Scientific Committee on Health, Environmental and Emerging Risks

SCHEER

Final Opinion on

Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC)

The SCHEER adopted this document by written procedure on 18 July 2022

ABSTRACT

The SCHEER was asked to evaluate groundwater quality standards proposed for additional pollutants, including pollutant groups, in the annexes to the Groundwater Directive. These included per- and polyfluorinated alkyl substances (PFAS), pharmaceuticals, in particular carbamazepine and sulfamethoxazole, and non-relevant metabolites of plant protection products. The SCHEER is of the opinion that uniform EU-wide quality standards should be set for the groundwater body for chemicals with no natural background concentrations. The SCHEER is aware of the Guidance document by the European Medicines Agency (EMA, 2018) that requests to use an additional assessment factor of 10 for the protection of groundwater organisms. The SCHEER supports such a precautionary approach, although it considers the size of such an assessment factor as still being uncertain, especially for non-pharmaceuticals.

The SCHEER endorses the relative potency approach for PFAS and suggests using a quality standard for groundwater of 4.4 ng L^{-1} for PFOA equivalents. The SCHEER does not agree with a group QS of 0.50 µg L^{-1} for total PFAS.

The SCHEER concludes that the groundwater QSs for carbamazepine (0.5 µg.L^{-1}) and sulfamethoxazole (0.1 µg.L^{-1}) may not be sufficiently protective, in view of the additional assessment factor required for the protection of groundwater organisms. A general standard of 0.5 µg L^{-1} for all pharmaceuticals would also not be sufficiently protective.

The SCHEER does not support a group total quality standard for non-relevant metabolites of pesticides of 10 µg.L^{-1}. Although a quality standard of 0.75 µg L^{-1} for all non-relevant metabolites will protect human health (unless additional relevant toxicological information becomes available, e.g., ED effects), the SCHEER recommends using a quality standard of not more than 0.1 µg.L^{-1} in groundwater to protect the groundwater ecosystem, human health and against the development of antibiotic resistance.

The SCHEER does not see any scientific reason to consider moving PFAS, pharmaceuticals or non-relevant metabolites of pesticides as a group to Annex II.

Keywords: PFAS, carbamazepine, sulfamethoxazole, pharmaceuticals, non-relevant metabolites, pesticides, plant protection products

Opinion to be cited as:

SCHEER (Scientific Committee on Health, Environmental and Emerging Risks), Final opinion on groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC). 18 July 2022

ACKNOWLEDGMENTS

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SCHEER

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2.1. Background

Groundwater as a resource

Groundwater (GW) constitutes the largest reservoir of freshwater in the world, is a valuable resource for drinking water, irrigation and industry and has an increasing environmental value. It provides a base flow for surface water systems, feeds wetlands and river flows, and acts as a buffer through dry periods.

The combination of a wide range of pressures arising from human activity and the longer residence times of groundwater in the subsurface can result in long-term contamination and risks to environmental and human health. Pollution that occurred decades ago - whether from agriculture, industry or other human activities - may still threaten GW quality today and, in some cases, will continue to do so for decades to come. GW policy and legislation in the EU therefore emphasise the need to prevent contamination and deterioration of GW quality. In addition, new and emerging pollutants are detected in GW nearly everywhere and pose a risk to this source.

Legislative framework and updates

As required by Water Framework Directive (WFD) Article 17, the Groundwater Directive (GWD), as a WFD 'daughter directive', has as its main focus the prevention and control of groundwater pollution, with a view to ensuring the protection of drinking water sources and dependent ecosystems. The GWD clarifies the criteria for good chemical status of groundwater and provides EU-wide GW quality standards for nitrates and pesticides (individual and total, in Annex I). It also requires Member States (MS) to set their own threshold values and apply them for all other pollutants that put groundwater bodies at risk of failing to meet good chemical status, taking into account identified pressures and the minimum lists of pollutants in Annex II.

The GWD Annex II was revised in 2014. The amendments included adding principles for the determination of natural background levels (an important factor behind the variation in threshold values between MS), and nitrites and phosphorus (total)/phosphates to the minimum list of pollutants for Member States (MS) to consider when setting threshold values. This revision also acknowledged the need to establish a voluntary watch list mechanism to increase monitoring and knowledge of substances posing a potential risk to groundwater (including emerging pollutants).

Although the GW Watch List (GWWL) mechanism is voluntary, substances identified through it as posing a relevant risk should be considered for inclusion in Annex I or Annex II to the GWD; some might require additional monitoring before a decision is made.

As a result of recent work using data reported by MS on a voluntary basis, several substances have been identified for possible inclusion in Annex I or II of the GWD and the GWWL, and prioritised on the basis of a methodology defined in a concept paper (acknowledged by EU Water Directors). The prioritisation process ranks substances for the GWWL based on (i) groundwater monitoring data (i.e. occurrence in EU MS GW), (ii) theoretical environmental exposure, mobility and persistence and (iii) toxicity, i.e. the relative risk they pose in the groundwater environment (Gaston *et al.* 2019).

As indicated in Article 10 of the GWD, the Commission is under the legal obligation to regularly review the lists of pollutants in Annexes I and II. The need to review them was confirmed by the results of the recent Fitness Check (evaluation) of the water

legislation. The Fitness Check concluded that the covered water directives were broadly fit for purpose, but it also concluded that there was some room for improvement to tackle chemical pollution, confirmed the need to reflect the latest scientific insights, and highlighted the need to consider additional pollutants of emerging concern, such as pharmaceuticals and PFAS. In addition, the previously mentioned GWWL technical work on groundwater has allowed the gathering of data on non-relevant metabolites (nrMs) of pesticides, which will be considered in the review of the GWD annexes.

The Commission is currently working on an Impact Assessment to support legislative proposals regarding the lists of groundwater pollutants. The Commission has recently launched a study to quantify the costs and benefits (economic, social and environmental; direct and indirect) of the most relevant policy options. The Commission plans to publish the Impact Assessment study by the end of 2021, and table legislative proposals in 2022.

For this process, it is essential to have a scientific expert opinion on quality standards for the pollutants (or groups of pollutants) to be proposed for inclusion in Annex I to the GWD, and on the possible alternative inclusion of those pollutants in Annex II.

2.2. Terms of Reference

The SCHEER is requested by the DG for Environment to provide scientific advice on the quality standards for substances that could be proposed for inclusion in Annex I to the GWD. In particular, quality standards might be established for certain PFAS, pharmaceuticals and non-relevant metabolites from pesticides found in GW (as described in the Appendix to this mandate). More specifically, the SCHEER is asked to express its opinion on the following points:

- Would the quality standard proposed for 10 PFAS provide adequate protection (to human health and dependent ecosystems) from those PFAS if applied to groundwater? (The value is linked to that for 20 PFAS in the Drinking Water Directive (DWD) Recast). If not, what value would the SCHEER propose, taking into account the DWD Recast and the findings of the GWWL PFAS report, and the risk from individual PFAS?

- Following WHO recommendations and to seek coherence with the approach in the DWD recast, which includes a limit of 0.5 µg/l for PFAS total, does the SCHEER consider enough scientific basis to propose the same quality standard at EU level for total PFAS in Groundwater for comparison with the relevant measured concentration total?

- Would the quality standards proposed for the two individual pharmaceuticals (Carbamazepine, Sulfamethoxazole) provide adequate protection (to human health and dependent ecosystems) if applied to groundwater? (values based on quality standards work for these substances in surface waters). If not, what values would the SCHEER propose?

- In the opinion of the SCHEER, which scientific criteria could the Commission use propose a quality standard at EU level for all pharmaceuticals (i.e. addressing pharmaceuticals as a group of substances) or for subgroups of pharmaceuticals (e.g. human and veterinary pharmaceuticals, pharmaceuticals with particular modes of action), for comparison with the relevant concentration total? In the light of the findings of the report from the GWWL experts on pharmaceuticals in GW and the risk from individual pharmaceuticals, does the SCHEER consider enough scientific basis to propose a group total quality standard?

