# Proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge: SCHEER scientific advice

Rizzo, L.; Krätke, R.; Linders, J.; Scott, M.; Vighi, M.; de Voogt, P.

**DOI**
10.1016/j.coesh.2017.12.004

**Publication date**
2018

**Document Version**
Final published version

**Published in**
Current Opinion in Environmental Science & Health

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in
Environmental Science & Health

# Proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge: SCHEER scientific advice

Luigi Rizzo[1], Renate Krätke[2], Jan Linders[3,a], Marian Scott[4], Marco Vighi[5] and Pim de Voogt[6,7]

**Abstract**
This manuscript summarizes the opinion of the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) on the report prepared by the European Commission Joint Research Centre entitled “Proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge” (draft V.3.3, February 2017). The SCHEER concludes that, while the methodology chosen is appropriate and the report considers many important elements, the document is deficient in key details. In particular the report inadequately addresses (i) contaminants of emerging concern, (ii) antibiotic resistance spread through urban wastewater treatment plants’ effluents, and (iii) possible risks associated with disinfection and/or advanced treatment of urban wastewater (e.g. formation of disinfection by products and related toxicity). Therefore, the SCHEER is of the opinion that the minimum quality requirements proposed provide insufficient protection both to environmental and human health. The SCHEER supports the case-by-case approach proposed, but recommends that common criteria be defined for the development of case-by-case assessments, in order to ensure comparable minimum quality requirements across EU Member States.

**Addresses**
[1] Department of Civil Engineering, University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano, SA, Italy
[2] Federal Institute for Risk Assessment, Berlin, Germany
[3] RIVM, Bilthoven, NL, The Netherlands
[4] School of Mathematics and Statistics, University of Glasgow, Glasgow G12 8QQ, UK
[5] IMDEA Water Institute, Avenida Punto Com, 2-28805 Alcalá de Henares, Madrid, Spain
[6] Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands
[7] KWR Watercycle Research Institute, Groningenhaven 7, 3430 BB Nieuwegein, The Netherlands

Corresponding author: Rizzo, Luigi (l.rizzo@unisa.it)
[a] Current address: De Waag 24, NL-3823 GE Amersfoort, The Netherlands.

**Current Opinion in Environmental Science & Health** 2018, **2**:7–11

This review comes from a themed issue on **Wastewater and reuse**

Edited by **Paola Verlicchi** and **Paolo Roccaro**

For a complete overview see the Issue and the Editorial

https://doi.org/10.1016/j.coesh.2017.12.004



**Keywords**
Agricultural irrigation, Aquifer recharge, Antibiotic resistance, Contaminants of emerging concern, Joint research centre, Toxicity, Wastewater reuse.

## Introduction

### Background

Europe is facing increasing incidences of water scarcity and droughts are affecting many of its regions; water reuse can help address this issue but its potential remains largely untapped in the EU. Water reuse for irrigation or industrial purposes is considered to potentially have a lower environmental impact and lower cost less than other alternative water supplies (e.g. water transfers or desalination), but it is only used to a limited extent in the EU. Because of inconsistent national legislation across Member States (MSs) and a limited public awareness about actual risks and benefits, water reuse tends to be a costly practice subject to distrust from the general public; potential obstacles to the free movement of agricultural products irrigated with reused water are an additional risk deterring investment. The European Commission announced that in 2017, it planned to discuss a legislative proposal on minimum quality requirements (MQR) for water reuse in agricultural irrigation and aquifer recharge. DG Environment is leading this initiative in the Commission and mandated the Joint Research Centre (JRC) of the European Commission to elaborate the basis for the proposal. The JRC finalized a (technical) draft report [1] proposing MQR for reuse categories including agricultural irrigation and aquifer recharge as well as covering the related relevant aspects (e.g. water quality, application, monitoring). To ensure that the proposed EU MQR appropriately address risks and ensure a high level of health and environmental protection, scientific advice of the European Food Safety Authority (EFSA) and of the Scientific Committee on Health, Environment and Emerging Risks (SCHEER) on JRC’s draft technical report were requested by DG-Environment. In the present manuscript, the terms of references for the SCHEER and the methodology used in JRC’s draft technical report are briefly introduced before summarizing the SCHEER’s scientific advice on the JRC’s technical report.

