Update 2024

RIWA

RIWA-Meuse

Drinking water relevant substances in the Meuse

An update of the lists with substances that are relevant for the production of drinking water from the river Meuse

RIWA - Vereniging van Rivierwaterbedrijven

Colophon

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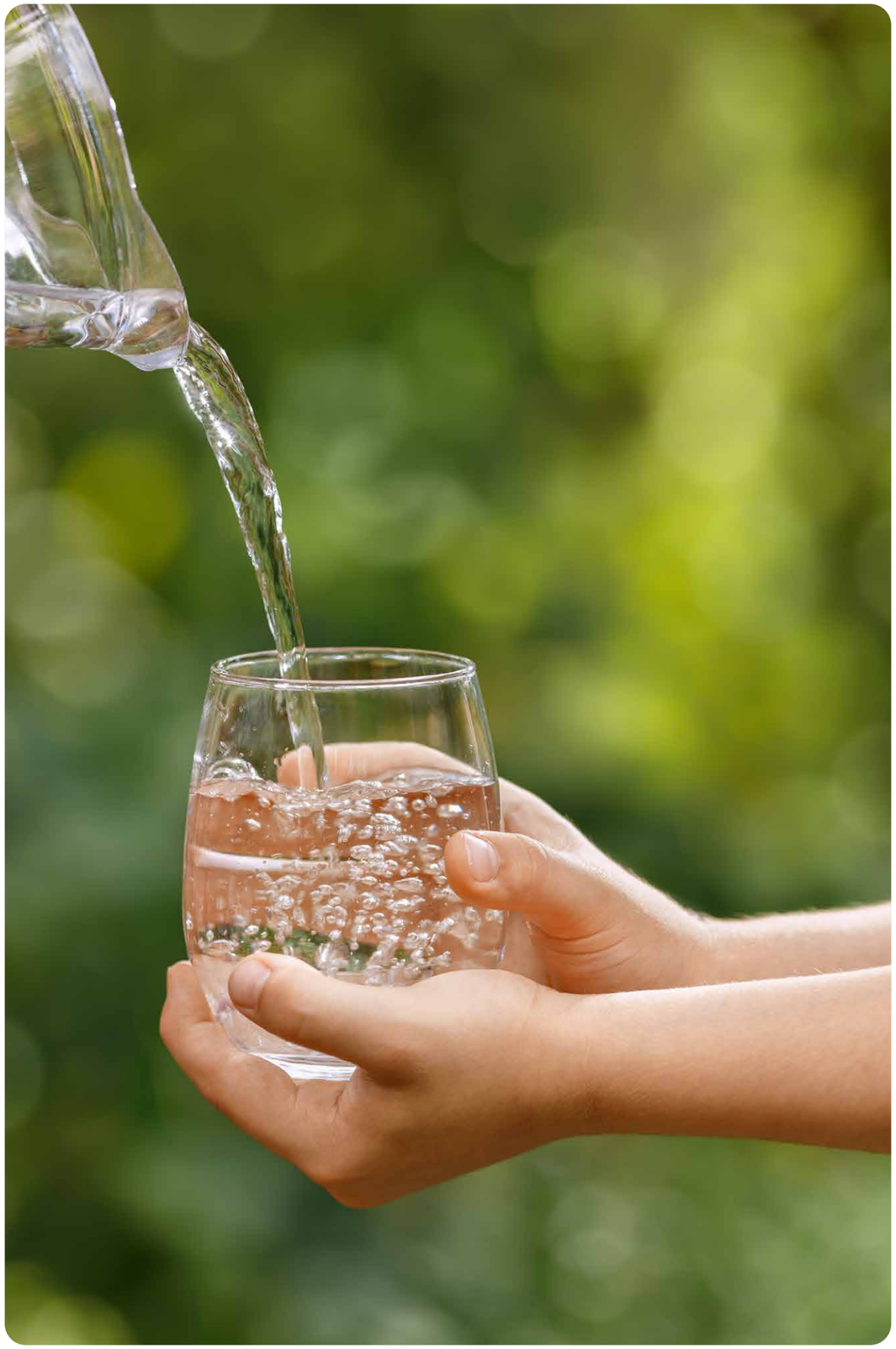
Summary

RIWA-Meuse, the Association of River Water Works along the Meuse, represents the interests of drinking water companies in Belgium and the Netherlands using the Meuse as a source. Its goal is to ensure clean river water for a sustainable supply of high-quality drinking water. RIWA-Meuse monitors water quality and advocates for improvements where needed. Since 2007, it has focused on substances relevant to drinking water production.

This study aims to evaluate and update the lists of (1) drinking water relevant substances and (2) candidate substances for drinking water relevance. Substances are classified as relevant if they meet a defined set of criteria, including detection frequency, concentrations exceeding ERM target values, (potential) removal efficiency during water treatment, toxicity, odour or taste thresholds, and public perception. The assessment of these criteria requires the availability of monitoring data. Substances anticipated to be present in the Meuse but not yet monitored are designated as candidate relevant substances. The criteria for determining relevance to drinking water production have been refined over time.

The candidate list is divided in A) a list of substances that a are known to be present in the Meuse and are recommended for monitoring with a target analysis and B) a list that contains the substances that will first be monitored with a screening method (since this is more practical to quickly screen whether a substance is present or not). This means the following lists are used:

- **List 1** : Drinking water relevant substances
- **List 2** : Candidate drinking water relevant substances
  List 2a : Candidate substances for quantitative monitoring
  List 2b : Candidate substances for screening
- **List 3** : Substances which no longer meet the criteria



Besides, a parking list is introduced this evaluation for substances that are found to be present, but for which advocating for reduction is of little value, e.g. in case of naturally occurring substances.

The evaluation was performed based on measurement data from the monitoring stations and intake points along the Meuse in the period 2019-2023. New candidate drinking water relevant substances are identified based on a literature study and screening data. All associated drinking water companies are recommended to monitor the selected compounds on List 1, 2a and 2b in order to have a detailed insight in the water quality of the river Meuse.

"RIWA-Meuse monitors water quality and advocates for improvements where needed. Since 2007, it has focused on substances relevant to drinking water production."

List 1 now includes a total of 42 substances (one of which is a substance group, i.e. PFAS). Nine of these are grouped into four sets, as they consist of parent substances and their corresponding metabolites. The percentage distribution of substances according to application was analysed and compared to the previous report from 2021. The results show a similar pattern, with most substances categorized as industrial applications, pharmaceuticals (including metabolites), pesticides (including metabolites), and disinfection by-products. Industrial substances and disinfection by-products together account for approximately half of the total substances.

List 2a includes 13 components for which an analytical method is available. It is recommended to include these substances in the joint monitoring program of the Meuse and analyse them using quantitative analytical methods. For the 50 substances from List 2b, it is suggested to either add them to the screening database and initially track them in the Meuse through targeted screening or to do a preliminary screening using non-target screening (NTS).

List 3 contains all substances that are completely evaluated, but do not or no longer fulfil the criteria to be present on List 1 or 2. This list is kept in order to secure the information with regard to the evaluation of these substances and to avoid duplication of efforts during a following evaluation.

Contents

Abbreviatons

ADI	Acceptable Daily Intake
AMPA	Aminomethylphosphonic acid
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQZ	Aqualab Zuid
BQ	Benchmark Quotient
BTO	Bedrijfstakonderzoek (Joint Research)
CALUX	Chemical Activated Luciferase gene eXpression
CMR	Carcinogenic, Mutagenic, or toxic for Reproduction
DDAC	Didecyldimethylammonium
DDD	Daily Defined Dose
DIPE	Diisopropylether
DMMM	Di(methoxymethyl)melamine
DTPA	Diethylenetriaminepentaacetic acid
EC	European Commission
ECHA	European Chemicals Agency
EDDP	((2E,5R)-2-Ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine)
EDTA	Ethylenediaminetetraacetic acid
EFSA	European Food Saftey Authorization
EMA	European Medicines Agency
EQS	Environmental Quality Standards
ERM	European River Memorandum
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
HIV	Human Immunodeficiency Virus
HMMM	Hexa(methoxymethyl)melamine
HMSA	Halogenated methanesulfonic acid
HWL	Het Waterlaboratorium
HYPA	3-Propyl-1H-1,2,4-triazole-5-amine
IAZI	Industrial Wastewater Treatment Plant
IBA	Indole-3-butyric acid
JECFA	Joint Expert Committee on Food Additives
KIWK	Kennisimpuls Waterkwaliteit (Water quality knowledge boost program)
K_{ow}	Octanol/water partition coefficient
KWR	KWR Watercycle Research Institute
LANUV	Landesamt fÜr Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen
LC	Liquid chromatography
LUBW	Landesanstalt für Umwelt Baden-Württemberg
Max	Maximum concentration in the Meuse in 2019-2023
MGDA/-ADA	Methylglycindi acedic
MMMM	Mono(methoxymethyl)melamine
MRL	Maximum Residue Limit
NORMAN	Network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances
NRTI	Nucleoside Reverse Transcriptase Inhibitors
NSAID	Non-Steroidal Anti-Inflammatory Drug
NTA	Nitrilotriacetic acid
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFECHS	Perfluoro-p-ethylcyclohexylsulfonic acid
PFPrA	Perfluoropropionic acid
PFPrS	Perfluoropropanesulfonic acid
pGLV	Provisional drinking water guideline value
PMMM	Penta(methoxymethyl)melamine
PMT	Persistent, mobile and toxic
(p)SVHC	(potential) Substance of Very High Concern (Dutch: ZZS)
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (Dutch Nationale Institute for Health and Environment)
RIWA	Association of River Waterworks
RWS	Rijkswaterstaat (the executive agency of the Ministry of Infrastructure and Water Management in the Netherlands)
STOWA	Stichting Toegepast Onderzoek Waterbeheer (Foundation for Applied Water Research)
TCA	Trichloroacetic acid
TDI	Tolerable Daily Intake
TFA	Trifluoroacetic acid
TMMM	Tri(methoxymethyl)melamine
TTC	Threshold of Toxicological Concern
UHPLC-qToF-MS	Ultra-High Performance Liquid Chromatography with Quadrupole Time-Of-Flight Mass Spectrometry
US EPA	United States Environmental Protection Agency
vPvM	Very Persistent, Very Mobile
WFD	Water Framework Directive
WHO	World Health Organization
WiCE	Water in the Circular Economy
WLN	Waterlaboratorium Noord
WWTP	Wastewater Treatment Plant

1 Background

In 2007 RIWA-Meuse began to focus on specific substances which are relevant for the production of drinking water. Relevant in the sense that these substances have the potential of ending up in drinking water after going through a natural treatment process; a situation which is clearly undesirable. The reason behind this approach was article 7.3 of the Water Framework Directive 2000/60/EC (WFD), which states: "Member States shall ensure the necessary protection for the bodies of water identified with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water. Member States may establish safeguard zones for those bodies of water."

The WFD sets European environmental quality standards (EQS) for Priority Substances and Priority Hazardous Substances in order to achieve good chemical status of water bodies. For each river basin additional standards can be set for specific substances which hinder reaching good chemical and good ecological status. As RIWA-Meuse felt this was insufficient, it started looking for a framework that helps set the target on reducing the level of purification treatment required in the production of drinking water. River water companies had already published several memoranda in which they published target values that permit sustainable production of drinking water with basic natural treatment methods. By determining which substances disallow this benchmark, RIWA-Meuse thereby focused on their emissions. In the beginning these substances were called 'threatening the drinking water function of the river Meuse'.

In 2007 a total number of 16 substances were classified as 'threatening' and 34 as 'potentially threatening' (Van den Berg et al., 2007). After an update in 2009, a number of 19 substances were classified as 'threatening' and again 34 as 'potentially threatening' (Van den Berg, 2009). Due to the term 'threatening' being deemed as having a severe connotation, as of 2011 the classification was renamed 'substances which are relevant for the production of drinking water from the river Meuse' or 'drinking water relevant substances' for short. In 2011 a total number of 19 substances were classified as 'drinking water relevant' and this was also the first time they were ranked by relevance (Fischer et al., 2011). Likewise, 23 substances were classified as 'potential drinking water relevant' based on 13 measurements per year. Another 30 substances were also classified as 'potential drinking water relevant' based on 4 measurements per year.

During an evaluation in 2015, a number of 28 substances were classified as 'drinking water relevant' and 34 as 'candidate drinking water relevant' which is the new name for what previously was called 'potential drinking water relevant' (Van der Hoek et al., 2015). For the first time also, a list was drawn of 53 'no longer drinking water relevant substances'. After the evaluation in 2018, the list of drinking water relevant substances now consists of 33 chemical compounds (Van der Velden-Slootweg et al., 2018). A number of 15 substances were classified as 'candidate drinking water relevant' and the list of 'no longer drinking water relevant substances' contains 82 chemical compounds. The previous evaluation in 2021 resulted in a list of 30 drinking water relevant substances, of which one is a group consisting of 20 perfluoroalkyl and polyfluoroalkyl substances (PFAS) so technically the total number of substances on that list is 49 (Slootweg et al., 2021). A distinction was made between 14 candidate drinking water relevant substances to enter the joint monitoring program of RIWA Meuse and follow them with a quantitative analytical method and 19 candidate drinking water relevant substances to be followed with targeted screening.

In this study new candidate drinking water relevant substances were identified. The evaluation was performed using measurement data from the monitoring stations and intake points along the Meuse during the period 2019-2023. The criteria used for determining the relevance of substances for drinking water production have evolved over the years. The current selection criteria are described in paragraph 2.1.

2

Methodology

2.1 Ranking methodology

To assess the relevance of substances for drinking water production using the Meuse as a source, specific criteria were defined, which a substance must meet. These criteria concern the following parameters:

- Measured concentrations
- Frequency of detection
- Distribution across the Meuse catchment area
- Recent occurrences
- Toxicological properties*
- Potential or actual removal efficiency during water treatment*

* *These two characteristics are used to calculate an individual substance score (see Appendix I.1)*

Figure 1 on page 16-17 presents a schematic of the evaluation process for these substances.

Substances are only included on List 1 if sufficient monitoring data from the Meuse is available. To address gaps in data, List 2 was introduced in 2015. This list includes substances identified through various sources (e.g., literature, screening data, external monitoring, usage data) as potentially relevant for drinking water derived from the Meuse. When adequate monitoring data becomes available, the status of substances on List 2 can be reassessed for potential inclusion on List 1.

A practical challenge arises when analytical methods are unavailable for some candidate substances. Developing these methods can be costly and time-intensive, especially if the expected concentration range is uncertain. To address this, newer (target) screening techniques based on liquid chromatography (LC) offer a flexible solution: substances that are likely present in the Meuse, but in unknown concentration ranges, can initially be added to the target screening database. This approach allows for preliminary monitoring in surface and drinking water. If screening results indicate relevance, a targeted analysis method can then be developed to quantify the substance and determine if it should move to List 1.

The ranking methodology has therefore been adapted in 2021 by including an additional list for candidate substances recommended for screening-based monitoring.

In some cases, both a parent substance and its metabolite(s) may appear on List 1 and/or List 2. As a rule, they are grouped and placed together on one list, as having monitoring data for both the parent substance and its metabolite can illustrate how the degradation of a substance into a persistent metabolite could impact water quality (Van der Hoek et al., 2015).

The following monitoring frequencies are maintained for each list:

List 1: **13 times** per year over **5 years**
List 2a: **13 times** per year over **1 year**
List 2b: **13 times** per year via **targeted screening**
List 3: Monitoring needs are determined individually by drinking water companies

During the latest update in 2021, adjustments were made to the methodology. The criterion of “public perception” was excluded from the scoring. Previously, the criterion of “public perception” was included in scoring, granting 3 points if a substance fell into categories like “pharmaceutical,” “pesticide,” “hormone,” or “hormone disruptor,” based on public concerns around biologically active substances (Fischer et al., 2011). However, this led to a scoring bias, as these substances already received high scores due to their toxicity. Industrial substances, particularly those with harmful properties like PFAS, were also perceived as undesirable, so public perception is no longer a scoring criterion.