- Would the proposed uniform quality standard(s) for individual nrMs and for total nrMs provide adequate protection (to human health and dependent ecosystems) if applied to groundwater in relation to the 16 listed nrMs (and possibly others)?

The proposed approach is analogous to the current approach in the GWD and DWD to "pesticides" and takes into account the range of values established by MS and the

magnitude of certain values mentioned in the guidance on establishing relevance of metabolites in groundwater (Sanco, 2003), although that guidance recommends a case-by-case approach. The SCHEER is asked to take into account: relevant data from the assessment of individual substances performed in the context of Regulation (EC) No 1107/2009, the reasons underpinning the limit values already established by MS, relevant literature on the nrMs listed, and on others, as well as any relevant surface water quality standards and the Technical Guidance Document on Deriving EQS for pollutants in surface waters.

- The SCHEER is also asked to provide a scientific view on whether the "uniform standard" approach is appropriate, and on whether the appropriateness of a uniform group standard would depend upon whether the group is limited to the 16 listed nrMs. It might wish to consider involving the European Food Safety Authority (EFSA) where necessary to ensure coherence and harmonisation in the spirit of the 'one substance, one assessment' approach as outlined in the EU Chemicals Strategy, bearing in mind that the approach supports a gradual move away from assessing and regulating chemicals substance-by-substance to regulating them as groups.

- In the opinion of the SCHEER, and given the existing data and reports, as well as geographical and geological differences in MS, would it be more scientifically justified to include any of the proposed PFAS, pharmaceuticals or nrMs in Annex II instead of Annex I ? i.e. would it be more appropriate for MS to set threshold values at national, river-basin-district (RBD) or water-body level to take account of variability in their presence/relevance, or differences in hydrological settings and aquifer types? In answering this question, it would be helpful if the Committee could consider the intention of the legislator to achieve where possible a level playing field regarding quality standards, the inter-comparability of results, and uniform implementation across the EU.

3. OPINION

3.1. Introduction

Groundwater is a permanent presence and a potential drinking water resource in all MS of the EU. Groundwater abstracted from boreholes not only supports humans, via drinking water, but also agriculture via irrigation. Ultimately groundwater, connected via rivers and lakes, also supports human activity and agriculture. Where GW is used as a drinking water source, the treatment does not include advanced purification processes that are applied when river water is the source because of the assumed quality of aquifer water. Moreover, considering the difficulty to restore a contaminated GW body, it should be in any case protected as a drinking water resource, even if a given groundwater body is not used for such a purpose at the moment.

Groundwater ecosystems are energy-poor in general, due to the absence of photosynthetic primary producers, and metabolic activities are therefore typically low. Groundwater bodies harbour unique ecosystems that are typically characterised by simplified trophic webs-dominated micro-organisms often without large predators (the highest trophic levels are usually represented by invertebrates). The micro-organisms found in subterranean ecosystems include archaea, bacteria, protozoa and fungi, which remain largely unknown.

Groundwater invertebrates have been classified into stybophilious organisms, which can adapt to the subsurface conditions, and stygoxenous species, whose presence is temporary. The stygobionts (specialised organisms which live exclusively in groundwater are dominated by crustacean types (Deharveng *et al.*, 2009). They are highly adapted (troglomorphic), often lacking pigmentation and eyesight, but possessing well-developed chemoreceptors and sensory appendages.

Currently, our understanding of the sensitivity of stygobiontic organisms is poor, as ecotoxicological investigations are limited to a few studies on acute toxicity. Data on the sensitivity of terrestrial species is completely absent (Castaño-Sánchez, 2020). There is no strong evidence yet that the unique groundwater invertebrates have a similar sensitivity to chemical exposure to surface freshwater invertebrates. The SCHEER is aware of the analysis by EMA (2018) of the potentially higher sensitivities of groundwater invertebrates compared to freshwater. Thus, an additional assessment factor may be required, although the SCHEER considers the size of such an assessment factor as being uncertain, especially for non-pharmaceuticals.

3.2. The position of SCHEER

Given that freshwater biodiversity is accounted for in the derivation of the EQSs of freshwater, the SCHEER is of the opinion that it is appropriate to apply freshwater EQSs to groundwater until new scientific data become available.

3.2.1. Relationship between quality standards for surface waters, drinking water and groundwater

Groundwater feeds rivers, lakes and wetlands. There should never be the need to consider a groundwater body of good chemical status as a major pollution source when assessing surface water quality or performing chemical risks assessments for surface water ecosystems. In other words, groundwater of good chemical status should never transform into surface water of poor chemical status simply because a water body reaches the surface. The SCHEER is therefore of the opinion that groundwater quality standards must not exceed the concentrations put forward as quality standards for surface waters (AA-EQS). However, given the slow renewal rate of groundwater, its immediate value for drinking water production and our limited understanding of groundwater ecology, there might be good reasons to go below surface water QS values, in particular for PMT / vPvM compounds, antibiotics

and chemicals with insecticidal properties. The SCHEER is also of the opinion that quality standards set for contaminants in GW should not be higher than those for drinking water and that, for harmonising principles, existing drinking water quality standards may be used as GW standards, unless specific ecotoxicological sensitivities emanate, e.g., for pharmaceuticals (Rosi-Marshall *et al.*, 2013).

3.2.2. Mixtures

Chemicals do not occur as isolated entities in the environment, including in groundwater bodies. Real-world exposure is to multi-component mixtures and not to single compounds. Empirical evidence indicates that the risk of such mixtures typically exceeds the risk of each individual chemical, by an amount that depends on the number of mixture components, their concentrations and (eco)toxicological hazard profiles. As a consequence, individual regulatory thresholds are currently not always sufficiently protective.

The complexity of real-world exposures implies that not all mixtures can be empirically tested. Mixture assessments therefore often apply models that are based on the notion that the overall risk of a mixture can be predicted from the concentrations and hazards of the mixture components. Guidelines and critical reviews of these methodologies have been published by, amongst others, the EU Commission, JRC, EFSA, OECD and the WHO (Meek *et al.*, 2011; OECD, 2018; Bopp *et al.*, 2019; EFSA, 2019; EC, 2020.)

Although these reports differ in scope, they are all based on assessment principles that centre on the classical concepts of Concentration Addition (CA, also known as Dose Addition) and Independent Action (IA, also known as Response Addition). CA is also discussed in the EQS guidance document (EC, 2018) and basically assumes that the compounds in a mixture share a similar mode of action and that, therefore, the total toxicity or risk of a mixture can be estimated as the sum of the individual toxic units (e.g. PEC/EC50 ratios), respectively risk units (e.g. PEC/PNEC ratios). CA provides the conceptual basis for relative potency factors (RPF) that have, for example, found widespread use in the form of so-called toxicity equivalents (TEQs) for the assessment of mixtures of dioxins, PFAS, and the assessment of petroleum products. IA on the other hand assumes that the mixture components contribute to a common adverse outcome in relation to their individual potencies, via different pathways. More advanced mixture tools, e.g., PBPK/TD models, require detailed knowledge about the physiology and ecology of the exposed organisms, the pharmacokinetics of all mixture components and the dynamics of their interactions. Given these data requirements, such sophisticated tools are confined to data-rich situations, e.g., for the assessment of possible impacts of insecticide mixtures on bee health.

IA and CA both assume that all components of a mixture are known, that they do not interact and that the components of a mixture are also toxic as single entities. Both concepts estimate that the overall toxicity or risk of a mixture exceeds the toxicity or risk of each component, with one important distinction: CA assumes that mixture components always contribute to the overall toxicity, in direct proportionality to the corresponding toxic unit. IA, on the other hand, assumes that, if all components are present at true zero-effect concentrations, the mixture will also not cause any toxicity. Regulatory thresholds such as PNECs, RACs or EQS values might not always reflect true zero-effect levels. However, if they allow for individually negligible effects this might, even under the assumption of IA, give cause for concern from a mixture perspective.

