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PROMISCES

Preventing **R**ecalcitrant **O**rganic **M**obile **I**ndustrial chemical**S** for **C**ircular **E**conomy in the soil-sediment-water **S**ystem

Annex C

Summary of Co-creation Stakeholder Workshops for the Danube Basin (CS2)

Developing a system-wide, zero pollution strategy to ensure future drinking water production along the Danube

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Background

Current situation

The Danube River is a fundamental source of water abstraction for drinking water production. This production process relies on riverbank filtration (RBF) systems. RBF systems naturally filter river water through the surrounding sediments as it flows from the river to nearby wells, effectively reducing some contaminants' concentrations before it is extracted for drinking water treatment. However, the chemical water quality is increasingly impacted by various discharges into the river, with wastewater treatment plants (WWTPs) being the largest contributors. These discharges contain a range of persistent, mobile and toxic (PMT) substances. Some of these PMT substances, such as PFAS, are hardly removed in the RBF systems. This raises concerns about the future reliability of RBFs for drinking water production, and introduces the need for additional advanced treatment processes. Finally, pressure on the drinking water quality and production process will increase as the recast of Directive 2020/2184 "on the quality of water intended for human consumption" is implemented.

To address this issue, it is necessary to consider solutions that go beyond treatment of such PMT substances during drinking water production. This broader approach requires focusing on upstream solutions, such as reducing emission at WWTPs, identifying and controlling industrial discharges, and reconsidering the use of certain chemicals. This last approach includes examining whether specific chemicals are essential for use and if their potential substitutes are safer alternatives with desirable environmental behaviour.

Regulatory updates play a critical role in addressing water quality issues. There is a concern that ensuring future drinking water production through RBFs may not be guaranteed without costly additional treatment, particularly if drinking water standards become more stringent. The EU Urban Wastewater Treatment Directive is updated. The co-legislators aligned the thresholds and timelines for tertiary treatment (i.e. the removal of nitrogen and phosphorus) and quaternary treatment (that is, the removal of a broad spectrum of micropollutants). By 2039 and 2045 respectively, Member states will have to ensure the application of tertiary and quaternary treatment in larger plants of 150 000 population equivalent (p.e.) and above, with intermediate targets in 2033 and 2036 for tertiary treatment and in 2033 and 2039 for quaternary treatment (Urban wastewater: Council and Parliament reach a deal on new rules for more efficient treatment and monitoring - Consilium (europa.eu)).

Finally, an additional challenge to consider is legacy contamination within the river system. This type of contamination refers to the long-lasting environmental presence of chemicals, such as PFAS, often from historical industrial or consumer use. Therefore, even if emission from WTTPs and/or industries along the river are significantly reduced or eliminated, the long-term impact of existing PMT pollution would persist. Because the full extent of this legacy contamination contribution to overall PMT concentrations in the Danube River is still uncertain, it must be considered when developing future water quality management strategies.

PROMISCES Case study

Within the PROMISCES case study, PFAS within the Danube River and RBF systems are studied. Specifically, the case study focuses on developing methods:

- for the identification and quantification of the origin of selected chemicals discharged to the Danube River.

- to assess the behaviour of these chemicals during filtration in the riverbanks and during drinking water abstraction.
- to identify effective measures to control pollution levels in rivers and in drinking water impacted by rivers.

Co-Creation Process to Create Zero-Pollution Strategies

To create a viable strategy for dealing with micropollutants and ensuring future drinking water production along the Danube, a system view is essential, both in understanding the problem(s) and identifying potential solutions. To support this, PROMISCES organized a co-creation process with stakeholders. This interactive online co-creation workshop took place on October 2 2024, and it involved 11 stakeholders. The goals of this in-person workshop were to (Figure 1):

- Define the problem of micropollutants in the Danube and the future drinking water production
- Identify barriers and other factors that need to be addressed to ensure future drinking water
- Define solutions to overcome these barriers
- Co-create an interdisciplinary, system-wide strategy that incorporates the defined solutions and needed actors

To prepare the stakeholders for the ensuing discussion on barriers and solutions, PROMISCES created a preliminary online survey. In this survey, participants could provide their opinion on the importance and feasibility of various solution types. Additionally, the workshop made use of the online "Miro" to involve the participants in the group and gather their direct input. In the Miro board, the participants can work together on a digital whiteboard. The Miro board was set up to facilitate discussion and collaboration for each of the parts in the workshop.