### Terms of reference

The SCHEER was asked to review and provide scientific advice on the report prepared by the JRC on "Proposed EU MQR for water reuse in agricultural irrigation and aquifer recharge" [1]. More specifically, the SCHEER was asked to answer the following questions:

- Q1: Is the methodology used by the JRC to develop the MQR on water reuse considered appropriate to address environmental risks associated with water reuse for agricultural irrigation and aquifer recharge, and with human health safety for aquifer recharge?
- Q2: Do the proposed MQR provide sufficient protection against environmental risks that may be associated with water reuse for agricultural irrigation and aquifer recharge?
- Q3: Do the proposed MQR provide sufficient protection against the human health risks that may be associated with water reuse for aquifer recharge?
- Q4: Have any risks been overlooked, and if so how should they be taken into account?

### Methodology used in JRC's technical report

In its technical report entitled 'Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge' [1], JRC proposed MQR for two specific reuse categories: agricultural irrigation and aquifer recharge. These requirements should ensure a high level of health (human and animal health) and environmental protection and thus provide public confidence in reuse practices. The JRC document includes some requirements (namely water quality parameters and monitoring requirements) for both reuse categories. Moreover, some aspects for agricultural irrigation (type of crops to be irrigated and application conditions) as well as aquifer recharge (type of groundwater use and application conditions) were taken into account to finalize the document. Existing reference guidelines for water reuse applications and existing national legislation in MSs on water reuse were considered.

## SCHEER scientific advice

### Question 1

It is the opinion of the SCHEER that (1) the reviewed JRC report did not include a detailed methodology for the selection of MQR for water reuse in the EU and (2) further refinement of the general methodology is required. In particular, the SCHEER recommended that the JRC document should introduce some of the methods presented in a more prescriptive manner (e.g. quantitative microbial risk assessment should be part of any case-by-case evaluation). According to the methodology adopted by other International Bodies and Regulatory Authorities (such as the World Health Organisation (WHO) [2], the US Environmental Protection Agency (EPA) [3], the International Organization for Standardization (ISO) [4], the Australian Guidelines for Water Recycling and the Australian Drinking Water Guidelines [5−7]), the JRC report relies on monitoring as the main risk assessment method, including validation, operational and verification monitoring. In the opinion of the SCHEER, monitoring should not be considered as the first option in the risk assessment process because it is more often used as the last tier in a tiered approach, with screening and estimation techniques such as modelling occurring in the earlier tiers. Therefore, the SCHEER considers that it is not practicable to monitor all relevant biological and chemical agents in the development of water reuse plans and, accordingly, recommended the JRC to develop more detailed guidance on how to apply a tiered approach to setting MQR for water reuse in the EU. The guidance should include a list of chemical and biological agents and relevant toxicity values. Moreover, the procedures proposed by JRC for irrigation or aquifer recharge are not always consistent (e.g. compliance with the Groundwater Directive is mandatory for agricultural irrigation, whereas the GWD is not mentioned in the aquifer recharge preventive measures). The SCHEER is of the opinion that there is no principal difference in the procedures to derive MQR for agricultural irrigation or for aquifer recharge.

### Question 2

The SCHEER is of the opinion that in their current form, the MQR proposed provide insufficient protection against environmental risks. Firstly, the JRC's report includes numerical values for a limited number of parameters in Table 1 of the JRC document (summarized in Table 1 of this paper), but provides no explanation about the sources of these values; furthermore, information is lacking about why some parameters (namely metals) were selected as the indicators in Table 3 of the JRC report. Secondly, the number of parameters is considered insufficiently wide to provide protection against environmental risks. Finally, a detailed guidance on how MSs and risk managers should derive the proposed MQR is missing.

