



CA21134

Topic: Pesticide residues, exposure and risk assessment in crop protection: achievements, gaps and future needs

Thematic synthesis prepared within COST Action CA21134 TOP-AGRI-Network

Virtual Mobility Grant | Dr Tijana Milićević | 10 September 2026

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1 Purpose and scope

This report synthesises the outcomes of a Virtual Mobility activity focused on the relationship between pesticide residues, environmental and human exposure, risk assessment and more preventive crop-protection strategies. The work responds to a recurring gap identified in TOP-AGRI exchanges: pesticide use and residue occurrence are frequently reported, but measured concentrations are not always converted into realistic estimates of exposure, risk and priorities for intervention. The report therefore considers the complete evidence chain, from pesticide use and environmental fate to sampling, chemical analysis, exposure scenarios, risk characterisation, prevention and communication.

The synthesis addresses food and environmental monitoring; occupational, residential and dietary exposure, bioavailability and bioaccessibility, multiple residues and mixture exposure, regulatory and methodological limitations, and the contribution of Integrated Pest Management, biological products, resistant varieties, soil health and precision agriculture. It is intended as a concise technical contribution to the final reporting of COST Action CA21134 and as a basis for future comparative research and stakeholder cooperation.

2 How the report was prepared

The report was prepared through an international online meeting held on Microsoft Teams on 10th September 2026 from 12:00 to 13:00 CEST. Ten participants represented Serbia, Albania, Israel, Portugal, Bosnia and Herzegovina, Montenegro, the Czech Republic and Lithuania. Written follow-up extended the geographical scope through contributions from the Netherlands and Latvia. Before the meeting, the grantee circulated an invitation and guiding questions concerning national monitoring practice, environmental and human exposure assessment, bioavailability and bioaccessibility, multiple residues and mixtures, methodological gaps, and relevant projects or stakeholder initiatives.

The grantee organised and chaired the discussion, presented a short introduction and examples from Serbia and international cooperation with France and Croatia, and documented the exchange. The evidence base comprised the invitation, introductory presentation, meeting record and chat, approximately 51 minutes of available audio, a timestamped working transcript, screenshots and written follow-up. The national observations reflect the contributors' professional experience and are not intended as exhaustive legal reviews. They are reported as illustrative evidence that reveals common needs and contrasts among monitoring systems.

3 Starting point from previous TOP-AGRI activities

Earlier TOP-AGRI workshops had identified reduced pesticide dependency, stronger IPM, greater availability of biopesticides and resistant varieties, precision agriculture, improved monitoring, education and knowledge transfer as key priorities. They also showed that the main difficulty is often implementation rather than the absence of technical options. Insufficient advisory support, shortages of specialists, limited long-term research and funding, and complex administrative procedures can slow adoption. The VMG meeting extended this work by asking whether monitoring describes actual farm and market conditions and whether residue data are translated into health-relevant evidence.

4 Monitoring practices and country experience

The country examples showed that regulatory monitoring provides an essential food-safety baseline, particularly when results are compared with EU maximum residue levels. However, contributors repeatedly questioned whether available sample numbers, matrices, locations and inspection frequencies adequately represent domestic markets, small farms, intensive production systems and real pesticide-use patterns. The following table summarises the documented perspectives.