IA-based mixture risk assessments should therefore only be applied if the underlying assumptions (dissimilar and fully independent modes of action of all mixture components across all relevant concentrations) can be proven for the considered mixture scenario(s). Additionally, the proper application of IA for

regulatory purposes requires far more data than the application of CA, which might also be the reason for the lack of empirical data on the validity of IA for real-world mixtures.

Because of these challenges and because CA usually predicts a slightly, but not excessively, higher mixture risk than IA, guidelines and reviews typically recommend a tiered approach for mixture assessment in which CA serves as the first tier, independent of the mixture composition. If the CA-based assessment in tier 1 indicates potential reason for concern, resources might be invested for higher-tier studies, which might consider, depending on the mixture scenario of interest, IA and/or more sophisticated mixture models, including the detailed study of interactions that might cause a higher (synergisms) or lower (antagonisms) mixture toxicity than anticipated by either model. The application of CA as well as IA depends on a valid, unbiased and complete exposure assessment.

The setting of regulatory environmental thresholds (such as quality standards) for mixtures is still under development and has been implemented only for a few mixtures, such as "dioxins and dioxin-like compounds" in the context of Directive 2013/39/EU or the threshold of 0.5 µg/L in Directive 2006/118 for the sum of all pesticides detected in a groundwater body. It should be pointed out that the latter is not based on a risk assessment, but relates only to typical chemical-analytical detection limits for pesticides from the 1990's.

In fact, assuming a concentration-additive behaviour, the regulatory threshold of a mixture always sits between the minimum and the maximum of the regulatory thresholds of the mixture components, weighted according to their concentration ratio. If all components in a mixture share the same regulatory threshold, e.g., as a consequence of applying an (eco) Threshold of Toxicological Concern (TTC, Munro *et al.*, 2008) approach, the regulatory threshold of the mixture equals the regulatory threshold of each individual component.

3.2.3. Inclusion in Annex I or Annex II?

GW guideline values must protect humans (GWD Art2(1)) and should be based on drinking water quality requirements. Even if a GW is not currently used as a drinking water source, it should always be considered as potential drinking water resource for the future. The SCHEER could not identify any scientific reason why drinking water requirements with respect to chemical contamination should not be identical throughout the EU.

GW guideline values must also protect the environment (GWD Art2(1)), i.e., groundwater ecosystems. Although the exposed ecological communities likely vary between Member States, the current knowledge on the ecology of groundwater bodies and the sensitivity of stygobiotic organisms to chemical exposure is insufficient to justify different guideline values in different groundwater bodies. For the time being, the SCHEER therefore recommends setting uniform EU-wide quality standards for the groundwater body for chemicals with no natural background concentrations. Member-State specific standards should only be set if necessary for specific and explicitly stated scientific reasons.

The physico-chemical conditions such as pH, redox potential, temperature, ion-exchange capacity and organic matter content vary between groundwater bodies. This might argue for MS-specific QS values for chemicals whose bioavailability and transport processes are affected, especially metals.

Similar to the approach applied for setting QS values for surface waters, naturally occurring (geogenic) background concentrations need to be taken into account for chemicals such as metals.

In conclusion, the SCHEER is of the opinion that keeping a level-playing-field across the EU when setting quality standards is not only helpful in the context of chemical authorisation procedures and drinking water production, but would also make things easier for Member State authorities.. In the future, these uniform standards may be reconsidered if new scientific knowledge comes to light.

3.3. PFAS

There is an urgent need to assess and control the exposure levels of PFAS in order to protect both the environment and humans. Several members of the PFAS group, notably alkyl acids and sulfonates, are extremely persistent in the environment, whereas many others will be transformed into persistent intermediates after being emitted into the environment. As a consequence, recent pleas for limiting the entire class of PFAS (including fluoropolymers) to essential uses have been published in the scientific literature (Blum *et al.*, 2015; Cousins *et al.*, 2019). The SCHEER therefore endorses efforts of the EC to set guideline values for PFAS in different exposure media.

As a result of the nature of PFAS production and uses, exposure to PFAS occurs in complex mixtures of multiple PFAS. However, usually fewer than 50 individual PFAS (often fewer than 10) are commonly measured in monitoring programs. For example, EPA's validated Method 537.1 ensures laboratories can effectively measure 18 PFAS in drinking water (US-EPA, 2021). New analytical techniques which measure, for example,total organic fluorine, have revealed evidence that humans and wildlife are exposed to more PFAS than previously estimated (Kwiatkowski *et al.*, 2020).

Thus far, PFAS have been mostly regulated one chemical at a time. However, subgroups of PFAS have also been regulated, with a focus on PFalkyl acids (PFAAs) and their precursors. Targeting chemical subgroups often assumes that the toxicological endpoints of the members are similar (see section 3.1.2), which allows for extrapolation from well-studied chemicals to those less studied. However, assessing only small subgroups systematically ignores the majority of PFAS and underestimates the overall risk, particularly when many of the chemicals are unknown (Kwiatkowski *et al.*, 2020).

In most of the EU MS, GW is a drinking water source. GW abstracted for drinking water production often undergoes more simplistic treatment processes compared to surface water used for the same purpose. The SCHEER is of the opinion that, as a consequence, the quality standards for GW should be based on available drinking water quality standards. In the opinion of the SCHEER, EU quality standards for substances, in particular for groups of substances such as the PFAS, should be harmonised as much as possible. Considering its preference to treat the PFAS as a group of compounds and to harmonise setting of quality standards, the SCHEER thus recommends that for PFAS similar quality standards should be used for freshwater and groundwater. The SCHEER is in favour of using the same number of PFAS that have been the basis for drafting provisional EQSs by the JRC (Niegowska *et al.*, 2021), i.e., 24 compounds, for the setting of quality standards in groundwater(s) in Europe. The EQSs proposed by the JRC are based on a RPF approach, which is based on the well-established mixture toxicity concept of Concentration Addition and is therefore endorsed by the SCHEER.

The SCHEER endorses assessing combined exposures to PFAS (e.g., in drinking water, food, air, consumer products, and waste) as a basis to set regulatory limits. The environmental behaviour of PFAS in aqueous environments is dominated by their sorption properties and mobility (Higgins and Luthy, 2007; Brusseau, 2018). Thus, short-chain PFAS, which have been proposed as replacements of long-chain PFAS, will be more likely to reach GW than long-chain PFAS because of the inherent mobility of the former (Brendel *et al.*, 2018) and because long-chain PFAS will sorb much stronger to soil particles (Gellrich et al, 2012). The toxic pressure in GW from the more potent PFAS will be 'counteracted' by their relatively low concentrations in GW because of the stronger sorption. Hence, a standard derived with an RPF approach will not result in

an over-conservative quality standard. One must note here that RPFs depend on the endpoint chosen and may need modification when new toxicity data become available.

As argued above, GW should basically safeguard drinking water quality for future generations and therefore the QS recently proposed for drinking water should also be adopted for GW. Although the SCHEER is aware of the possible higher sensitivity of groundwater species that led the EMA to propose an additional AF for protecting GW species against pharmaceuticals (EMA, 2018), application of this AF may not be warranted in an RPF approach, in particular when data become available for GW species. The proposed (Niegowska *et al.*, 2021) provisional $EQS_{dw,hh}$ is currently 4.4 $ng.L^{-1}$ for PFOA equivalents. The SCHEER proposes to adopt this value as a quality standard for GW.

3.3.1. Adequacy of quality standards for 10 PFAS

Would the quality standard proposed for 10 PFAS provide adequate protection (to human health and dependent ecosystems) from those PFAS if applied to groundwater? (The value is linked to that for 20 PFAS in the Drinking Water Directive (DWD) Recast). If not considered strict enough, or too strict, what value would the SCHEER propose, taking into account the DWD Recast and the findings of the GWWL PFAS report, and the risk from individual PFAS?