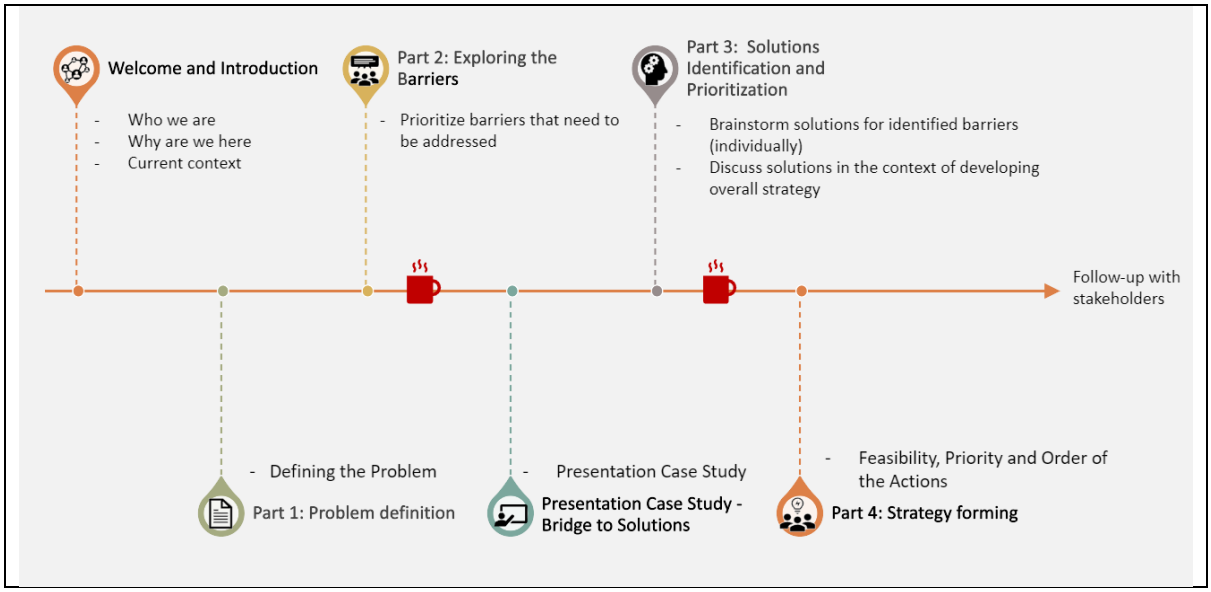

Figure 1. Structure and agenda of the online workshop.

Co-Creation Workshop

Part 0: Introduction

The workshop began with an explanation of the co-creation process. Additionally, the context and problem surrounding micropollutants within the Danube were explained together with an explanation of the case study activities.