Country perspective	Main points raised during the VM meeting or provided in written contributions
Serbia	Monitoring covers food and crops, while research examples also include apples, other fruit and vegetables, teas, agricultural soils, sediments, fish and human milk. Export-related controls were described as detailed, but participants expressed concern about the representativeness of controls for the domestic market. It was also noted that regulations and inspections are not always consistently implemented in practice and that producer and consumer awareness remains limited.
Albania	An annual food-residue plan is organised through the Ministry of Agriculture and Rural Development and the National Food Authority. Farm and market samples are analysed in an accredited food-safety and veterinary laboratory and compared with EU MRLs. Limited sample numbers, staff and infrastructure constrain coverage, particularly for intensive fruit and greenhouse vegetables.
Portugal	Food and drinking-water monitoring operates within EU requirements and involves agricultural and public-water authorities. Exceedances were described as uncommon, but the discussion questioned whether surveillance adequately represents national conditions and farm practice. Human resources and funding limit expansion.
Bosnia and Herzegovina	The participant described differences in legislation and responsibilities among the Republic of Srpska, the Federation of Bosnia and Herzegovina and the state level. A pesticide-monitoring initiative implemented through an IPA cross-border project involving Bosnia and Herzegovina, Montenegro and Croatia was also mentioned.
Montenegro	Montenegro was represented at the meeting. It was noted during the discussion that pesticide testing is conducted in different crops and that research cooperation exists with colleagues from neighbouring countries. No detailed national monitoring or regulatory overview was provided during the recorded discussion.
Israel	The contribution emphasised fungicide resistance as an immediate agronomic driver for transition. Biological and conventional products may need to be combined during an intermediate phase so that disease control remains reliable while dependence on conventional fungicides is reduced.
Czech Republic and Lithuania	Participants from the Czech Republic and Lithuania attended the meeting. However, no detailed national examples from these countries were captured in the available recording.
Latvia	Written input referred to the EU Northern Zone framework for the authorisation of plant protection products, illustrating how zonal cooperation can support shared evaluation while national conditions and risk-mitigation measures remain relevant.
Netherlands and SPRINT	Written input identified the Horizon 2020 SPRINT project as a major source of data and recommendations. SPRINT examined real-world exposure to plant protection products across ecosystems, plants, animals and humans and developed an integrated Global Health Risk Assessment Toolbox.

5 From residue occurrence to exposure and risk

A maximum residue level is primarily a legal compliance value for a pesticide-crop combination. Comparison with an MRL is essential, but it does not by itself quantify the dose received by a person, identify the most exposed population or describe environmental effects. Exposure assessment must connect concentration data with who is exposed, through which pathway, how frequently and for how long. For consumers, relevant inputs include food consumption, body weight, processing and transfer from the raw commodity. For pesticide applicators and other agricultural workers, relevant factors include the application method, use of personal protective equipment, work duration and re-entry time. Residents may require information on spray drift, volatilisation, contaminated dust and proximity to treated areas.

The meeting supported an exposure-scenario approach that distinguishes agricultural workers, consumers and nearby populations and considers sensitive life stages where data permit. Oral exposure can arise through food, water, soil or dust ingestion, dermal exposure through handling products, contact with treated plants or contaminated soil, and inhalation through aerosols, vapours and resuspended particles. Combining relevant exposure pathways can provide a more realistic estimate of exposure, but the assessment must avoid double counting. Monitoring design and risk modelling should therefore be planned together rather than treated as separate endpoints.

Deterministic calculations remain appropriate for screening because they are transparent and can use conservative point estimates. When adequate distributions are available, probabilistic assessment can represent variability in concentrations, contact rates, food intake, body weight and exposure frequency. It can estimate the probability of exceeding a reference value and identify the variables that drive uncertainty.

6 Environmental persistence and human biomonitoring

The Serbian research examples highlighted that residues are not limited to freshly treated crops. Legacy organochlorine pesticides may persist for decades after restriction or non-approval and can still be detected in soil, sediment, water, fish tissue and human milk. These matrices describe different parts of the source-pathway-receptor continuum. Soil and sediment can act as long-term reservoirs; aquatic organisms integrate exposure and transfer within food webs; and human milk reflects maternal body burden and transfer to infants. Such evidence supports post-market surveillance and long-term environmental observation in addition to product authorisation and current-use monitoring.

Human biomonitoring can confirm that internal exposure has occurred, but interpretation requires care. Concentrations in biological matrices integrate multiple sources and pathways and do not automatically identify a particular crop-protection use. Questionnaire data, dietary information, occupation, residence and temporal context are therefore needed. Ethical procedures, suitable reference values and communication plans are especially important when vulnerable groups are involved.