On the other hand, substances with low benchmark quotients (BQ) but that exceed legal standards — such as aminomethylphosphonic acid (AMPA) — remain significant for water companies, as exceeding legal limits requires an exemption to use surface water for drinking water production. Substances exceeding legal norms now receive 3 points.

An issue for the toxicity scoring of candidate substances is the lack of measured concentrations. In the methodology an estimated concentration of 1 or 10 µg/L is now used to calculate a BQ and toxicity score. These estimates, based on literature or monitoring data, provide a preliminary risk indication by comparing the estimated concentration with the provisional drinking water guideline value (pGLV).

The specific criteria for each list:

List 1 Drinking water relevant substances

1. **Detection Frequency:** The substance must have been detected at two or more RIWA Meuse monitoring stations or intake points over the last 5 years (for a minimum of two years), with a detection frequency of at least 7% of the measurements[1]; *and*
2. **Exceeding Target Values:** The substance must have exceeded the European River Memorandum (ERM) target values or the Dutch Drinking Water Standards at least twice in the past 5 years at different RIWA Meuse monitoring stations or intake points (considering potential removal via conventional treatment) with a detection frequency of at least 1%; *and*
3. **Recent Exceedance:** The substance must have exceeded either the drinking water standard or the ERM target value used by drinking water companies at least once in the past 3 years; *and*
4. **Scoring Threshold:** The substance must achieve a total score of 10 or higher, with at least 1 point attributed to each removal-related parameter (polarity, volatility, and biodegradability). Details on scoring are provided in Appendix I.1.

If the benchmark quotient of a substance is 1 or higher, it is automatically referred as relevant for drinking water, allowing criteria 2, 3, and 4 to be bypassed.

List 2a Candidate substances for quantitative monitoring

1. **Current Concentrations:** The substance is detected in the Meuse at concentrations above the ERM target value; *or*
2. **Expected Increase:** The concentration of the substance is expected to rise in the near future due to increased usage within the catchment area (e.g., changes in pesticide application), as assessed by expert judgment; *and*
3. **Feasibility of Monitoring:** The substance can be monitored using a cost-effective analytical technique that achieves a reasonable limit of detection.

1 *If the substance is monitored more than 13 times per year, it has to be detected at two or more RIWA Meuse monitoring stations with a frequency of at least 7% of the measurements per year. This criterion is equivalent to the criterion requiring that the substance with a monitoring frequency of 13 times a year, is detected at least once a year.*

Listing drinking water relevant substances

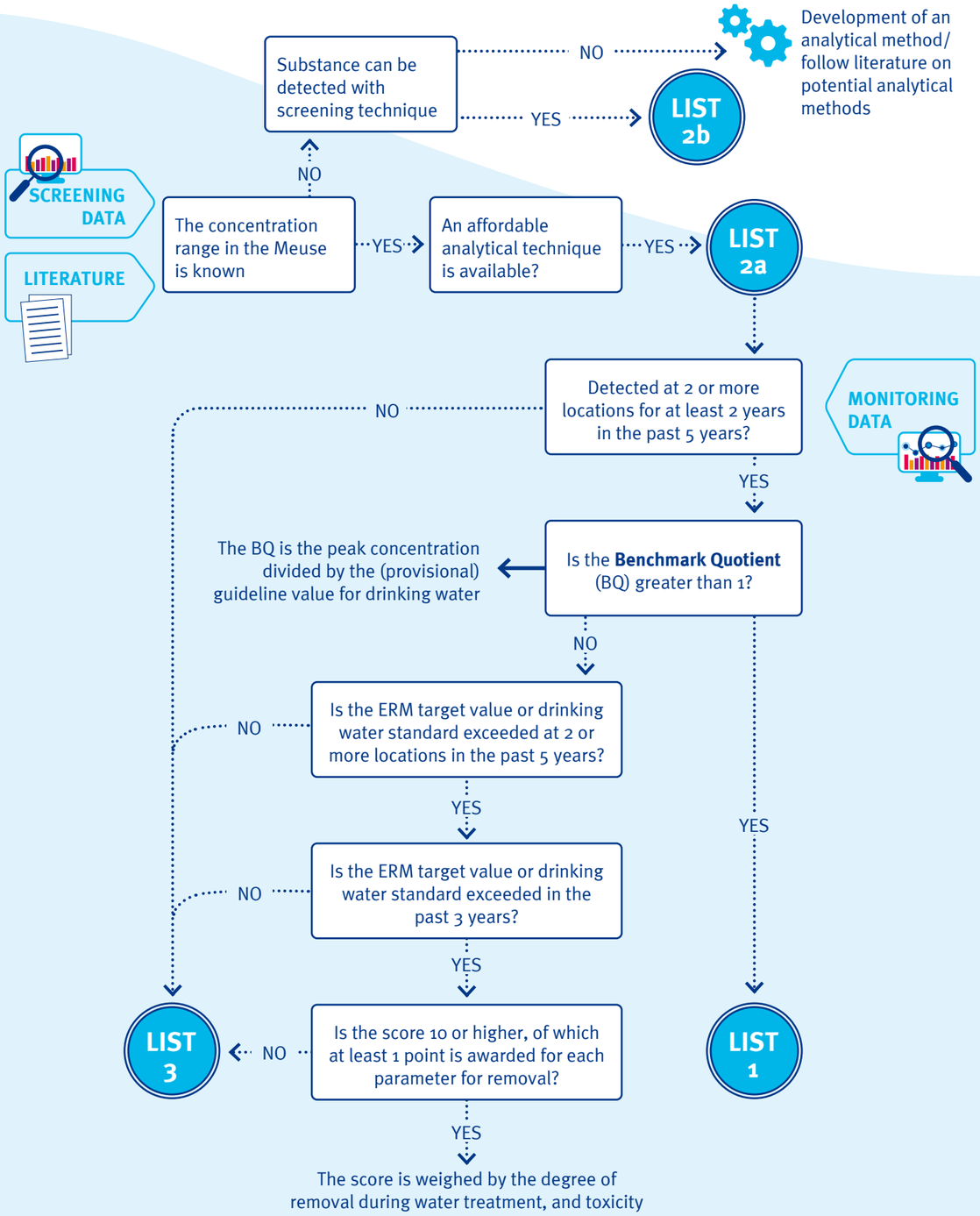


Figure 1 A schematic overview of the ranking scheme used to establish the list of drinking water relevant substances

The specific criteria for each list:

LIST 1 DRINKING WATER RELEVANT SUBSTANCES

1. The substance was detected at two or more RIWA Meuse monitoring stations or intake points in the last 5 years (for a minimum of two years), with a frequency of at least 7% of the measurements[1] *and*
2. The substance was found to exceed ERM target values or the Drinking Water Standards from the Dutch Drinking Water Regulation on at least two different RIWA Meuse monitoring stations or intake points in the past 5 years (taking into account possible removal by conventional treatment), with a frequency of at least 1% of the measurements *and*
3. The substance was found to exceed the drinking water standard or the ERM target value used by the drinking water companies, at least once in the past 3 years *and*
4. The total score of the substance has to be 10 or higher, of which at least 1 point is awarded for each parameter defining the substance removal (polarity, volatility, and biodegradability) (the exact calculation of the score is explained in Appendix I.1).

If the benchmark quotient of the substance is 1 or higher, the substance is considered drinking water relevant and criteria 2, 3, and 4 can be neglected.

LIST 2a CANDIDATE SUBSTANCES FOR QUANTITATIVE MONITORING

1. The substance is present in the river Meuse at concentrations well above the ERM target value *or*
2. The concentration of the substance is expected to increase due to increased use in the catchment area in the near future (e.g. due to a change in usage of pesticides) (based on expert judgement) *and*
3. The substance can be monitored with an affordable measuring technique with a reasonable limit of detection.

LIST 2b CANDIDATE SUBSTANCES FOR SCREENING

1. The substance has undesirable properties for the production of drinking water and is expected to be present in the river Meuse (based on research), but the concentrations are unknown *and*
2. The substance can be detected with an available targeted screening technique and can be added to the database.

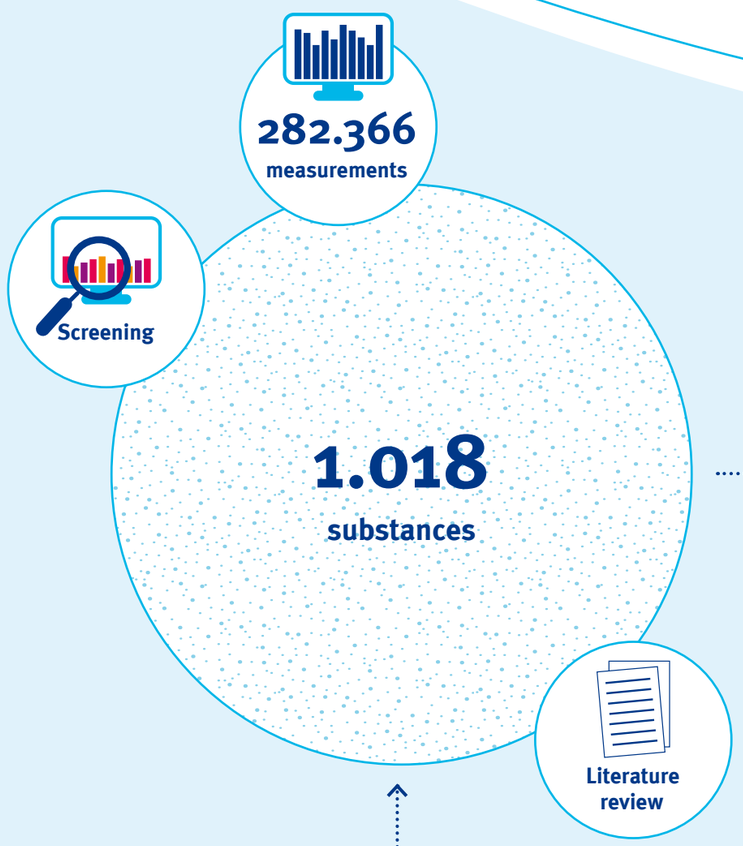
List 3 contains all substances that are completely evaluated, but do not or no longer fulfil the criteria. This list is kept in order to secure the information with regard to the evaluation of these substances and to avoid duplication of efforts during a following evaluation.

LIST 3 NEED FOR MONITORING DECIDED BY DRINKING WATER COMPANIES INDIVIDUALLY

Former List 1 and 2 substances which do not meet the criteria of List 1 in the past 5 years.

*1 If the substance is monitored more than 13 times per year, it has to be detected at two or more RIWA Meuse monitoring stations with a frequency of at least 7% of the measurements per year. This criterion is equivalent to the criterion requiring that the substance with a monitoring frequency of 13 times a year, is detected at least once a year.

Drinking water relevant substances



Evaluation
+
Recommendations

Selection based on

- Concentration
- Frequency of Detection
- Toxicity
- Purification Requirement
- Expert Judgement

LIST 1 DRINKING WATER RELEVANT SUBSTANCES

Industrial compounds and consumer products

- PFAS*
- Dibromomethane sulfonic acid
- Dichloromethane sulfonic acid
- Dibromoacetic acid
- Tribromomethane
- Trichloroacetic acid (TCA)
- Hexa(methoxymethyl)melamine (HMMM)
- Melamine
- 8-Hydroxypenillic acid
- Ethylenediaminetetraacetic acid (EDTA)
- 1,4-Dioxane
- Trifluoroacetic acid (TFA)
- Methenamine/urotropine
- Cyanuric acid
- Diethylenetriaminepentaacetic acid (DTPA)
- Nitriloacetic acid (NTA)
- Sulfamic acid
- Tolyltriazole
- Bromate

Pharmaceuticals and endocrine disrupting chemicals (EDC's)

- Lithium
- Valsartanic acid
- Valsartan
- Metformin
- Guanylurea
- 2-Hydroxibuprofen
- Candesartan
- Hydrochlorothiazide
- Lamotrigine
- Tramadol
- N-formyl-4-aminoantipyrine
- Bisphenol A
- Ketoprofen
- Naproxen
- Vigabatrin

Pesticides, biocides and their metabolites

- Chlorate
- S-metolachlor
- Metolachlor-ESA
- Metolachlor-OA
- Aminomethylphosphonic acid (AMPA)
- Glyphosate
- Prosulfocarb
- Propamocarb

* PFAS is a group of substances

For the lists the following monitoring frequencies are maintained:

LIST 1 **13x a year for 5 years**

LIST 2a **13x a year for 1 year**

LIST 2b **13x a year via targeted screening**

LIST 3 **Need for monitoring decided by drinking water companies individually**

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Evaluated every 3 years

LIST 2a — CANDIDATE SUBSTANCES FOR QUANTITATIVE MONITORING

Industrial compounds and consumer products

- 1,2,4-Triazole
- 1,2-Dimethoxyethane (monoglyme)
- Methylglycindi acedic acid (α-ADA, MGDA)
- PFPrA
- PFPrS

Pharmaceuticals and endocrine disrupting chemicals (EDC's)

- Adamantan-1-amine
- Bisphenol-F
- Fexofenadine
- Flecainide
- Levocetirizine
- Oxipurinol
- Ritalinic acid

Pesticide metobolite

- Chlorothalonil R471811

LIST 2b — CANDIDATE SUBSTANCES FOR SCREENING

Industrial compounds and consumer products

- ((Perfluorododecyl)methyl)oxirane
- 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodoheptadecane
- 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodooctadecane
- 1,3-Dicyclohexylurea
- 1-Phenyl-1,2-propanediol
- 2,4-Dimethylaniline
- 2-Methyl-2H-benzotriazole
- 2-Phenylquinoline
- 3-Bromo-5-chloro-2- hydroxybenzoic acid
- 6PPD-quinone
- Benzothiazole-2-sulfonic acid
- Benzylchloride
- Cotinine N-oxide
- Dicyclohexylamine
- (Methoxymethyl)melamines (mono-, di-, tri- and penta-) (MMM)
- Perfluoro-p-ethylcyclohexylsulfonic acid (PFECHS)
- Phthalic anhydride
- Tributyl citrate acetate

Pharmaceuticals and endocrine disrupting chemicals (EDC's)

- 10-Hydroxy-amitriptyline
- 4-Amino-3-hydroxybenzoic acid
- 4-Hydroxy-omeprazole
- Abacavir
- Altrenogest
- Benserazide
- Betamethasone
- Carprofen
- Chlortetracycline
- Dioxoaminopyrine
- Doxycycline
- EDDP ((2E,5R)-2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine)
- Emtricitabine
- Florfenicol
- Flubendazol
- Fluralaner
- Levofloxacin
- Losartan carboxylic acid
- Mesterolone
- Monensin
- Tenofovir
- Toltrazuril
- Triaprost
- Xylazine

Pesticides, biocides and their metabolites

- Acetamiprid
- Didecyldimethylammonium (DDAC)
- Fluopyram-7-hydroxy
- Haloaniline
- Lauryl guanidine
- Metamitron-desamino
- 3-Propyl-1H-1,2,4-triazole-5-amine (HYPA)
- Simetone