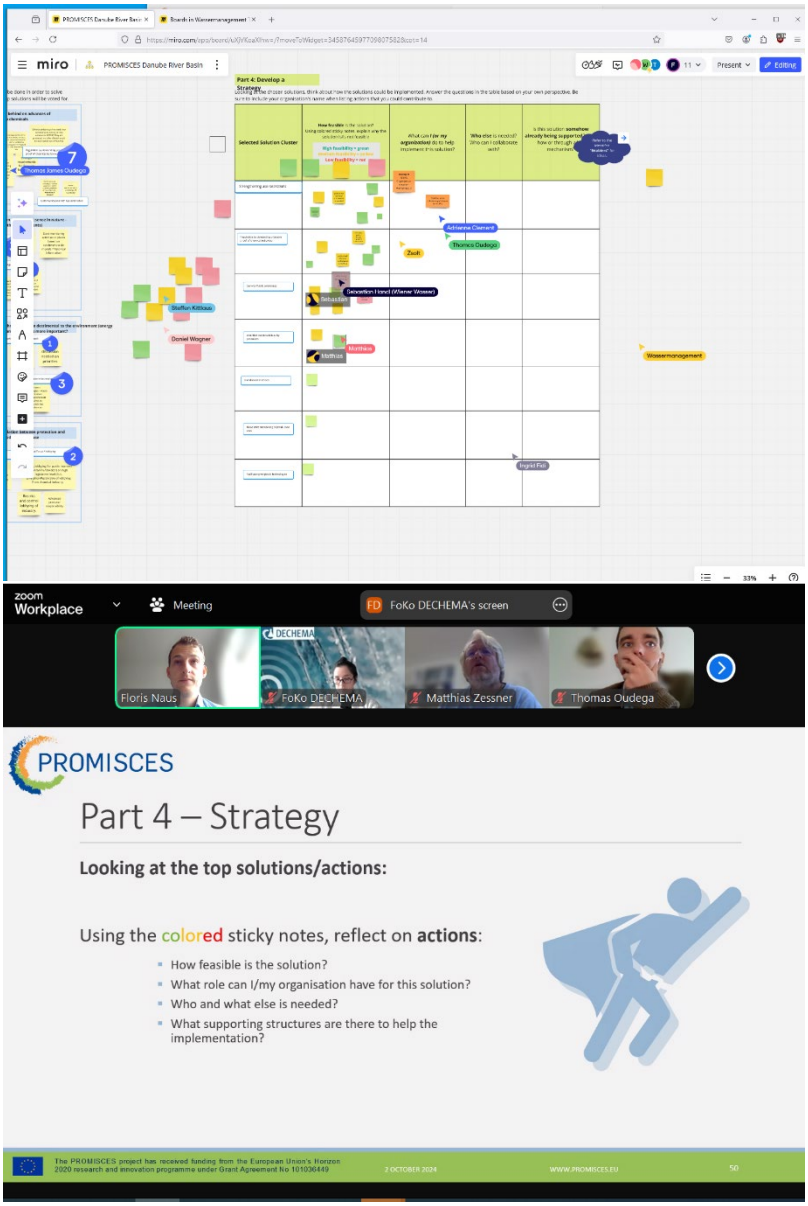

Figure 2 The online workshop. Above: stakeholders collaboration on the Miro board. Below: the Zoom meeting (note: only the presenters are shown, to ensure the privacy of the participants.)

Workshop Part 1: Problem Definition

In the first part of the workshop, the focus was on defining and discussing the problem, to get all the stakeholders on the same page. This was done by:

- Firstly, presenting a brief overview of the problem by a member of the PROMISCES case study team.
- Secondly, the initial survey was used to give a first overview of the opinion of various solution types by the stakeholders.
- Finally, there was an opportunity for the stakeholders to provide their reflection and to discuss the problem definition.

The discussion of the problem definition did not lead to large changes from the initial description of the problem, but did lead to a shared view of the problem among the stakeholders.

Workshop Part 2: Barriers & Enablers

Identifying Barriers

During the second part of the co-creation workshop, barriers and enablers were identified in a world café setting in six relevant aspects. This was done in break out groups, and the barriers and enablers were noted down in an online collaboration space (the Miro board).

The output from this session is presented in Table 1, with barriers and enablers listed per category. The barriers indicated in bold were prioritised in the next workshop phase (see below).

Table 1. Barriers and enablers for the problem of microcontaminants in the Danube. The bolded text are the prioritized barriers.

BARRIERS	Enablers
Environmental health	
• Substance properties result in wide dispersion • Groundwater: PFAS sources, movements • Transformation processes unkown / unclear in speed • **Legacy pollution (Diverse presence in nature - long lasting supply from the environments)** • PFAS contamination in many regions unknown • Very slow degradation rate in most matrices	• Some industries have high emissions, which makes them suitable for a pre-treatment • Where does pollution come from? how much comes from groundwater? (PFAS pollution) • organisms able to degrade PFAS as a co-substrate • use of soil to address less complicated compounds
Public health	
• Is the health effect and dose of each PMT substance known? Both academic and 'broader' • Unclear which substance is responsible for health effect	• General information on PFAS / public awareness • responsible way of communication, vs misuse of information • 'effect analytics', such as bio essays

BARRIERS	Enablers
• What risk is acceptable? esp. for drinking water. Emotions are concerned and hinder open discussion • Lack of regulation or awareness (and effect) on doses of medication	• more precise treatment (for example near hospitals)
Social	
• People are not aware of PMTs (except a little bit about PFAS) • limited education of general public (without alarming) • Certain knowledge of chemistry needed to understand what PFAS or even PMT are • increasing need for pharmaceutical compounds • social solid waste management is sometimes lacking • tricky advertisement of "flushable" products • Expectation of the public, that things needs to be known without uncertainties before action is taken • **High societal request for products that contain PMT substances**	• Anything that makes people aware of PMTs: ads, packaging that says "PFAS-free", news articles, "horror" stories • Documentaries, Deepper news articles - Example - Forever_MAP - • distinguish between essential and non-essential use of chemicals • Nature connection/recreational uses increases awareness on waste/pollution (ecosystem services awareness) • Better education in chemistry • High-profile court cases (e.g. Dutch government vs. 3M) • Togetherness to address the issue
Technical	
• **Information barrier: which PFAS to measure? Which are important? Which methods? What are their price? What is the removal rate?** • **Legacy pollution (Diverse presence in nature - long lasting supply from the environments)** • Research results are usually very uncertain • Groundwater: how do you sample PFAS • **Treatment techniques can be detrimental to the environment (energy intensive) - priority / balance of what is more important?** • **Difficult substance properties for removal & destruction** • Regulation may come in the future, which can affect treatment options/choices now • GAC: What to do with the waste?	• Deep ocean sinks? • Method to measure sum parameter • Monitoring / mapping of contamination • Quaternary treatment at WWTPs (e.g. ozone) • Research about removal technologies and their efficiency • Innovation in treatment / destruction
Financial	