7 Bioavailability and bioaccessibility

Total concentration represents the amount measured in a sample, whereas bioavailability concerns the fraction that reaches systemic circulation and the target tissue. Bioaccessibility is an operational estimate of the fraction released from a matrix under simulated physiological conditions and potentially available for absorption. For contaminated soil and dust, oral tests can simulate gastrointestinal extraction, inhalation-oriented methods can examine dissolution in lung fluids, and dermal methods can investigate release into sweat or contact media. These approaches can provide more realistic exposure estimates than conservative assessments based solely on total concentrations.

The discussion referred to collaborations with France and Croatia, including BORG and EnvironPollutHealth projects, as examples of work on bioaccessibility and multi-matrix exposure. Wider application to pesticides requires matrix-specific validation, recovery and repeatability data, appropriate blanks and controls, stability checks, matrix-matched comparisons and transparent treatment of uncertainty. Bioaccessibility corrections should not be applied automatically. For risk assessment, the selected pathway, matrix, physiological model and the relationship between the in vitro fraction and the toxicity reference value should first be justified.

8 Multiple residues, cumulative exposure and mixtures

Participants identified multiple residues as one of the clearest gaps between routine compliance monitoring and real-world exposure. A person can encounter several pesticides in one food item, through a daily diet, during occupational use and through environmental media. Reporting the number of detected substances or simple co-occurrences is informative but is not equivalent to cumulative risk assessment. Cumulative assessment generally requires a defined grouping rationale, for example a shared target organ, common mode of action or common adverse outcome. Broader mixture assessment must also consider compounds with different mechanisms and possible interactions, although toxicological evidence is often incomplete.

Priorities include harmonised handling of results below detection or quantification limits, retention of sample-level co-occurrence data, reliable food-consumption and activity-pattern information, and clear separation of acute and chronic time frames. Hazard index or relative-potency approaches can provide screening estimates for suitable groups, while more advanced probabilistic methods can integrate concentration and consumption distributions. Across pathways, oral, dermal and inhalation estimates must use compatible time bases. Realistic mixtures should be prioritised using substances that actually co-occur in crops, workplaces or environmental matrices rather than arbitrary combinations.

SPRINT provides a relevant European reference because it linked direct and indirect exposure routes with environmental, plant, animal and human health and examined real-life mixtures of plant protection products. Its Global Health perspective illustrates the value of combining pre-market assessment with post-market surveillance, case-study evidence and stakeholder participation. The project does not remove the need for country-specific data, but it offers concepts and tools that can be adapted and compared across regions.

9 Achievements and promising preventive strategies

- Regulatory monitoring and accredited laboratories provide a necessary baseline for food-safety control, trend analysis and enforcement.
- IPM combines prevention, observation, thresholds and targeted intervention and should remain the main framework for reducing dependence on pesticides.
- Biological products and resistant varieties can reduce chemical inputs, although performance, availability, cost and farmer confidence influence adoption.
- Fungicide resistance creates a direct agronomic incentive for rotation of modes of action and integration of non-chemical or biological measures.
- Healthy soils and balanced nutrition can improve plant resilience. Precision and variable-rate fertilisation can reduce unnecessary inputs and support preventive crop management.
- Monitoring technologies, advisory services and farmer training can translate technical options into decisions made at field level.
- Multi-actor workshops can influence programmes when producers, advisers, scientists, laboratories and policy makers remain engaged after the event.

10 Main gaps and barriers

Coverage and representativeness: Limited sample numbers, seasonal coverage and inspection frequency can leave small farms, domestic markets and intensive production underrepresented.

Resources and infrastructure: Authorities and laboratories may lack staff, field support, analytical capacity, reference materials and sustainable funding.

Fragmented governance: Responsibilities divided among institutions or administrative levels can hinder harmonisation, timely exchange and interpretation of data.

Exposure metadata: Residue results often lack information on pesticide use, application, task, consumption, contact behaviour and population characteristics.

Methods beyond compliance: Bioaccessibility, probabilistic modelling and cumulative assessment remain predominantly research tools and need regulatory guidance.

