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Solutions for present and future emerging pollutants in land and water resources management

THEME

ENV.2013.6.2-2

Toxicants, environmental pollutants and land and water resources management

Start date of project: 1st October 2013

Duration: 5 years

D8.3 Final report on communication, dissemination and training

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Dissemination Level			
PU	Public	Х	
PP	Restricted to other programme participants (including EC)		
RE	Restricted to a group specified by the consortium (including EC)		
CO	Confidential, only for members of the consortium (including EC)		

1.1 Summary

SOLUTIONS allocated major efforts on communication, dissemination and exchange of scientific concepts, approaches and results focusing on internal communication, stakeholder dialogue, dissemination to the scientific community and raising awareness in the general public. The efficient organization of the internal communication within the SOLUTIONS consortium was the prerequisite for an optimized scientific exchange and a maximum benefit from the interdisciplinary collaboration and the joint expertise of the excellent SOLUTIONS consortium. Internal communication has been based on regular meetings and videoconferences on all organizational levels with the Annual General Assembly and Project Meeting as the most important gathering of the whole consortium and THE forum for scientific and organizational exchange. An attractive intranet well perceived and with input from all partners and the exchange of e-mails and telephone calls were used for daily communication.

SOLUTIONS has been designed as a scientific project producing concepts, approaches, models and tools, cutting edge scientific results and innovation that were targeted at water managers, agencies, international river associations, water industry and other stakeholders for closing gaps in WFD-related monitoring, assessment, prioritization and abatement of pollution in European water resources. Thus the team was charged with providing science-based support for the implementation and the advancement of the WFD. SOLUTIONS thereby put particular focus on an intensive, well-structured and professionally facilitated stakeholder dialogue with a highly active Stakeholder Board meeting twice a year and the direct participation of SOLUTIONS stakeholders in the development of the SOLUTIONS concepts and products. An extensive description of the composition and activities of the Stakeholder Board but also of their advice, requests and assessment is provided in this deliverable.

The exchange with the scientific community has been based on more than 100 scientific publications, a large number of presentations on scientific events as well the organization of own conferences and workshops. The final results of SOLUTIONS have been presented to scientists and stakeholders in a targeted way, respectively, with a special session at SETAC 2018 for the scientific community and the SOLUTIONS Final Conference with a strong focus on the discussion with stakeholders. The general public has been informed with a highly attractive website, freshwater blogs, press releases, and TV clips.

Small and medium enterprises strongly contributed to the success of SOLUTIONS. They developed products that increased the European competitiveness and provided novel market opportunities for these SMEs.



1.2 [publishable] Graph



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3. List of Abbreviations

CIS	Chemical Implementation Strategy
EBM	Effect based methods
GA	General Assembly
JDS	Joint Danube Survey
LVSPE	Large volume solid phase extraction
NGO	Non-governmental organisation
PCC	Project Coordination Committee
PO	Project Office
RBSPs	River Basin Specific Pollutants
SETAC	Society of Environmental Toxicology and Chemistry
SP	Sub-project
WG	Working Group
WFD	Water Framework Directive
WP	Work Package
WWTP	Waste water treatment plant

Acronyms of stakeholder organisations are explained in the text.

4. Section(s)

4.1 Introduction

Between the scientific community and stakeholders from regulation, industry and NGOs, as well as with the general public often only limited exchange of knowledge and ideas is occurring. This hampers the mutual understanding, the awareness of the public and the stakeholders about scientific progress, the consideration of stakeholder needs into research and the implementation of scientific results in practice. At the same time communication is also key within these groups and particularly within the consortium of a large collaborative project. Thus, SOLUTIONS allocated major efforts into the establishment of efficient communication within the project and between the project and the scientific community, and also towards relevant stakeholders and the general public. This required the use of different channels, formats and media to address the different groups. Moreover, efforts were made to go beyond a pure dissemination of findings and reach out for an active dialogue with stakeholders providing opportunities to directly impact on the research in the project. SOLUTIONS was quite successful in establishing efficient communication structures that helped to optimize research and development, that facilitated dissemination and that enhanced the awareness of SOLUTIONS activities and results on a European level but also nationally and worldwide.

4.2 Management structure

As a highly integrated and collaborative large project a powerful and efficient management structure was established with clearly defined elements as shown in Figure 1. SOLUTIONS required close integration across all subprojects and this had been carefully considered in the proposed organisation structure. The co-ordination structure of SOLUTIONS was based on experience gained from managing other major research projects with similarly rigorous requirements.

The Coordinator

The Project Coordinator, Werner Brack, was the overall scientific and administrative coordinator of the project and was the responsible contact person for the European Commission. He was the overall contact person of the project. The coordinator was responsible for the set-up and implementation of the Consortium Agreement based on the DESCA model. He also organized the management of the entire project as well as the liaison between the various subprojects and work packages. The coordinator and the Project Co-ordination Committee (PCC) met twice a year, with one meeting coinciding with the general assembly meeting. Discussion summaries or minutes of the meetings were circulated to all partners by email. The coordinator was responsible for the timely submission of the project progress reports to the EU-Commission. Werner Brack was assisted by a highly qualified team at the UFZ which is very experienced in the scientific co-ordination of large interdisciplinary research projects and has been involved in many international projects, including EU projects within FP7 and previous framework programmes (e.g. NoMiracle, RISKBASE, KEYBIOEFFECTS), co-ordinating several of them (e.g. SCALES, EDA-EMERGE, TIMBRE, iSOIL, ModelPROBE, OSIRIS).



Figure 1: Management structure of SOLUTIONS

The Project Coordination Committee (PCC)

The central body responsible for monitoring and evaluating project progress and supervising project objectives was the Project Coordination Committee (PCC), which took the necessary decisions in scientific co-ordinating and administration the project. Based on the contributions from the sub-projects and work packages, the PCC prepared the periodic reports and the final report in dialogue with the Stakeholder Board (SB). Reports and amendments to the Description of Work (DoW) were decided on by the General Assembly (GA). The PCC consisted of the Project Coordinator, the project manager, the heads and deputies of the subprojects responsible for overseeing their respective. The Project Coordinator (Werner Brack) headed both the PCC and the Project Office (PO).

Scientific Coordinator and	Werner Brack	Christin Müller
Manager	(UFZ, Germany)	(until 4/2018 David López Herráez)
	(012,000,00)	(UFZ, Germany)
SP 1: Concepts & Solutions	John Munthe	Annemarie van Wezel
-	(IVL, Sweden)	(KWR, The Netherlands)
SP2: Tools	Rolf Altenburger	Andreas Focks
	(UFZ, Germany)	(Alterra, The Netherlands)
		(Until 6/2015
		Knut-Erik Tollefsen,
		NIVA, Norway)
SP3: Models	Jos van Gils	Andreas Kortenkamp
	(Deltares, The Netherlands)	(Brunel, UK)
SP4: Cases	Jaroslav Slobodnik	Juliane Hollender
	(EI, Slovakia)	(Eawag, Switzerland)
Stakeholder Board	Bernd Gawlik	Igor Liska
	(JRC, EC, Italy)	(ICPDR, Austria)

 Table 1: Project Coordination Committee (PCC)

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The Project Office (PO)

The Project Office supported the Project Coordinator in the day-to-day operational management of the project and handled the administrative management. The PO consisted of the project management team, comprising of the project manager and experienced staff from the EU office. Additionally, members of the public relations and personnel departments contributed to the work of the PO as required during the course of the project. Their work effort comprised approximately the equivalent of about 0.5 persons (or 6 PM per year). The PO handled the financial administration and safeguarded the adequate execution of the project budget. A full time secretary was employed at the Department of the Project Coordinator and provided additional administrative support for the PO where needed for correspondence, project controlling, take care of financial and budgetary matters and collect the financial statements and audit certificates from the project partners.

The General Assembly (GA)

The GA consisted of all partners (represented by one delegate from each partner) and was the highest decision making body of the project. The GA decided on all issues of fundamental importance for the whole project. The GA was always held at the annual SOLUTIONS project meeting. These meetings were used for strategic planning, presentation and discussion of scientific results, and discussion of major management issues.

4.3 Internal communication

In agreement with the SOLUTIONS management structures highly efficient communication on all levels of the SOLUTIONS structure was established. Major pillars of communication in addition to day-to-day communication via e-mail and telephone were (1) a highly efficient and user-friendly intranet, (2) the Annual General Assembly together with the biannual PCC meetings, (3) frequent teleconferences and meetings on the WP and SP level in order to coordinate the progress of the work on this level, (4) monthly videoconferences of the Project Coordinator, the PO and all SP heads to organize the integration of the scientific work and the dissemination activities of the SPs and (5) several scientific workshops and conferences that served three objectives, focused scientific discussions and strategic work planning, the dissemination of project results to stakeholders and the scientific community, and the stimulation of internal exchange and communication.



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eicome, Werner Brack!		
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lune 8, 2018 European Union Project FP7 SOLUTIONS Workshop	October 10, 2018 - October 12, 2018 XENOWAG II Conference: Challenges and Solutions	< NOVEMBER 2018 >
o-organized by VITO and VERI- hosted by Veolia H Paris - 4th June 2018	related to Xenobiotics and Antimicrobial Resistance in the Framework of Urban Wastewater Reuse	1 2 3 4
september 19, 2017	June 25, 2018 - June 28, 2018	5 6 7 8 9 10 11
SOLUTIONS yearly Assembly in The Netherlands entember 2017	6th International conference on Emerging Contaminants	19 20 21 22 23 24 25
		26 27 28 29 30
Scientific Publications	Archivo	Decent Files
Scoping Papers	Official documents	integrated with IPCheM and RiBaTox
Tools	Reports	Impact of industrial waste water
Models	Minutes	and drinking water sources
Cases	Presentations	Concepts & Solutions WP17 Substance Properties Predictions
Other Projects	Stakeholder input	Chemical Set 10 SOLUTIONS Project Data
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Public Relations Material Did you know? ...

