Deliverable D1.3 – Report on the Investigation of Selected POPs-Related Hazards and Effects focused on the identification of hazards, effects, and vulnerable receptors. The S-P-R model, i.e. source–pathway–receptor, was used for the assessment, enabling a systematic analysis of where the contamination originates, how it spreads, and which environmental components or population groups may be affected. This model was complemented by the H&V index methodology, which links the hazardous properties of a substance with the degree of environmental vulnerability. The result was a preliminary assessment of selected sites and the identification of priority sources and scenarios requiring further, more detailed assessment.

Deliverable D1.4 – Report on the Investigation of the Relationship between Environmental Changes and Pollution by Selected POP Substances extended the previous deliverables by adding a dynamic dimension. Environmental factors that may influence the mobilization, transport, and persistence of PCBs in the environment were analyzed, particularly hydrological extremes, floods, droughts, sediment resuspension, temperature changes, and changes in land use. Particular attention was paid to the possibility that environmental and climatic changes may activate historical PCB reservoirs and create new or intensified exposure scenarios. The deliverable also proposed the use of compartment-based and fugacity modelling as a tool for understanding PCB transport among water, sediment, soil, and biota.

Deliverable D1.5 – Report on the Analysis and Identification of Critical Scenarios and Their Classification integrated the previous results into a coherent assessment framework. The concept of a “PCB source case history” was developed, enabling systematic recording of source identification, historical development, transport pathways, environmental conditions, probability of activation, chronicity, and potential consequences. This approach makes it possible to assess PCB sources not only as static environmental burdens but also as dynamic systems whose risk level may change over time depending on environmental and hydrological conditions.

Based on Deliverables D1.1 to D1.5, an integrated static–dynamic PCB risk assessment framework was developed, linking source identification, monitoring factors, transport pathways, vulnerable receptors, consequence assessment, source chronicity, and the influence of environmental changes. This framework is schematically illustrated in Fig. 1 and provides the basis for further development of the C&HMS methodology.