### General comments

Quantitative quality requirements are reported in Table 1 of the JRC report for a small number of basic parameters (5 days Biochemical Oxygen Demand ($BOD_5$), Total Suspended Solids (TSS), turbidity, *E. coli*). Otherwise, lists of parameters are proposed but without any quantitative indication of (minimum) quality requirements in Table 3 of the JRC report (summarized in Table 1 of this paper). No mention is made of additional parameters such as the Water Framework Directive (WFD) priority chemicals, while other organic pollutants (contaminants of emerging concern (CEC), such as pharmaceuticals, personal care products, microplastics etc.), that are frequently observed in urban wastewater treatment plants (UWWTP) effluents [8], are only briefly mentioned in chapter 6 of the JRC report. The SCHEER recommends that quantitative minimum values be developed by the EC for the parameters in Table 3 of the JRC report. MSs

**Table 1**

**Summary of Tables 1, 3, 6 and 7 of JRC's report (draft V.3.3, February 2017).**

| Table | Caption | Information/Comment |
|---|---|---|
| 1 | Minimum reclaimed water quality criteria for agricultural irrigation | Minimum values for *E. coli*, $BOD_5$, TSS and turbidity are included according to four reclaimed water quality classes, namely: class A (Secondary treatment, filtration, and disinfection (advanced water treatments), class B (Secondary treatment, and disinfection), class C (Secondary treatment, and disinfection), class D (Secondary treatment, and storage, stabilization ponds or constructed wetlands). In particular, *E. coli* minimum values (CFU/100 mL) were set as $\leq$10 or below detection limit, $\leq$100, $\leq$1000 and $\leq$10,000 for class A, B, C and D, respectively. |
| 3 | Physico-chemical parameters to be monitored for agricultural irrigation | Just a list of parameters was provided (including Aluminium, Arsenic, Beryllium, Bicarbonate, Cadmium, Chloride, Chromium, Cobalt, Copper, Electrical conductivity (EC), Fluoride, Iron, Lead, Lithium, Manganese, Mercury, Molybdenum, Nickel, Nitrates, Nitrogen, pH, Phosphorus, Selenium, Sodium, Sodium Adsorption Ratio (SAR), Sulphate, Tin, Tungsten and Titanium, Vanadium, Zinc) and MSs are asked to "specify, if necessary, minimum quality requirements on a case-by-case basis to be complied with by reclaimed water effluent and to be included for verification monitoring." |
| 6 | Recommended operational monitoring for some common treatment processes | A list of operational monitoring parameters and corresponding indicative frequencies only for a limited number of treatment processes, namely: Secondary treatment (activated sludge), Low-rate biological systems (stabilization ponds), Soil-aquifer treatment, Media filtration system, Membrane bioreactor (MBR), Membrane filtration technology, Ultraviolet light disinfection (UV) |
| 7 | Minimum reclaimed water quality criteria for managed aquifer recharge | Minimum values for *E. coli*, TSS and turbidity as well as "Indicative technology target" (Secondary treatment, filtration, and disinfection (advanced water treatments); Secondary treatment, and disinfection) were proposed for two "managed aquifer recharge categories" (direct injection vs surface spreading). |

could then propose stricter standards on a case-by-case basis if so wished. However, there is a need to define precise criteria for the development of the case-by-case requirements, in order to ensure a comparable minimum level of protection in all MSs. In addition, with using a tiered approach it is questionable whether a case-by-case approach would be necessary in all situations, since many non-critical cases will be filtered out in an earlier tier. A good example of the application of a tiered approach is the EU-methodology for the evaluation of groundwater and surface water as developed by the FOCUS-group and as amended by the EFSA (FOCUS; URL: http://esdac.jrc.ec.europa.eu/projects/focus-dg-sante).