LIST 3 — NEED FOR MONITORING DECIDED BY DRINKING WATER COMPANIES INDIVIDUALLY

- 1,2-Benzisothiazol-3(2H)-one
- 1,2-Diacetylbenzene
- 1,3-Diethyldiphenylurea
- 1,3-Diphenylguanidine
- 10,11-Dihydro-10,11-dihydroxycarbamazepine
- 1-Chloro-2,2,3,3-tetrafluorocyclobutane ($C_4H_3ClF_4$)
- 1H-Benzotriazole
- 2-(Methylthio)benzothiazole
- 2,2,6,6-Tetramethyl-4-oxopiperidinonoxy
- 2,2'-Dimorpholinyldiethyl-ether
- 2,3,3,3-Tetrafluoro-2-(heptafluorpropoxy) propanoate (GenX substance)
- 2,4-D (2,4-dichlorophenoxyacetic Acid)
- 2-[4-(Diethylamino)-2-hydroxybenzoyl] benzoic acid
- 2'-Aminoacetophenone
- 2'-Methoxycinnamaldehyde/ cassiastearoptene
- 3,5,6-Trichloro-2-pyridinol (TCP)
- 4-Methylbenzotriazole
- 4-n-Nonyl phenol
- Acesulfame-K
- Acetaminophen (paracetamol)
- Acetone
- AHTN (6-acetyl-1,1,2,4,4,7-hexamethyltetraline)
- Amidotrizoic acid
- Amoxicillin
- Anti-androgenic activity (expressed in flutamide-equivalents)
- Aspirin (acetylsalicylic acid)
- Azelaic acid
- BAM (2,6-dichlorobenzamide)
- Barbital
- BBP (butylbenzylphtalate)
- Benzo(a)pyrene
- Benzothiazole
- Benzyldimethyltetradecylammonium
- Bis(2-chloroisopropyl) ether
- BPS (4,4'-sulfonyldiphenol)
- Butan-2-one O,O',O''-(methylsilanetriyl) oxime
- Caffeine
- Caprolactam
- Carbamazepine
- Carbendazim
- Cetirizine
- Chloridazon
- Chloridazone-desphenyl
- Chlorotoluron
- Ciprofloxacin
- Citalopram
- Clarithromycin
- Clindamycin
- Clopidol
- Cloxacilline
- DBP (dibutyl phthalate)
- DEP (diethyl phthalate)
- DIBP (di-(2-methyl-propyl)phthalate)
- Diclofenac
- Diethyl-2-phenylacetamide
- Diglyme (bis(2-methoxyethyl)ether)
- Diisopropyl ether (DIPE)
- Dimethenamid
- Dimethyl octadecylphosphonate
- Dimethyldisulfide
- Di-n-butyltin
- Diundecyl phthalate (DUP)
- Diuron (DMCU)
- DMSA (N,N-dimethylaminosulfanilide)
- Dodecylbenzene sulfonic acid
- Dotarem (Gd-DOTA)
- Erucamide
- Erythromycin
- Estrone
- ETBE (ethyl-tertiairy-butyl-ether)
- Ethyl sulphate
- Fenbendazol
- Fluoride
- Gabapentin
- Gadolinium (containing contrast agents)
- Gadovist (Gd-BT-DO3A)
- Galaxolide (HHCB)
- Helional
- Hexa(methoxymethyl)melamine
- Ibuprofen
- Iohexol
- Iomeprol
- Iopamidol
- Iopromide
- Ioxaglic acid
- Ioxitalamic acid
- Irbesartan
- Isoproturon
- Isosafrol
- Lincomycin
- Magnevist (Gd-DTPA),
- MCPA (4-chloro-2-methylphenoxyacetic acid)
- Mecoprop (MCPP)
- Metamizol
- Metazachlor
- Metazachlor-ethane sulfonic acid
- Metazachlor-oxanilic acid
- Methoxymethyltriphenylphosphonium
- Methyl-desfenylchloridazon
- Metofluthrin
- Metoprolol
- Monepantel
- Monobromoacetic acid
- Monochloramine
- MTBE (methyl-tert-butylether)
- Multihance (Gd-BOPTA)
- Musk (ketone)
- Musk (xylene)
- N-(2-carboxyethyl)-N-octyl-β-alanine
- N,N-Dimethyldodecylamine
- N,N-Dimethyldodecylamine n-oxide (DDAO)
- N,N-dimethylsulfamid (DMS)
- N-butylbenzenesulphonamide
- NDMA (nitrosodimethylamine)
- Nicosulfuron
- O-desmethylvenlafaxine
- Oxadiazon
- Pentobarbital
- Phenanthrene
- Phenazone
- Phenobarbital
- Pyrazole
- Sabinene
- Safrol
- Salicylic Acid
- Sebuthylazine
- Sotalol
- Sucralose
- Sulfamethoxazole
- Surfynol 104
- TBP (tributylphosphate)
- TCEP (tris(2-chloroethyl) phosphate)
- TCPP (tri-(2-chloroisopropyl) phosphate)
- Telmisartan
- Terbuthylazine
- Tetrabroombisfenol A
- Tetrachloroethene
- Tetrahydrofuran
- Thiabendazole
- Tilmicosine
- Triamcinolonehexacetonide
- Trichloroethene
- Trichloromethane
- Triethyl citrate
- Trifluoromethanesulfonic acid (F_3-MSA)
- Triflusulfuron-methyl
- Triisobutyl phosphate
- Trimellitic anhydride
- Triphenylphosphine oxide (TPPO)
- Venlafaxine
- Vinylchloride

List 2b Candidate substances for screening

1. Undesirable Properties: The substance has properties that make it undesirable for drinking water production and is anticipated to be present in the Meuse (based on research), though its concentrations are currently unknown; *and*
2. Screening Capability: The substance can be detected using an available targeted screening technique and can be added to the screening database.

List 3 Need for monitoring decided by drinking water companies individually

List 3 contains all substances that are completely evaluated, but do not or no longer fulfil the criteria to be present on List 1 or 2. This list is kept in order to secure the information with regard to the evaluation of these substances and to avoid duplication of efforts during a following evaluation. Substances can be reintroduced on List 1 if new information on toxicity or measured concentrations supports this decision.

2.2 Data collection

2.2.1 Monitoring data

Monitoring data for substances was obtained from the RIWA Meuse database. This database compiles monitoring data from drinking water companies and water management agencies along the Meuse. Data from the period 2019–2023 was used for this evaluation. The monitoring stations are listed in Table 1. (Figure 2).

Table 1 - RIWA monitoring stations located near the Meuse, in order of downstream appearance

Monitoring station/intake point		Abbreviation	Drinking water company/ water management agency
1	Tailfer	TAI	Vivaqua
2	Namêche	NAM	Water-link
3	Liège/Luik	LUI	Water-link
4	Eijsden	EYS	Rijkswaterstaat Water, Verkeer en Leefomgeving
5	Roosteren	ROO	NV Waterleiding Maatschappij Limburg
6	Heel	HEE	NV Waterleiding Maatschappij Limburg
7	Brakel	BRA	Dunea
8	Heusden	HEU	Dunea
9	Bergsche Maas (until June 2021 Keizersveer)	BSM	Evides NV/WBB
10	Haringvliet/Stellendam (combined)	HAV/STE	Evides NV

2.2.2 Substance information

To rank substances by relevance for the drinking water function of the Meuse, substances were scored based on the following properties:

- Toxicity (benchmark quotient)
- Removal potential by water treatment (indicated by polarity, volatility, biodegradability)
- Odour/taste threshold

The scoring system is outlined in Appendix I.1 and detailed in the 2011 RIWA Meuse report (Fischer et al., 2011).

Figure 2

To calculate a benchmark quotient, the maximum concentration of each substance in surface water was compared to a provisional drinking water guideline value (pGLV) based on toxicity data. Most pGLVs for substances on List 1 were derived from:

- Indicative pGLV's derived by the Dutch National Institute for Public Health and the Environment (RIVM). These pGLV's can be found on the RIVM website (https://rvszoeksysteem.rivm.nl/)
- Guidelines for Drinking-water Quality, World Health Organization (WHO) (Fourth Edition) (WHO 2017)

For substances without an available pGLV from RIVM or WHO, toxicity data were collected from official risk assessments by institutions such as European Food Safety Authority (EFSA), Joint Expert Committee on Food Additives (JECFA), United States Environmental Protection Agency (US EPA), and Canada Health (Canadian federal institute of Health).

If no formal risk assessment was available, data were obtained from REACH[2] registration files or the literature. For pharmaceuticals lacking toxicity data, the defined daily dose (DDD) was used to estimate a pGLV, as described in Appendix I.1. If neither toxicity data nor a DDD were available, the threshold of toxicological concern (TTC) was applied (Kroes et al., 2004), with a standard TTC value of 0,1 µg/L.

Information needed to estimate the removal by water treatment was either collected from the REACH registration files; the PubChem database (https://pubchem.ncbi.nlm.nih.gov/) or from the program EPI Suite™, v4.11 (https://www.epa.gov/tsca-screening-tools). It concerns these parameters:

- **Polarity:** Measured by the octanol/water partition coefficient (Log K_{ow}), obtained experimentally or estimated with "KOWWIN v1.68 Log Kow estimate" in EPI Suite™.
- **Volatility**: Assessed by vapor pressure, either measured or estimated using the "mean vapor pressure of Antoine & Grain methods" in EPI Suite™.
- **Biodegradability:** Estimated using the "BioWIN3 Ultimate Survey Model" in EPI Suite™.

2.3 Literature study

To identify candidate drinking water relevant substances (Lists 2a and 2b), various information sources were utilized, including:

- Scientific literature (accessed via Web of Science and ScienceDirect)
- Reports from the KWR Watercycle Research Institute, conducting joint studies for Dutch drinking water companies (BTO reports requested via BTO/WiCE-Net.
- RIVM reports
- Measurement data from RIWA and Rijkswaterstaat (RWS)
- Screening data from Aqualab Zuid (AQZ), Het Waterlaboratorium (HWL), and Water-link

Information was gathered from the years 2022–2024, using the following search terms in various combinations:

- Substance/pollutant/compound
- Emerging
- Water (drinking, surface, waste, river)
- Screening (non-target, suspect, target)

2 Registration, Evaluation, Authorisation and Restriction of Chemicals

3

Results

3.1 Proposal for the new monitoring program for the Meuse

3.1.1 Drinking water relevant substances

The criteria 1, 2, and 3, as described in Figure 1 of paragraph 2.1, were applied to select parameters from the RIWA-Meuse database. This database contains all monitoring results from RIWA-Meuse members and Rijkswaterstaat at intake points or main monitoring stations along the river Meuse, listed in Table 1.

Although several parameters met all three criteria, some were excluded for the following reasons:

- The parameter is not a substance: Examples include temperature and electrical conductivity. Similarly, bioassays such as CALUX tests were excluded. While these effect parameters provide valuable water quality information, it is recommended to first identify the substance(s) responsible for the measured activity if the ERM target value is exceeded.
- Oxygen and acidity (pH) were excluded because their ERM target values are expressed as minimal values or bandwidths rather than specific thresholds.

Following these exclusions, the remaining parameters were tested and ranked based on criterion 4, detailed in paragraph 2.2.2 and Appendix I.1.

The resulting proposal for the updated List 1 is presented in Table 2. Compared to the previous List 1 in 2021, seven substances are newly included, 3 originate from List 2, and seven originate from List 3.

Furthermore, bromate and PFAS are included because they are measured in concentrations above the indicative drinking water guideline established by RIVM. As mentioned in the methodology substances with a benchmark quotient above 1 is automatically deemed relevant.

Four substances, dimethenamide, ethylsulphate, metoprolol, and thiabendazole strictly meet the criteria but have not been included because they were detected at only one monitoring station over the past three years and were already on List 3. To avoid substances moving on and off the list, it was decided to keep these substances on List 3. Although the same applies to bisphenol A, this substance has been included on List 1. This decision was made because EFSA recently derived a new, lower tolerable daily intake (TDI) of 0,2 ng/kg bodyweight/day for bisphenol A based on effects on the immune system in mice (EFSA, 2023). If this TDI were to be converted into a drinking water guideline value by RIVM, bisphenol A would certainly be considered relevant for drinking water from a toxicological perspective. Since RIVM did not derive a new drinking water guideline yet, the existing drinking water guideline from the European Drinking Water Directive is still used to calculate the score in this evaluation.

Four other substances on List 1, candesartan, ketoprofen, tolyltriazole and valsartan have also been detected above the target value only once in the past three years. These substances were already on List 1 in 2021, but it is quite possible that they will not meet the criteria anymore in the next evaluation.

List 1 now includes a total of 42 substances. Nine of these are grouped into 4 sets, as they consist of parent substances and their corresponding metabolites.

Figure 3 - Percentage distribution of substances by application category

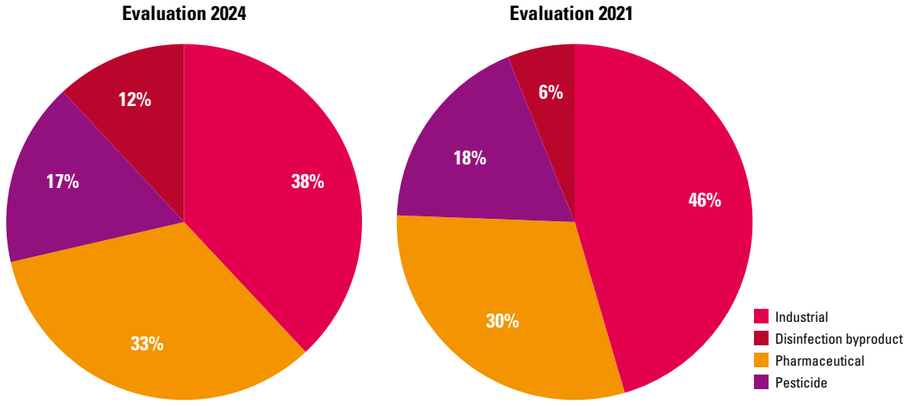


Figure 3 shows the percentage distribution of the substances by application category both for the evaluation in 2021 and the current evaluation. The distribution is quite similar with most substances having an industrial application, followed by pharmaceuticals (including metabolites), pesticides (including metabolites) and disinfection byproducts. Industrial substances and disinfection by-products account for approximately half of the substances. However, compared to 2021, there are relatively fewer industrial substances (-8%) and more disinfection by-products (+6%).

Table 2 –Proposed list of drinking water relevant substances for the river Meuse (List 1)

#	Substance	CAS RN	Category	Score	Previous List
1	PFAS	NA	industrial	27	1
2	chlorate	14866-68-3	biocide/ disinfection byproduct	26	2
3	dibromomethane sulfonic acid	859073-88-4	disinfection byproduct	26	New
4	dichloromethane sulfonic acid	53638-45-2	disinfection byproduct	26	2
5	lithium	7439-93-2	pharmaceutical/ natural	26	New
6	dibromoacetic acid	631-64-1	disinfection byproduct	25	1
7	tribromomethane	75-25-2	disinfection byproduct	25	3
8	trichloroacetic acid (TCA)	76-03-9	industrial	25	3
9A	valsartanic acid	164265-78-5	pharmaceutical	25	1
9B	valsartan	137862-53-4	pharmaceutical	12	1
10A	metformin	657-24-9	pharmaceutical	14	1
10B	guanylurea	141-83-3	pharmaceutical (metabolite)	20	1
11	hexa(methoxymethyl)melamine (HMMM)	68002-20-0	industrial	20	New
12	melamine	108-78-1	industrial	20	1
13	2-hydroxibuprofen	51146-55-5	pharmaceutical (metabolite)	19	New
14	8-hydroxypenillic acid	3053-85-8	industrial	19	New
15	ethylenediaminetetraacetic acid (EDTA)	64-02-8	industrial	19	1
16A	s-metolachlor	87392-12-9	pesticide	17	1

#	Substance	CAS RN	Category	Score	Previous List
16B	metolachlor-ESA	171118-09-5	pesticide (metabolite)	19	3
16C	metolachlor-OA	152019-73-3	pesticide (metabolite)	13	New
17	1,4-dioxane	123-91-1	industrial	18	1
18	candesartan	139481-59-7	pharmaceutical	18	2
19A	aminomethylphosphonic acid (AMPA)	1066-51-9	pesticide/industrial	17	1
19B	glyphosate	1071-83-6	pesticide	11	1
20	trifluoroacetic acid (TFA)	76-05-1	industrial	16	1
21	hydrochlorothiazide	58-93-5	pharmaceutical	15	1
22	prosulfocarb	52888-80-9	pesticide	15	1
23	methenamine/urotropine	100-97-0	industrial	15	3
24	lamotrigine	84057-84-1	pharmaceutical	14	1
25	tramadol	27203-92-5	pharmaceutical	14	1
26	cyanuric acid	108-80-5	industrial	13	1
27	diethylenetriaminepentaacetic acid (DTPA)	67-43-6	industrial	13	1
28	N-formyl-4-aminoantipyrine	1672-58-8	pharmaceutical (metabolite)	13	1
29	nitriloacetic acid (NTA)	139-13-9	industrial	13	1
30	sulfamic acid	5329-14-6	industrial	13	1
31	tolyltriazole	29385-43-1	industrial	13	3
32	bisphenol A	80-05-7	industrial	12	3
33	bromate	15541-45-4	industrial	12	1
34	ketoprofen	22071-15-4	pharmaceutical	12	1
35	naproxen	22204-53-1	pharmaceutical	12	1
36	propamocarb	24579-73-5	pesticide	10	New
37	vigabatrin	60643-86-9	pharmaceutical	10	3

3.1.2 Candidates for the list

To compile new candidate lists, a literature review was conducted on emerging substances. In addition, monitoring and screening data from water companies were evaluated to identify potentially relevant substances for the drinking water function of the Meuse. Details of this study are provided in paragraph 3.2.