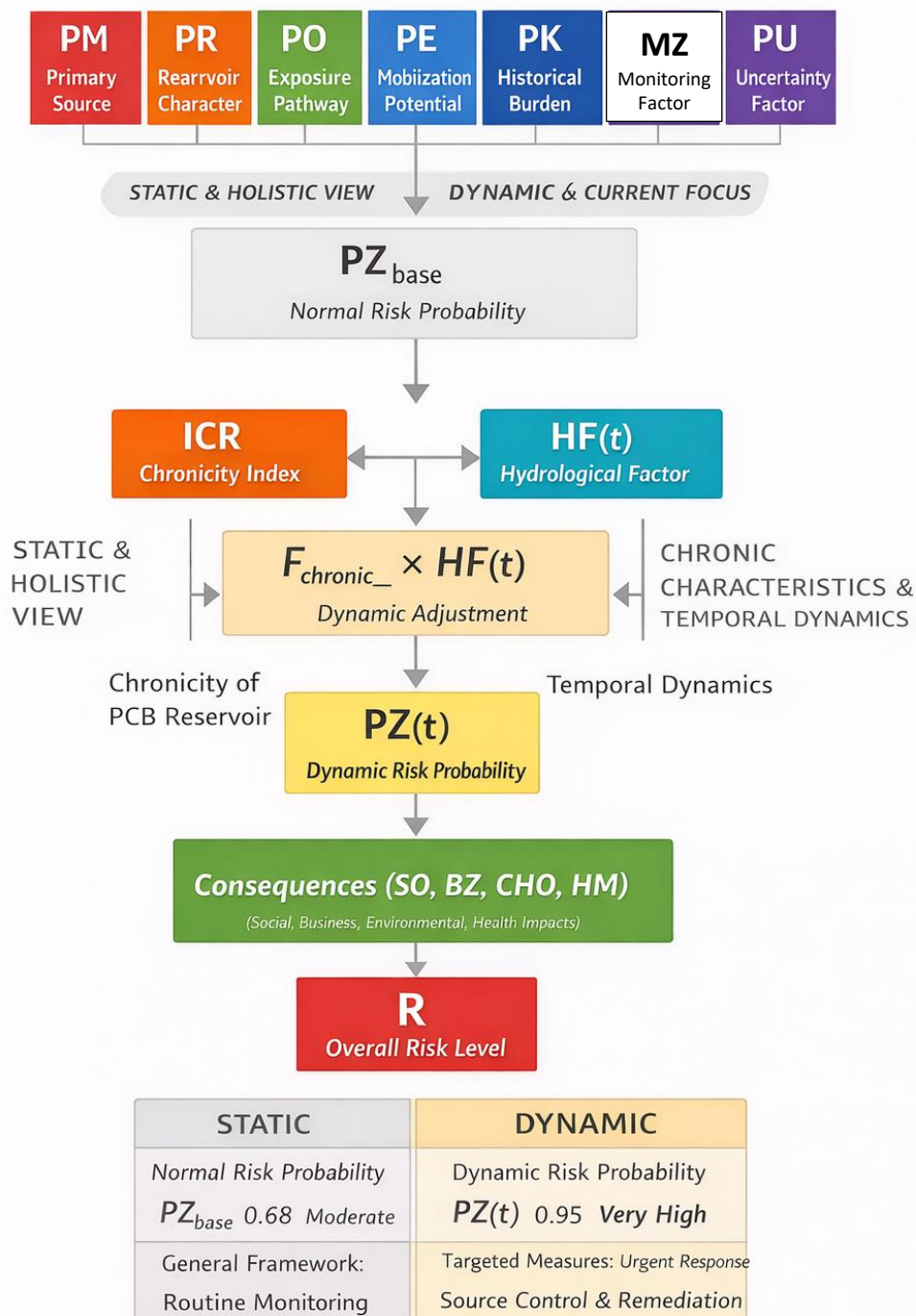


Fig. 1 Holistic model for PCB source risk assessment – KPB1 output

3.1 Overview of KPB1 Deliverable Completion

Work package KPB1 was defined in the project specification as an analytical and preparatory phase aimed at establishing a basic framework for identifying hazardous POPs/PCB sources, describing their transport scenarios, and preparing the basis for the design of a holistic risk management methodology. This objective was achieved through the gradual preparation of Deliverables D1.1 to D1.5, which formed a logically interconnected system of knowledge (Table 1).

Table. 1 Summary of KPB1 partial deliverables and their results

Task / output	Main focus	Result achieved
D1.1	Analysis of the State of POPs Risk Management	Knowledge base established; existing sources of knowledge, methodological gaps, and the need for a unified PCB risk assessment framework identified
D1.2	Specific Requirements for POPs Detection and Boundary Conditions	Categorisation of PCB sources, basic parameters for probability estimation and assessment, and the importance of monitoring proposed
D1.3	Investigation of Selected POPs-Related Hazards and Effects	S-P-R model and H&V index applied; priority sites and receptors identified
D1.4	Relationship Between Environmental Changes and POPs Pollution	Dynamic perspective on PCB mobilisation and transport under the influence of climatic and hydrological factors developed
D1.5	Critical Scenarios and Their Classification	“PCB source case history” concept and an integrated framework for the classification of critical scenarios developed
D1.6	Public Report on KPB1 Results	Summary of the main results, contributions, and prospects for further project work

The deliverables prepared in this way confirm that work package KPB1 fulfilled its role by establishing the analytical prerequisites for subsequent stages of the project. The results also demonstrated the need to integrate environmental data, monitoring, GIS tools, vulnerability assessment, and decision models into a single comprehensive PCB risk management support system.

4. Contribution of the Work Package

The proposed methodological framework makes a significant contribution to the systematic assessment of historical environmental burdens caused by PCBs. Its main added value lies in linking several levels of assessment – from source identification, through transport mechanisms and receptor vulnerability, to consequences for health, the environment, and socio-economic activities in the affected area.

The principal contribution of the work package is that it established a basis for a uniform and reproducible assessment of PCB sources. Instead of assessing individual measurements or sites in isolation, the proposed approach makes it possible to evaluate a source within a broader systemic context. It considers not only the current contaminant concentration, but also the historical nature of the source, its links to sediments, watercourses, soil, biota, and potential human exposure pathways.

Another significant contribution is the introduction of the “PCB source case history” concept. This concept makes it possible to view a contaminated source as a dynamic environmental system with its own origin, development, condition, activation mechanisms, and potential consequences. Such an approach is particularly suitable for long-term environmental burdens where the risk does not arise solely from a single release, but from the chronic presence of the contaminant in the environment.