## Microbiological risks

The SCHEER is of the opinion that microbiological risks associated with water reuse for agricultural irrigation and aquifer recharge were not sufficiently addressed in the JRC document. In relation to wastewater (reclaimed water) monitoring, the only point of compliance recommended by JRC is "the final reclaimed water effluent after adequate treatment". Unfortunately, under typical operating conditions implemented in UWWTPs, in terms of either disinfectant dose or UV-C radiation intensity, disinfection processes cannot completely inactivate indigenous microorganisms, which can regrow after treatment as suitable environmental conditions occur [9–11], thus, possibly, resulting in stored wastewater not being in compliance with the standards set in Table 1 of the JRC report. The JRC document also fails to address the contribution of UWWTPs effluents to the risk of antibiotic resistance transfer through wastewater reuse for agricultural irrigation. While the JRC report recognises that "some pathogens may survive on crop surfaces and in soils with the potential to be transmitted to humans or animals or to groundwater or surface water", it does not take into account that antibiotic resistant bacteria (ARB) may follow the same fate thus resulting in an additional threat to humans and the environment. UWWTP effluents contain high bacterial loads which harbour antibiotic resistant genes that have a potential to be propagated amongst the bacterial community [12,13]. Moreover, the amount of ARB that can be discharged on wastewater irrigated fields is very high and these organisms may proliferate in soils and/or plants [14]. The SCHEER is of the opinion that the JRC document should recommend to MSs that disinfection and advanced treatments be selected and operated to address the corresponding limits of *E. coli* set in Table 1 of the JRC report as well as to minimise the release of ARB, while complying with disinfection by-products (DBPs) concentration and toxicity requirements. Table 6 of the JRC report (also summarized in Table 1 of this paper) should be improved/updated to include missing processes. As new (chemical) disinfectants and advanced oxidation treatment methods are developed and applied, unregulated DBPs and/or toxic oxidation intermediates may form [15], which would not be monitored. In order to control microbial regrowth risk, "the point of compliance of the reclaimed water quality" should also include storage facilities just before wastewater reuse.

**Question 3**

The SCHEER is of the opinion that the proposed minimum quality criteria do not provide sufficient protection against microbiological and chemical risks to human health associated with water reuse for aquifer recharge.

### General comments

According to the previous paragraph 2.2.1, the list of parameters for monitoring should be expanded with other relevant chemicals (e.g. those identified by the WHO [2] or other regulatory bodies). Monitoring of those additional chemicals may be based on a case-by-case decision regarding the origin of the wastewater and the probability of their presence. The WHO also lists maximum tolerable soil concentrations of various toxic chemicals (see also section 2.4) based on aspects relating to human health protection [2]. In addition, guidance on a procedure to set MQR (e.g., on the basis of toxicity, persistence or carcinogenic, mutagenic or toxic for reproduction properties of chemicals or groups of chemicals) for chemicals of emerging concern should be provided.

The SCHEER suggests that to Table 7 of the JRC report other criteria should be added in accordance with Table 3 of the JRC report (both tables summarized in Table 1 of this paper). The SCHEER recommends organic and inorganic chemicals as well as nutrients be included, all of which were identified as important by other regulatory bodies e.g. in the Australian Environment Protection and Heritage Council documents [7].

### 2.3.2. Microbiological risk

It is worth noting that detection of ARB and genes in disinfected wastewater and in soil is technically challenging. In particular, when they occur at very low levels, it may be difficult to quantify them by using commonly used techniques (e.g. qPCR), in spite of their potential biological impact (e.g. facilitating horizontal gene transfer). Therefore, "the risks of transmission of antibiotic resistance from the environment to humans must be managed under the precautionary principle, because it may be too late to act if we wait until we have concrete risk values" [16]. The JRC document should clearly recommend to MSs that disinfection and advanced treatments should be selected and operated to address the corresponding limits of *E. coli* set in Table 1 of the JRC report while complying with DBPs concentration and toxicity requirements recommended in the subsequent paragraphs of the report.

**Question 4**

Although strictly speaking, risks have not been overlooked in the JRC document, the SCHEER has identified several issues it considers as having not been sufficiently addressed in the document. In case of aquifer recharge, injection of water is not mentioned specifically in the JRC report. Water injection at a depth of more than approximately 30 cm below the ground's surface is different from a surface recharge, where passage through the soil takes place. Although aquifer recharge through infiltration may reduce the contaminant load of the reused water, this will be less if the pollutant is more mobile. Appropriate data about persistent mobile organics are scarce and very limited [17] and for these compounds the SCHEER proposes that a more conservative approach should be applied (e.g. the Threshold of Toxicological Concern (TTC), see for example [18]). Deeper water injection is considered inappropriate for this reason. Moreover, as CECs are of concern, the JRC document appears to have overlooked ongoing efforts at EU level to identify chemical, microbiological and effect-directed indicators to control and possibly minimise the CECs-related risks for human health and environment (see e.g. NORMAN network (http://www.norman-network.net/), COST Action NEREUS ES1403 (http://www.nereus-cost.eu/ [19]), and EU projects such as PROMOTE (http://www.ufz.de/promote/), SOLUTIONS (http://www.solutions-project.eu/ [20]), DEMOWARE (http://demoware.eu/en), ANSWER MSCA ITN (http://www.answer-itn.eu/)). Therefore, a more balanced approach for CECs is needed, taking into account current knowledge and/or using the principle of TTC. The SCHEER suggests that the JRC expand their chemical list (Table 3 in JRC document) with the most important chemicals identified by WHO, EU (watch list) or other regulatory bodies, taking into account the more recent studies on the occurrence and toxicity of CECs. Monitoring of those additional chemicals may be based on a case-by-case decision regarding the origin of the wastewater and the probability of their presence. The WHO also lists maximum tolerable soil concentrations of various chemicals based on aspects regarding human health protection. The JRC might consider recommending MSs to adopt guidelines which ensure that wastewater irrigation does not result in exceeding these concentrations. Furthermore, the SCHEER is of the opinion that the radiological hazards of water reuse have not been addressed in the JRC document (apart from a definition being given).