Figure 2: Screenshots from the SOLUTIONS intranet

The intranet was organized around a dashboard serving major needs of internal information and communication (Figure 2) including the dissemination of news and events, facilitation of organization project events by using an interactive calendar, the availability of all SOLUTIONS scientific publications for the whole consortium, an archive for important documents, the highlighting of recently uploaded files, the structured upload and sharing of important presentations given at scientific and stakeholder-related events, a collection of logos and templates, partner addresses, a discussion forum, a black board, the latest version of databases under development and public relations material.

The integrated Annual Project Meetings and General Assemblies have been organized by different partners (UFZ, Deltares, EI, Alterra) and were very well attended with typically around 100 participants from all partner institutions including those from Brasil, China and Australia with more challenging travel schedules. These meetings brought together fruitful and well organized scientific discussions within and particularly across SPs and WPs and were important drivers of scientific progress. This was achieved by the combination of different targeted and innovative discussion formats including world café, open space formats but also well prepared presentations of new scientific findings. Also, scientists from different academic career stages were given platforms for participation. In addition, the GA was used to discuss and decide on all organizational issues including reporting, deliverables etc.

Intensive communication and collaboration was organized on all levels. The communication on SP and WP level was key for the scientific progress and was organized by SP and WP heads. The formats were selected according to the specific needs and included the exchange of e-mails, the frequent organization of teleconferences but also physical meetings at many different locations.

Monthly videoconferences of the Project Coordinator and PO with all SP heads were most important for the efficient organization of the whole project, for supporting information exchange and collaboration between the SPs, for coordinating SOLUTIONS disseminations activities and for the preparation of GAs, PCC meetings and scientific workshops and conferences. Where needed for specific discussions and decisions, additional partners were involved in these conferences.

Many scientific workshops and conferences facilitated the internal exchange and dissemination to the outside world. Examples were the three workshops on compound prioritization, the four think tank workshops on future pollution and the workshops held to develop RiBaTox.

4.4 Stakeholder communication

4.4.1. General approach of SOLUTIONS to stakeholder interactions

The aim of SOLUTIONS to deliver an advanced conceptual framework for environmental and water policies, obviously, cannot be reached by scientific activity alone. Rather, science must be complemented by the experience and expectations of stakeholders who will later on eventually make use of the projects results.

Therefore, the Description of Work for SOLUTIONS lists for WP 8 the methodical involvement of stakeholder groups as important part of the projects external communication. *Distinguished targets* were:

- incorporating requests to the project by main users, at an early stage,
- gaining support from competent stakeholders and their networks,
- early, informing of interest groups (not examined in this report module).

SOLUTIONS has tracked these targets via stakeholder interactions in different formats and on various levels of the projects work process.

The SOLUTIONS *Stakeholder Board* was set up on the coordination level of the project. It involved central authorities and main users of results at European and at river basin level, as well as experts from international technical authorities, thus assembling a group of highly competent external stakeholders representing a broad range of relevant experience. In this body leading representatives of SOLUTIONS reported on interim results and on decisions regarding the course of the project, for further detail see section 4.4.2.

On the working level, SOLUTIONS *Work Packages and Case Studies* included a number of elaborate formats for stakeholder interactions on scientific and science-related questions (see section 4.4.5).

Regardless of the specific format, stakeholder interactions were designed to follow *basic principles*, in particular

- representation of all important issues,
- comprehensive information,
- frank discussions,
- responsiveness by SOLUTIONS to stakeholder contributions and questions.

4.4.2. Characteristics and operations of Stakeholder Board

In order to provide reasonable support, especially for external stakeholders, for their participation, the Board followed clear procedures and was organized in a reliable and transparent mode.

In succession, discussions have been highly interactive and have led to intensive advice for decisions on SOLUTIONS course of action throughout the projects run-time. The external stakeholders followed and supported the project continuously, providing recommendations, data and knowledge and promoting SOLUTIONS in their networks see section 4.3.3.

Basic procedures, composition and main issues of the Boards work are outlined below together with the advice by external Board members.

4.4.2.1 Basic procedures

Gathering stakeholders expectations

Already at SOLUTIONS Kick Off in October 2013, main stakeholders took part and presented their expectations to the project. Then, concurrent with the buildup of SOLUTIONS work process in the first project months, in December 2013 a questionnaire was circulated to the external members of the Stakeholder Board to specify stakeholders problems and requirements. Resulting issues were discussed at the first regular Board meeting and the members agreed on proceedings how to integrate them in the project.

Assuring shared understanding of the Boards scope and tasks

SOLUTIONS proposed and the Board agreed on rules and procedures. Herewith, the focus for the Boards work was set on open discussion and information, voting procedures were left aside. External Board Members and external guests were obliged to sign a non-disclosure agreement.

Periodic facilitated meetings with timely announcements

Board meetings took place twice a year, one during the General Assemblies in late autumn, and a second

one subsequent to SETAC conferences in spring. The Boards timetable was set up long-term and communicated early. The program was timely circulated.

Distinct Board meetings and continuous stakeholder communications were facilitated by SOLUTIONS partner Hammerbacher (HAM) who brought in comprehensive experience in stakeholder interactions.

Online platform for stakeholders for archive and selected information

A password protected online platform for external stakeholders supported the Board members. It served as an always accessible archive for basic documents, minutes and presentations of the Board and also for documents provided by external Board members. The platform compiled selected scientific publications on SOLUTIONS results with special relevance for external stakeholders. It also gave them privileged access to project deliverables - official deliverables as well as selected internal deliverables. Furthermore, the Stakeholder Forum allowed for online discussions.

Participatory assessment of the Boards work

To gain a congenial assessment of the Boards common work, in the beginning of the concluding project year 2018, Board members were asked to answer a questionnaire. Main results of this survey see section 4.3.4, 4.3.5 and 4.3.6. Also, the Board members were asked for their comments on the draft of this report.

4.4.2.2 Composition of the Board

SOLUTIONS Stakeholder Board consisted of three member groups

- A external stakeholders (external),
- B partners of SOLUTIONS who concurrently represented external stakeholders (double-role),
- C members of SOLUTIONS Coordination Committee and leaders of strategic work packages (SOL).

In terms of proportions, in the consolidated Board, group A represented 12 stakeholder organizations, Group B represented 4 stakeholder organizations and group C comprised 11 leading representatives of SOLUTIONS. Also, further external stakeholders participated in single discussions of the Board (details see below).

The double role of group B was due to the high ambitions and broad conception of SOLUTIONS. Since the project aimed for integration of all relevant knowledge regarding innovative tools, models and methods to support environmental and water quality, it had to include important institutions regarding technical and political aspects as partners in SOLUTIONS work process. At the same time those partners represented important societal stakes with respect to the projects issues.

Even though the role of these Board members cannot be viewed as pure stakeholders, they clearly and frequently expressed stakeholder interests in the Boards discussions.

The Board needed roughly a year to reach its consolidated composition. Due to capacity overload by several of the originally addressed persons, time was needed to nominate adequate alternative persons. In this respect, the nomination of young experts by the requested stakeholder organizations proved to be a successful way.

The following organizations participated with regular representatives in group A external stakeholders, (alphabetical order):

- Catalan Water Agency ACA,
- Environment Canada,
- European Commission, DG Environment,
- European Environment Agency EEA,

Deliverable Report

- European Federation of National Association of Water and Waste Water Services EUREAU,
- German Environment Agency UBA,
- International Commission for the Protection of the Rhine ICPR,
- Italian National Institute for Environmental Protection and Research ISPRA,
- Oekotoxzentrum, Swiss Centre for Applied Ecotoxicology Eawag EPFL,
- Swedish Chemical Agency KEMI,
- US-Environment Protection Agency EPA,
- Veolia Environment.

Additional external views gave a former representative of EEA to SOLUTIONS Board, who retired during the projects run time but proceeded in the role of an independent senior consultant.

In group B – external stakeholders and at the same time partners of SOLUTIONS, the following organizations were represented:

- ICPDR as responsible board for the implementation of the Danube River Protection Convention,
- JDS Joint Danube River Survey,
- NORMAN network of reference laboratories for monitoring of emerging environmental pollutants,
- JRC / WFD-CIS expert groups.

Several more stakeholders contributed to single meetings resp. special issues of the Stakeholder Board (alphabetical order):

- Arctic Monitoring and Assessment Program AMAP,
- Association of Water Companies in Slovakia,
- International Associations of Water Works in the Danube Catchment Area IAWD,
- Ministry of the Environment, Japan,
- Two related EU projects, representing special interests of WFD CIS: GlobAqua: Managing the effects of multiple stressors on aquatic ecosystems with water scarcity, MARS: Managing aquatic ecosystems and water resources under multiple stress.

SOLUTIONS invited also the European Chemical Industry Council CEFIC, the European Food Safety Agency EFSA and the European Chemicals Agency ECHA for participation as member of the Stakeholder Board, however, without a positive response. Nevertheless, EFSA and ECHA scientists participated in SOLUTIONS workshops on prioritization of chemicals in European waters.

The request of environmental and consumer protection NGOs to participate continuously in Stakeholder Board was considered. With respect to the scientific focus of the project and the already broad presence of environmental competences and protection authorities in the Board, the decision was taken to ask for NGOs feedback after consolidated results of the project would be available.

4.4.2.3 Intensity of participation in Board meetings, General Assemblies, online discussions

On the whole, the Board Members met 10 times in distinct Board Meetings. *Average attendance at Board meetings* was between 8 and 9 stakeholders (external and double-role). With a minimum of 6 and a maximum of 13 stakeholders per meeting, a continuous and sophisticated discussion with stakeholders perspectives was thus ensured.