The study resulted in the proposal of 54 new substances. For 6 substances an analytical method is available and therefore these are included on List 2a (Table 3). Four substances were found to have a natural origin and are not included but instead assigned to the parking list 4 (see Chapter 3.2.4). The other 48 new substances will be included on List 2b (Table 4).

Six substances proposed for List 2a in 2021 remain on List 2a, as they have not yet been sufficiently monitored, one substance originates from List 2b. From the substances that were added to List 2b in 2021, 2 are not yet added to a screening database and will remain on this list.

It is recommended to include the 13 substances on List 2a in the joint monitoring program of the Meuse and analyse them using quantitative analytical methods. After one year, the monitored substances can be evaluated according to the methodology described in paragraph 2.1, and a decision can be made to add them to either List 1 or List 3.

Furthermore, it is suggested to add the substances from List 2b to a screening database and initially track them in the Meuse through targeted screening. Based on their detection rates, a decision can then be made on whether to monitor these substances using quantitative methods.

Table 3 - Proposed candidate drinking water relevant substances for monitoring in the river Meuse (List 2a)

#	Substance	CAS RN	Category	Score	Previous List
1	1,2,4-triazole	288-88-0	industrial	11	2a
2	1,2-dimethoxyethane (monoglyme)	110-71-4	industrial	14	new
3	adamantan-1-amine	768-94-5	pharmaceutical	13	2b
4	bisphenol-F	620-92-8	industrial	13	2a
5	chlorothalonil R471811	?	pesticide (metabolite)	12	new
6	fexofenadine	83799-24-0	pharmaceutical	14	2a
7	flecainide	54143-55-4	pharmaceutical	19	new
8	levocetirizine	130018-77-8	pharmaceutical	20	new
9	methylglycindi acedic acid (α-ADA, MGDA)	164462-16-2	industrial	10	2a
10	oxipurinol	2465-59-0	pharmaceutical	20	2a
11	PFPrA	422-64-0	PFAS	13	new
12	PFPrS	423-41-6	PFAS	26	new
13	ritalinic acid	19395-41-6	pharmaceutical	20	2a

Table 4 - Proposed candidate drinking water relevant substances for screening in the river Meuse (List 2b)

#	Substance	CAS RN	Category	Score	Previous List
1	((perfluorododecyl)methyl)oxirane	94158-66-4	PFAS	24	new
2	1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodoheptadecane	129838-39-7	PFAS	24	new
3	1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodooctadecane	129838-40-0	PFAS	24	new
4	1,3-dicyclohexylurea	2387-23-7	industrial	24	new
5	10-hydroxy-amitriptyline	1246833-15-7	pharmaceutical (metabolite)	24	2b
6	1-phenyl-1,2-propanediol	1855-09-0	industrial	13	new
7	2,4-dimethylaniline	95-68-1	industrial	13	new
8	2-methyl-2H-benzotriazole	16584-00-2	Industrial	10	new
9	2-phenylquinoline	612-96-4	Industrial	24	new
10	3-bromo-5-chloro-2- hydroxybenzoic acid	4068-58-0	Industrial	24	new
11	4-amino-3-hydroxybenzoic acid	2374-03-0	pharmaceutical	25	2b
12	4-hydroxy-omeprazole	301669-82-9	pharmaceutical	19	new
13	6PPD-quinone	2754428-18-5	Industrial	12	new
14	abacavir	136470-78-5	pharmaceutical	13	new
15	acetamiprid	160430-64-8	pesticide	13	new
16	altrenogest	850-52-2	veterinary drug	25	new
17	benserazide	14919-77-8	pharmaceutical	20	new
18	benzothiazole-2-sulfonic acid	941-57-1	industrial	26	new
19	benzylchloride	100-44-7	industrial	25	new

#	Substance	CAS RN	Category	Score	Previous List
20	betamethasone	378-44-9	pharmaceutical	26	new
21	carprofen	53716-49-7	veterinary drug	12	new
22	chlortetracycline	57-62-5	veterinary drug/pharmaceutical	15	new
23	cotinine N-oxide	36508-80-2	metabolite nicotine	14	new
24	dicyclohexylamine	101-83-7	industrial	12	new
25	didecyldimethylammonium (DDAC)	20256-56-8	biocide	11	new
26	dioxoaminopyrine	519-65-3	pharmaceutical	26	new
27	doxycycline	564-25-0	veterinary drug/pharmaceutical	15	new
28	EDDP ((2E,5R)-2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine)	106293-55-4	pharmaceutical (metabolite)	19	new
29	emtricitabine	143491-57-0	pharmaceutical	14	new
30	florfenicol	73231-34-2	veterinary drug	21	new
31	flubendazol	31430-15-6	veterinary drug/ pharmaceutical	14	new
32	fluopyram-7-hydroxy		pesticide (metabolite) (PFAS)	27	new
33	fluralaner	864731-61-3	veterinary drug	13	new
34	haloaniline	39885-50-2	pesticide (metabolite) (PFAS)	14	new
35	lauryl guanidine	135-42-2	biocide	24	new
36	levofloxacin	100986-85-4	pharmaceutical	27	new
37	losartan carboxylic acid	124750-92-1	pharmaceutical (metabolite)	24	new
38	mesterolone	1424-00-6	pharmaceutical	19	new
39	metamitron-desamino	36993-94-9	pesticide (metabolite)	25	new
40	(methoxymethyl)melamines (mono-, di-, tri- and penta-) (MMM)	NA	industrial	15	new
41	monensin	17090-79-8	veterinary drug	13	new
42	perfluoro-p-ethylcyclohexylsulfonic acid (PFECHS)	646-83-3	PFAS	25	new
43	phthalic anhydride	85-44-9	industrial	10	new
44	3-propyl-1H-1,2,4-triazole-5-amine (HYPA)	60016-62-8	pesticide (metabolite)	25	new
45	simetone	673-04-1	pesticide	26	new
46	tenofovir	147127-20-6	pharmaceutical	26	new
47	toltrazuril	69004-03-1	veterinary drug	12	new
48	triaprost	71116-82-0	veterinary drug	24	new
49	tributyl citrate acetate	77-90-7	industrial	11	new
50	xylazine	7361-61-7	veterinary drug	27	new

3.1.3 Preliminary screening results from candidate substances (2b) from 2021

Of the 16 substances from List 2b in 2021 that were added to the database of the target screening method by AQZ (Table 5), four compounds were detected at drinking water intake points. At Heel, cyanoguadinine was detected once. At Bergsche Maas, p-toluenesulfonamide was detected once (the ortho- and para-isomers are detected together) and gliclazide was detected 36 times between January 1st 2022 and October 31st 2024.

It is recommended to review the screening data of these 16 substances during the 2027 evaluation to determine, based on the longer time period, whether gliclazide or other substances should be moved to List 2a.

Table 5 - List 2b substances from 2021 that are added to a screening database

#	Substance	CAS RN	Category	Score	Previous List
1	benzovindiflupyr	1072957-71-1	pesticide	10	2b
2	cyanoguanidine	461-58-5	industrial	8	2b
3	cyanopropanal	3515-93-3	industrial	26	2b
4	ethyldimethylcarbamate	687-48-9	industrial	25	2b
5	gamma-cyhalothrin	76703-62-3	pesticide	15	2b
6	gliclazide	21187-98-4	pharmaceutical	19	2b
7	isofetamid	875915-78-9	pesticide	10	2b
8	kojic acid	501-30-4	food additive	20	2b
9	levothyroxine	51-48-9	pharmaceutical	25	2b
10	mefentrifluconazole	1417782-03-6	pesticide	10	2b
11	oxathiapiprolin	1003318-67-9	pesticide	10	2b
12	p-toluenesulfonic acid	104-15-4	industrial	8	2b
13	pyriofenone	688046-61-9	pesticide	10	2b
14	toluenesulfonamide (ortho)	88-19-7	industrial	25	2b
15	toluenesulfonamide (para)	70-55-3	industrial	10	2b
16	β-asarone	5273-86-9	pharmaceutical/ food additive	24	2b

3.1.4 Substances which no longer meet the criteria

Since 2015 a list of substances which no longer meet the criteria for drinking water relevancy is drafted. This list contains substances:

a) of which the concentrations have dropped under standards or target values frequent enough at multiple monitoring points during several years;
b) for which the standards or target values have been changed;
c) that have newer/better scientific assessment of their properties (e.g. their toxicity is better known so the safety factors have dropped).

In this evaluation seven substances were withdrawn from the drinking water relevance list: the industrial substance di-n-butyltin, benzothiazole, monobromoacetic acid, diisopropyl ether (DIPE) and fluoride, and the pesticide terbuthylazine and pesticide metabolite chloridazone-desphenyl.

Fluoride and DIPE are emitted by Société de Prayon in Engis as impurities during the process of upgrading technical phosphoric acid to food-grade phosphoric acid. The process was optimized in 2014, resulting in a reduction in fluoride emissions, and concentrations have decreased ever since (a). This is an example of how advocacy by RIWA Meuse contributes to a cleaner Meuse.

Benzothiazole and di-n-butyltin did not meet criterion 1. Benzothiazole exceeded the ERM target value of 1 µg/L only once during the period 2019–2023, while di-n-butyltin did not exceed the ERM target value of 0.1 µg/L at all (a).

For monobromoacetic acid, a new indicative drinking water guideline of 164, µg/L was derived by RIVM (2022). Due to a lower toxicity score, criterion 4 is no longer met (c).

Concentrations of terbuthylazine sporadically exceeded the ERM target value of 0.1 µg/L; however, the percentage of exceedances decreased to below 1% of the total number of measurements. Therefore, criterion 2 is no longer met (a).

Chloridazone-desphenyl was removed from the list because lower concentrations were measured during the period 2019–2023 compared to 2016–2020. The maximum concentration decreased from 2.4 µg/L to 0.5 µg/L. Since this metabolite is assessed as not relevant by RIVM, the legal limit is 1 µg/L[3]. This limit has not been exceeded in the past five years, and criterion 4 is no longer met (a).

"Undoubtably EU wide bans on several plant protection products has had a significant positive impact on water quality in the river Meuse."

It is up to the individual drinking water companies whether they want to maintain these substances in their monitoring program or not. These substances still might the interesting to follow from other perspectives such as ecological relevance or regional or local emissions.

In previous evaluations several formerly drinking water relevant substances were de-prioritized because they no longer meet the criteria:

a) the herbicides chlorotolurone, 2,4-D, diurone, isoproturon, metolachlor, metazachlor, MCPA, MCPP and nicosulfurone, the fungicide carbendazim and the pharmaceuticals diclofenac, ibuprofen and sotalol;
b) iodine based X-ray contrast media such as diatrizoic acid, iohexol, iopamidol, iopromide and iomeprol and the polycyclic aromatic hydrocarbon benzo(a)pyrene.

It is not always possible to pinpoint exactly why concentrations of drinking water relevant substances have dropped (a) but focussing attention on them has possibly contributed. Undoubtably EU wide bans on several plant protection products has had a significant positive impact on water quality in the river Meuse. Also measures that were taken to meet the objectives of the Water Framework Directive could have had such an impact, be it directly or indirectly. And specific restrictions in several permits for the discharge of waste water by chemical industries have helped as well.

In total about 30% of all substances which are or ever were labelled as drinking relevant (82) now no longer are. The list of substances that were candidate for drinking water relevancy (list 2) but did not meet the criteria – yet – (list 1) consists of over 75 substances.

3 *https://rvszoeksysteem.rivm.nl/stof/detail/5495*

3.2 Compiling the candidate list

3.2.1 Literature

For this study 87 publications were consulted, including 47 scientific papers and 40 reports and studies from sources such as the Joint Research of drinking water companies in the Netherlands and Belgium (BTO), the Dutch Foundation of Applied Water Research (STOWA), and reports from consultancy agencies. A complete list of the literature that was included in this study is shown in Appendix I.9.

From these sources, a total of 94 substances were included on a candidate list. For these substances, physical and chemical data were collected, and a provisional guideline value was derived to estimate the risk. Based on these properties, 54 substances were selected for List 2a or 2b.

Several publications were identified in which analytical screening methods had been applied to surface water from rivers. Below are examples of studies from which three or more candidate substances were selected:

Krettek (2017) conducted a screening study in Swedish surface waters. Using a database of approximately 20,000 substances, 143 potential pollutants were prioritized. New substances identified with the highest confidence level were added to the candidate list, such as the rubber additive benzothiazole-2-sulfonic acid and the plasticizer tributyl citrate acetate. **Ng et al.** (2022) screened for nearly 5,000 PFAS in surface water, wastewater, and groundwater in the Danube River Basin. Several PFAS were identified, and 18 were assessed as being of environmental concern. Three PFAS with a risk score of more than 1 were added to the candidate list: ((perfluorododecyl)methyl)oxirane ; 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodoheptadecane; and 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodooctadecane.

Abafe et al. (2022) conducted a non-target screening analysis to identify pollutants in South African wastewater and surface waters. A wide range of "new" pharmaceuticals, pesticides, and metabolites were documented in South African waters for the first time. Based on use and approval in the Meuse catchment area, not all substances are expected to be present in surface water. A selection was made, and several substances were placed on the candidate list, including abacavir and tenofovir. **Yang et al.** (2022) optimized a method to simultaneously screen for 1200 anthropogenic substances and transformation products. From these, three new substances were detected in the surface water of a river in Guangxi, South China, with high confidence and added to the candidate list: 2,4-dimethylaniline (industrial), betamethasone (pharmaceutical), and simetone (herbicide).

Kang et al. (2024) used suspect and non-target screening to detect emerging pollutants in urban receiving waters during stormwater events. They tentatively identified 65 substances, and those confirmed with high confidence were added to the candidate list, including the industrial substances 1,3-dicyclohexylurea, 6PPD-quinone, and dicyclohexylamine.

Furthermore, three exploratory studies from the Netherlands resulted in the inclusion of three or more candidate substances. VEWIN, the national association of water companies in the Netherlands, commissioned CLM Research and Advice to conduct a study on the use of PFAS pesticides due to concerns that these pesticides may threaten the quality of groundwater as a source of drinking water (**Dekker et al**., 2024). Based on the outcomes of this study, three metabolites of PFAS pesticides were added to the candidate list: fluopyram-7-hydroxy, a metabolite of fluopyram; haloaniline, a metabolite of tau-fluvalinate; and 3-propyl-1H-1,2,4-triazol-5-amine (HYPA), a metabolite of fluazinam.