### Microbiological risks

The SCHEER's view on issues related to microbiological risks in water reuse practice are discussed in paragraph 2.2.2, and related specific recommendations are explained there. Additionally, as antibiotic resistance spread is of concern, the SCHEER is of the opinion that a realistic first step to control this threat would be to incorporate the measurement of antibiotic-resistant *E. coli* when measuring "total" *E. coli* in UWWTP's effluents, a parameter that is already part of the listed MQR in the JRC document. In particular, cefotaxime (a third-generation cephalosporin that is on the WHO essential list of medicines) resistance is a good indicator for human sources of antibiotic resistance. Accordingly, Table 1 of the JRC document may be revised by adding to *E. coli* values $\leq 1$ (or below detection limit), 10, 100 and 1000 CFU/100 mL cefotaxime resistant *E. coli* for A, B, C and D reclaimed water quality classes, respectively. These values correspond to 10% of resistance prevalence – which is a compromise between adequacy to monitor wastewater resistance levels and the feasibility of analyses.

## Conclusions

While the JRC document considers many of the important elements in proposing EU MQR for water reuse in agricultural irrigation and aquifer recharge, the SCHEER is of the opinion that, in its current form, the MQR proposed provide insufficient protection both to environmental and human health. The SCHEER is of the opinion that the methodology should be extended and more details could and should be included in order to provide detailed guidance to member states and risk assessors on how minimum quality requirements should be derived.

## References

Papers of particular interest, published within the period of review, have been highlighted as:

* of special interest

1. *Proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge. Draft V.3.3.* Ispra: Joint Research Centre; February 2017.

2. WHO: *Guidelines for the safe use of wastewater, excreta and greywater*. *Wastewater use in agriculture*, vol. 2. Geneva, Switzerland: World Health Organization; 2006.

3. USEPA: *Guidelines for water reuse.* Washington, DC, USA: (EPA/600/R-12/618) United States Environmental Protection Agency; 2012.

4. ISO 16075: *Guidelines for treated wastewater use for irrigation projects.* Geneva, Switzerland: International Organization for Standardization; 2015.

5. NRMMC-EPHC-AHMC: *Australian guidelines for water recycling: managing health and environmental risks: phase 1. National Water Quality Management Strategy.* Canberra, Australia: Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, Australian Health Ministers' Conference; 2006.

6. NRMMC-EPHC-NHMRC: *Australian guidelines for water recycling: managing health and environmental risks: phase 2. Augmentation of Water Drinking Supply. National Water Quality Management Strategy.* Canberra, Australia: Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, Australian Health Ministers' Conference; 2008.

7. NRMMC-EPHC-NHMRC: *Australian guidelines for water recycling: managing health and environmental risks: phase 2c: Managed Aquifer Recharge. National Water Quality Management Strategy.* Canberra, Australia: NRMMC-EPHC-AHMC; 2009.

8. Pal A, He Y, Jekel M, Reinhard M, Gin K Yew-Hoong: **Emerging contaminants of public health significance as water quality indicator compounds in the urban water cycle**. *Environ Int* 2014, **71**:46–62.