Option a. The 10 PFAS listed are proposed for inclusion in GWD Annex I with an EU ***"group of 10"*** *quality standard, i.e. "Sum of PFAS"* ***0.10 µg.L^{-1}****. (Technical guidelines regarding analytical methods for 20 PFAS including these have to be issued by 2023 according to the Drinking Water Directive (DWD) Recast). The 10 PFAS would be a subset of the 20 in the DWD Recast, but the sum would have the same standard.*

Rather than using a separate "group of 10" quality standard for GW, the SCHEER suggests to use in the GWD Annex I the same (provisional) quality standard that has been proposed as an EQS for surface water, i.e. a total value of 4.4 $ng.L^{-1}$ PFOA-equivalents (see also section 3.3.2 below). There are, as far as the SCHEER is aware, no toxicity data for stygobionts or GW ecosystems as a whole. Because acute and chronic effect levels in freshwater organisms are higher than the proposed value of 4.4 $ng.L^{-1}$, it is the opinion of the SCHEER that an EQS of 4.4 $ng.L^{-1}$ PFOA-equivalents in total will provide adequate protection to human health and groundwater ecosystems.

The group of PFAS identified in option a. of annex 1 of the mandate is a subset of the list of PFAS included in the 'sum of PFAS' definition used in the EU-DWD recast. No argumentation is given as to why the sum standard for the subset should have the same value as the standard set in the DWD recast for the 20 PFAS. The SCHEER admits that the 10 PFAS identified as candidates for Annex II are the most frequently reported PFAS from the total of 20 compounds, but this might be simply because the other PFAS compounds are rarely included in monitoring programmes. In addition, other members of the group may turn out to be more important in the future as a consequence of changing use and production patterns. Moreover, the toxic potency of the PFAS excluded from the 10 that make up the option a. proposal needs to be further assessed.

As argued above, the SCHEER would strongly suggest using an RPF approach resulting in a quality standard that is the same in freshwater and in GW and therefore the SCHEER is not in favour of option a.

If option a. were to be selected by the EC, the SCHEER proposes that an additional assessment factor be applied to account for these uncertainties and for the possible higher sensitivity of GW species. Currently, the magnitude of this additional AF cannot be determined by the SCHEER.

3.3.2. A quality standard at EU level for total PFAS?

Following WHO recommendations and to seek coherence with the approach in the DWD recast, which includes a limit of 0.5 µg/l for PFAS total, does the SCHEER consider enough scientific basis to propose the same quality standard at EU level for total PFAS in Groundwater for comparison with the relevant measured concentration total? (Option b: PFAS are proposed for inclusion in GWD Annex I with an EU group quality standard of "PFAS-total" 0.50 µg/l covering all PFAS.)

The SCHEER endorses the plea from scientists all over the world to manage as one chemical class the thousands of chemicals known as PFAS (Blum *et al.* 2015). A group quality standard as proposed would be in line with this type of management.

Option b. of annex 1 to the mandate proposes that all PFAS will be included in GWD Annex I with an EU group quality standard of "PFAS-total" of 0.50 µg.L^{-1} covering all PFAS. Coverage of all PFAS requires the availability of an analytical method that is planned to be implemented in 2024. In the request for this opinion, DG-ENV defined 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available analytical methods and monitoring guidelines. Currently more than 4700 PFAS are known to exist (NIEHS, 2021) and the development of an appropriate analytical method that indeed covers all PFAS is both a challenging and critical task. The limitation inherently provided by the definition cited above implies that not all PFAS may be covered by 2024 by the analytical method that is available then. For the 24 PFAS that are included in the proposed $EQS_{dw,hh}$, analytical methods are currently available.

As discussed above, the SCHEER is of the opinion that the value proposed as a GW standard must not exceed the concentration suggested as a QS for the protection of freshwater. Therefore the SCHEER does not agree with an EU group quality standard of "PFAS-total" of 0.50 µg.L^{-1}, which stands in sharp contrast to the suggested quality standard for surface waters (AA-EQS) of 0.0044 µg.L^{-1}, i.e. 4.4 ng.L^{-1}.

The SCHEER recommends initiating further development of analytical methodologies and their implementation in Europe so that MS will be able to monitor at least the 24 PFAS identified in the proposed EQS. The SCHEER also recommends supporting further studies for the development of methodologies to determine the total PFAS concentration.

3.3.3.PFAS on Annex I or Annex II?

In the opinion of the SCHEER, and given the existing data and reports as well as geographical and geological differences in MS, would it be more scientifically justified to include any of the proposed PFAS, pharmaceuticals or nrMs in Annex II instead of Annex I? i.e. would it be more appropriate for MS to set threshold values at national, river-basin-district (RBD) or water-body level to take account of variability in their presence/relevance, or differences in hydrological settings and aquifer types? In answering this question, it would be helpful if the Committee could consider the intention of the legislator to achieve where possible a level playing field regarding quality standards, the inter-comparability of results, and uniform implementation across the EU.

*Per- and Polyfluoroalkyl Substances (PFAS) identified as candidates for the annexes: either **all PFAS**, or the following **10 PFAS**: Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexanoic Acid (PFHxA), Perfluoroheptanoic Acid (PFHpA), Perfluorohexane Sulfonate (PFHxS), Perfluorobutane Sulfonate (PFBS), Perfluorodecanoic Acid (PFDA), Perfluorononanoic Acid (PFNA), Perfluoropentanoic Acid (PFPeA), Perfluorobutanoic Acid (PFBA).*

*Option c. Instead of being included in Annex I, PFAS are proposed as a group to consider under **Annex II** to the GWD, for which Member States (MS) should set **threshold values** for the specific substances that pose a risk to their groundwater bodies.*

The SCHEER does not see any scientific reason to consider moving the PFAS as a group to Annex II (option c) and therefore does not support option c. GW bodies in MS should meet the EU standards for groundwater (see section 3.1.2). As said, for the 24 PFAS that are included in the proposed $EQS_{dw,hh,}$ analytical methods are currently available which can be relatively easily implemented in monitoring programmes of the MS.

3.4. Pharmaceuticals, including Carbamazepine and Sulfamethoxazole

3.4.1. Adequacy of quality standards for Carbamazepine and Sulfamethoxazole

Would the quality standards proposed for the two individual pharmaceuticals (Carbamazepine, Sulfamethoxazole) provide adequate protection (to human health and dependent ecosystems) if applied to groundwater? (values based on quality standards work for these substances in surface waters[1]). If not, what values would the SCHEER propose? Option a. These two pharmaceuticals are proposed for the GWD Annex I with an EU quality standard of 0.5 µg.L^{-1} for Carbamazepine and 0.1 µg.L^{-1} for Sulfamethoxazole (based on work on possible quality standards for surface waters) (Option a).

3.4.1.1. Carbamazepine

The EU has proposed a quality standard for carbamazepine in groundwaters of 0.5 µg.L^{-1}. The carbamazepine dossier that the SCHEER is reviewing in parallel proposed an AA-EQS of 0.006 µg.L^{-1}.

The SCHEER identifies the following protection goals:

A. Regarding human health, the carbamazepine dossier provided by the Commission refers to 54 µg.L^{-1} as a suitable drinking water guidance value (Moermond, 2014). The SCHEER proposes by including a safety factor of 100 a carbamazepine $QS_{dw,hh}$ of 0.54 µg.L^{-1} (SCHEER, 2021). Therefore, the SCHEER is of the opinion that a 0.5 µg.L^{-1} standard for carbamazepine will be suitable to protect human health.

B. For protecting groundwater ecosystems, the dominant organism groups are bacteria and invertebrates, with in some cases vertebrates. For bacteria the carbamazepine dossier has not found toxic effects below 8.9 mg.L^{-1} (NOEC). For freshwater invertebrates chronic effects, most of the data reported in the EU dossier report the first toxic effects occurring at concentrations between 25 and 2,400 µg.L^{-1} with one value of 0.3 µg.L^{-1}. The currently proposed carbamazepine freshwater AA-EQS is 0.006 µg.L^{-1}, but the SCHEER does not agree with this value and proposes an alternative AA-QS_{FW} of 2.5 µg L^{-1} in their opinion (SCHEER, 2021). Reported effects for freshwater vertebrates are at the mg.L^{-1} levels.