The Working Group “Aanpak Opkomende Stoffen” (“Approach to Emerging Substances”) was established under the supervision of the Dutch Ministry of Infrastructure and Water Management and focuses on unknown substances and their potential undesirable effects. The Working Group commissioned AD Eco Advies to perform a review study on available research regarding micropollutants, aiming to summarize the current state of knowledge on emerging substances in the effluent of municipal wastewater treatment plants (WWTPs) and identify substances warranting further attention (**Derksen, 2022**). Several substances from this synthesis were added to the candidate list either because they were identified as substances of concern (e.g., the biocides didecyldimethylammonium and N,N-dimethyldodecylamine) or prioritized based on risk in a NORMAN case study involving WWTPs discharging into the Danube River (e.g., 4-hydroxy-omeprazole).

“The monitoring programs of drinking water companies evolve over time, driven by the development of new analytical methods and the inclusion of emerging substances in existing analytical methods.”

In the “Kennisimpuls Waterkwaliteit” (Water Quality Knowledge Boost Program, KIWK), the Dutch government, provinces, water authorities, drinking water companies, and research institutes collaborate to gain insights into the quality of groundwater and surface water, as well as the factors influencing it. The program started in 2018 and ran for four years. Within the KIWK program, 10 projects were established, including one on veterinary medicines to investigate the main sources, pathways, and risks[4]. As part of this project, a guideline was developed for a Veterinary Medicines Monitoring Strategy. Based on this strategy, several veterinary medicines were recommended for monitoring, including antibiotics (chlortetracycline, monensin), painkillers (carprofen), and antiparasitic subtances (flubendazole).

3.2.2 Screening

Drinking water companies along the Meuse are regularly monitoring their intake water and drinking water with advanced screening methods. Substances detected in >50% of the samples and which are not yet monitored with a quantitative analytical method are included in List 2a. For these substances it is recommended to develop an analytical method. It concerns the following pharmaceuticals: flecainide and levocetirizine.

Besides the industrial substances mono(methoxymethyl)melamine (MMMM), di(methoxymethyl)melamine (DMMM), tri(methoxymethyl)melamine (TMMM), and penta(methoxymethyl)melamine (PMMM) are often detected with screening. However, for these substances is already known that it will be complicated to develop an analytical method because standards are not available for each substance. Since their presence is related to the presence of HMMM and melamine (both on List 1) it is recommended to keep following these 4 substances with screening and they are therefore included in List 2b.

3.2.3 Monitoring

The monitoring programs of drinking water companies evolve over time, driven by the development of new analytical methods and the inclusion of emerging substances in existing analytical methods. Since risk-based monitoring has been introduced in the Netherlands in response to amendments to the European Drinking Water Directive (van der Aa et al., 2017), risk analyses are regularly conducted by the drinking water companies, including inventories of new chemical threats—similar to the approach taken in this study.

Not all substances are relevant to every drinking water company, and a substance may be incorporated into one monitoring program based on its risk profile but not yet included elsewhere. Substances that are not monitored at multiple locations cannot meet the criteria for inclusion on List 1. Therefore, this study also considers substances that exceed the ERM target value but are only monitored at a limited number of locations.

Substances that are included on List 2a based on measurements performed for drinking water companies are 1,2,4-triazole which was detected in surface water of the Scheldt. The perfluorinated substances perfluoropropionic acid (PFPrA) and perfluoropropanesulfonic acid (PFPrS) were monitored and detected by Evides. The industrial substances 1,2-Dimethoxyethane (monoglyme) is also monitored by Evides and was detected in concentrations up to 1 µg/L in Haringvliet. The relevant chlorothalonil-metabolite R471811 was detected in the Scheldt in concentrations above 1 µg/L.

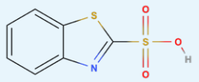
3.2.4 Parking list

Some substances on the candidate list have a natural origin, although they may also have anthropogenic applications, for example as pesticides. Since it is difficult to determine from measurements whether their presence is natural or due to human use, these substances are temporarily placed on a parking list. If their use increases in the future, they can be reassessed. For now, the decision has been made not to include natural substances, as advocating for the reduction of natural concentrations is of little value, with the exception of e.g. toxins from algae. Also, RIWA Meuse is in favour of the use of natural substances as plant protection product.

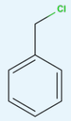
The substances in question are aflatoxin B1, indolebutyric acid, (9E)-9-octadecenamide and pelargonic acid, which have been added to Annex I.6.

4 *Diergeneesmiddelen: wat zijn de belangrijkste bronnen, routes en risico’s? (KIWK) | STOWA*

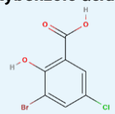
Benzothiazole-2-sulfonic acid



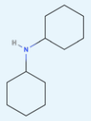
Benzyl chloride



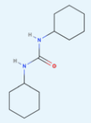
3-Bromo-5-chloro-2-hydroxybenzoic acid



Dicyclohexylamine

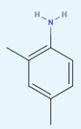


1,3-Dicyclohexylurea



1,2-Dimethoxyethane

2,4-dimethylaniline



3.3 Background information on the new relevant and candidate substances

In this chapter background information is provided for the substances that are newly added to List 1, 2a or 2b. The substances are grouped to their use as either (veterinary) pharmaceutical, pesticide or in an industrial application.

All information on each substance provided below is sourced from reliable databases, including PubChem, REACH files, ECHA files, and the EFSA online library. These platforms contain comprehensive data on each substance. Details regarding chemical properties, safety, and regulatory guidelines for each substance are available within these resources. For further verification or in-depth analysis, you can refer directly to the databases mentioned. The DDD for the pharmaceuticals are obtained for 2023 from the Dutch gipdatabank.

3.3.1 Industrial substances

Benzothiazole-2-sulfonic acid is a transformation product of benzothiazole derivatives. Benzothiazoles are compounds composed of a benzene ring fused with a thiazole ring, both of which can be substituted to produce a wide range of derivatives. These derivatives are primarily used as vulcanization accelerators in tire production.

Benzyl chloride is used in production of dyes and plastic. It is classified in The Netherlands as a substance of very high concern (SVHC). Benzyl chloride is classified as carcinogenic. This substance has shown to be readily biodegradable, as it showed 70% degradation after 28 days.

3-Bromo-5-chloro-2-hydroxybenzoic acid is a halogenated derivative of salicylic acid containing both bromine and chlorine atoms. It is primarily used in organic synthesis as an intermediate for producing chemicals, such as pharmaceuticals and agrochemicals. Due to its halogen substituents, it may exhibit reactive properties.

Dicyclohexylamine is an organic compound used as an intermediate in the production of corrosion inhibitors, rubber additives, herbicides, and pharmaceuticals.

1,3-Dicyclohexylurea plays an important role as a reagent and catalyst in organic synthesis. It can undergo derivatization reactions with compounds such as amino acids, peptides, and proteins, facilitating compound separation and detection. It can also be used in acylation and urea reactions of compounds. It is used in the pharmaceutical industry and in the dye- and coating industry.

1,2-Dimethoxyethane (also known as monoglyme) is a colorless, highly flammable liquid with the formula $C_4H_{10}O_2$. It is widely used as a solvent in chemical synthesis, such as in Grignard reactions and electrolyte solutions for batteries. Although stable, it can form hazardous peroxides upon exposure to air.

2,4-dimethylaniline is substance that is used in the production of pharmaceuticals, pesticides and dyes. It is classified as genotoxic (https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID8026305).

8-Hydroxypenillic acid was previously used as an additive in the purification process of the Industrial Wastewater Treatment Plant (IAZI) at Circle Infra Partners in Sittard/Geleen.

Methoxymethylmelamines are melamine resins used as crosslinkers in coatings, paints, adhesives, and textile finishing. They enhance the strength, durability, and chemical resistance of materials by linking polymers. The specific properties of these resins vary depending on the number of methoxymethyl groups:

- **Mono(methoxymethyl)melamine (MMMM):** Contains one methoxymethyl group and is used in industrial coatings and automotive paints for improved durability and abrasion resistance.
- **Di(methoxymethyl)melamine (DMMM):** With two methoxymethyl groups, it provides enhanced chemical resistance and durability in coatings and textiles.
- **Tri(methoxymethyl)melamine (TMMM):** Contains three methoxymethyl groups, strengthening materials and improving their chemical resistance.
- **Penta(methoxymethyl)melamine (PMMM):** With five methoxymethyl groups, it offers high abrasion resistance and chemical stability.
- **Hexa(methoxymethyl)melamine (HMMM)** is added to various products to enhance their quality, examples include paint, printing ink, various coatings (for the automotive industry, household appliances, cans, and agricultural machinery), paper, textiles, leather, and rubber (tires). Because HMMM is used in such a wide range of products, it can enter surface water through numerous pathways[5].

While these resins significantly enhance the performance of industrial and consumer products, improper handling can cause skin and eye irritation, making safe handling essential.

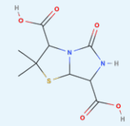
2-Methyl-2H-benzotriazole (Tolyltriazole) is used as a corrosion inhibitor in industrial applications such as coolants and metalworking fluids. However, it can be harmful to the environment due to its persistence and potential to accumulate in aquatic ecosystems.

1-Phenyl-1,2-propanediol is a substance that could be used in drug production and classified as a carcinogenic, mutagenic, or toxic for reproduction (CMR)-substance (Van Leerdam et al., 2022). It 'is a reagent in pharmaceutical chemistry, used in the synthesis of nor(pseudo)ephedrine related compounds' (https://www.chemicalbook.com/ChemicalProductProperty_EN_CB7921553.htm). No information on this substance was available from PubChem or ECHA.

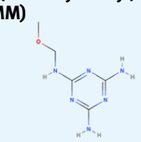
2-Phenylquinoline is an organic compound containing a quinoline ring and a phenyl group. It is used in organic synthesis and has applications in materials such as Organic Light Emitting Diodes (OLEDs) and pharmaceutical research. Some derivatives exhibit antitumor or antibacterial properties.

5 *Hexa(methoxymethyl) melamine (HMMM): bronnen en concentraties in water - Rijkswaterstaat Publicatie Platform*

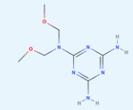
8-Hydroxypenillic acid



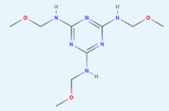
Mono(methoxymethyl) melamine (MMMM)



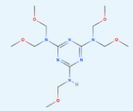
Di(methoxymethyl) melamine (DMMM)



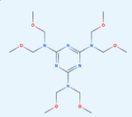
Tri(methoxymethyl) melamine (TMMM)



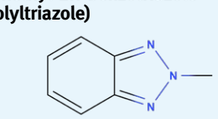
Penta(methoxymethyl) melamine (PMMM)



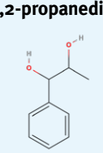
Hexa(methoxymethyl) melamine (HMMM)



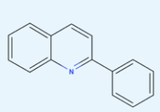
2-Methyl-2H-benzotriazole (Tolyltriazole)



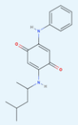
1-Phenyl-1,2-propanediol



2-Phenylquinoline



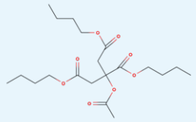
6PPD-Quinone



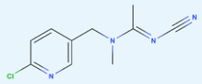
Phthalic anhydride

1,2,4-Triazole

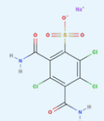
Tributyl citrate acetate



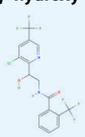
Acetamiprid



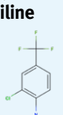
Chlorothalonil R471811



Fluopyram-7-hydroxy



Haloaniline (2-Chloro-4-(trifluoromethyl)aniline



6PPD-Quinone is a toxic degradation product of 6PPD, a chemical widely used as an antioxidant in rubber, particularly in car tires. 6PPD protects tires from aging due to exposure to ozone and oxygen. When tires wear and 6PPD enters the environment, it can react with ozone and water, forming 6PPD-quinone. This compound is highly toxic to aquatic organisms, especially coho salmon.

Phthalic anhydride is a key chemical used in the production of plasticizers, alkyd resins, polyester resins, and dyes. It plays a crucial role in the manufacture of flexible plastics, paints, and coatings.

1,2,4-Triazole is a stable organic compound containing three nitrogen atoms in a five-membered ring. It is a white solid with a characteristic odour. 1,2,4-Triazole is used in pharmaceuticals, fungicides, pesticides, and as a catalyst. Common metabolites of triazole-containing fungicides include triazole acetic acid (TAA), triazole alanine (TA), 1,2,4-triazole (1,2,4-T), and triazole lactic acid (TLA), which form during the degradation of these substances.

Tributyl citrate acetate is a non-toxic, biodegradable plasticizer widely used as a safe alternative to phthalates in plastics, such as PVC, and in products like cosmetics, food packaging, and medical devices. It is transparent, odourless, and thermally stable, making it suitable for various applications. Tributyl citrate acetate is considered safe for food contact and complies with international safety standards, including FDA and EU approvals.

3.3.2 Pesticides and metabolites

Acetamiprid is an insecticide that belongs to the neonicotinoid class. It is used to control a wide range of insect pests, such as aphids, whiteflies, and beetles, in both agriculture and horticulture. Acetamiprid is widely used due to its effectiveness and relatively low toxicity to mammals, although there are concerns about its impact on insect populations. Acetamiprid is included in the third renewal program for pesticides ("AIR3") under Regulation (EU) No 844/2012 and was first approved in 2004. Its approval was renewed in 2018, with the next renewal process required to start by February 28, 2030. The maximum residue limits (MRLs) are set by Regulation (EC) No 396/2005.

Chlorothalonil R471811 is a metabolite of chlorothalonil, a fungicide that was banned by the EU in 2019. From May 2020 onwards, the use of this pesticide was prohibited. Notably, chlorothalonil R471811, which is derived from chlordecone, is considered to be a much more toxic carcinogen than glyphosate.

Fluopyram-7-hydroxy is a metabolite of fluopyram, a fungicide that inhibits fungal growth. It is formed through the breakdown of fluopyram in the environment or within organisms. Both fluopyram and its metabolite belong to the class of PFAS.

Haloaniline (2-Chloro-4-(trifluoromethyl)aniline) is a metabolite of the PFAS-pesticide tau-fluvalinate. There is limited information available for this substance, but EFSA provides some data. EFSA states that haloaniline has a moderate to high persistence, it's mobility in groundwater is medium to low and its toxicity is three orders lower than tau-fluvalinate (https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2010.1645).

Metamitron-desamino is a degradation product of the herbicide metamitron, which is used for weed control in sugar beet cultivation. It is formed through microbial or chemical degradation in the environment.

S-Metolachlor is widely used as an herbicide. It is a derivative of aniline and is a member of the chloroacetanilide family of herbicides. It is highly effective toward grasses. Metolachlor oxanilic acid (OA) is a major soil metabolite of S-metolachlor and often detected in groundwater and surface water.

Propamocarb is a systemic fungicide used for control of soil, root and leaf disease caused by oomycetes. It is used by watering or spraying. Propamocarb is absorbed and distributed through the plant's tissue. In Belgium and the Netherlands, crop protection products based on the active substance propamocarb have been or are authorized under names such as Budget Propamocarb-Fosetyl (NL), Matix (NL), Previcur Energy (BE, NL), Profo Energy (BE), and Wopro Energy (NL). In 2021 the substance was emitted together with prosulfocarb by a company in Wandre, resulting in high concentrations in the Meuse.

3-Propyl-1H-1,2,4-triazole-5amine (HYPA) is a metabolite of PFAS-pesticide fluazinam. Limited information is available about this metabolite, as there is no information on PubChem or ECHA. Fluazinam, its parent substance, is a fungicide and is approved in The Netherlands (https://sitem.herts.ac.uk/aeru/ppdb/en/Reports/325.htm).