BARRIERS	Enablers
• **Costs of treatment methods (financial and energy); not all countries are able to afford tertiary/quaternary treatment.** • Penalties for larger companies will have to be paid by consumers (eg medicine cost increase) • High costs for analysis • Yearly cost of treatment of annual PFAS production is higher thatn the global GDP • Costs of PFAS destruction (only at extremely high temperatures) • Banning pesticides could increase food price	• Increase treatment cost (drinking water or WWTP) • "Penalties" for producers - e.g. health insurance doesn't cover PFAS illnesses • Governmental support (e.g. financial)
Legislative, Governance	
• Lack of regulation and enforcing existing fire extinguishing systems • Polluters have the responsibility to report pollution, which does not always work in practice • Some laws work better on paper than in reality • **Balancing with economic interest for production and use** • **Legislation is always lacking behind on advances of research and/or the creation of new chemicals** • Focus on single chemicals, in relation to the high number of new chemicals • (lack of) threshold values	• Better database on actual emissions - legislative force to make it happen • better regulation of registration/permissions of chemicals • New academic insights could help formulate new legislation, (e.g. sum parameters, or health effect parameters) • Development in analytics, so substances can be detected in low levels

Prioritizing Barriers

After finalizing the lists of barriers, the participants voted on the priority of the barriers in the Miro board. The most important barriers (those with the highest number of votes) are indicated in bold in Table 1 above and are listed below.

Most prioritized barriers had a link to the categories of technical (4), legislative/governance (2), and environmental (2). Additionally, one priority barrier was identified within the financial category and one in the social category. Note that the barriers can be related to multiple categories (Table 2).

Table 2. The complete list of prioritized barriers.

	Prioritized barrier	**Category**
1	Difficult substance properties for removal & destruction	Technical

	Prioritized barrier	Category
2	Legislation is always lacking behind on advances of research and/or the creation of new chemicals	Legislative
3	High societal request of products that contain PMT substances	Social
4	Legacy pollution (Diverse presence in nature - long lasting supply from the environments)	Environmental and technical
5	Information barrier: which PFAS to measure? Which are important? Which methods? What is their price? What is the removal rate?	Technical
6	Treatment techniques can be detrimental to the environment (energy intensive) - priority / balance of what is more important?	Environmental and technical
7	Costs of treatment methods (financial and energy); not all countries are able to afford tertiary/quaternary treatment.	Financial
8	Balancing regulation between protection and economic interest for production and use	Legislative

Workshop Part 3: Identifying Solutions

Brainstorming Solutions

The last step was to identify solutions for the eight prioritized barriers. This started with a 'brain-dump' by the participants, in which they provided as many solutions are possible for each of the identified barriers, in the Miro board.

The results of this brainstorm of solutions are indicated in Table 3, together with the clusters they belong to (see below).

Table 3. Solutions proposed by the participants for the eight prioritized barriers.

Difficult substance properties for removal & destruction
Green Chemistry Research & Biological degradation facilitation • Find a way to add some chemical group to these substances to make them more easily accessible to biological degradation • stronger support of development of "green" chemistry • research on biological degradation and how to increase the rates **Strengthening use restrictions** • very strong restriction of use • restriction on use • implement strict advanced producer responsibility **Research Investments** • enhance investments in research • advances in technology needed (in cases avoidance does not work)

Legislation is always lacking behind on advances of research and/or the creation of new chemicals