   In principle, the SCHEER can accept that the Commission could propose a more protective EQS for groundwater than that proposed for surface freshwater. This would also be in line with the evaluation of GW invertebrate sensitivity made by the EMA (2018). In the opinion of the SCHEER, the science behind setting a freshwater carbamazepine EQS_{eco} should be revisited by the Commission. Based on the human health drinking water assessment by the SCHEER, a groundwater standard of 0.5 µg.L^{-1} could be proposed, but in view of the additional assessment factor required for the protection of groundwater organisms this level may not be sufficiently protective.

3.4.1.2. Sulfamethoxazole

The EU has proposed a quality standard for sulfamethoxazole in groundwater from that derived from freshwater. The EQS proposed is 0.1 µg.L^{-1}. The presence of antibiotics in European groundwater has been reported (Lapworth *et al.*, 2012; Viana *et al.*, 2021). The Commission has provided SCHEER with a draft dossier on sulfamethoxazole to allow a review on the ecotoxicity data, the

[1] JRC Technical report. Selection of substances for the 3rd Watch List under the Water Framework Directive, 2020. https://ec.europa.eu/jrc/en/publication/selection-substances-3rd-watch-list-under-water-framework-directive

review of Straub (2016) is also useful. In deciding how to respond, the SCHEER identifies the following protection goals:

A. For human health: A typical drinking water consumption for an adult is 2 $L.d^{-1}$ (WHO, 2017), hence, a level of 0.1 $\mu g.L^{-1}$ would result in a human exposure which is far below the ADI of 25 $\mu g.kg^{-1}_{bw}.d^{-1}$ derived from Swarm *et al.* (1973). The Commission draft dossier for sulfamethoxazole has considered a German report (2001) on drinking water and considers that no safe limit need be set. However, based on an ADI of 510 $\mu g.kg^{-1}_{bw}.d^{-1}$ (Bruce et al, 2010), Schriks *et al.* (2010) derived a provisional drinking water guideline value of 1 $\mu g.L^{-1}$. Therefore, the SCHEER is of the opinion that 0.1 $\mu g.L^{-1}$ should be safe from a drinking water perspective.

B. For protecting groundwater ecosystems, the dominant organism groups are bacteria and invertebrates, with in some cases vertebrates. The lowest inhibitory concentration in bacteria for sulfamethoxazole reported was 1000 $\mu g.L^{-1}$ (Bengtsson-Palme and Larsson, 2016), however, higher tier ecotoxicity studies using biofilms show that even at 0.5 $\mu g.L^{-1}$, sulfamethoxazole can alter microbial activity which might affect nutrient cycling (Kergoat *et al.*, 2021; Yergeau *et al.*, 2012). The EU draft dossier on sulfamethoxazole reviewed the literature and found the lowest value was a NOEC of 6 $\mu g.L^{-1}$ on cyanobacteria and so a deterministic derived AA-EQS of 0.6 $\mu g.L^{-1}$ was proposed. For freshwater invertebrates and vertebrates chronic effects, most of the data report effects between 10 and 250 $\mu g.L^{-1}$ (Straub, 2016). Reported effects for vertebrates are at the $mg.L^{-1}$ levels.

C. For antibiotics, promoting further antibiotic resistance in the environment should be avoided. The review of Bengtsson-Palme and Larsson (2016) examined the potential for certain levels that might promote antibiotic resistance. They suggest that a threshold of 16 $\mu g.L^{-1}$ for sulfamethoxazole would be protective, i.e. levels should not exceed this. Thus an EQS of 0.1 $\mu g.L^{-1}$ sulfamethoxazole is sufficiently protective for freshwater ecosystems, but may not be sufficiently protective for groundwater ecosystems in view of the additional AF required.

3.4.2. A quality standard at EU level for all pharmaceuticals

In the opinion of the SCHEER, which scientific criteria could the Commission use to propose a quality standard at EU level for all pharmaceuticals (i.e. addressing pharmaceuticals as a group of substances) or for subgroups of pharmaceuticals (e.g. human and veterinary pharmaceuticals, pharmaceuticals with particular modes of action), for comparison with the relevant concentration total? In the light of the findings of the report from the GWWL experts on pharmaceuticals in GW and the risk from individual pharmaceuticals[2], does the SCHEER consider enough scientific basis to propose a group total quality standard?

Pharmaceuticals are proposed as a group for GWD Annex I with a ***group total quality standard*** *of* ***0.5 µg/l.*** *(Option b)*

A general standard of 0.5 $\mu g.L^{-1}$ for all pharmaceuticals is suggested as an option by the Commission but without an offered scientific rationale. It is presumed that the Commission is asking for opinions in an either/or form to have a single joint standard or to have a series of case-by-case QSs such as proposed for carbamazepine and sulfamethoxazole.

[2] Pilot exercise on pharmaceuticals with results from 12 participating countries (2016). https://circabc.europa.eu/d/a/workspace/SpacesStore/a1e23792-6ecd-4b34-b86c-dcb6f1c7ad1c/1600204%20Pharm%20Pilot%20Study.docx

An issue that might undermine regulating a standard of 0.5 $\mu g.L^{-1}$ for all pharmaceuticals is the ability or inability of MS to quantify all of the 1000 or so pharmaceuticals present on the market.

In deciding how to respond, the SCHEER has identified the following protection goals:

A. For human health, which is at risk via drinking water, with hormonal agonists, such as synthetic estrogens or progestogens, a level of 0.5 $\mu g.L^{-1}$ may not be protective. For cancer chemotherapy drugs, known as antineoplastics, it has been advised that there is no safe level for exposure for pregnant mothers. In conclusion, the SCHEER considers that a group total quality standard of 0.5 $\mu g.L^{-1}$ for all pharmaceuticals might not be sufficiently protective.

B. For protecting groundwater ecosystems, the dominant organism groups are bacteria and invertebrates, with in some cases vertebrates. Returning to some of the EQSs proposed by the Commission for pharmaceuticals in rivers, these include MAC-EQSs of 0.18 $\mu g.L^{-1}$ for azithromycin, 0.13 $\mu g.L^{-1}$ for clarithromycin and 0.523 $\mu g.L^{-1}$ for erythromycin. This implies that even if azithromycin and clarithromycin were present together, for example, and their combined concentrations were below 0.5 $\mu g.L^{-1}$, they could still be at a level of concern for wildlife in groundwater. The issue of mixtures and the need to avoid underestimating risk is discussed above in section 3.1.2.

C. Finally, for those pharmaceuticals that are antibiotics, there is a concern of promoting further antibiotic resistance in the environment. One review (Bengtsson-Palme and Larsson, 2016) examines the potential for certain levels that might promote antibiotic resistance. A number of these, e.g., azithromycin, chloramphenicol and fidaxomycin, are predicted to risk generating resistance at levels below 0.5 $\mu g.L^{-1}$.

Thus, the opinion of SCHEER is that a general standard of 0.5 $\mu g.L^{-1}$ for all pharmaceuticals would not be sufficiently protective. In due time, it might be possible to derive an overarching limit, but this would require more research (see section 3.2.2) and consideration. One possible direction might be to generate limits for sub-classes of similar pharmaceuticals such as anti-neoplastics, endocrine disrupters (EDs) and antibiotics. However, even if a lower standard was chosen, the concept might be undermined by the analytical difficulties of measuring all the pharmaceuticals present in groundwater.

3.4.3. Pharmaceuticals on Annex I or Annex II?

In the opinion of the SCHEER, and given the existing data and reports as well as geographical and geological differences in MS, would it be more scientifically justified to include any of the proposed PFAS, pharmaceuticals or nrMs in Annex II instead of Annex I? i.e. would it be more appropriate for MS to set threshold values at national, river-basin-district (RBD) or water-body level to take account of variability in their presence/relevance, or differences in hydrological settings and aquifer types? In answering this question, it would be helpful if the Committee could consider the intention of the legislator to achieve where possible a level playing field regarding quality standards, the inter-comparability of results, and uniform implementation across the EU.