Simetone (N,N'-diethyl-6-methoxy-1,3,5-triazine-2,4-diamine) is a triazine-herbicide (like atrazine). It is used to control of broadleaf and weeds in farmlands planted with maize, pineapple, sugarcane, banana, or citrus (Yang et al., 2022). It has a known transformation product: simazine-2-hydroxy (Pubchem). No information could be found on ECHA about simetone. This herbicide is approved in The Netherlands (https://sitem.herts.ac.uk/aeru/ppdb/en/Reports/3629.htm#none).

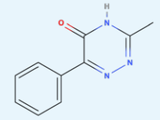
3.3.3 Biocides

Dibromomethane sulfonic acid is a halogenated methanesulfonic acid (HMSA) HMSA's are recently discovered polar disinfectant byproducts.

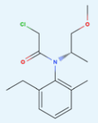
Didecyldimethylammonium chloride (DDAC) is a quaternary ammonium compound widely used as a disinfectant and biocide. It belongs to the group of quaternary ammonium compounds, known for their antimicrobial properties and commonly used for cleaning and disinfecting surfaces in hospitals, food processing facilities, and other industrial environments

Lauroguadine is an organic compound with antimicrobial and cleaning properties, commonly used in disinfectants and personal care products. Due to its long lauryl chain, it functions as a surfactant, capable of binding oil and dirt, making it useful in cleaning products.

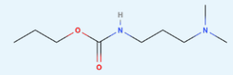
Metamitron-desamino



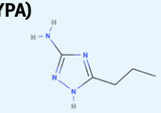
S-Metolachlor



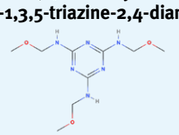
Propamocarb



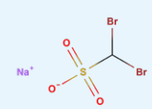
3-Propyl-1H-1,2,4-triazole-5amine (HYPA)



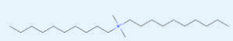
Simetone (N,N'-diethyl-6-methoxy-1,3,5-triazine-2,4-diamine)



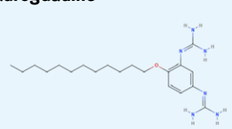
Dibromomethane sulfonic acid



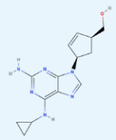
Didecyldimethylammonium chloride (DDAC)



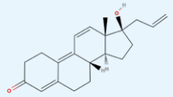
Lauroguadine



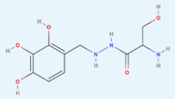
Abacavir



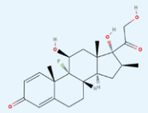
Altrenogest



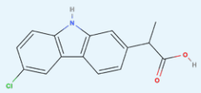
Benserazide



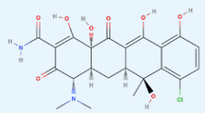
Betamethasone



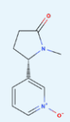
Carprofen



Chlortetracycline



Cotinine N-oxide



3.3.4 (Veterinary) pharmaceuticals

Abacavir is an antiviral medication used to treat HIV (Human Immunodeficiency Virus)-infections. It belongs to the class of drugs known as nucleoside reverse transcriptase inhibitors (NRTI). These drugs inhibit the enzyme reverse transcriptase, which is essential for the virus to replicate within human cells. Abacavir reduces the viral load in the body and helps strengthen the immune system, but it does not cure HIV. It is used to improve quality of life and reduce the risk of HIV-related complications. Abacavir is typically used in combination with other antiretroviral agents. The drug Triumeq®, which contains abacavir, is in the top 500 of most used medicines (based on DDD), with almost 600.000 DDD in 2023.

Altrenogest is a synthetic progestogen, a hormone similar to natural progesterone, primarily used in veterinary medicine. It is commonly used in horses and pigs to control the reproductive cycle, particularly to suppress or synchronize estrus in female animals. Altrenogest is frequently used in breeding programs and livestock management.

Benserazide is a medication primarily used in combination with levodopa for the treatment of Parkinson's disease. It is a dopa-decarboxylase inhibitor, meaning it prevents the breakdown of levodopa in the body outside the brain. This allows more levodopa to reach the brain, where it is converted into dopamine, the neurotransmitter deficient in Parkinson's disease. Benserazide enhances the effectiveness of levodopa and helps alleviate the motor symptoms of Parkinson's. Benserazide is not found in the top 500 medicines used in 2023 (based on DDD).

Betamethasone is a systemic corticosteroid, used to treat for example eczema. It is also marked as an anti-asthmatic drug. Simulations using QSAR showed that betamethasone is not readily biodegradable (ECHA). Betamethasone has a known transformation product in betamethasone-21-acetate. In The Netherlands, betamethasone was ranked 72nd in 2023, based on more than 26 million DDD's in 2023.

Carprofen is a veterinary non-steroidal anti-inflammatory drug (NSAID) primarily used in dogs to treat pain and inflammation, such as in osteoarthritis and post-surgical recovery. It works by inhibiting the cyclooxygenase (COX)-2 enzyme to reduce the production of prostaglandins, which cause pain and inflammation.

Chlortetracycline is an antibiotic of the tetracycline class. It is used to treat various bacterial infections in both humans and animals. Chlortetracycline works by binding to bacterial ribosomes, disrupting protein synthesis. This inhibits bacterial growth and reproduction, ultimately stopping the infection. Chlortetracycline is not found in the top 500 medicines used in 2023 (based on DDD).

Cotinine N-oxide is a metabolite of nicotine. It accounts for less than 5% of the nicotine dose when excreted by smokers (https://hmdb.ca/metabolites/HMDB0001411). No additional information about this substance is available on PubChem or ECHA.

Dioxoaminopyrine is a metabolite of aminopyrine, a non-narcotic analgesic and antipyretic once widely used but now less common due to the risk of severe side effects such as agranulocytosis (a dangerous decrease in white blood cells). This compound is chemically classified as a monocarboxylic acid amide derivative and is mainly studied in relation to the degradation and biochemical activity of aminopyrine

Doxycycline is an antibiotic belonging to the tetracycline class. It works by inhibiting bacterial protein synthesis, which halts bacterial growth and eventually leads to their death. Doxycycline binds to bacterial ribosomes, blocking the production of new proteins. It is used to treat a wide range of bacterial infections, including respiratory, skin, eye, and urinary tract infections, as well as sexually transmitted infections such as chlamydia and gonorrhea. It is also prescribed for malaria and acne treatment. Based on DDD, doxycycline ranks as 152nd in the top 500 most prescribed medicines in 2023 (based on DDD) with a little under 10 million DDD.

(2E,5R)-2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine (EDDP) is a metabolite of methadone, an opioid used for pain management and addiction treatment. It is formed in the liver during the enzymatic breakdown of methadone. EDDP itself has no pharmacological activity, but its presence in urine or blood is often used as an indicator of methadone use or compliance with treatment. With over 7 million DDD, methadone is ranked 179th in the top 500 medicines used in 2023 (based on DDD).

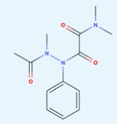
Emtricitabine is pharmaceutical, more specifically an antiretroviral drug. It is used to treat infections of HIV and Hepatitis B. In The Netherlands, it is offered in combination with other pharmaceuticals. The highest DDD in 2023 was 1,36 million, which was the medicine Biktarvy®.

Flecainide is a class Ic antiarrhythmic drug used to treat abnormal heart rhythms by blocking sodium channels, slowing electrical conduction in the heart. It is prescribed for atrial fibrillation and supraventricular arrhythmias. Side effects can include severe arrhythmias and dizziness. In 2023, a little over 8 million DDD were prescribed in the Netherlands.

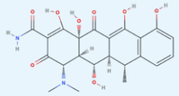
Florfenicol is an antibiotic used in veterinary medicine to treat bacterial infections in livestock and fish. It works by inhibiting bacterial protein synthesis, thereby stopping bacterial growth. Unlike chloramphenicol, it is safer and does not cause aplastic anemia in humans, making it suitable for use in food production. Florfenicol is often administered through feed, water, or injections and is effective against bacteria such as Pasteurella and Escherichia coli.

Flubendazole is an anthelmintic drug used to combat worm infections in both humans and animals. It belongs to the benzimidazole class and is effective against various types of parasitic worms, such as roundworms and tapeworms. It works by disrupting the worms' energy production, leading to their death. Flubendazole is commonly used for infections like pinworms and roundworms and is known for its broad efficacy and low toxicity. Flubendazole is not found in the top 500 medicines used in 2023 (based on DDD). Flubendazole belongs to the class of PFAS.

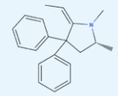
Dioxoaminopyrine



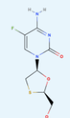
Doxycycline



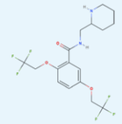
(2E,5R)-2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine (EDDP)



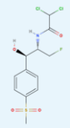
Emtricitabine



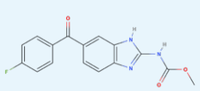
Flecainide



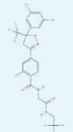
Florfenicol



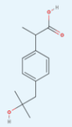
Flubendazole



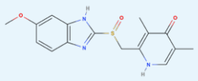
Fluralaner



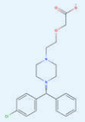
2-Hydroxibuprofen



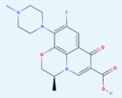
4-Hydroxy-omeprazole



Levocetirizine



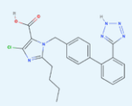
Levofloxacin



Lithium

Li

Losartan carboxylic acid



Fluralaner is a systemic insecticide and acaricide. It is primarily used in veterinary medicine to treat and prevent infestations of fleas and ticks in dogs and cats. Fluralaner works by inhibiting the gamma-aminobutyric acid (GABA)-gated chloride channels in the nervous systems of parasites, leading to their paralysis and death. It is commonly administered as a chewable tablet or topical solution, providing long-lasting protection. Fluralaner belongs to the class of PFAS.

2-Hydroxibuprofen is the metabolite of ibuprofen, which is widely used as a non-steroidal anti-inflammatory drug (NSAID) that helps reduce pain, inflammation, and fever. With more than 9 million DDD in 2023, ibuprofen is one most prescribed medicines in the Netherlands.

4-Hydroxy-omeprazole is a metabolite of omeprazole, a drug used to treat acid reflux and ulcers by reducing stomach acid production. It is converted to 4-hydroxy-omeprazole via the CYP2C19 enzyme, a key enzyme responsible for the breakdown of omeprazole in the body. Omeprazole is the most used drug in The Netherlands in 2023 (based on DDD), with over 400 million DDD prescriptions.

Levocetirizine, the active (R)-enantiomer of cetirizine, is a selective H1-receptor antagonist and an antihistamine used to treat allergic symptoms such as sneezing, itching, and a runny nose. It is the active form of cetirizine and works by blocking histamine receptors, which are responsible for allergic reactions. Levocetirizine is commonly prescribed for hay fever, allergic rhinitis, and urticaria (hives). It only exhibits sedative effects at high doses. Levocetirizine is in the top 50 of prescribed medicines, with almost 58 million DDD in 2023. Levocetirizine belongs to the class of PFAS.

Levofloxacin is a broad-spectrum antibiotic from the fluoroquinolone class, used to treat infections such as pneumonia, bronchitis, urinary tract infections, and skin infections. It works by inhibiting bacterial DNA replication. Levofloxacin had almost 0,5 million DDD in 2023.

Lithium is an alkali metal that occurs naturally. It is most commonly used in batteries but is also applied in the ceramics and glass industries. The demand for lithium is rapidly increasing, particularly due to the rise of electric vehicles equipped with rechargeable lithium batteries. In addition, lithium is widely used as a medication for mania and depression. Lithium works by affecting the flow of sodium in nerve and muscle cells, which helps regulate mood and reduce manic episodes. Lithium salts (Priadel®) are frequently prescribed in the Netherlands, with 7,6 million reported DDD.

Losartan carboxylic acid is the primary active metabolite of losartan, an angiotensin II receptor blocker (used to treat high blood pressure and certain heart and kidney conditions. Losartan itself is a prodrug, meaning it is converted in the body to this active metabolite, which is responsible for most of its antihypertensive effects. Losartan was 12th on the list of the most used medicines in 2023 (based on DDD) with almost 153 million DDD.

Mesterolone is an oral anabolic-androgenic steroid and a synthetic derivative of testosterone. It is primarily used in the treatment of male hypogonadism and infertility, as it helps improve sperm production and restore normal testosterone levels. Mesterolone has relatively weak anabolic effects and is not commonly used for muscle-building purposes. It is known for its low risk of aromatization, meaning it does not convert to oestrogen, reducing the likelihood of oestrogen-related side effects. The brand name of mesterolone is Proviron®.

Monensin is an antibiotic belonging to the ionophore group, primarily used in livestock farming. It works by disrupting ion transport processes in microorganisms, particularly in coccidia, leading to their dysfunction and death. Monensin is commercially sold under names like Rumensin® and is widely used in intensive livestock farming to improve productivity and prevent parasitic infections.

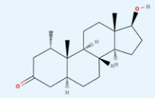
Tenofovir is an antiviral medication used to treat HIV and hepatitis B. It belongs to the class of drugs known as nucleoside reverse transcriptase inhibitors (NRTI) and works by inhibiting the enzyme reverse transcriptase, which is essential for viral replication. While tenofovir effectively suppresses the viral load, like other antiretroviral drugs, it does not cure the infection. However, it helps reduce the risk of HIV-related complications and prevents the spread of the virus. Several medicines which contain tenofovir are available, the one with the highest DDD in 2023 is Biktarvy®, with over 1,3 million DDD.

Toltrazuril is an antiprotozoal agent used to treat coccidiosis, a parasitic infection, in animals such as poultry, pigs, cattle, and sheep. Toltrazuril disrupts the parasite's development in the host's intestinal epithelium. It targets multiple stages of the parasite's life cycle, preventing coccidia from growing and reproducing.

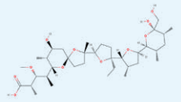
Triaprost is a synthetic prostaglandin analogue that acts as a vasodilator and antithrombotic agent. It is used for animals to treat conditions such as pulmonary arterial hypertension by dilating blood vessels and preventing blood clots. Compared to natural prostacyclin, triaprost is more stable and has a longer duration of action. Triaprost is not found in the top 500 medicines used in 2023 (based on DDD).

Xylazine is a sedative, analgesic, and muscle relaxant primarily used in veterinary medicine for sedation, pain relief, and as a pre-anaesthetic in animals such as dogs, cats, horses, and cattle. It works by activating alpha-2 adrenergic receptors in the central nervous system, leading to sedation and muscle relaxation. Possible side effects include respiratory depression and bradycardia. Although intended for animals, xylazine is sometimes abused by humans, posing serious health risks.

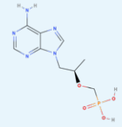
Mesterolone



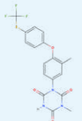
Monensin



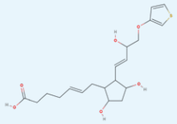
Tenofovir



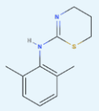
Toltrazuril



Triaprost



Xylazine



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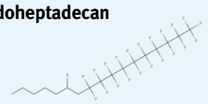

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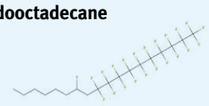
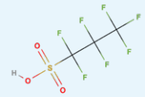


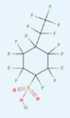
((Perfluorododecyl)methyl) oxirane

Perfluoropropanoic acid (PFPrA)

Perfluoropropane-1-sulfonic acid (PFPrS)



Perfluoro-p-ethylcyclohexylsulfonic acid (PFECHS)



3.3.5 PFAS

1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodoheptadecane is a PFAS with a long fluorinated carbon chain and an iodine atom. It is highly stable and used in industrial applications such as coatings and lubricants. Due to its strong carbon-fluorine bonds, it is difficult to degrade, raising environmental concerns about bioaccumulation and persistence.