The KPB1 results also support public administration decision-making when setting priorities for monitoring, remediation, and preventive measures. The proposed framework makes it possible to identify sites that pose a higher risk due to the combination of PCB hazardousness, environmental vulnerability, hydrological connectivity, and the potential for long-term exposure of populations or ecosystems.

5. Alignment with Policies and Strategic Priorities

The results of work package KPB1 are aligned with the strategic priorities of the Slovak Republic and the European Union in the areas of environmental protection, pollution reduction, and support for a sustainable bioeconomy. The issue of persistent organic pollutants, particularly PCBs, is directly related to the objectives of the Stockholm Convention, European POPs legislation, and strategic documents focused on zero pollution, public health protection, and the restoration of environmentally burdened areas.

The project also supports the principles of the European Green Deal, particularly in the areas of pollution prevention, ecosystem protection, sustainable use of natural resources, and strengthening the environmental resilience of regions. In eastern Slovakia, this issue is particularly important given the historical PCB burden of the area and the need to establish a scientifically grounded framework for decision-making on monitoring, remediation, and long-term risk management.

The KPB1 results are also consistent with the project objective of creating a knowledge base for the future comprehensive and holistic C&HMS methodological support. The work package established a level of basic analytical prerequisites corresponding to the initial Technology Readiness Levels TRL 1–TRL 3, i.e., the stage of formulating basic principles, developing the analytical framework, and verifying critical methodological functions.

6. Societal and Environmental Benefits

The societal benefit of work package KPB1 lies primarily in establishing an expert basis for more transparent and systematic decision-making on PCB environmental risks. Historical PCB contamination is an issue that affects not only the environment, but also public health, food-chain quality, land use, recreation, agriculture, and the overall development of the affected regions.

The proposed risk assessment framework enables better identification of sites where long-term exposure of populations or ecosystems may occur. It also supports the need for more targeted monitoring, focused not only on PCB concentrations themselves but also on the processes affecting their transport, accumulation, and remobilisation.

The environmental benefit lies in the fact that the KPB1 deliverables provide a basis for a better understanding of PCB behaviour in environmental compartments. Of particular importance is the interconnection among contaminated sediments, surface waters, biota, and the food chain. Such a systemic perspective enables better design of preventive and remediation measures that respond not only to isolated measurements, but to the entire source–pathway–receptor chain.

The results of the work package (Appendix, Fig. 2) may therefore contribute to protecting public health, reducing environmental risks, supporting the restoration of contaminated areas, and strengthening public confidence in evidence-based decision-making.

7. Prospects for Further Work

The results of work package KPB1 provide a basis for subsequent stages of the project, which will focus on further developing comprehensive and holistic methodological support for POPs/PCB risk management. Building on the identified sources, transport pathways, receptors, and critical scenarios, the risk assessment methodology will need to be further developed towards practical use in decision-making processes within public administration and professional practice.

Further work should focus primarily on linking the proposed model with current environmental monitoring data. It will be important to supplement the existing data with new measurements in relevant environmental compartments, particularly sediments, water, soil, biota, and food chains. These data will make it possible to verify the assumptions of the proposed model and refine risk assessment at specific sites.

Another important direction for further work is the development of GIS support and spatial visualisation of risks. Linking the model with geographic information systems will make it possible to visualise risk sites, transport pathways, vulnerable areas, and potential receptors. Such an approach can significantly support the planning of monitoring, remediation, and preventive measures.

In subsequent stages, the assessment of the effectiveness of risk-reduction measures will also need to be further developed. The proposed methodology should make it possible to assess not only the risk level itself, but also the suitability, effectiveness, and sustainability of the proposed measures in terms of health protection, environmental protection, economic costs, and the long-term development of the area.

A significant future opportunity is also the integration of smart technologies, sensor-based solutions, aerial monitoring, and digital data processing. These tools can contribute to more accurate source identification, faster data processing, and the preparation of decision-support information for public administration, local authorities, and other stakeholders.

Conclusion

Work package KPB1 fulfilled its role as the analytical and preparatory phase of the project. It established a knowledge base on POPs/PCB issues, identified the main sources and transport pathways of contamination, evaluated selected hazards and effects, assessed the significance of environmental changes, and proposed a framework for critical scenarios.

The KPB1 results confirmed that PCB risk cannot be assessed solely as a static state of contamination but must be considered as a dynamic process influenced by source characteristics, hydrological and climatic conditions, sediments, biota, and exposure pathways. The integrated framework developed within KPB1 therefore provides the basis for the further design of the comprehensive and holistic C&HMS methodological support.