Regulation by demanding producer proof of chemical behaviour

- EU-wide enforcing of research into persistance & toxicity of new substances BEFORE they are produced, not after (Global would be even better but unfeasible)
- Strict application of the precautionary principle, so only allow industrial use for substances thoroughly investigated for their environmental fate
- implement strict advanced producer responsibility
- Stronger pressure on chemical production by legislations (e.g. very strong proof to be provided for new chemicals with regard to their effects on human and ecosystem health)
- stronger requirements for licences for chemicals

Communication with General Public to raise awareness and reduce demand

- Communication campaigns - raising awareness of the potential problems of new chemicals - Reduction of demand

Improve application of knowledge in legislation

- Better communication / exchange of knowledge

High societal request of products that contain PMT substances

Price adjustments on products

- Price of products should be "real" - i.e. should include costs of remediation

Raising public awareness

- Raise awareness of ecosystems services and the harm from chemicals
- Communication campaigns - raising awareness of the potential problems of new chemicals
- Awareness raising for wellbeing without the need for consumption
- Behaviour changes

Legacy pollution (Diverse presence in nature - long lasting supply from the environments)

More strict monitoring of production sites

- Start monitoring activities in places based on catchment scale models / historical information
- increase legal responsibility of producers of pollution (at least for the future)

Active approach to legacy pollution

- identification of locations, development of remediation technologies and their application
- More research to identify legacy pollution sites
- Containment of known legacy pollution sites until appropriate treatment becomes available

Information barrier: which PFAS to measure? Which are important? Which methods? What is their price? What is the removal rate?

Standardize (monitoring) methods

- Development of "standard methods" of sampling and analyzing PFAS
- Guidelines can do heavy lifting (e.g. focus on the sum of 24 PFAS)

Innovate in methods

• Innovative analytical methods (such as non-targeted, biosensors)
Treatment techniques can be detrimental to the environment (energy intensive) - priority / balance of what is more important?
Priorities on how to approach • Apply life cycle assessment with appropriate indicators to decide where to treat and where not to treat • Open discussion needed on priorities • Focus treatment where it is needed most (e.g. wastewater directly at its source) **Facilitate synergies in technologies** • Connect technologies - waste incineration produces the heat required to demolish the substances • Avoidance first, treatment second
Costs of treatment methods (financial and energy); not all countries are able to afford tertiary/quaternary treatment.
Alternative water sources • Consideration of alternative sources (mainly for new plants) - Deep groundwater instead of bank filtration etc. **Extended responsibilities by producers** • Emitters / producers should help pay for remediation • Avoid pollution: Do not allow export of chemicals restricted in EU from production in the EU into other parts of the world.
Balancing regulation between protection and economic interest for production and use
Raising general population awareness • Public awareness could increase public (and thus political) pressure to increase protection - i.e. health effects of unborn babies **Political Focus / lobbying** • Strong lobbying for public interest (environment/water) on high legislative level (EU). Limitation/Restriction of lobbying from chemical industry. • Restrict and control lobbying of industry. • Advanced producer responsibility

Selecting Priority Actions

After the 'brain-dump' activity, the identified solutions were clustered into separate actions. During this clustering, the participants discussed the proposed actions. The clusters are presented in the above table as the bold headings for the individual suggestions. There was a large discussion, especially on the extended user responsibility, and it was noted that producers themselves were not present in the workshop.

Next, the clusters were prioritized by voting on the Miro board. Based on the voting, the following seven priority focus areas for actions were identified:

1. Strengthening use restrictions
2. Regulation by demanding producer proof of chemical behaviour
3. Raising public awareness
4. Extended responsibilities by producers
5. Standardize (monitoring) methods
6. More strict monitoring of production sites
7. Facilitate synergies in technologies

Workshop Part 4: Towards a strategy

In the fourth part of the workshop, there were three activities:

1. Stakeholders judged the feasibility of the solution clusters using the colour of the sticky notes in the Miro board (green = more feasible; yellow = less feasible).
2. Stakeholders identified actions for themselves for each of the solutions;
3. Stakeholder identified who else is needed/has responsibility for each of the actions

The result of this activity is presented in the table below. Table 44. The results from the fourth part of the workshop. For each solution, the stakeholders judged the feasibility using the colour of the sticky note and indicated actions for their organisation.