Implementation and equity: Small producers may have less access to testing, personal protection, independent advice and affordable alternatives.

Science-policy transfer: Research findings are not always converted into surveillance priorities, prevention measures or understandable messages for stakeholders.

11 Priorities and recommendations

1. Use risk-based and statistically defensible sampling designs that cover farms, domestic markets, seasons, high-use systems and relevant environmental matrices.
2. Define the exposure question before sampling and collect the metadata required for worker, consumer, resident and bystander scenarios.
3. Connect occurrence data with deterministic screening and, where distributions are adequate, probabilistic analysis and sensitivity assessment.
4. Develop and validate bioaccessibility methods through inter-laboratory studies for relevant pesticide-matrix-pathway combinations before their routine use in risk assessment.
5. Retain sample-level multi-residue information and advance cumulative and mixture assessment with transparent toxicological grouping and uncertainty statements.
6. Strengthen laboratory and inspection capacity, quality assurance, interoperable databases and cooperation across administrative and national borders.
7. Expand practical education on application, personal protection, resistance management, IPM, biological alternatives and interpretation of monitoring results.
8. Evaluate combined transition strategies under realistic farm conditions, including efficacy, resistance, residues, costs and unintended environmental effects.
9. Maintain the T0P-AGRI network through shared protocols, comparative studies, joint proposals and continued interaction with authorities, advisers and farmer groups.

12 Contribution to CA21134 and planned follow-up

The Virtual Mobility strengthened international interaction within CA21134 and connected earlier T0P-AGRI work on crop-protection innovation with environmental chemistry, exposure science and human health risk assessment. The main outputs included an international cross-country discussion, an introductory presentation, meeting recordings, screenshots and a timestamped transcript. Additional written contributions were received from colleagues in the Netherlands and Latvia. Together, these materials document shared achievements, constraints and research priorities and provide evidence that can be incorporated into the final Action report.

Future collaborative work could focus on defining a minimum common dataset covering sampling context, analytical quality, pesticide use and exposure determinants. Comparative studies could then address representative residue monitoring, deterministic and probabilistic risk assessment, validation of bioaccessibility approaches and prioritisation of real-world pesticide mixtures. Further cooperation should involve researchers, competent authorities, laboratories, advisory services and farmer groups to ensure that scientific evidence is translated into practical preventive measures and better-informed crop-protection decisions.

Meeting participation and supporting material

The meeting was attended by ten participants representing eight countries: Tijana Milićević, Antonije Žunić and Vladimir Ćirić from Serbia; Ferdi Brahushi from Albania; Ofir Degani from Israel; Elisabete Figueiredo from Portugal; Vesna Tunguz from Bosnia and Herzegovina; Mitar Đukanović from Montenegro; Bojana Petrović from the Czech Republic; and Deividas Valiūnas from Lithuania. Additional written contributions were received from colleagues in the Netherlands (Vera Felix da Graca Silva) and Latvia (Viktorija Zagorska).

The online meeting, entitled “Pesticide residues, exposure and risk assessment in crop protection: achievements, gaps and future needs”, was held on 10 September 2026 from 12:00 to 13:00 CEST. Supporting materials included the invitation and guiding questions, a four-slide introductory presentation, the meeting attendance record and Teams chat, screenshots, video recordings, a working transcript and additional written contributions.

A technical problem with the original Teams link

(<https://teams.live.com/join/936997353279?p=S3ZBTSb5r2rkcr2xii>) was resolved immediately by issuing a replacement link (<https://teams.live.com/join/9362600578831?p=GS1hLV050rf2Km8ME4>).

The planned activity was completed without further deviation from the initial work plan.

Selected project resources

SPRINT Horizon 2020 project and Global Health Risk Assessment Toolbox: <https://sprint-h2020.eu/>

EnvironPollutHealth project: https://projekti.imi.hr/environtpolluthealth/?lang=en&page_id=176

BORG project: <https://l2a.univ-lorraine.fr/index.php/programmes/recherche/46>