Besides the discussion of the projects work progress and results as presented by SOLUTIONS, external stakeholders presented and discussed information on matters of their own interest. Presentations to the Board were given on the following subjects:

- Present tasks and issues of WG Chemicals,
- Overview of U.S. EPA Regulatory and Research Approaches to Assessing Emerging Contaminants in the Aquatic Environment,
- Overview of Canadian federal research and regulatory approaches on emerging contaminants,
- Potential synergies between SOLUTIONS and EEA,
- Micropollutants as a new challenge in the protection of the Rhine,
- EC Study on the environmental risks of the medicinal products: roadmap of possible legislative and non-legislative solutions from the EC perspective,
- KEMI's prioritisation tool for chemicals,
- Monitoring Programme in Catalan Basins,
- Comparison of Limits of River Basin Specific Pollutants [RBSP] under European Water Framework Directive,
- Fitness check of chemical legislation by EU,
- Challenges regarding the field of drinking water as seen by EUREAU,
- The new Drinking Water Directive,
- Issues of interest by Italian National Institute for Environmental Protection and Research (ISPRA),
- Reporting of chemicals in RBMPs,
- SOLUTIONS for risk management of steroidal estrogens.

SOLUTIONS designed it's *General Assemblies in general open for stakeholders*. Only in specific cases meetings were marked as internal project discussions. Therefore, the Board meetings in combination with General Assemblies turned out to be especially attractive for stakeholders because of the more comprehensive information and contact opportunities.

The Boards' *external stakeholder members took active roles* in SOLUTIONS Kick-Off, in General Assemblies and in the concluding discussions of the final conference. According to their individual interests, they participated in a number of discussion rounds and workshops during the General Assemblies.

Also, external members of the Board followed requests by SOLUTIONS work packages to contribute to special questions.

Stakeholder members of the Board expressed their interest in *online discussion* by SOLUTIONS. In this respect SOLUTIONS scientists offered the following subjects:

- Draft paper 'Potential synergies between distinctive regulatory frameworks'.
- Draft paper 'Guidance Document for Tools'.

The intensity of interactions between SOLUTIONS and its stakeholders are also highlighted by several cases of early stakeholder inclusion in the drafting of main documents. This included the Paper 'Potential synergies between distinctive regulatory frameworks' (Resulting in a report on chemical policies and regulations), the paper "Towards the review of the European Union Water Framework management of chemical contamination in European surface water resources"[1] together with NORMAN, and the Guidance Document for Tools (D9.1).

4.4.3. Main subjects of discussion and advice by external stakeholders

The project was, during its 5 years duration, accompanied by extensive discussions, advice and support by external stakeholders.

In summary, external stakeholders on the one hand gave plenty of conceptual as well as detailed support to SOLUTIONS work. On the other hand, they consistently pointed to uncompleted questions and tasks, focusing on issues like e.g. standardization and applicability of novel tools, the need for cost benefit analysis, information and inclusion of relevant levels of Member States, dissemination strategy and contents of policy briefs etc.

In the following the broad range of issues and contributions are compiled and organized according to their relation to SOLUTIONS tasks.

4.4.3.1 Stakeholders issues in the beginning

Issues from the Kick Off in October 2013 and from the survey in December 2013 made up for an extensive list of aspects that, from the perspective of stakeholders, needed attention by SOLUTIONS. Below, the initially called issues are arranged according to main work tasks of the project.

Conceptual framework should consider:

- Pathways and life cycle of chemicals.
- Risk assessment of mixtures.
- Consequent chain of measures.

Modelling should consider:

- Remobilisation and stocks of PBT substances, abraded materials.
- Communication of uncertainty and variability.

Tool development should consider:

- Source identification, identification of emerging transformation products etc.
- Discussion on integration and storing routines of high resolution / non-target screening.
- Proved general relevance and standardized proceedings.
- User-friendly tools, providing easy application and cost-efficiency.

Abatement options should consider:

- Precautionary actions instead of end-of-pipe-techniques only.
- New properties of emerging pollutants.

Scenarios for upcoming risks/chemicals of the future should consider:

- Climate change and hydrology.
- Upcoming technologies e.g. nanotechnology.
- Spatial distribution and pressure areas.

Evaluation of policy and regulation should consider:

- Overview on legislations influencing chemicals use.
- Exploration of areas where WFD and REACH need communication.
- Consistent regulations on regional, national and European levels.
- Routines for exchange and use of confidential data.

SOLUTIONS communication strategy should consider:

- Discussion and cooperation with EU Member States, industry and NGO's to achieve greater acceptability for outcomes.
- Early information and collaboration with member states regarding River Basin Specific Pollutants.

- Ensuring relevant information from CIS group and on CIS process.
- Disseminating results: use of existing platforms e.g. WISE-RTD and others.
- Communicating with the public: stress increasing contribution of private consumption, focus more on toxicity than on concentration.

Also, stakeholders expressed overall interest in *relationships between human health and ecological risk*, pointing to the matters of consistency of protection levels, long-term risks, secondary poisoning, and the role of mixtures, metabolites and transformation products.

4.4.3.2 Stakeholders advice while following SOLUTIONS work process

The above listed initial issues were discussed repeatedly by the SOLUTIONS Stakeholder Board. Beyond that, subsequent discussions followed the even more complex actual work process of the project and resulted in numerous notions and recommendations, ranging from scientific details to conceptual questions and communicative and networking support by external stakeholders. As SOLUTIONS, in the second half of the run time, approached applicable results, external stakeholders focused on advice how to improve the practical conditions of applicability.

The following shows the range of substantial advice to SOLUTIONS, highlighting the course of stakeholders response to the projects actual process.

Regarding conceptual framework:

- Consider also industry in the framework.

Regarding modelling and monitoring:

- Filling missing data with modelling data: preferably use comparable set of samples analyzed with the best tests available.
- Search for more comprehensive emission source inventory and tracking.

Regarding tool development:

- Deal with individual chemicals, or strategy for cluster into groups of chemicals.
- Prioritization of mixtures in water bodies should include considerations of the production and use patterns of chemicals.
- Decrease the large number of tools in analysis: select appropriate tools, define for which purposes the tools will be used.
- Separate tools which are ready to be used from the ones being under research.
- Clarify as much as possible, which EBMs are fit for diagnoses / investigative purposes and which ones for regular monitoring.
- Too many bioassays can lead to burdens so a focus on screening EBM for regulatory purposes is wished, but for investigative monitoring larger biotest batteries can be proposed.
- A full validation for all tests and bioassays for the specific purpose of surface water monitoring, which comprises the necessary enrichment step and clear statements as to sensitivity, false positive results and uncertainties, is needed.

Regarding abatement options:

- Clarify the responsibility for proof of risk and for the setting of different abatement options, with possible points for intervention from avoiding release of chemicals to technical options at WWTP; therefore need of defining the targets of abatement.

- It should be clear from SOLUTIONS deliverables that increasing the level of treatment in WWTPs is just one possibility among others and that all possibilities should be considered to identify the most suitable one taking into account that pollution should be reduced preferably at the source.
- Take into account the fate of contaminants in water work plants.

Regarding efforts and costs to apply SOLUTIONS outcomes:

- Cost and benefits: it is crucial to address the cost / efficiency ratio of SOLUTIONS tools; provide decision-makers and regulators with calculations on costs of the proposed strategies including bioassays i.e. the cost-benefit analysis associated with the identification of the risk, and with the identification of chemicals causing this risk and their sources; demonstrate the reduction of costs when using bioassays vs. chemical analytical techniques.
- Clarify efforts (cost, man-power etc.) and minimal requirements for the use of proposed tools, models, abatement options etc. at lower scales and to regional practitioners

Regarding Scenarios for upcoming risks/chemicals of the future:

- Keep a strong focus on unknown chemicals.
- Consider: current impacts of concern e.g. nanomaterials, microplastics; pharmaceuticals, also veterinary medicinal products; new processes on sludge recycling.
- Consider: ageing issues e.g. increase of personal care products; activities of SusChem and EC-DG for Health and Consumers especially ageing issues.
- Authorities applying monitoring program of WFD have difficulties at the time of identifying chemical sources, therefore needing information on what kind of human activities are producing compounds of emerging concern.

Regarding evaluation of policy and regulations:

- Watch unknown aspects to connect WFD with other regulations.
- Include: Common Agricultural Policy CAP; regulations on pharmaceuticals and cosmetics.
- Consider the Strategic Approach to International Chemicals Management (SAICM by the United Nations Environment Programme) as global policy framework to foster sound management of chemicals.

Regarding formats providing SOLUTIONS results for endusers (platforms, guidance):

- Confidential data: use the experience of Swedish Chemical Agency with the SPIN Database, how to deal with confidential data; avoid confidentiality conflicts e.g. by avoiding geo-coordinates.
- Decision support tool for River Basin specific Toxicants RiBaTox: clear definition of user groups; clear guidance for users and direct way to answers for users questions.
- Use of common nomenclature.
- Guidance documents: Involve stakeholders in guidance drafting from the very beginning; identify highly ranked questions to be addressed, especially from Member States participating in CIS process.

Regarding SOLUTIONS communication strategy:

- Provide a vision on products and outcomes of SOLUTIONS and also benchmarking recommendations.
- Inclusion of Member States: perform information activities on recommendations regarding improvement of EU chemicals legislation at the level of Member; involve in the discussion on

SOLUTIONS concepts and ideas towards WFD national water authorities and water boards; consider targeting the communication of SOLUTIONS outcomes to higher levels of water-decision making e.g. EU Member States ministerial level.