Instead of being included in Annex I, pharmaceuticals are proposed as a group to consider under Annex II to the GWD, for which Member States (MS) should set threshold values for the specific substances that pose a risk to their groundwater bodies. Carbemazepine and Sulfamethoxazole are included in the minimum list of pollutants (part B). Additionally, as a guideline, a reference to the GWWL is added, which includes nine pharmaceuticals: Clopidol, Cortamiton, Amidozoic Acid, Sulfadiazin, Primidone, Sotalol, Ibuprofen, Erythromycin, Clarithromycin (Option c).

Given that Quality standards for plant protection products and biocides are supposed to be set as EC criteria (GWD Recital 8), the SCHEER does not see any scientific reason to consider moving pharmaceuticals as a group to Annex

II (option c.). GW bodies in MS should meet the EU standards for groundwater (see section 3.1.3).

3.5. Non relevant metabolites of pesticides

Non-relevant metabolites from pesticides identified as candidates for the annexes: ***desphenylchloridazon, methyl-desphenyl-chloridazon, 2,6-dichlorbenzamid, aminomethylphosphonic acid, metazachlor-acid (OXA), metazachlor-sulfonic acid (ESA), atrazine-2-hydroxy, N,N-dimethylsulfamid (DMS), S-metolachlor-acid (OXA), chlorothalonil-SA (R417888, chlorotalonilsulfonic acid), metolachlor-sulfonic acid (ESA), dimethenamid-ESA, flufenacet-sulfonic acid (ESA), alachlor-t-sulfonic-acid (ESA), S-metolachlor NOA 413173 or VIS-01, dimethachlor CGA 369873.***

3.5.1. Introduction

With respect to its opinion on non-relevant metabolites of pesticides (nrMs), the SCHEER would like to make some remarks upfront.

Although SCHEER recognises the Sanco (2003) document as the currently applicable guidance document for the assessment of non-relevant pesticide metabolites (nrMs), SCHEER would like to emphasise that this document urgently needs to be updated. The main legal frameworks that the Sanco guidance document uses to develop decision criteria for nrMs, especially Council Directive 91/414/EEC and Directive 67/548/EEC, have been repealed and replaced by EC Regulations EC 1107/2009 and EC 1272/2008 respectively. Furthermore, recent scientific assessments of the TTC approach for assessing data-poor chemicals (in particular the EFSA Guidance from 2012 as updated by EFSA (2019b), as well as the SCHER Opinion from 2012) should be taken into account in an updated guidance document. Such an update would also provide the opportunity to align the approaches with the strategies used for assessing other "emerging contaminants" and mixtures.

However, in the following evaluation, the SCHEER has used the Sanco (2003) document as the basis for its evaluation, according to the mandate provided.

3.5.2. Identification of non-relevant metabolites

Degradation of plant protection products, also called pesticides, leads to the formation of metabolites, which have been a topic of discussion for some time. The discussion started around the end of the 90s leading to, in 2003, the publication of the Guidance document (Sanco, 2003) on the assessment of metabolites under the Plant Protection Products (PPP) Directive 91/414/EC which was replaced by Regulation 1107/2009. The document proposes an approach to distinguish between relevant and non-relevant metabolites. A decision tree was developed to aid to the question of relevance (Sanco, 2003). For relevant metabolites (>10% of applied radioactivity), the applicant of a PPP is required to submit a complete PPP soil data set (degradation (DT_{50soil}), sorption (K_{om}) to be taken into account by the EU authorities for their registration decision. In principle, the DT_{50soil} (d) and the K_{om} ($dm^3\ kg^{-1}$) are sufficient to determine potential leaching to groundwater.

Other metabolites are further screened using data on biological activity, genotoxicity and toxicity, but are considered non-relevant if certain criteria are met. The SCHEER would describe the procedure as follows:

According to the Guidance Document (Sanco, 2021), non-relevant metabolites are defined as metabolites that:

- do not fulfil the criteria for metabolites of no concern, and are not active substances, and
- do have a biological activity of less than 50% of the parent compound, and

- do not cause gene mutation (in both bacterial and mammalian cells), or cause structural chromosomal alterations (clastogenicity) or cause numerical chromosomal alterations (aneugenicity), and
- do not qualify for classification as Acute Tox. categories 1, 2 or 3, STOT SE1 or STOT RE1 according to the Regulation (EC) No 1272/2008, and
- do not qualify for classification for reproductive toxicity (any category: 1A, 1B or 2 according to the Regulation (EC) No 1272/2008), and
- do not originate from parent-active substances classified as category 1A or category 1B carcinogens according to Regulation (EC) No 1272/2008), and
- convincing evidence is available, for a metabolite from parent-active substances classified as category 2 carcinogens according to Regulation (EC) No 1272/200818), that the metabolite will not lead to any risk of carcinogenicity, and
- there are no reasons to expect that the metabolite may raise toxicological hazards of concern, and
- the groundwater exposure does not exceed 0.75 µg/L.

3.5.3. Adequacy of proposed uniform quality standards for individual nrMs and for total nrMs

Would the proposed uniform quality standard(s) for individual nrMs and for total nrMs provide adequate) protection (to human health and dependent ecosystems) if applied to groundwater in relation to the 16 listed nrMs (and possibly others)? The proposed approach is analogous to the current approach in the GWD and DWD to "pesticides", and takes into account the range of values established by MS and the magnitude of certain values mentioned in the guidance on establishing relevance of metabolites in groundwater (Sanco, 2003), although that guidance recommends a case-by-case approach. The SCHEER is asked to take into account: relevant data from the assessment of individual substances performed in the context of Regulation (EC) No 1107/2009, the reasons underpinning the limit values already established by MS, relevant literature on the nrMs listed, and on others, as well as any relevant surface water quality standards and the Technical Guidance Document on Deriving EQS for pollutants in surface waters.

Option. The listed nrM are proposed for inclusion in GWD Annex I with an individual EU quality standard[3] of 1 µg.L^{-1} for each nrM substance.

The SCHEER identifies the following protection goals:

A Protecting human health:

In the opinion of the SCHEER, the proposal to use a uniform quality standard for individual nrMs provides adequate protection for human health and dependent ecosystems if applied to groundwater.

The SCHEER is of the opinion that a value of 0.75 µg L^{-1} as suggested by Sanco (2003) for all non-relevant metabolites, protects human health unless additional relevant toxicological information comes to light that suggests otherwise, e.g., concerning ED effects. The SCHEER does not support the proposed value of 1.0 µg L^{-1} because no reason is provided for the deviation from the value of 0.75 µg L^{-1} used in Sanco (2003).

B Protecting the environment:

[3] According to the data provided within the EU Working Group Groundwater, for those countries in Europe that have set legal or guiding groundwater limits for nrMs, they have set limits within the range of 0.1 µg L^{-1} - 1 µg L^{-1} (with an exceptional case of 4.5 µg L^{-1} for one particular nrM). The uniform value of 1 µg/l is proposed by analogy with the existing uniform value for individual "pesticides" in Annex I of the GWD. In addition, Annex I point 3 of the GWD indicates that Member States can establish more stringent values if the EU quality standards could result in failure to achieve the environmental objectives. The Sanco guidance of 2003 suggests a case-by-case assessment but with an (individual) upper limit of 10 µg L^{-1} and a value of 0.75 µg L^{-1} if a risk assessment has been performed but is incomplete.

As outlined above, a quality standard that is protective for freshwater ecosystems may not be sufficiently protective for ground water ecosystems. The SCHEER notes that the scientific literature currently suggests a protective value of 0.1 µg L^{-1} for data-poor chemicals in freshwater ecosystems, based on the ecoTTC-approach (De Wolf *et al.*, 2005; Gutsell *et al.*, 2015). The value of 0.1 µg.L^{-1} can serve as a benchmark to which an additional AF should be applied, because the SCHEER does not yet have strong evidence that the unique groundwater invertebrates have a similar sensitivity to surface freshwater invertebrates and, therefore, there is a precautionary requirement for an additional AF.