1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodooctadecane is a highly fluorinated PFAS with a long carbon chain and an iodine atom. It is extremely stable and used in industrial applications like coatings and lubricants. Its hard-to-degrade structure poses environmental risks due to long-term persistence and bioaccumulation. This compound has one additional carbon atom compared to its heptadecane counterpart, which may lead to subtle differences in physical properties.

((Perfluorododecyl)methyl)oxirane is a fluorinated epoxide used in coatings, surface treatments, and polymer chemistry due to its water- and dirt-repellent properties and chemical resistance. It belongs to the class of PFAS and its perfluoroalkyl chain makes it highly persistent in the environment, raising potential environmental and health risks similar to other perfluorinated compounds.

Perfluoropropanoic acid (PFPrA) is another short-chain PFAS with a carboxylic acid group. It is extremely stable and barely degradable, contributing to environmental pollution. Although it accumulates less in organisms than long-chain PFAS, its health risks remain unclear. Evidence from human epidemiological studies is limited, showing no consistent associations with glycaemic indicators, thyroid hormones, or sperm parameters. No reliable effects of PFPrA concentrations were found, but due to the low sensitivity of the studies, this cannot be taken as evidence of no effect.

Perfluoropropane-1-sulfonic acid (PFPrS) is a short-chain PFAS known for its chemical stability and water- and grease-repellent properties. It is highly resistant to environmental breakdown and can bioaccumulate, albeit less than long-chain PFAS. PFPrS is used in products such as coatings and firefighting foams.

Perfluoro-p-ethylcyclohexylsulfonic acid (PFECHS) is a PFAS compound known for its extreme environmental persistence, resistance to degradation, and potential for bioaccumulation in water and organisms. It is likely used in industrial applications due to its water- and grease-repellent properties. The environmental and health risks of PFECHS, such as hormonal disruption, immune system effects, and cancer, are comparable to other PFAS compounds. Although less studied, PFECHS is increasingly monitored due to ongoing concerns about pollution and toxicity.

3.3.6 Natural compounds (parking list)

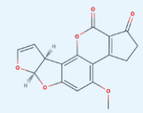
Aflatoxin B1 is a mycotoxin from Aspergillus flavus and Aspergillus parasiticus. It was concluded that this substance is carcinogenic and genotoxic. Aflatoxin B1 also showed to be the most toxic and most abundant aflatoxin, among others (e.g. aflatoxin B2, M1, M2, G1 and G2). In food, other aflatoxins never show up without aflatoxin B1 also being present. EFSA states that 'Aflatoxin-producing fungi are found in areas with a hot, humid climate. Climate change is anticipated to impact on the presence of aflatoxins in food in Europe' (https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2020.6040).

Indolebutyric acid, also known as indole-3-butyric acid (IBA), is a plant hormone belonging to the auxin class, which regulates plant growth and development. IBA is commonly used as a growth promoter, especially to stimulate root development in cuttings.

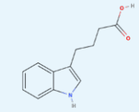
(9E)-9-Octadecenamide, also known as oleamide, is a fatty acid amide naturally occurring in the body, particularly in cerebrospinal fluid. It plays a role in promoting sleep and is being studied for its calming effects on the nervous system. Additionally, it has industrial applications as a lubricant in plastic processing and as an anti-slip agent in products like polyolefins.

Pelargonic acid (nonanoic acid) is a saturated fatty acid with nine carbon atoms. It is naturally found in plants like geraniums. Widely used as a biological herbicide, it damages plant cell walls and causes dehydration. It is also used in fragrances, lubricants, and cosmetics. Pelargonic acid is biodegradable, has low toxicity, but may cause skin and eye irritation.

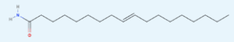
Aflatoxin B1



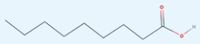
Indolebutyric acid



(9E)-9-Octadecenamide



Pelargonic acid (nonanoic acid)



4

Conclusions

List 1 Drinking water relevant substances

- The RIWA list of relevant drinking water substances (List 1) has been updated based on new monitoring data from the period 2019-2023.
- List 1 contains 42 substances, including one substance group (PFAS).
- Compared to 2021, 14 new substances have been added to the list. These substances include 6 industrial substances, 4 disinfection by-products, 4 pharmaceuticals (including 1 metabolite), and 3 pesticides (including 2 herbicide metabolites).

New on List 1	Application	Score
chlorate	disinfection byproduct	26
dibromomethane sulfonic acid	disinfection byproduct	26
dichloromethane sulfonic acid	disinfection byproduct	26
lithium	pharmaceutical	26
tribromomethane	disinfection byproduct	25
TCA	industrial	25
HMMM	industrial	20
2-hydroxibuprofen	pharmaceutical metabolite	19
8-hydroxypenillic acid	industrial	19
metolachlor-ESA	pesticide metabolite	19
candesartan	pharmaceutical	18
methenamine/urotropine	industrial	15
metolachlor-OA	pesticide metabolite	13
tolyltriazole	industrial	13
bisphenol A	industrial	12
propamocarb	pesticide	10
vigabatrin	pharmaceutical	10

Removed from List 1	Application
benzothiazole	industrial
chloridazone-desphenyl	pesticide metabolite
DIPE	industrial
di-n-butyltin	industrial
fluoride	industrial
monobromoacetic acid	disinfection byproduct
terbuthylazine	pesticide

List 2 Candidate drinking water relevant substances

- A literature study has been conducted, resulting in the proposal of new candidate substances.
- For 6 substances, an analytical method is available at a known laboratory. These substances are proposed to be included in List 2a, along with 7 substances that were already placed on the list in 2021, making a total of 13 substances.
- 48 substances have been proposed for targeted screening (List 2b). These include 22 pharmaceuticals and/or veterinary drugs, 17 industrial substances (including 4 PFAS), 8 pesticides and biocides, and 1 nicotine metabolite. Two pharmaceutical substances proposed in 2021 remain on List 2b, making a total of 50 substances.

- Naturally occurring substances, such as indolebutyric acid, have not been included in Lists 2a or 2b but are temporarily placed on a parking list, as advocating for the reduction of natural concentrations is of little value.

New on List 2a	Application	Score
PFPrS	PFAS	26
levocetirizine	pharmaceutical	20
flecainide	pharmaceutical	19
monoglyme	industrial	14
PFPrA	PFAS	13
chlorothalonil R471811	pesticide (metabolite)	12

New on List 2b	Application	Score
fluopyram-7-hydroxy	pesticide metabolite (PFAS)	27
levofloxacin	pharmaceutical	27
xylazine	veterinary drug	27
benzothiazole-2-sulfonic acid	industrial	26
betamethasone	pharmaceutical	26
dioxoaminopyrine	pharmaceutical	26
simetone	pesticide	26
tenofovir	pharmaceutical	26
altrenogest	veterinary drug	25
benzylchloride	industrial	25
metamitron-desamino	pesticide metabolite	25
PFECHS	PFAS	25
HYPA	pesticide metabolite	25
((perfluorododecyl)methyl)oxirane	PFAS	24
1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodoheptadecane	PFAS	24
1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-henicosafluoro-12-iodooctadecane	PFAS	24
1,3-dicyclohexylurea	industrial	24
2-phenylquinoline	Industrial	24
3-bromo-5-chloro-2- hydroxybenzoic acid	Industrial	24
lauryl guanidine	biocide	24
losartan carboxylic acid	pharmaceutical metabolite	24
triaprost	veterinary drug	24
florfenicol	veterinary drug	21
benserazide	pharmaceutical	20
4-hydroxy-omeprazole	pharmaceutical	19
EDDP	pharmaceutical (metabolite)	19
mesterolone	pharmaceutical	19
chlortetracycline	veterinary drug/pharmaceutical	15
doxycycline	veterinary drug/pharmaceutical	15
methoxymethyl)melamines	industrial	15
cotinine N-oxide	metabolite nicotine	14
emtricitabine	pharmaceutical	14
flubendazol	veterinary drug/pharmaceutical	14
haloaniline	pesticide (metabolite) (PFAS)	14

New on List 2b	Application	Score
1-phenyl-1,2-propanediol	industrial	13
2,4-dimethylaniline	industrial	13
abacavir	pharmaceutical	13
acetamiprid	pesticide	13
fluralaner	veterinary drug	13
monensin	veterinary drug	13
6PPD-quinone	Industrial	12
carprofen	veterinary drug	12
dicyclohexylamine	industrial	12
toltrazuril	veterinary drug	12
DDAC	biocide	11
tributyl citrate acetate	industrial	11
2-methyl-2H-benzotriazole	Industrial	10
phthalic anhydride	industrial	10

List 3 Substances which no longer meet the criteria

- Seven substances are no longer considered drinking water relevant. These include the industrial substances di-n-butyltin, benzothiazole, monobromoacetic acid, DIPE, and fluoride, as well as the herbicide terbuthylazine and herbicide metabolite chloridazone-desphenyl. For fluoride and DIPE, discussions between RIWA and the producing industry have contributed to reduced concentrations of these substances.
- Although these substances no longer meet the criteria used in this evaluation, they may still be relevant to individual drinking water companies, and each company can choose to continue monitoring them.

5

Recommendations

- It is advised to use the updated 2023 lists 1 and 2a as a basis for a joint monitoring program among the drinking water companies along the river Meuse. For 2025, the proposed substances to be monitored include:

List 1	
Substance	**CS RN**
1,4-dioxane	123-91-1
2-hydroxibuprofen	51146-55-5
8-hydroxypenillic acid	3053-85-8
AMPA	1066-51-9
glyphosate	1071-83-6
bisphenol A	80-05-7
bromate	15541-45-4
candesartan	139481-59-7
chlorate	14866-68-3
cyanuric acid	108-80-5
dibromoacetic acid	631-64-1
dibromomethane sulfonic acid	859073-88-4
dichloromethane sulfonic acid	53638-45-2
DTPA	67-43-6
EDTA	64-02-8
guanylurea	141-83-3
metformin	657-24-9
HMMM	68002-20-0
hydrochlorothiazide	58-93-5
ketoprofen	22071-15-4
lamotrigine	84057-84-1
lithium	7439-93-2
melamine	108-78-1
methenamine	100-97-0
S-metolachlor	87392-12-9
metolachlor-ESA	171118-09-5
metolachlor-OA	152019-73-3
naproxen	22204-53-1
N-formyl-4-aminoantipyrine	1672-58-8
NTA	139-13-9
PFAS	NA
propamocarb	24579-73-5
prosulfocarb	52888-80-9
sulfamic acid	5329-14-6
tolyltriazole	29385-43-1
tramadol	27203-92-5
tribromomethane	75-25-2
TCA	76-03-9
TFA	76-05-1
valsartan	137862-53-4
valsartanic acid	164265-78-5
vigabatrin	60643-86-9

List 2a	
Substance	**CS RN**
1,2-Dimethoxyethane (monoglyme)	110-71-4
Adamantan-1-amine	768-94-5
Bisphenol-F	620-92-8
Chlorothalonil R471811	geen CAS
Fexofenadine	83799-24-0
Flecainide	54143-55-4
Levocetirizine	130018-77-8
MGDA	164462-16-2
Oxipurinol	2465-59-0
PFPrA	422-64-0
PFPrS	423-41-6
Ritalinic acid	19395-41-6

- It is recommended to prioritize the development of new analytical methods for bisphenol F, which is listed under List 2a.

- It is recommended to add the substances from list 2b to a screening database and initially track them in the Meuse through targeted screening. Based on their detection rates, a decision can then be made on whether to monitor these substances using quantitative methods. Another suggestion would be to do a preliminary screening using non-target screening (NTS) for the substances from List 2b.

- It is recommended to review the screening data of the 16 substances that were added on List 2b in 2021 during the next evaluation when screening data is available for 5 years and determine whether these substances should possibly be moved to List 2a.

- It is recommended to examine during the next evaluation whether adjustments to the criteria for assessing removal in water treatment are necessary. It is advised to align as much as possible with other consortia that evaluate these properties for substances, such as the ZeroPM methodology for assessing PMT properties (noting that evaporation is not included in their approach, although this a relevant parameter for water treatment). Additionally, consideration could be given to using the Henry's constant as an alternative parameter for predicting evaporation from water because it provides a more specific representation of the physicochemical properties of a substance in aqueous systems. Other options to consider are the inclusion of the EpiSuite calculations of the half-life from a model for rivers and lakes and calculations of a half-life based on BioWin3.

- Another point that is recommended to discuss for the next evaluation is the use of the maximum concentration for the calculation of the BQ. There are arguments to use the P90 or P50 value instead to be sure that the focus is on substances that form a structural problem.

6

References

Abafe, O.A., Lawal, M.A., Chokwe, T.B., 2023.
Non-targeted screening of emerging contaminants in South African surface and wastewater. Emerging Contaminants 9 (4); 100246. https://doi.org/10.1016/j.emcon.2023.100246

Dekker, A., Leendertse, P., Bosland, H., Holleman, S.
PFAS pesticides and groundwater. CLM report 1193.

Derksen, A., 2022.
Aandachtvragende stoffen in rwzi-effluent - Samenvatting van de huidige stand van de kennis. In opdracht van:Werkgroep Aanpak Opkomende Stoffen. Opgesteld door: Anja Derksen (AD eco advies)

European Chemicals Agency (ECHA) REACH files.
https://echa.europa.eu/nl/information-on-chemicals

European Food and Safety Authority (EFSA).
https://efsa.onlinelibrary.wiley.com/

European Food and Safety Authority (EFSA), 2023.
Re evaluation of the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs. Scientific Opinion. https://doi.org/10.2903/j.efsa.2023.6857

Fischer, A., Bannink, A., Houtman, C.J. (2011).
Relevant substances for Drinking Water production from the river Meuse. An update of selection criteria and substances lists. HWL report 201117, Haarlem.

Gipdatabank.
https://www.gipdatabank.nl/

Kennisimpuls Waterkwaliteit (Foundation for Applied Water Research STOWA; KIWK).
https://www.stowa.nl/kennisimpuls

Kang, D., Yun, D., Hwa Cho, K., et al., 2024.
Profiling emerging micropollutants in urban stormwater runoff using suspect and non-target screening via high-resolution mass spectrometry. Chemosphere 352; 141402. https://doi.org/10.1016/j.chemosphere.2024.141402

Khan, U., Nicell, J., 2015.
Human Health Relevance of Pharmaceutically Active Substances in Drinking Water. AAPS J 17(3): https://doi.org/558-85 10.1208/s12248-015-9729-5

Krettek, A., 2017.
Identification of new emerging pollutants in surface water using suspect screening analysis and prioritisation strategies based on regulatory databases. Master's thesis in European Master in Environmental Science – Soil, Water, and Biodiversity. Swedish University of Agricultural Sciences.

Ng, K., Alygizakis, N., Androulakakis, A., et al. 2022.
Target and suspect screening of 4777 per- and polyfluoroalkyl substances (PFAS) in river water, wastewater, groundwater and biota samples in the Danube River Basin. Journal of Hazardous Materials 436; 129276. https://doi.org/10.1016/j.jhazmat.2022.129276

NICNAS, 2004.
National Industrial Chemicals Notification and Assessment Scheme; Methyl glycine diacetic acid, trisodium salt. File No. STD/1092

PubChem database.
https://pubchem.ncbi.nlm.nih.gov/

Rijkswaterstaat, 2021.
Uitvoeringsprogramma rivierdossier waterwinningen Maas 2022-2027. Uitvoeringsprogramma rivierdossier waterwinningen Maas 2022-2027 - Rijkswaterstaat Publicatie Platform

RIVM, 2022.
Mededelingen (Communication) RIVM – 29 november 2022 Adviesgroep Waterkwaliteit

Slootweg T., Van Genderen - de Kloe G., Rousseau B., Oomen T., Bannink A. (2021).
An update of the lists with compounds that are relevant for the production of drinking water from the river Meuse – 2021. RIWA-Meuse, Rotterdam. ISBN/EAN 9789083075952.