- Target groups and channels: identify appropriate receivers e.g. OECD water quality program, EC water blueprint initiative etc.; share the scientific experience regarding strategies and tools with water professionals e.g. EUREAU; make use of existing European level institutional platforms e.g. WISE (Water Data Centre, JRC-modelling etc.), IPChem.
- Policy briefs: emphasize the limitations of the current system and propose working tools which could solve the problems identified; present respective advantages and drawbacks of current system and proposed solutions, including possibilities for large-scale routine implementation in the short term (2-3 years); provide a brief comparative presentation of advantages and drawbacks of the most relevant approaches, supporting final recommendations; recommendations should take into account feasibility and cost; provide documents based on scientific evidence that can easily be interpreted by policy makers and address not just 'what to do' but also 'how to do it'; need for a brief on Europe wide simulations, considering lessons learned from SOLUTIONS case study simulations.
- General tasks in communicating science: regulators need to be supported by scientifictechnological approaches delivering facts at the time of taking environmental action; the accessibility of facts must not be restricted to an elite; scientists must communicate with the general public in a common language easy to understand.

4.4.3.3 Stakeholder inclusion in drafting main documents

The intensity of interactions between SOLUTIONS and its stakeholders are also highlighted by several cases of early stakeholder inclusion in the drafting of main documents.

- Draft paper 'Potential synergies between distinctive regulatory frameworks' (Resulting in a report on chemical policies and regulations),
- Draft paper "Towards the review of the European Union Water Framework management of chemical contamination in European surface water resources", together with NORMAN, released in Science of the Total Environment 576, 2017,
- Draft paper 'Guidance Document for Tools'. (Final Version represents SOLUTIONS Deliverable 9.1).

These draft papers were shared with the external Board members und received detailed commenting.

4.4.3.4 Stakeholders requests regarding further research needs

With respect to further research needs, SOLUTIONS stakeholders at 9th meeting of Stakeholder Board in (Wageningen, Sept 13th, 2017) pointed to a number of issues:

- Integrate chemical release patterns and the use of materials in society into modeling e.g. construction materials which need to be non-toxic,
- ➢ Microplastics,
- > ECHA evaluation procedures for chemicals accumulation in biota,
- Metabolites studies in relation to agricultural practices,
- Include ecosystem services and expertise of water managers in taking measures against chemical pollution,
- > Consider also to provide economic and cost perspectives along with scientific perspectives

especially in relation to human health issues,

- Consider to expand the current practice in some Member States having effluent charges on the discharge of organic matter and nutrients by inclusion of parameter(s) responding to the discharge of chemicals. This could provide incentives for, e.g., the water utility sector and chemical industry sector to reduce the discharge of e.g. genotoxic and endocrine disrupting substances in particular if economic revenues would be returned to the sectors for research and abatement measures,
- Focus technological studies not only for central and northern European scenarios but also for southern and eastern European ones, since problems regarding WWT are more urging in mediterranean and eastern countries, especially in the scarce or near null natural discharge scenarios.

4.4.4. Assessment of SOLUTIONS Stakeholder Board

To gain a congenial assessment of the Boards work by its members, questionnaires were mailed in February and March 2018. The survey addressed:

- ▶ 12 external members (return flow 10),
- ➤ 3 double role members (return flow 2),
- > 11 members representing SOLUTIONS (return flow 9).

The questionnaires included identical questions for all members and specific questions for the different member groups, considering the different areas of interests with respect to the Boards work. Main results are displayed in the following.

4.4.4.1 Appraisal of SOLUTIONS Stakeholder Board

Question: Looking back to SOLUTIONS Stakeholder Board, how do you appraise the Board's work?

	SOLUTIONS (9)	Double role (2)	External (10)
Presented contents			7,9 (6-9)
Frankness of discussions			8,6 (7-10)
Responsiveness to questions and contributions by stakeholders			8,1 (6-9)
Contact intensity with (external) stakeholders	6,4 (5-9)	6 (5-7)	
Overall value for SOLUTIONS tasks	6,5 (5-10)	8 (7-9)	
Value of (external) stakeholders contributions for adjustments of SOLUTIONS scientific work	5,4 (3-8)	6 (3-9)	
Documentation of Stakeholder Board (via stakeholder online forum)	5,6 (2-8)	6	7,9 (6-10)
Organization and facilitation of meetings	8,5 (8-9)	9,5 (9-10)	8,7 (7-10)

Table shows average rankings and range of rankings for each item and each member group (Scale: 1 = insignificant, 10 = excellent).

External stakeholders also ranked further interaction formats for stakeholders they had taken part in. Answers highlighted especially the value of taking part in general assemblies and main conferences of SOLUTIONS as a stakeholder – these events received an average ranking of 8,9 (8-10). *Overall*, external stakeholders expressed very high satisfaction about SOLUTIONS stakeholder interaction, mounting in final comments like: "Very constructive interactions", "Very well organized and conducted workshops", "A very worthwhile experience", "Very good working attitude", "Very interesting and useful meetings".

SOLUTIONS representatives and double role members also assessed the ratio between efforts and outcomes of SOLUTIONS stakeholder interactions. This assessment was done by choosing between four categories and showed a clearly positive outcome:

unsatisfactory = 0 $tolerable = 0$ $adequate = 0$	$6 \qquad well invested = 5$
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Also, the ranking of direct stakeholder interaction by the Work Packages was high, see section 5.

4.4.4.2 Appraisal of SOLUTIONS achievements

	SOLUTIONS (9)	Double role (2)	External (10)
Scientific results	7,5 (7-10)	9 (8-10)	8,8 (7-10)
Applicability in practice	6,5 (5-9)	8,5 (7-10)	7,7 (7-9)
Usefulness for water and environmental policy	7,0 (7-9)	8,5 (7-10)	7,8 (6-9)

Question: What is your ranking of SOLUTIONS achievements?

Table shows average rankings and range of rankings for each item and each member group (Scale: 1 = insignificant, 10 = excellent).

The answers demonstrate a high satisfaction of SOLUTIONS stakeholders, contrasted by a clearly positive but more cautious assessment of achievements by SOLUTIONS scientists.

Question: What, in your opinion, is SOLUTIONS biggest achievement?

This question leads to the call of numerous aspects cumulating into three main achievements:

- *Model integration* of knowledge and disciplines Europe-wide and internationally. Bridging chemical and ecological assessment. Integrating hydrological modeling and emission data. Consistent and holistic approaches e.g. harmonised methodology for identification of RBSPs.
- *Innovative tools and approaches*. In particular effect based tools for complementary monitoring, prioritization on hazardous substances monitoring, comprehensive modelling tools.
- *Interfacing science, stakeholders and policy*. E.g. bringing the concept of effect-based screening into regulation. Multi-authored reference documents.

Remarkably, nominations by SOLUTIONS representatives and by stakeholders were closely spaced, thus pointing to the comprehensive discussion and consistent perception of the project.

4.4.4.3 External memorandum by North American stakeholders

Finally, SOLUTIONS novel achievements and the high degree of stakeholder engagement were highlighted in the External Stakeholder Board Memorandum authored by representatives of the North American national regulatory authorities Environment and Climate Change Canada and U.S. Environmental Protection Agency. For details see the Memorandum in Appendix I.

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4.4.5. Stakeholder interactions by Work Packages and Sub Projects

On the working level, Work Packages and Sub Projects of SOLUTIONS performed specific stakeholder formats, directly related to their scientific tasks. For detailed information see specific reports.

- ➤ Work Package 1 Conceptual framework and integration of concepts and solutions
 - Online discussion on draft paper 'Potential synergies between distinctive regulatory frameworks'
 - Several informal meetings for discussion of interim results regarding WP1 research on policies and tools, in 2016-2018.
 - Presentations and discussions of potential applications and of future harmonisation of chemicals legislations, with representatives of the Swedish National Agencies for Environment, for Water, for Chemicals of the Swedish Ministry of Environment, in 2017, 2018.
 - Presentation and discussion of potential contributions to global science-policy dialogue, with representatives of SAICM secretariat, in 2017.
- Work Package 2 Advanced methodology for the prioritisation of contaminants
 3 Workshops on prioritisation methodologies in 2014, 2017, 2018
- Work Package 4 RiBaTox Web-based Decision Support System
 - 11 Work package meetings with stakeholder interaction at General Assemblies
 - 3 RiBaTox-surveys
 - Workshop with water managers, co-hosted together with SB-member Veolia, June 2018
 - Work Package 6 Trends and scenarios, Think tank 'Pollution of tomorrow and options to act'
 - o 3 Workshops on future pollutants in 2015, 2016, 2017
 - Advice and comments from SE regarding the use of patent database and the use of the SPIN database
- ➢ Work Package 14 − Integrated Models
 - Presentations and discussions with various Dutch stakeholders in 2015, 2016
 - Participation in meeting of EU WG Chemicals December 2016, related to Data Request from research project SOLUTIONS
 - Participation in ICPDR EG Pressures and Measures (April 2016, October 2017, planned for April 2018)
- ➢ Work Package 19 − Danube River Basin case study
 - 9 regional events with local, regional and state officials, NGOs, research institutions and the public. The events demonstrated the scientific work and provided the public with direct contact to scientists. At locations in Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Ukraine and Romania. Each event included a press conference.
 - Specific website www.danubesurvey.org and numerous leaflets and fact sheets in different languages with information about the JDS3 survey
- Sub Project 2 Tools
 - o Online discussion on draft paper 'Guidance Document for Tools'

Average ranking of the value by those formats for the work packages was high: 7,7 on the scale: 1 =insignificant, 10 = excellent.

4.4.6. Learnings for future projects from SOLUTIONS Stakeholder Board

4.4.6.1 Recommendations by SOLUTIONS Board members

All three member groups gave concrete suggestions how to further improve stakeholder interactions by future scientific projects. Suggestions were closely spaced. In the following they are compiled according to main issues.

Easy accessible and timely information overviewing the project

Annual overviews of the project's overall progress (avoid: the blind people and the elephant phenomena). Greater level of summarization of the project and sub-project progress. Provide relevant background papers in advance, helps stakeholders to contribute well. Website should make it easy to find new content.

More focusing on topics and more specific formats

Prioritization of topics. Select specific topic for discussion. Specific Board meetings on specific topics, also allows to involve stakeholder experts on specific topics.