3.5.4. Appropriateness of the "uniform approach" for nrMs

The SCHEER is also asked to provide a scientific view on whether the "uniform standard" approach is appropriate, and on whether the appropriateness of a uniform group standard would depend upon whether the group is limited to the 16 listed nrMs. It might wish to consider involving the European Food Safety Authority (EFSA) where necessary to ensure coherence and harmonisation in the spirit of the 'one substance, one assessment' approach as outlined in the EU Chemicals Strategy, bearing in mind that the approach supports a gradual move away from assessing and regulating chemicals substance-by-substance to regulating them as groups.

Option b. All (or only the above-listed) nrM are proposed as a group for GWD Annex I with a group total quality standard of 10 µg L^{-1}. [4]

The SCHEER concluded that a uniform approach should be followed in the evaluation of nrMs. The SCHEER is also of the view that given the definition of nrMs, setting a quality standard is not underpinned by science but guided by monitoring data and the precautionary principle.

Based on the reasoning above, the SCHEER does not agree with a group total quality standard of 10 µg L^{-1} (option b). If a group total quality standard would be preferred, it is the opinion of the SCHEER that the principles of mixture toxicity assessment as outlined in section 3.2.2 should be followed. The SCHEER also recommends that the approach should not be limited to the 16 named nrMs but also applied to potentially other nrMs identified in the future.

3.5.5. nrMs on Annex I or Annex II

In the opinion of the SCHEER, and given the existing data and reports as well as geographical and geological differences in MS, would it be more scientifically justified to include any of the proposed PFAS, pharmaceuticals or nrMs in Annex II instead of Annex I? i.e. would it be more appropriate for MS to set threshold values at national, river-basin-district (RBD) or water-body level to take account of variability in their presence/relevance, or differences in hydrological settings and aquifer types? In answering this question, it would be helpful if the Committee could consider the intention of the legislator to achieve where possible a level playing field regarding quality standards, the inter-comparability of results, and uniform implementation across the EU.

Option c. nrM are included in Annex II to the Groundwater Directive; MS have to consider establishing threshold values in accordance with Article 3.

The SCHEER is of the opinion that local, national, regional, river basin or water body differences will always influence the presence of nrMs. Setting a specific standard based on such differences is a scientific challenge and the SCHEER would support scientific progress in this area, on a case-by-case basis that could lead to setting specific criteria.

In the opinion of the SCHEER, option c., listed in the Annex to the mandate, including the nrMs in Annex II, is not appropriate.

[4] The group value of 10 µg.L^{-1} is proposed by analogy with the existing group value for "pesticides". GWD Annex I point 3 also applies (see Footnote 1).

In conclusion, the SCHEER is of the opinion that keeping a level-playing-field across the EU when setting quality standards is not only helpful for the person/ body submitting the pesticides dossier and the consumer, but also for the MS authorities, who would be saved a substantial amount of work. In the future, these standards may be reconsidered if new scientific knowledge suggests the need for changing them.

4. MINORITY OPINION

None

5. CONCLUSIONS

The SCHEER was asked to evaluate groundwater quality standards for proposed additional pollutants, including pollutant groups, in the annexes to the Groundwater Directive. To do so, the SCHEER discussed the specificity of groundwater ecosystems, the relationship between quality standards for surface waters (freshwaters) and groundwater, the risk assessment of mixtures, and the harmonisation of quality standards in MS.

General conclusions

The SCHEER is of the opinion that

1. uniform EU-wide quality standards should be set for the groundwater body for chemicals with no natural background concentrations,
2. an additional assessment factor for the protection of groundwater organisms is warranted, following the Guidance document by the European Medicines Agency (EMA, 2018). However, the SCHEER considers the size of such an assessment factor as still being uncertain, especially for non-pharmaceuticals,
3. groundwater quality standards should not exceed the concentrations put forward as quality standards for surface waters (AA-EQS),
4. quality standards set for groundwater should not be higher than those for drinking water,
5. for harmonising principles, drinking water QS may be used as GW standards, unless lower specific EQS exist, such as, for pharmaceuticals.

Specific conclusions

The SCHEER is of the opinion that

For PFAS

6. the relative potency factor (RPF) approach should be used for QSs of PFAS,
7. the value of 4.4 ng.L^{-1} for PFOA equivalents can be adopted as a quality standard for GW. The SCHEER does not agree with an EU group quality standard of "PFAS-total" of 0.50 µg L^{-1},

For pharmaceuticals

8. the value of 0.5 µg.L^{-1} proposed as a groundwater quality standard for carbamazepine is not sufficiently protective,
9. the proposal for a sulfamethoxazole groundwater QS of 0.1 µg.L^{-1} is not sufficiently protective,
10. a general standard of 0.5 µg.L^{-1} for all pharmaceuticals would not be sufficiently protective,

11. there is no scientific reason to consider moving pharmaceuticals as a group to Annex II.

For non-relevant metabolites of PPP

12. a uniform approach should be followed in the evaluation of nrMs,
13. the proposal to use a uniform quality standard(s) for individual nrMs and for total nrMs does provide adequate protection for human health and dependent ecosystems,
14. a group total quality standard for nrMs of 10 $\mu g.L^{-1}$ is not supported,
15. a value of 0.75 $\mu g.L^{-1}$ for all non-relevant metabolites should protect human health if no additional relevant toxicological information is made available, e.g., ED effects. However, the SCHEER recommends using a value of 0.1 $\mu g.L^{-1}$, adjusted by an additional AF (see above), as an interim quality standard for nrMs in the groundwater body, protecting exposed groundwater biota,
16. the approach should not be limited to the 16 nrMs currently identified but also applied to other nrMs identified in the future.

6. REFERENCES

Bengtsson-Palme J, Larsson DGJ (2016) Concentrations of antibiotics predicted to select for resistant bacteria: Proposed limits for environmental regulation. Environment International 86, 140-149.

Blum A, Balan SA, Scheringer M, Trier X, Goldenman G, Cousins I, Diamond M, Fletcher T, Higgins C, Lindeman AE, Peaslee G, de Voogt P, Wang Z, Weber R (2015) The Madrid Statement on Poly- and Perfluoroalkyl Substances. Environ. Health Perspect.123, A107-A111.

Bopp SK, Kienzler A, Richarz AN, van der Linden SC, Paini A, Parissis N, Worth AP (2019) Regulatory assessment and risk management of chemical mixtures: challenges and ways forward. Critical Reviews in Toxicology, 49, 174-189.

Brendel S, Fetter E, Staude C, Vierke L, Biegel-Engler A (2018) Short-chain perfluoroalkyl acids: environmental concerns and a regulatory strategy under REACH, Environmental Science Europe 30, 11.

Bruce GM, Pleus RC, Snyder SA (2010). Toxicological relevance of pharmaceuticals in drinking water. Environmental Science and Technology, 44, 5619-5626.

Brusseau ML (2018) Assessing the potential contributions of additional retention processes to PFAS retardation in the subsurface. Science of the Total Environment 613-614:176-185.

Castaño-Sánchez A, Hose GC, Reboleira ASP (2020) Ecotoxicological effects of anthropogenic stressors in subterranean organisms: A review. Chemosphere, 244, p.125422.

Cousins IT, Goldenman G, Herzke D, Lohmann R, Miller M, Ng CA, Patton S, Scheringer M, Trier X, Vierke L, Wang Z, DeWitt JC (2019) The concept of essential use for determining when uses of PFASs can be phased out. Environmental Science: Processes and Impacts, 21, 1803-1815.

Deharveng L, Stoch F, Gibert J, Bedos A, Galassi D, Zagmajster M, *et al.* (2009) Groundwater biodiversity in Europe. Freshwater Biology 54, 709-726.