9. Li D, Zeng S, Gu AZ, He M, Shi H: **Inactivation, reactivation and regrowth of indigenous bacteria in reclaimed water after chlorine disinfection of a municipal wastewater treatment plant**. *J Environ Sci* 2013, **25**:1319–1325.

10. Fiorentino A, Ferro G, Alferez M Castro, Polo-López MI, Fernández-Ibañez P, Rizzo L: **Inactivation and regrowth of multidrug resistant bacteria in urban wastewater after disinfection by solar-driven and chlorination processes**. *J Photochem Photobiol B* 2015, **148**:43–50.

11. Giannakis S, Voumard M, Grandjean D, Magnet A, De Alencastro LF, Pulgarin C: **Micropollutant degradation, bacterial inactivation and regrowth risk in wastewater effluents: influence of the secondary (pre)treatment on the efficiency of Advanced Oxidation Processes**. *Water Res* 2016, **102**: 505–515.

12. Rizzo L, Manaia C, Merlin C, Schwartz T, Dagot C, Ploy MC, Michael I, Fatta-Kassinos D: **Urban wastewater treatment plants as hotspots for antibiotic resistant bacteria and genes spread into the environment: a review**. *Sci Total Environ* 2013, **447**:345–360.

13. Vaz-Moreira I, Nunes OC, Manaia CM: **Bacterial diversity and antibiotic resistance in water habitats: searching the links with the human microbiome**. *FEMS Microbiol Rev* 2014, **38**: 761–778.

14. Becerra-Castro C, Lopes AR, Vaz-Moreira I, Silva EF, Manaia CM, Nunes OC: **Wastewater reuse in irrigation: a microbiological perspective on implications in soil fertility and human and environmental health**. *Environ Int* 2015, **75**: 117–135.

15. Rizzo L: **Bioassays as a tool for evaluating advanced oxidation processes in water and wastewater treatment**. *Water Res* 2011, **45**:4311–4340.

16. * Manaia CM: **Assessing the risk of antibiotic resistance transmission from the environment to humans: non-direct proportionality between abundance and risk**. *Trends Microbiol* 2017, **25**:173–181.

This is an opinion paper where the author makes an overview of some risk-determinant variables related to antibiotic resistance spread into the environment and raises questions regarding research needs. The most important conclusion is that the risks of transmission of antibiotic resistance from the environment to humans must be managed under the precautionary principle, because due to the limits of quantification of the methods commonly used for the characterization of antibiotic resistance (e.g., to screen antibiotic resistance genes), it may be too late to act if we wait until we have concrete risk values.

17. Reemtsma T, Berger U, Arp HPH, Gallard H, Knepper TP, Neumann M, Quintana JB, de Voogt P: **Mind the gap: persistent and mobile organic compounds—water contaminants that slip through**. *Environ Sci Technol* 2016, **50**:10308–10315.

18. * Malchi T, Maor Y, Tadmor G, Shenker M, Chefetz B: **Irrigation of root vegetables with treated wastewater: evaluating uptake of pharmaceuticals and the associated human health risks**. *Environ Sci Technol* 2014, **48**:9325–9333.

This is one of a few field studies aimed to quantify pharmaceutical compounds (PCs) uptake by treated wastewater-irrigated root crops and to evaluate potential risks. Using threshold of toxicological concern (TTC) approach, the authors show that the TTC value of lamotrigine can be reached for a child at a daily consumption of half a carrot (~60 g). This study highlights that certain PCs accumulated in edible organs at concentrations above the TTC value should be categorized as contaminants of emerging concern.

19. Fatta-Kassinos D, Manaia C, Berendonk TU, Cytryn E, Bayona J, Chefetz B, Slobodnik J, Kreuzinger N, Rizzo L, Malato S, Lundy L, Ledin A: **COST action ES1403: new and emerging challenges and opportunities in wastewater reuse (NEREUS)**. *Environ Sci Pollut Res Int* 2015, **22**:7183–7186.

20. Brack W, Altenburger R, Schüürmann G, Krauss M, López Herráez D, van Gils J, Slobodnik J, Munthe J, Gawlik BM, van Wezel A, *et al.*: **The SOLUTIONS project: challenges and responses for present and future emerging pollutants in land and water resources management**. *Sci Total Environ* 2015, **503–504**:22–31.