Separate forum of stakeholders and water managers to provide additional case studies. Specific formats to create Science to Policy interface. Knowledge transfer and capacity building to turn results and tools into practice.

More time for direct interaction

Longer time devoted to the Board meetings given the time and money allocated for the members to be present. More time for the Board meetings. More time for discussions. More dedicated time for discussions per topic. Expanded occasions to come together in a casual atmosphere for intensive contacts. Regular phone resp. web-meetings e.g. twice a year.

Closer and more inclusion of stakeholders

A pre-project phase with stakeholders during formulation of objectives. More efforts in involving NGOs and industry. More room for adjusting the planned work based on suggestions from stakeholders. The role of stakeholders in especially deliverables with a demonstrative character could be made explicit. A final report by the Stakeholder Board.

4.4.6.2 Recommendations by the facilitator (partner HAM)

For good reasons, SOLUTIONS stakeholder interactions have received very positive ranking by involved stakeholders and high ranking by involved scientists. Especially looking at the continuous participation and at the numerous competent notions and recommendations by external stakeholders, the result of the stakeholder interaction in SOLUTIONS is impressive.

However, from the view of professional facilitation, the improvement of some basic procedures is suggested to allow future projects even better use of the potential of stakeholder interactions.

Representation of 'the whole system', early analysis of stakes

Especially with respect to projects of importance for European politics, the range of circumstances and interests of Member States needs appropriate representation in stakeholder interactions. In the case of SOLUTIONS Stakeholder Board, continuous direct representation during the run-time has taken place by bilateral authorities of 4 Member States and 1 country, all from Western Europe. For future projects a more multisided representation is recommended. To come closer to representing 'the whole system', it is necessary to overview potentially important stakes - at an early stage and always with respect to the specific scope and goals of a project. This should be done by neutral analysis, operated in

the first months of a project and will provide a sophisticated basis to decide on issues and stakes which need to be represented and on the appropriate selection of representatives. As well for the representation of main societal stakeholders with considerable influence on the latter implementation of results like affected branches and civil society groups, the initial analysis should clarify interfacing issues and interests. This procedure needs additional efforts and costs, but helps to achieve best possible stakeholder input and well-timed support for the subsequent implementation of results.

Consistent use of online information and interaction; shared rules, intuitive work flow

Complex transdisciplinary and transnational projects with a potentially high societal impact need the best use of online information and interaction to reach comprehensive understanding and consistent communication between scientists and societal players. However, experience not only from the SOLUTIONS project shows that online work spaces still mostly are used by individual choice and by chance, resulting in little initiatives and insufficient sharing.

To overcome this barrier, interactive online information and communication – between scientists and between scientists and stakeholders – (1) should be defined as mandatory basic standard, (2) shared criteria for causes and extent of online information and interaction should be developed when establishing the organizational and communicative setting of a project, (3) online workspaces need a high quality intuitive design and must provide satisfying work flows for their users.

Adequate planning and budgeting with respect to stakeholder interactions

If scientists are requested to undertake sophisticated stakeholder interactions, this needs to be defined as a regular work task and accounted for in their time tables and budgets. Otherwise meaningful and effective interactions are hard to reach, since scientists will not be able to provide adequate time to inform and to communicate with stakeholders and to use the results of interaction by including insights in the scientific process. Particularly, planning and budgeting of the project coordination must consider stakeholder interaction a task which has to be worked on continuously by the leading persons.

To gain a reliable basis for planning stakeholder interactions of a project, an overall concept including tasks, participants, issues, formats, online support, time schedule and extent of stakeholder interaction is needed. Stakeholder interaction experts therefore must be included in an early stage of preparing application for a project.

The extension of time budgets to allow sophisticated stakeholder interaction by scientists certainly leads to additional efforts and costs. But it represents a necessary condition to make best use not only of stakeholders single competences but especially of stakeholders and scientists transdisciplinary and cross-sector insights. To reach this, a dedicated process in addition and in parallel to the time schedule for scientific work is needed.



4.5 Specific support of stakeholders in the River Danube riparian states

The SOLUTIONS approach supported the review of the list of Danube RBSPs. The project provided a substantial contribution to the third Joint Danube Survey (JDS3) organized by the ICPDR, by analysing the samples for a wide range of hazardous substances and preparing the respective chapters for the JDS3 report. Analysing this large amount of organic substances during JDS3 enabled SOLUTIONS experts to provide first suggestions for the update of the Danube river basin-wide list of specific pollutants, which were included into the Danube River Basin Management Plan – Update 2015. This was a significant contribution by SOLUTIONS to the implementation of the EU Water Framework Directive in the Danube River Basin District.



Figure.3: The SOLUTIONS Sub-project Case Studies leader Jaroslav Slobodnik giving presentation at the JDS3 Press conference in Slovakia in August 2013

The SOLUTIONS Sub-project Case Studies leader Jaroslav Slobodnik acted as the Technical Coordinator of JDS3 and in this capacity during all JDS3 public events in 2013 (Regensburg: 14 August, Vienna: 20 August, Gabcikovo: 22 August, Budapest: 27 August, Vukovar: 01 September, Belgrade: 05 September, Ruse: 17 September, Vilkovo: 23 September, Tulcea: 26 September, Figures 3 and 4) he managed to introduce the activities and objectives of the SOLUTIONS project to the various Danube stakeholders.

Jaroslav Slobodnik through his regular participation at the meetings of the ICPDR Monitoring and Assessment Expert Group provided the Danube stakeholders with a continuous update on the progress of the SOLUTIONS activities and, in particular, on the development and identification of the Danube River Basin Specific Pollutants. He was also collecting feedback from the Danube stakeholders on the progress of the project and on the appropriateness of the project deliverables.

He participated at:

- 19th meeting of the ICPDR Monitoring and Assessment Expert Group, 03-04 April 2014, Koblenz, Germany;
- 20th meeting of the ICPDR Monitoring and Assessment Expert Group, 07-08 October 2014, Zagreb, Croatia;
- 21st meeting of the ICPDR Monitoring and Assessment Expert Group, 05-06 March 2015, Prague, Czech Republic;
- 22nd meeting of the ICPDR Monitoring and Assessment Expert Group, 06-07 October 2015, Bratislava, Slovakia;
- 23rd meeting of the ICPDR Monitoring and Assessment Expert Group, 19-20 April 2016, Ingolstadt, Germany;
- 24th meeting of the ICPDR Monitoring and Assessment Expert Group, 12-13 October 2016, Chisinau, Moldova;
- 25th meeting of the ICPDR Monitoring and Assessment Expert Group, 29-30 March 2017, Belgrade, Serbia;
- 26th meeting of the ICPDR Monitoring and Assessment Expert Group, 05-06 October, Vienna 2017, Austria;
- 27th meeting of the ICPDR Monitoring and Assessment Expert Group, 12-13 April 2018, Sarajevo, Bosnia and Herzegovina;
- 28th meeting of the ICPDR Monitoring and Assessment Expert Group, 17-18 October 2018, Ljubljana, Slovenia.

The draft list of the Danube River Basin Specific Pollutants that have been identified by the SOLUTIONS experts is being used by the ICPDR for the preparation and planning of the fourth Joint Danube Survey, which will be organised in 2019.



Figure.4: The SOLUTIONS Sub-project Case Studies leader Jaroslav Slobodnik presenting SOLUTIONS results at the 26th meeting of the ICPDR Monitoring and Assessment Expert Group, 05-06 October, Vienna 2017, Austria



Within the project implementation, SOLUTIONS consortium offered the ICPDR the possibility to analyse samples from wastewater treatment plants (WWTPs) in the Danube Basin for a wide range of organic emerging chemicals in a highly advanced laboratory. The ICPDR was strengthening its efforts for pollution control of hazardous substances and was highly interested to deepen the knowledge on sources and pathways of hazardous substances in the Danube Basin as a basis for efficient management strategies. Therefore, the ICDPR supported the WWTP sampling initiative of SOLUTIONS to get more source related information on hazardous substances. A basin-wide study organized by the ICPDR and implemented by UFZ and EI was designed and carried out in autumn of 2017. It was focused on WWTP effluents as one of the most important inputs of chemical pollutants. Composite seven-days samples and spot large volume solid-phase extraction (LVSPE) samples from 12 WWTPs in nine countries in the Danube River Basin were collected and analysed.

A state-of-the-art target and non-target screening methodology developed in SOLUTIONS SP Tools was applied. The composite samples were subjected to non-target screening by LC-HR-MS and GC-MS (EI, PCI, NCI), suspect screening of ca. 40,000 substances from the NORMAN Suspect Exchange List (http://www.normandata.eu/normansusdat/) and target screening of more than 2,100 substances. First results of specific target screening of ca. 650 antibiotics, drugs of abuse and 14 antibiotic resistance genes are available at http://www.norman-data.eu/EWW_DANUBE.

Based on these results a proposal has been made for a response plan of actions for operators of WWTPs in the Danube Basin.

The results of the SOLUTIONS project in the field of identifying the Danube RBSPs can be considered not only as a support to fulfilling requirements of the provisions of the WFD but also as an excellent tangible example of a science-to-policy interface driven by the European Commission. Appreciating the significant inputs by SOLUTIONS into the river basin management activities in the Danube River Basin, the ICPDR at its 20th Ordinary Meeting in December 2017 adopted the following resolution:

The ICPDR appreciates the substantial support the SOLUTIONS project continuously provides to the ICPDR, in particular with the development of the list of Danube River Basin Specific Pollutants during and after the JDS3 and welcomes the ongoing cooperation on the preparation of the JDS4;

and, at its 16th Standing Working Group Meeting in June 2018 the ICPDR adopted the following resolution:

The ICPDR expresses gratitude for the significant support and concrete contribution the SOLUTIONS project provided to ICPDR in numerous scientifically challenging tasks, necessary for the development and update of the Danube River Basin Management Plan.