De Wolf W, Siebel-Sauer A, Lecloux, A, Koch V, Holt M, Feijtel T, Comber M, Boeije G (2005) Mode of action and aquatic exposure thresholds of no concern. Environmental Toxicology and Chemistry 24, 479

EC (European Commission, 2018). Common implementation strategy for the Water Framework Directive (2000/60/EC). Technical report 2011-055.Guidance Document No. 27. Technical guidance for deriving Environmental Quality Standards. Updated version 2018.

EC (European Commission, 2020). Commission Staff Working Document: Progress report on the assessment and management of combined exposures to multiple chemicals (chemical mixtures) and associated risks. SWD 250 final.

ECHA (European Chemicals Agency, 2011). Background Document to the Opinion proposing harmonised classification and labelling at Community level of Metazachlor. ECHA/RAC/CLH-O-0000001586-69-01/A1, Helsinki.

EFSA (European Food Safety Authority, 2019a) Guidance on harmonised methodologies for human health, animal health and ecological risk assessment of combined exposure to multiple chemicals. EFSA Journal 17:5634 (77 pp), Parma.

EFSA (European Food Safety Authority, Scientific Committee, 2019b). Guidance on the Use of the Threshold of Toxicological Concern Approach in Food Safety Assessment. EFS2, 17 (6), Parma.

EMA (European Medicines Agency, 2018). Guideline on assessing the environmental and human health risks of veterinary medicinal products in groundwater (EMA/CVMP/ERA/103555/2015,London.

Gaston L, Lapworth DJ, Stuart M, Arnscheidt J (2019) Prioritization approaches for substances of emerging concern in groundwater: a critical review. Environmental Science and Technology 53(11), 6107–6122. DOI: 10.1021/acs.est.8b04490.

Gellrich V, Stahl T, Knepper TP (2012) Behavior of perfluorinated compounds in soils during leaching experiments, Chemosphere, 87, 1052-1056.

Gutsell S, Hodges G, Marshall S, Roberts J (2015) ecotoxicological thresholds-practical application to an industrial inventory: ecotoxicological thresholds and industrial inventory. Environmental Toxicology and Chemistry 34, 935–942.

Kergoat L, Besse-Hoggan P, Leremboure M, Beguet J, Devers M, Martin-Laurent F, *et al.* (2021) Environmental concentrations of sulfonamides can alter bacterial structure and induce diatom deformities in freshwater biofilm communities. Frontiers in Microbiology 12, 12.

Kwiatkowski CF, Andrews DQ, Birnbaum LS, Bruton TA, *et al.* (2020). Scientific basis for managing PFAS as a chemical class. Environmental Science and Technology Letters, 7, 532−543.

Lapworth DJ, Baran N, Stuart ME, Ward RS (2012) Emerging organic contaminants in groundwater: A review of sources, fate and occurrence. Environmental Pollution 163, 287-303.

Meek ME, Boobis AR, Crofton KM, Heinemeyer G, van Raaij M, Vickers C (2011) Risk assessment of combined exposure to multiple chemicals: A WHO/IPCS framework. Regulatory Toxicology and Pharmacology 60 (2011) S1–S14.

Moermond CTA (2014). Environmental risk limits for pharmaceuticals: Derivation of WFD water quality standards for carbamazepine, metoprolol, metformin and amidotrizoic acid. RIVM, Bilthoven, the Netherlands., RIVM Letter Report 2014.

Munro IC, Renwick AG, Danielewska-Nikiela B (2008). The Threshold of Toxicological Concern (TTC) in risk assessment. Toxicology Letters 180, 151-156.

Niegowska M, Pretto P, Porcel-Rodriguez E, Marinov D, Ceriani L, Lettieri T (2021). Per- and polyfluoroalkyl substances (PFAS) of possible concern in the aquatic environment. EC Joint Research Centre Technical Report, EUR 30710 EN.

NIEHS (2021) www.niehs.nih.gov/health/topics/agents/pfc/index.cfm#footnote2 (accessed Sep 2021).

OECD (2018) Considerations for Assessing the Risks of Combined Exposure to Multiple Chemicals, Series on Testing and Assessment No. 296, Environment, Health and Safety Division, Environment Directorate.

Rosi-Marshall EJ, Kincaid DW, Bechtold HA, Royer TV, Rojas M, Kelly JJ (2013) Pharmaceuticals suppress algal growth and microbial respiration and alter bacterial communities in stream biofilms. Ecological Applications 23, 583-593.

Schriks M, Heringa M, van der Kooi MM, de Voogt P, van Wezel AP (2010) Toxicological relevance of emerging contaminants for drinking water quality. Water Research 44, 461-476.

SCHEER (2021). Scientific Opinion on draft environmental quality standards for priority substances under the Water Framework Directive. Carbamazepine (in preparation).

SCHER/SCCS/SCHENIR (2012). Opinion on use of the threshold of toxicological concern (TTC) approach for human safety assessment of chemical substances with focus on

cosmetics and consumer products. European Commission. Directorate General for Health and Consumers. Publications Office: Luxemburg.

Scientific Committee on Plants (2002). Opinion of the Scientific Committee on Plants regarding the draft guidance document on relevant metabolites (Document SANCO/221/2000-Rev. 7b of 3 July 2002) - (opinion adopted by the scientific committee on plants on 17 December 2002) scp/guide-metab/002 bis final of 1 December 2002, Luxemburg.

Sanco (2003). Guidance document on the assessment of the relevance of metabolites in groundwater of substances regulated under council directive 91/414/EEC, Luxemburg.

Sanco (2021). Guidance document on the assessment of the relevance of metabolites in groundwater of substances regulated under Regulation (EC) No 1107/2009. Sanco/221/2000 – rev.11; 21 October 2021, Luxembourg.

Straub JO (2016). Aquatic environmental risk assessment for human use of the old antibiotic sulfamethoxazole in Europe. Environmental Toxicology and Chemistry 35, 767-779.

Swarm RL, Roberts GKS, Levy AC, Hines LR (1973) Observations on the thyroid gland in rats following the administration of sulfamethoxazole and trimethoprim. Toxicology and Applied Pharmacology, 24, 351–363.

U.S. Environmental Protection Agency (2021). PFAS methods and guidance for sampling and analyzing water and other environmental media (Technical Brief). https://www.epa.gov/water-research/pfas-methods-and-guidance-sampling-and-analyzing-water-and-other-environmental-media (accessed Sept 2021).

Viana P, Meisel L, Lopes A, de Jesus R, Sarmento G, Duarte S, *et al.* (2021) Identification of Antibiotics in Surface-Groundwater. A Tool towards the Ecopharmacovigilance Approach: A Portuguese Case-Study. Antibiotics-Basel 10, 22.

WHO (2017). Guidelines for drinking-water quality, 4th edition. Geneva. ISBN: 978-92-4-154995-0.

Yergeau E, Sanschagrin S, Waiser MJ, Lawrence JR, Greer CW (2012) Sub-inhibitory concentrations of different pharmaceutical products affect the meta-transcriptome of river biofilm communities cultivated in rotating annular reactors. Environmental Microbiology Reports 4, 350-359.

7. LIST OF ABBREVIATIONS

AA	annual average
AI	active ingredient (of a PPP)
bw	body weight
CA	concentration addition
DT50	Half-life; time it takes for an amount of a compound to be reduced by half through degradation
DWD	drinking water directive of the EU
EC_{50}	(effect) concentration where 50% of the effect is exhibited
ED	endocrine disrupter
EPA	US Environmental Protection Agency
EQS	environmental quality standards
GW	groundwater
GWWL	groundwater watch list
HH	human health
IA	independent action
MAC	maximum admissible concentration
MS	EU Member States
NOEC	no observed effect concentration
nrM	non-relevant metabolite of a pesticide
PEC	predicted environmental concentration
PFAA	perfluorinated alkyl acid
PFAS	per- and polyfluorinated alkyl substances
PMT	persistent, mobile and toxic
PPP	plant protection product
QS	quality standard
RAC	regulatory acceptable concentration
STOT	specific target organ toxicity
vPvM	very persistent, very mobile
TTC	threshold of toxicological concern
WFD	water framework directive of the EU