Solution cluster 1: Strengthening use restrictions
4 green sticky notes Comments: - probably more effective and implementable than relying on public awareness and consumer responsibility
3 yellow sticky notes Comments: - political will (EU level and beyond) is needed
0 red sticky notes
What can I (or my organization) do to help implement this solution?
TU Wien: - show substance persistance & mobility - contribution to national and international organizations - contribute to the co-creation workshops BME: - Publish research results
Who else is needed? Who can I collaborate with?
EU/WHO

Solution cluster 2: Regulation by demanding producer proof of chemical behaviour
3 green sticky notes
3 yellow sticky notes Comments: - Difficult to push it through legislative mechanisms - political will (EU level and beyond is needed)
0 red sticky notes
What can I (or my organization) do to help implement this solution?
TU Wien: - Identify which information on chemicals is needed Tyrol: - Opinion/comment on the implementation of the WW directive
Who else is needed? Who can I collaborate with?
Solution cluster 3: Raising public awareness
1 green sticky note
3 yellow sticky notes Comments: - political will (EU level and beyond) is needed
4 red sticky notes Comments: • public awareness should be used to help strengthen regulation. relying on public awareness for consumer bahaviour change will not work on a long therm basis • Requires better education, which is not easy/fast to achieve • you only reach a relatively small bubble. Other interests are stronger promoted • Difficult to breach peoples thresholds for information
What can I (or my organization) do to help implement this solution?
TU Wien: - Public presentations - Education, raising the awareness of young people WTP Linz (LINZ AG): - Mentioning the issues in guided tours BME:

- Education, raising the awareness of young people Tyrol: - Public relations
Who else is needed? Who can I collaborate with?
- NGOs focusing on these type of problems - Schools
Solution cluster 4: Extended responsibilities by producers
2 green sticky notes Comments: - already on its way
3 yellow sticky notes Comments: - But not limited to one branch as currently proposed. And then identification of responsible producers might become challenging.
0 red sticky notes
What can I (or my organization) do to help implement this solution?
TU Wien: - Contribute to (EU) working groups on legislative changes
Who else is needed? Who can I collaborate with?
- Organisations representing groups of producers
Solution cluster 5: Standardize (monitoring) methods
4 green sticky notes Comments: - this is in what science has a long history of establishing
2 yellow sticky notes
0 red sticky notes
What can I (or my organization) do to help implement this solution?
TU Wien: - Take part in projects focusing on method standardization

Who else is needed? Who can I collaborate with?
- Standardisation organisations (ISO...)
Solution cluster 6: More strict monitoring of production and polluted sites
4 green sticky notes
3 yellow sticky notes
0 red sticky notes
What can I (or my organization) do to help implement this solution?
WTP Linz (LINZ AG): - restriction of allowed pollutions and forced analysis TU Wien: - Propose monitoring in projects - Extent the scope of monitoring by modeling to improve basis for management Tyrol: - implementation of the ww directive, "water supervision"
Who else is needed? Who can I collaborate with?
- Local authorities
Solution cluster 7: Facilitate synergies in technologies
1 green sticky note Comments:
3 yellow sticky notes Comments: - It is also a legislative question. Should be incorporated in the BAT process for industries - Might be challenging in timing and in spacial distribution
0 red sticky notes
What can I (or my organization) do to help implement this solution?
None indicated
Who else is needed? Who can I collaborate with?

BAT producing groups

Reflections and Conclusion

The structure of the workshop resulted in an action list of how to deal with PM(T) substances in the Danube basin. The workshop made clear that an action plan is needed, and priority actions for this were identified.

Two of the priority actions call for clear and strong regulation from legislation. These regulations focus on the prevention of the use of harmful components (such as PFAS) by strengthening use restrictions and regulating new chemicals by demanding producer proof of chemical behaviour. Additional focus on prevention was suggested by raising public awareness to reduce the demand for products with harmful components.

Further, the stakeholders focus on improving monitoring of PMT substances, by increasing the monitoring of production and polluted sites, and by standardizing monitoring methods. For the technologies.

The stakeholders suggested that the costs of the additional treatment and monitoring could be covered via extended producer responsibility. It should be noted that producers were not present in the workshop, and there was quite some discussion on whether this would actually be acceptable for the producers. It was noted that a strong political will is needed. Another selected priority solution was to focus on facilitating synergies in technologies, although none of the participants indicated that they could contribute to this action, and there were doubts on the feasibility for this solution.

The proposed priority actions highlight legislative, social and financial boundary conditions that must be met to address problems along the circular economy route. Special importance was given to clear and strong regulation.

Due to the time constraint of the stakeholder workshop, the various actions from the involved stakeholders are merely listed in the following table, without specifics regarding timing or priority. It is therefore recommended that stakeholder interaction continues in the future to transition these suggested actions into a comprehensive and collaborative strategy.

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