4.6 Attractive website and user-friendly products accessible via this website

The SOLUTIONS website <u>https://www.solutions-project.eu/</u> has been designed as a major entrance portal to the project, its results and the partners involved for the scientific community, for stakeholders and the general public. The website has been designed in a highly attractive and well-structured way in close collaboration of the SME KOCMOC with the UFZ coordination team. Already on the front page, an array of background information is available together with recent videos that explain the outcome and informing on the final conference. Via self-explanatory links with few klicks the visitor can gain extensive information on the project, the consortium, results and products and important collaborations (Figure 5).



Figure 5: Screenshot of start page of SOLUTIONS website

Under "Results & Products" (Figure 6) the outcomes of the project are available in the format of easily understandable short texts on results, summaries of the major products with direct links to the respective models and databases, the full set of publications, and the deliverables.

Deliverable Report





PRODUCTS	~
PUBLICATIONS	~
DELIVERABLES	~

Figure 6: Screenshot "Results and Products"



Figure 7: Screenshot of RiBaTox Guide

Major products such as RiBaTox (D4.1, Figure 7) and the Knowledge Base (D5.1) are directly interlinked and accessible via the website. Both tools can be regarded in themselves as key tools for dissemination. RiBaTox guides users through systematic decision trees in a self-explanatory way along the questions of the users towards the concepts, tools and other information developed and compiled by SOLUTIONS and intended to address specific problems with targeted solutions.

The knowledge base (Figure 8) provides access and allows easy search of data on environmental monitoring, toxicity and compound property data for a large set of chemicals. It also captures the results of prioritization exercises. The website furthermore provides direct links, pointing to six major partner projects, important networks such as NORMAN and EIONET, as well as other related and helpful websites.



Figure 8: Screenshot of SOLUTIONS knowledge base

4.7 Dissemination of results to stakeholders, scientific community and the broad public

Strong efforts have been undertaken and have been very successful in creating visibility and awareness of SOLUTIONS and its results in the scientific community, among decision makers and practitioners in the field of water and chemical monitoring and management as well as in the general public using targeted dissemination tools for each group.

4.7.1 Scientific publications

The scientific community was addressed with more than 100 highly ranked publications in peer-reviewed scientific journals that have been published so far. Additionally about 50 more manuscripts have been submitted or are in a preparation stage. Of particular importance were a series of integrated papers with a specific focus on policy-related issues such as the recommendations for the revision of the WFD [1, 2] and more specifically on the implementation of effect-based tools [3, 4]. These integrated publications are presented and discussed in detail in D1.2.

4.7.2 Contributions to scientific conferences

SOLUTIONS results have been presented in more than 60 oral presentations and numerous posters in different conferences on ecotoxicology and environmental chemistry, water research and management. There was a very high international awareness on and interest in SOLUTIONS findings, resulting in a number of invited keynotes on SOLUTIONS worldwide that shall be particularly highlighted here. Invited keynotes have been given on the International Conference on Emerging Contaminants in Kaohsiung (Taiwan, 2015), on the International Symposium on Chemical Risk Prediction and Management in Wuxi (China, 2016), on the Symposium on Environmental Chemistry in Niigata (Japan, 2016), on the Conference on Innovation in Environmental Monitoring in York (Great Britain, 2016) and on ISTA Conference in Limeiras (Brasil, 2017). A particular focus was given on the interaction with the FP7 projects on multiple stress MARS and GlobAqua with SOLUTIONS keynotes on their final conferences and several of their symposia. By discussing SOLUTIONS findings on all Annual General Assemblies of the European network NORMAN during the run-time of the project, we used this outstanding science-policy interface for dissemination and discussing SOLUTIONS results with scientists and stakeholders. The close interaction with NORMAN is also reflected by common workshops (e.g., the first workshop on prioritization of chemicals in Paris, 2015) as well as the common recommendation paper on WFD revision [1].

4.7.3 Organization of scientific conferences

In SOLUTIONS, the organization of conferences, workshops and special sessions on regular scientific conferences has been used as an important tool for dissemination. In many cases, these activities involved not only the scientific community but also had a strong focus on stakeholder involvement. Some outstanding examples include (1) the combined SOLUTIONS – EDA Emerge – MARS – GlobAqua – NORMAN – MOTREM student conference in 2015 that also demonstrates the close interaction with other projects, (2) three excellent workshops on prioritization of chemicals, which received a lot of attention from stakeholders from most relevant institutions including one joint workshop with the Swedish project FRAM (Figure 9), (3) a Special Session on the SOLUTIONS project at SETAC Europe 2018 with 18 presentations only in this session and many more distributed over other sessions, (4) the SOLUTIONS Final Conference in 2018 in Leipzig, (5) the SETAC-UNEP-LCI Workshop on environmental footprinting, and (6) the Conference Water Science for Impact in Wageningen. Several workshops were dedicated exclusively to specific stakeholder groups such as officers from DGs Research, Environment and Agriculture of the European Commission in 2017 in Brussels and the RiBaTox Workshop in Brussels. In addition, SOLUTIONS has been represented in all relevant scientific

conferences in the field.

Joint FRAM & SOLUTIONS workshop 2017



2nd SOLUTIONS Workshop on Prioritization Methodologies jointly held with the FRAM Center 9 – 10 February 2017 at the Wallenberg Conference Center, University of Gothenburg, Sweden

The workshop aimed to explore options for integrating assessments of mixture toxicity and cumulative risks of chemicals in the aquatic environment into prioritization procedures under the EU Water Framework Directive (WFD).

Documents



Figure 9: Video from the Joint FRAM and SOLUTIONS Workshop on prioritisation

The presentation and discussion of the final results from SOLUTIONS was done in a targeted way using particularly two complementary events. The first event was the SETAC Europe Conference 2018 in Rome, where a Special Session with 18 scientific presentations has been organized to target the scientific community. In contrast, the SOLUTIONS Final Conference (Figure 10) had a particular focus on the discussion of SOLUTIONS results with stakeholders from the SOLUTIONS Stakeholder Board but also far beyond. The Final Conference was attended by more than 100 scientists and stakeholders from European and national agencies, international river associations, industry and NGOs but also from the partner projects MARS and GlobAqua. In about 30 presentations in seven sessions SOLUTIONS PIs and stakeholders presented their views on achievements and requirements. Outstanding young researchers from SOLUTIONS had the opportunity to present their results to the broad audience and a podium discussion on requirements on European research on water quality and chemicals has been organized involving stakeholders from regulation, industry and NGOs as well as scientists from SOLUTIONS. An attractive notebook (Figure 11) with valuable information from the SOLUTIONS project has been provided to all participants of the conference.

Deliverable Report





Figure 10: SOLUTIONS Final Conference



Figure 11: SOLUTIONS notebook

4.7.4 Direct support for the WFD-CIS process

SOLUTIONS concepts and results have been presented at two WG Chemicals meetings in Brussels invited by DG ENV. Since SOLUTIONS demonstrated the added value of effect-based methods for monitoring as a key tool for addressing complex mixtures and providing extensive guidance for their implementation, the project was invited to join the WG on effect-based methods under the WG Chemicals of WFD CIS as permanent members. SOLUTIONS scientists attended all meetings of this group and presented and discussed the SOLUTIONS concept at EBM Task-WFD workshops (Figure 12).



A specific Workshop on the outcome of SOLUTIONS was organized at the Office of the Helmholtz Association in Brussels, organized especially for participation of officers of the European Commission involving DG ENV, DG RTD, DG AGRI and Water JPI. Lively discussions particularly regarding the conclusions for the implementation and review of the WFD took place. Also, based on SOLUTIONS findings, the opportunity was taken to discuss knowledge gaps and research needs.

Further highlights included a workshop on the development of mitigation and abatement options for a Dutch SOLUTIONS stakeholder group, the presentation of major SOLUTIONS findings on the EUREAU Workshop on micropollutants in Stockholm (Sweden) and at the Conference on pharmaceuticals and micropollutants in surface waters by the Ministry for the Environment in North Rhine-Westphalia (Düsseldorf, Germany), both in 2018.

4.7.5 Policy briefs

A series of 10 policy briefs (Table 2) are in preparation and will inform decisions of policy makers on the European, national and regional level about key findings and recommendations from SOLUTIONS. They are distributed individually, and as a brochure as well as a publication series in the scientific journal Environmental Sciences Europe. The first policy brief on effect-based methods has been finalized, distributed and submitted for publication. It is available as Annex II of this deliverable.

All policy briefs share the same structure. With a maximum of eight pages they provide brief and clear recommendations to policy and decision makers, water managers and authorities and agencies dealing

with the implementation of the WFD. On the front page, the reader gets the overall recommendation as a title of the Policy Brief together with a characteristic picture and the key points of the brief. Within the next two pages the challenge that shall be addressed and the detailed recommendations are given. This is followed by a short chapter on requirements that need to be fulfilled in order to follow the recommendation. Subsequently, interested readers are informed in more detail on the achievements of SOLUTIONS that help to follow the recommendations. This information together with a list of relevant references is supplemented with a relevant contact person.

The list of policy briefs in preparation with preliminary titles is given in Table 2.

Policy brief	Status
Diagnosis and management of chemical pollution. Tools, services and management	in press
options	
Address mixtures of contaminants	in prep
Advance assessment and prioritization of emerging contaminants and mixtures	in prep
Effect-based methods are key. SOLUTIONS recommends to integrate effect-base	disseminated
methods to diagnose and monitor water quality	and submitted
	for
	publication
Improve and harmonize monitoring to link ecological and chemical quality	in prep
Use models to fill data gaps and provide diagnostic capacity for chemicals of emerging	in prep
concern	
Use solution-oriented assessments to achieve a non-toxic environment	in prep
Increase coherence of cross-compliance of chemicals and water regulations	in prep
Support strong integrated European research on water quality and chemicals to	in prep
safeguard welfare and sustainable development in Europe	

4.7.6 Dissemination of SOLUTIONS to the general public

The general public has been addressed using different media. Five TV clips have been broadcasted in German, Slovakian and Serbia television. Seven videos were disseminated via the worldwide web. A particular highlight was the Video on the Joint Danube Survey 3 as the first large sampling campaign of SOLUTIONS (<u>https://www.youtube.com/watch?time_continue=25&v=-Zk3GlFYfRw</u>, Figure 13) that has been also used as the basis for a German TV broadcast.