The work package deliverables provide an expert basis for more targeted monitoring, site prioritization, support for public administration decision-making, and the preparation of measures to reduce environmental and health risks associated with PCBs. In this way, the project contributes to public health protection, the restoration of environmentally burdened areas, and support for sustainable development in line with the objectives of European environmental policy and a sustainable bioeconomy.

Appendix: Public Infographic on KPB1 Results

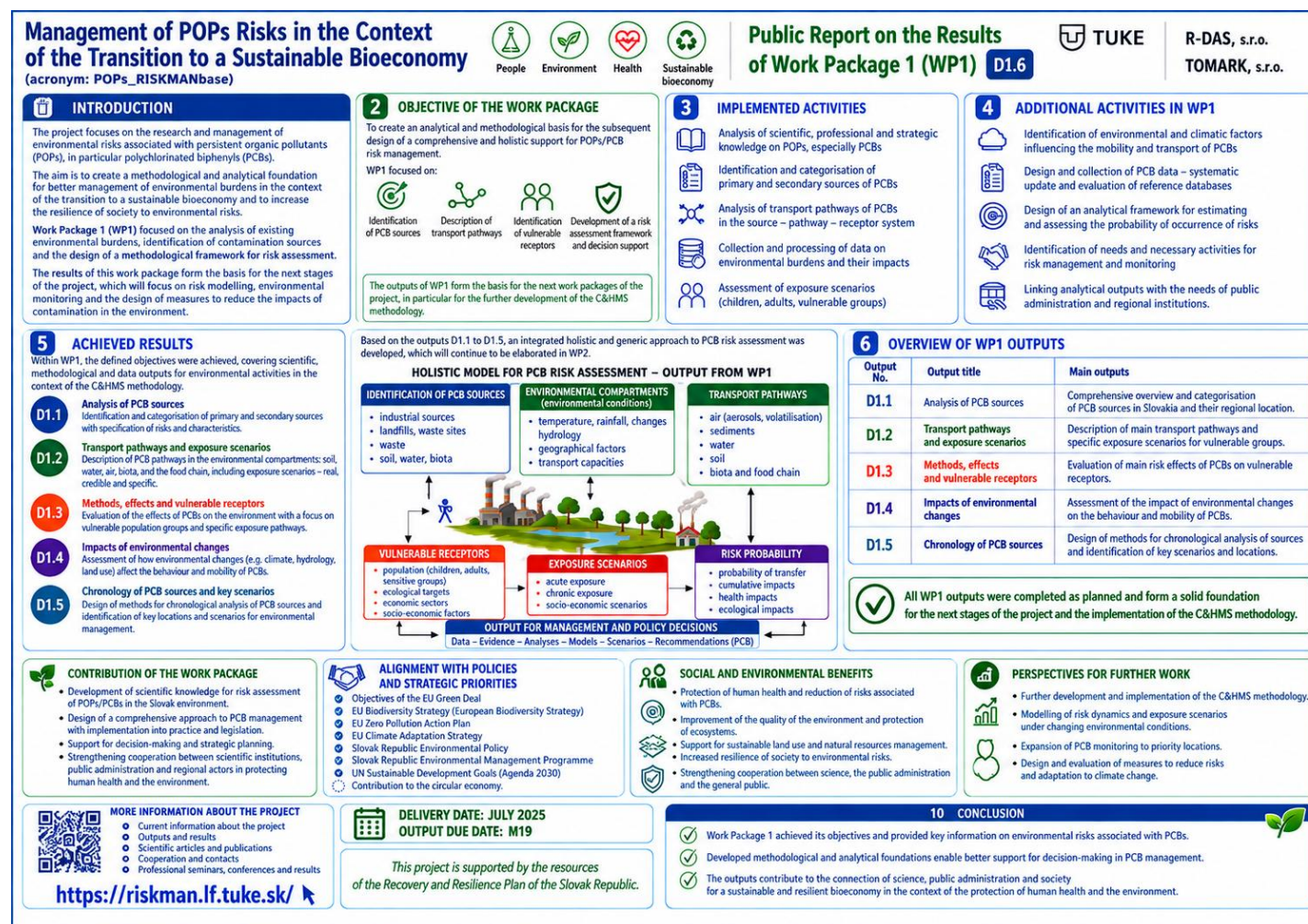


Fig. 2 Summary of work package KPB1 results