Several articles have published in the popular press of different partner countries based on media briefings and press releases. In addition, discussion with the local public has been organized in different formats such as the "Leipziger Umweltstammtisch" in 2016.



Figure 13: Video on JDS3 and SOLUTIONS accessible via the SOLUTIONS website



Figure 14: Screenshot of the Freshwater Blog

A series of 12 freshwater blogs highlighting important news from the project (Figure 14) have been published in collaboration with the sister project MARS. These blogs addressed workshop outcomes, cutting edge scientific results, novel technologies or the publication of scientific papers of particular relevance.



4.8 Increased market opportunities for innovative SMEs

SOLUTIONS involved nine innovative SMEs and one big enterprise and was very successful in developing novel market opportunities for their innovative approaches and tools. The SME EI played a key role in SOLUTIONS acting as head of the SP cases and as organizer of the JDS3 monitoring campaign. EI could demonstrate their excellent skills in scientific and logistic organization and evaluation of large sampling campaigns and related databases to the full range of Danube countries and was nominated also for the follow up survey JDS4, which will take place in 2019. The SME MAXX developed several versions of a large-volume solid phase extraction (LVSPE) device for in situ application that have been shown at three trade fairs. This device has been applied in different case studies (rivers Danube and Rhine) as well as in additional field studies. It demonstrated to be a very robust fit-for-purpose device for collecting extracts of sufficient quantity and with sufficient quality (free of toxicity blanks, excellent recovery of chemicals and effects) avoiding logistic challenges of transporting large volumes of water to the lab. The device is now available in different versions for 100 or 1000 L water enrichment, for event-based sampling, sampling with high temporal resolution and as a very mobile backpack version. The new devices have been demonstrated among others for European scale WWTP effluent sampling and sampling campaigns in China and Kenya. Recently, MAXX served a 500.000 Euro order by the German European Agency on 60 event-based LVSPE sampling devices that have been installed all over Germany to monitor small streams. The device will be also used in JDS4 and there is a good chance that this instrument will develop towards a standard sampling procedure for integrated effect-based and chemical monitoring in Europe and beyond. The SME Dynex developed in SOLUTIONS a High Performance Counter Current Chromatography (HPCCC) processor as a high performance separation device for the enrichment of organic micro-pollutants from river water and for analytical purposes. These developments led to a new patent while the new device will be offered as an innovative, commercially available processor. The SME WatchFrog developed and applied highly innovative in vivo effect-based methods and faces a great enhancement of market opportunities for the measurement of biological activities particularly for industrial chemicals and safeguarding of water supplies. They presented their tools at multiple conferences and trade shows opening new markets for the tools developed and successfully demonstrated in SOLUTIONS. Also the SME Synchem synthesizing new chemical standards for environmental monitoring strongly enhanced their product portfolio with chemicals that were shown to be of environmental and toxicological relevance but that have not been commercially available so far. The SME KOCMOC designed the excellent SOLUTIONS website (interand intranet) and thus provided an outstanding example for presentation of an international large-scale scientific project to a diverse public audience and by structuring internal as well as stakeholder communication for the project consortium. This opens new market opportunities in the field of web-based science communication. In a similar way this holds also for the SME HAM that facilitated stakeholder communication in SOLUTIONS to a level yet unusual for large-scale scientific project.

5. Conclusions

A highly efficient strategy for internal and external communication and dissemination has been established and targeted to the scientific community, stakeholders and the general public. SOLUTIONS as a whole strongly benefited from the intensive and well organized stakeholder dialogue that helped to improve SOLUTIONS products with respect to their usefulness for the implementation of the WFD and for improving monitoring and impact assessment by practitioners in the field. Water managers and policy makers are directly addressed with recommendations and policy briefs.

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Appendix I

SOLUTIONS External Stakeholders Memorandum





Environnement et a Changement climatique Canada

SOLUTIONS External Stakeholder Board Memorandum

31 August 2018

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1. Context

The SOLUTIONS project is a European Commission-supported five-year Collaborative Project under the 7th Framework Programme for Research and Technological Development of the European Commission (Grant Agreement #603437) coordinated by Professor-Dr. Werner Brack of the Helmholtz Centre for Environmental Research – UFZ, in Leipzig, Germany. The main goal of SOLUTIONS is to address major gaps and provide innovative approaches to assess the large number of legacy, present and future chemicals posing a risk to European water resources for future monitoring and regulation. The project started formally in October 2013 and will conclude in September 2018. Investigators from 39 European, Chinese, Brazilian and Australian research institutes have been directly supported by the project in disciplines ranging from ecotoxicology to hydrology to database management. The Stakeholder Board consists of approximately 20 members from several sectors including research, regulatory and business who may benefit from the findings of the SOLUTIONS project.

This memorandum provides the entirely personal perspectives of the success and shortcomings of the project as of the date prescribed above by the authors who served as

1

external Stakeholders and represented the federal regulatory environmental agencies of the United States and Canada.

2. Evaluation

Successes

The SOLUTIONS project itself was comprised of several sub-projects: Concepts and Solutions, Tools and Case Studies. On an overall technical basis, the SOLUTIONS project achieved many advances and pushed the science of environmental monitoring forward significantly.

- Some of the noteworthy technological breakthroughs included:
 - Scaling-up of sample extraction through development of a portable, large volume, comprehensive solid phase extraction device; novel sharing of multiple extracts across research institutions
 - Miniaturization of effects-directed assay (EDA) with high throughput capability, with development of novel 'Virtual EDA'
- Collaborative achievements were impressive. The SOLUTIONS project was able to capitalize on a number of other initiatives, realizing significant cost and time savings. Perhaps the best example of this is the Joint Danube River survey, which was already planned by the partners and which SOLUTIONS was able to ultimately partner with, thus adding even greater value to the initiative for all partners. Another example is the collaboration with the GLOBAQUA project (also funded under the 7th Framework Programme) and the Spanish project SCARCE with the Iberian basins of the rivers Llobregat and Ebro, that are also affected by water scarcity conditions along with anthropogenic contaminants.
- One of the main outcomes of SOLUTIONS was to recommend consideration of real world environmental contaminant mixtures that goes above and beyond so-called priority pollutants to establish river basin specific pollutants (RBSPs). This is a wake-up call to regulators and policy makers who often regulate on the basis of single chemicals.

- Comprehensive linkages were established between different levels of biological organization using effect-based approaches that examined impacts on cells, individual organisms and *in situ* populations. It should be noted that such an advance could only be realized through a project with the resources and expertise such as SOLUTIONS. Many tools were developed using this approach and were then validated with the linkages established between levels of biological organization. Products such as trigger values, bioassay panel modules and, ultimately, combining such measures with complementary chemical measurements will link chemical and ecological status, enabling prioritization of mixture effects, diagnoses of modes of action, and solutions-oriented water management.
- As noted above, SOLUTIONS seamlessly collaborated with the other projects funded by the 7th Framework Programme including GLOBAQUA as well as the MARS project, providing everyone involved, including the Stakeholders, with a much broader context for the range of projects supported by the European Commission and how they integrated together.
- Finally, the degree of Stakeholder engagement in SOLUTIONS was admirable. At every annual general assembly and interim meeting, SOLUTIONS held Stakeholder Board meetings to maintain communications and build confidence in the project. This level of engagement was manifested in the final general assembly in Leipzig where so many Stakeholders provided narratives giving evidence of their need and use of the SOLUTIONS products and expertise.

Shortcomings

Compared to the *Successes* of SOLUTIONS, the shortcomings are minor and limited.

The vast majority of the anthropogenic contaminants focused upon by SOLUTIONS were
organic compounds. While there are tens of thousands of these chemicals produced each
year and our knowledge of their fate and effects in the environment is often very limited,
other stressors including metals and ammonia can be present in European waters.
SOLUTIONS often under-emphasized these other stressors in favor of the organic

compounds. In the future, greater consideration of these other stressors is probably prudent.

 The following shortcoming is less a constructive criticism and more of a reflection of the scale of the SOLUTIONS project. During the project, so much data was being generated that it was challenging to communicate. In retrospect, having more time for the Stakeholders, as well as other audience members, to be exposed to the new data via presentations and posters would have been valuable.

3. Concluding Statement

The ultimate success of the SOLUTIONS project will depend on regulatory and policy uptake by the European Water Framework Directive and respective member countries. Other indicators of success could entail policy adoptions by other Stakeholder countries, such as the US and Canada.

The authors of this memorandum are consulting with their respective regulatory colleagues to assess the level of interest in sponsoring a SOLUTIONS webinar(s) designed to allow the SOLUTIONS participants to describe their progress to North American regulators and scientists. This approach may provide the mechanism for Canada and the USA to begin the process of adopting some of SOLUTIONS findings.

Appendix II





POLICY BRIEF

Effect-based monitoring

SOLUTIONS recommends to integrate effect-based monitoring tools into chemical monitoring of water quality



Daphnia magna. Foto: Andre Künzelmann

KEY POINTS

- Present monitoring and assessment of the chemical status fails to characterize the likelihood that complex mixtures of chemicals affect water quality
- This likelihood can be established with Effect-based methods complemented by chemical screening, and helps steering to solution-oriented monitoring in prioritizing sites, chemicals and eventually management measures
- A coherent battery of in vivo and in vitro bioassays is recommended for WFD monitoring to cover the major modes of action in the 'chemical universe'
- The likelihood of impacts can be established with effect-based trigger values, which differentiate good from poor water quality in close alignment with chemical-based Environmental Quality Standards and mixture toxicity considerations.
- The use of EBMs is suggested in the WFD as one of the lines of evidence to establish the likelihood of impacts of chemical pollution in European water systems

CHALLENGE

In line with the EU strategy for a non-toxic environment, the OECD Council Recommendation on Water and the Sustainable Development Goals by UN protecting water resources from contamination with toxic substances is a major task of water monitoring and management. Water quality monitoring according to the European Water Framework Directive [1] is presently based on chemical analysis of 45 Priority Substances (PS) [2] to assess the chemical status together with different sets of River Basin Specific Pollutants (RBSP) defined nationally. It has been demonstrated that these substances reflect only a (site-specific and typically unknown) fraction of the overall chemical risk. Mixture risks are not considered. Thus, the current approach is insufficient to reduce the likelihood that chemical contamination does not pose harm to human health or aquatic ecosystems.

European surface waters contain ten to hundred thousands of chemicals including pesticides, biocides, pharmaceuticals, surfactants, personal care products and many more together with numerous transformation products. These chemical cocktails may pose a risk to ecosystems and raise concerns about human health if water resources are used for drinking water production, fishing and recreation. The focus on Priority Substances helps phasing those out, but replacement by other and more chemicals posing similar hazards is an unresolved matter. Chemical monitoring of Priority Substances will be increasingly less informative towards the likelihood of chemicals to pose harm, whilst the probability to overlook significant risks is high and increasing. A strategy that would focus on monitoring all chemical concentrations would practically fail, forwarding the logical solution of evaluating and using integrative methods to evaluate the likelihood of complex mixtures causing harm.

Thus, the challenge is to characterize chemical pollution in a comprehensive way with limited resources, such the impact likelihoods can be established, and risks to ecosystems and human health and protecting resources for safe drinking water production can be prevented and limited at limited treatment costs.

RECOMMENDATIONS

- Implement effect-based methods (EBM) techniques to support the Analysis of Impacts under WFD-Annex II to support water management with adequate information on the risks posed by the 'universe of chemicals' [3]. EBMs are bioanalytical methods using the response of whole organisms (in vivo) or cellular bioassays (in vitro) to detect and quantify groups of chemicals in affecting toxicological endpoints of concern. EBMs are helpful
 - to detect the effects of mixtures of compounds in water resources demonstrating the potential to affect aquatic organisms and human health,
 - to minimize the risk to overlook hazardous chemicals, transformation products and chemical mixtures,
 - to detect hot spots of contamination for investigative monitoring and the identification of risk drivers and for the prioritization of management measures and
 - o to link chemical and ecological status
- Use the guidance on available EBMs to integrate the EBMs into a solution-oriented water quality assessment and monitoring in support of derivation of River Basin Management Planning
- Use a battery of bioassays covering major toxicological endpoints. This requirement can be met with the present state of the art applying

- apical bioassays representing at least fish (96h fish embryo acute toxicity), invertebrates (48h daphnia immobilization) and algae (72h inhibition of population growth) considered as Biological Quality Elements (BQE) for pelagic communities in WFD
- together with MoA-specific *in vitro* assays addressing endocrine disruption, mutagenicity and dioxin-like effects.
- Apply sample enrichment before applying EBMs in order separate organic micropollutants from other matrix components and to increase sensitivity of EBMs in order to assure that robust data based on concentration-effect models are derived and to reach detection limits for hazardous chemicals equivalent to Environmental Quality Standards (EQS) of PS and RBSP.
- Adopt regulatory frameworks supporting EBM application in monitoring in a way that they not only address currently established effects but also tackling endpoints of emerging concern. This is necessary since it may be expected that opening monitoring for EBMs will trigger the development of new cost-efficient methods that will address MoAs that are not yet covered.
- Integrate EBMs with chemical analytical screening for linking measured effects with the chemicals driving these effects

REQUIREMENTS

Integrating EBMs into surveillance, operational and investigative monitoring and interpretation of the results that will be obtained for water quality management requires

- recognition that given current concerns on water quality and adverse trends and the WFDdefinition of 'pollution' to relate to *all* chemicals – it is required to employ methods that enable the evaluation of the hazards of the 'universe of chemicals' where needed
- recognition that EBMs are one of the operationalized methods to provide information along one of the Lines of Evidence mentioned in the WFD (Annex II) to evaluate the likelihood of harm of complex mixtures
- agreement on and the establishment of a coherent battery of bioassays so as to cover modes
 of actions of all chemical groups considered to potentially pose harm to ecosystems and human
 health. The experience and expertise in SOLUTIONS, the NORMAN network on emerging
 substances and other leading scientists in this field can be used in support.
- (further) standardization of EBM-test systems with a focus on robust, small-volume and high-throughput assays to facilitate practices
- Using of and agreement on effect-based trigger values to assist in outcome interpretation of EBMs for all EBMs in relation to the need to know the likelihood to pose harm
- acknowledging and expanding effective demonstration and evaluation in practice-oriented case studies

ACHIEVEMENTS

Compilation of a battery of bioassays

A wide range of EBTs has been applied successfully in monitoring to establish the likelihood of impacts, most of them in a scientific development context for establishing robust and meaningful EBM-tools.

Important progress resulted. First, a comprehensive analysis of about 1000 typical water contaminants identified 31 major MoA categories while for a minority (37%) of the compounds no information on MoAs was available [4]. Second, MoA-specific in vitro assays fit for purpose of environmental monitoring are available for receptor-mediated endocrine effects, genotoxicity and mutagenicity, activation of metabolism, adaptive stress responses, photosynthesis inhibition and for each cell line cytotoxic effects are also registered [5-7]. Thus, *in vitro* assays address well-described MoAs with known environmental relevance, although not all potentially relevant effects are covered with present test systems. Related to the potential of specific impacts on the WFD-Biological Quality Element, it is recommended to complement *in vitro* assays by apical bioassays representing at least fish (fish embryo testing), invertebrates (daphnia) and algae (cell multiplication inhibition), which are specifically considered as Biological Quality Elements (BQE) for pelagic communities in WFD. Of the MoA-specific *in vitro* assays priority of application should be given to endocrine disruption and mutagenicity. Dioxin-like effects should be analyzed particularly in sediments, biota and equilibrium passive samplers since typical drivers of these effects are very hydrophobic and accumulate in these matrices.



Figure 1: Recommended test battery in the context of chemical and ecological status monitoring

Standardization and utility of test systems

In SOLUTIONS and the NORMAN network we proposed a test battery of in vitro and in vivo bioassays and published standard operating procedures for the standardized experiments [7, 8].

Availability of robust enrichment tools

Solid-phase extraction (SPE) was found to be a suitable sample preparation method for environmental water samples in bioassays, with effect recovery by current SPE methods similar to recovery by chemical analysis [9]. A robust mobile large-volume SPE has been developed for the use in the field avoiding the transportation of large volumes of water to the laboratory for enrichment [10] and allowing for time-integrated as well as event-based sampling. Equilibrium passive sampling may be useful to concentrate

hydrophobic chemicals in a biomimetic manner for subsequent EBM application [11]. For screening purposes also samplers for more hydrophilic compounds can be used.

Demonstration and evaluation in case studies

In SOLUTIONS, EBMs were applied in a series of case studies, where it was possible to show the likelihood that complex mixtures present in water systems pose specific (MoA-related) harm to the Biological Quality Elements, along a river stretch [12], around wastewater treatment plants [13] and close to inflows of untreated wastewater [14]. For the selected types of example sites, estrogenic, androgenic and anti-androgenic effects could be established as markers of the likelihood that treated and untreated wastewater affects aquatic life. In addition, the methods helped to establish the contribution of wastewater streams to surface water quality, and to assess the overall effects of chemical pollution on affecting aquatic life and thus water quality. The methods helped identify damage and associated causes, to support water quality management.

Recently quality/performance criteria for the benchmarking of estrogenic bioassays have been investigated in a round-robin study [15]. In a Europe-wide demonstration program supported by SOLUTIONS, the NORMAN network and the JRC, the reliability of EBMs for screening of endocrine disrupting compounds was analyzed to harmonize monitoring and data interpretation methods, and to contribute to the current WFD review process. Water and wastewater samples were collected across Europe and analyzed using chemical analyses and EBMs. The study demonstrated that (e.g. because of the lower LODs of the EBMs in comparison to the chemical analysis) the inclusion of effect-based screening methods into monitoring programs for estrogens in surface waterbodies are a valuable complement to chemical analysis [16, 17]. Based on the results and achievements of SOLUTIONS and the NORMAN network such comprehensive case studies should be also developed for other modes of action.

Development of effect-based trigger values (EBT)

Effect-based trigger values (EBT) were suggested defining an acceptable level of effect for most of the EBMs, in close alignment with the WFD protection goals and chemical Environmental Quality Standards, and useful for interpreting EBM-results towards the likelihood to pose harm [18][17]. Bioassay-specific EBTs are derived by reading across from AA-EQS using a transparent algorithm that does not require any user assumptions or judgements about the data. EBT are based on bioanalytical equivalent concentrations (BEQ) and can be read across from existing EQS for single chemicals. Bioassay-specific EBTs are key for the interpretation of results from water quality assessment, as EBM-effect below the threshold indicate a negligible likelihood that specific chemical mixtures, with specific MoA, pose harm whilst increasing effects imply increasingly clear insights into harm to aquatic life. Importantly, the proposed approach can be applied to any bioassay, provided there is sufficient effect data available.

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ABBREVIATION/FACTS/HYPERTEXT

EBM Integrate effect-based methods **EQS** Environmental Quality Standards **EBT** Effect-based trigger values **BEQ** bioanalytical equivalent concentrations

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