Van der Aa, N.G.F.M., van Leerdam, R.C., van de Ven, B.M., Janssen, P.J.C.M., Smit, C.E., Versteegh, J.F.M., 2017.
Evaluatie signaleringsparameter nieuwe stoffen drinkwaterbeleid. RIVM report 2017-0091

Van den Berg, G., S. de Rijk, A. Abrahamse & L. Puijker (2007).
Bedreigende stoffen voor drinkwater uit de Maas. KWR-rapport 07.043, Nieuwegein.

Van den Berg, G. (2009).
Threatening substances for Drinking Water in the river Meuse: an update. KWR-rapport 09.059, Nieuwegein.

Van der Hoek C, Bannink A, Slootweg T (2015).
An update of the lists with compounds that are relevant for the drinking water production from the river Meuse – 2015. HWL report 201507, Haarlem.

Van der Velden-Slootweg T., Bannink A. (2018).
An update of the lists with compounds that are relevant for the production of drinking water from the river Meuse – 2018. HWL report 201809, Haarlem.

WHO, 2017. World Health Organization; Guideline for Drinking-water Quality.
Fourth Edition incorporating the first addendum. ISBN 978-92-4-154995-0

Yang, W., Tang, Y., Jiang, L., et al., 2022.
Coupling suspect and non-target analytical methods for screening organic contaminants of concern in agricultural & urban impacted waters: Optimization and application. Science of The Total Environment 809; 151117. https://doi.org/10.1016/j.scitotenv.2021.151117

7

Appendices

I.1 Calculation of the substance score

The scoring system used was earlier described in Fischer et al. (2011).

The list of substances that are relevant to the drinking water function of the River Meuse are proposed to be scored, according to the following principles:

1. The main chemical properties that influence the removal by water treatment; polarity, volatility and removal by powdered activated carbon are ranked:
a) For polarity the log K_{ow} of the substance is used.
b) For volatility the vapor pressure of the substance is used.
c) For biodegradability of the substance the primary biodegradation model (BioWIN3, in EPI Suite 4.1) is used.

2. The toxicological benchmark quotient (BQ) is derived for each substance. BQ is the maximum concentration found in the river (C_{max} water) divided by the (provisional) toxicological drinking water guideline value (pGLV) The derivation of the pGLV is described in van der Aa et al. (2017)):

$$pGLV = \frac{ADI\ or\ TDI * m_{adult} * 20\%}{2L/day},$$

where ADI/TDI is the acceptable or tolerable daily intake in µg (kg body mass)$^{-1}$ day^{-1}, and m_{adult} is the average adult body mass in kg. For the calculations a m_{adult} of 70 kg is assumed.

For pharmaceuticals toxicological information is often not available. For these substances the daily defined dose (DDD) is alternatively used to establish a pGLV using a safety factor of 1000.

Table 1. Point attribution for polarity, volatility, biodegradability, and toxicity.

Polarity		Volatility		Biodegradability		Toxicity	
Log K_{ow}	Score	Vapor pressure (mm Hg)	Score	BioWIN3	Score	BQ	Score
>6	0	>52,5	0	>4,75 – 5	0	<0,01	0
>3 - 6	1	> 35 – 52,5	1	>3,25 – 4,75	1	0,01 – 0,1	6
0–3	2	17,5 – 35	2	2,25 – 3,25	2	>0,1 – 1	12
<0	3	<17,5	3	<2,25	3	>1	18

3. If the odour/taste threshold is breached by C_{max} water, 3 points are awarded.

I.2 Background information on substances List 1

Table 6 - Information on the drinking water relevant substances (List 1). Information is given on the ERM value used for the substance, the Dutch drinking water standard if available, the number of monitoring stations where the substance was monitored, the total number of measurements in the period 2019-2023, the number and percentage of measurements above the ERM, and the list on which the substance was placed in 2021. To calculate the percentage of measurements above the ERM, a lower bound scenario is chosen where values below the LOQ are considered 0, even if the LOQ is above the ERM.

Substance name	CAS	ERM (µg/L)	Dutch DW standard (µg/L)	# monitoring stations	# measure-ments	# measure-ments > ERM	% > ERM	List in 2018	Remarks
1,4-dioxane	123-91-1	0,1		8	397	167	42%	1	
2-hydroxibuprofen	51146-55-5	0,1		2	35	19	54%	New	
8-hydroxypenillic acid	3053-85-8	0,1		3	162	78	48%	New	
AMPA	1066-51-9	0,1	1	12	625	566	91%	1	
glyphosate	1071-83-6	0,1	0,1	10	625	45	7%	1	
bisphenol A	80-05-7	0,1	2,5	3	262	3	1%	3	1 exceedance in past 3 years
bromate	15541-45-4	0,1	1	6	201	85	42%	1	
candesartan	139481-59-7	0,1		3	190	24	13%	2	1 exceedance in past 3 years
chlorate	14866-68-3	1	250	9	431	431	100%	2	
cyanuric acid	108-80-5	1		7	215	68	32%	1	
dibromoacetic acid	631-64-1	0,1	60	4	245	24	10%	1	
dicbromomethane sulfonic acid	859073-88-4	0,1		3	180	11	6%	New	
dichloromethane sulfonic acid	53638-45-2	0,1		6	180	140	78%	2	
DTPA	67-43-6	1		8	429	72	17%	1	
EDTA	64-02-8	1		9	430	429	100%	1	
guanylurea	141-83-3	1		7	377	133	35%	1	
metformin	657-24-9	1		7	506	124	25%	1	
HMMM	68002-20-0	0,1		7	506	243	48%	New	
hydrochlorothiazide	58-93-5	0,1		2	281	7	2%	1	
ketoprofen	22071-15-4	0,1		2	280	4	1%	1	1 exceedance in past 3 years
lamotrigine	84057-84-1	0,1		8	289	58	20%	1	
lithium	7439-93-2	1	-	10	774	774	100%	New	
melamine	108-78-1	1		8	906	357	39%	1	
methenamine	100-97-0	1		9	422	178	42%	3	
S-metolachlor	87392-12-9	0,1	0,1	2	24	17	71%	1	
metolachlor-ESA	171118-09-5	1*	0,1	6	270	38	14%	3	
metolachlor-OA	152019-73-3	1*	0,1	4	376	28	7%	New	
naproxen	22204-53-1	0,1		4	424	11	3%	1	
N-formyl-4-aminoantipyrine	1672-58-8	0,1		4	365	72	20%	1	
NTA	139-13-9	1		7	430	75	17%	1	

Substance name	CAS	ERM (µg/L)	Dutch DW standard (µg/L)	# monitoring stations	# measure-ments	# measure-ments > ERM	% > ERM	List in 2018	Remarks
PFAS	NA	NA	0,1	NA	NA	NA	NA	1	Individual substances are measured
propamocarb	24579-73-5	0,1	0,1	4	805	53	7%	New	
prosulfocarb	52888-80-9	0,1	0,1	4	950	56	6%	1	
sulfamic acid	5329-14-6	1		6	180	180	100%	1	
tolyltriazole	29385-43-1	1		2	170	20	12%	3	1 exceedance in past 3 years
tramadol	27203-92-5	0,1		5	431	40	9%	1	
tribromomethane	75-25-2	0,1	25	6	849	26	3%	3	
TCA	76-03-9	0,1	60	5	249	169	68%	3	
TFA	76-05-1	0,1		7	270	259	96%	1	
valsartan	137862-53-4	0,1		3	441	8	2%	1	1 exceedance in past 3 years
valsartanic acid	164265-78-5	0,1		6	180	102	57%	1	
vigabatrin	60643-86-9	0,1		5	181	55	30%	3	

Table 7 - Information on the parameters that define the total score for the drinking water relevant substances (List 1)

Substance name	Total score	Max (µg/L)	(p)GLV (µg/L)	BQ	BQ score	Log K_{ow}		VP (mm Hg)		BIOWIN3		Exceedance taste/odour threshold	Exceedance legal standard	PMT score	(p)SVHC	Reference (p)GLV
1,4-dioxane	18	0,84	3	0,28	12	-0,27	3	3,8E+01	1	3,0	2	0	0	0,38	SVHC	RIVM
2-hydroxibuprofen	19	0,21	2,03	0,10	12	2,29	2	4,2E-07	3	2,7	2	0	0	0		Khan en Nicell
8-hydroxypenillic acid	19	2,90	10	0,29	12	1,96	2	1,6E-09	3	3,1	2	0	0	0		RIVM
AMPA	17	21,0	500	0,04	6	-2,47	3	5,8E-05	3	3,0	2	0	3	0,30		WHO
glyphosate	11	1,60	1500	0,001	0	-3,40	3	1,6E-08	3	3,2	2	0	3	0,25		RIVM
bisphenol A	12	0,23	2,5	0,09	6	3,32	1	2,3E-07	3	2,6	2	0	0	0,43	SVHC	EU DWD
bromate	27	0,86	0,2	4,3	18	NA	3	NA	3	NA	3	0	0		SVHC	RIVM
candesartan	18	0,20	0,4	0,50	12	4,79	1	1,8E-18	3	2,3	2	0	0	0		RIVM - pending
chlorate	26	133	21	6,33	18	<0	3	<0	3	3,0	2	0	0	0		RIVM - pending
cyanuric acid	13	3,38	40	0,08	6	1,95	2	4,4E-11	3	2,9	2	0	0	0		WHO
dibromoacetic acid	25	2,10	0,0104	202	18	0,70	2	2,3E-02	3	3,1	2	0	0	0,33		RIVM - pending
dicbromomethane sulfonic acid	26	0,54	0,1	5,40	18	-2,44	3	8,2E-11	3	2,9	2	0	0	0		TTC
dichloromethane sulfonic acid	26	0,69	0,1	6,90	18	-0,47	3	1,9E-04	3	2,7	2	0	0	0		TTC
DTPA	13	10,0	700	0,01	6	-4,91	3	1,2E-16	3	3,4	1	0	0	0,26		RIVM
EDTA	19	336	600	0,56	12	-13,2	3	1,5E-12	3	3,5	1	0	0	0		WHO
guanylurea	20	6,70	22,5	0,30	12	-1,22	3	8,7E-04	3	3,0	2	0	0	0,29		RIVM
hydrochlorothiazide	15	0,14	6	0,02	6	-0,07	3	1,8E-10	3	2,2	3	0	0	0,61		RIVM
metformin	14	2,70	196	0,01	6	-2,64	3	7,6E-05	3	2,9	2	0	0	0,33		RIVM
HMMM	20	0,97	9,1	0,11	12	1,61	2	1,1E-08	3	1,3	3	0	0	0		RIVM - pending
ketoprofen	12	0,18	7	0,03	6	3,12	1	1,5E-06	3	2,9	2	0	0	0,26		Khan en Nicell
lamotrigine	14	0,18	2,5	0,07	6	2,57	2	9,4E-09	3	2,0	3	0	0	0,64		RIVM - pending
lithium	26	13,6	7,7	1,77	18	<0	3	<0	3	3,1	2	0	0	0		RIVM - pending
melamine	20	20,0	35	0,57	12	-1,37	3	3,6E-10	3	2,3	2	0	0	0,64	SVHC	RIVM
methenamine	15	7,20	500	0,01	6	-4,15	3	4,0E-03	3	1,9	3	0	0	0,63		RIVM
S-metolachlor	17	0,18	10	0,02	6	2,90	2	3,1E-05	3	2,2	3	0	3	0,58		WHO
metolachlor-ESA	19	0,17	1,3	0,13	12	1,69	2	6,1E-12	3	2,5	2	0	0	0		OEHHA
metolachlor-OA	13	0,16	3,2	0,05	6	1,42	2	7,4E-08	3	2,7	2	0	0	0		OEHHA
naproxen	12	0,36	10,01	0,04	6	3,18	1	1,3E-06	3	2,9	2	0	0	0,32		Khan en Nicell
N-formyl-4-aminoantipyrine	13	0,26	9,1	0,03	6	0,50	2	1,3E-08	3	2,7	2	0	0	0,46		RIVM - pending
NTA	13	7,40	400	0,02	6	-3,81	3	7,2E-09	3	3,6	1	0	0	0,13		RIVM
PFAS	27	0,017 (PFOA)	0,0044	>1	18	NA	3	NA	3	NA	3	0	0	0	SVHC	RIVM (PFOA-equivalenten)
propamocarb	10	1,20	1680	0,001	0	1,12	2	5,5E-02	3	2,5	2	0	3	0,54		EFSA
prosulfocarb	15	2,76	35	0,08	6	4,65	1	5,2E-07	3	2,6	2	0	3	0,35		EFSA
sulfamic acid	13	120	1400	0,09	6	0,10	2	1,5E-15	3	3,0	2	0	0	0		RIVM
tolyltriazole	13	3,81	350	0,01	6	1,71	2	7,5E-01	3	2,8	2	0	0	0,35	pSVHC	RIVM
tramadol	14	0,20	9,8	0,02	6	2,63	2	4,6E-07	3	2,1	3	0	0	0,38		Khan en Nicell
tribromomethane	25	1,07	0,91	1,18	18	2,40	2	5,4E+00	3	2,7	2	0	0	0,42		RIVM - pending
TCA	25	1,20	0,1	12	18	1,33	2	6,0E-02	3	2,5	2	0	0	0,54		RIVM - pending
TFA	16	1,80	2,2	0,82	12	0,50	2	1,1E+02	0	2,8	2	0	0	0,34	pSVHC	RIVM - pending
valsartan	12	0,19	4	0,05	6	3,65	1	8,2E-16	3	2,8	2	0	0	0		RIVM - pending
valsartanic acid	25	0,55	0,24	2,29	18	1,83	2	8,5E-11	3	2,7	2	0	0	0		RIVM - pending
vigabatrin	10	1,40	500	0,003	0	-2,16	3	7,0E-09	3	3,3	1	0	0	0,18		Based on DDD

Max = maximum concentration in the Meuse in 2019-2023; (p)GLV=provisional guideline value; BQ = benchmark quotient; VP= vapor pressure; TTC = threshold of toxicological concern. Log K_{ow} and VP values in bold are experimental values, otherwise they are estimated. (p)SVHC = (potential) substance of very high concern (RIVM (p)ZZS-stof). PMT-score = Score for the persistency, mobility, and toxicity of a substance (https://rvszoeksysteem.rivm.nl/ScreeningTool)

I.3 Background information on substances List 2a

Table 8 - Information on the candidate drinking water relevant substances (List 2a). Source refers to either literature, monitoring data or screening data from where the candidate substance was selected

Substance name	CAS	Source	Remarks
1,2,4-triazole	288-88-0	Monitoring data	Relevant again
1,2-dimethoxyethane (monoglyme)	110-71-4	Monitoring data	2021 exceedance of alarm value at Lobith, max. conc. In Meuse since 2021 is 1 µg/L
adamantan-1-amine	768-94-5	List 2a (2021)	Max. conc. In Meuse since 2021 is 0,11 µg/L
bisphenol-F	620-92-8	List 2a (2021)	
chlorothalonil R471811	geen CAS	Monitoring data	Levels in Scheldt basin up to >1 µg/L, relevant metabolite
fexofenadine	83799-24-0	List 2a (2021)	Max. conc. In Meuse since 2021 is 0,13 µg/L
flecainide	54143-55-4	screening QTOF Dunea	Detected in >50% of the samples; max. conc. In Meuse since 2021 is 0,1 µg/L
levocetirizine	130018-77-8	screening QTOF Dunea	Detected in >50% of the samples
MGDA	164462-16-2	List 2a (2021)	
oxipurinol	2465-59-0	List 2a (2021)	Max. conc. In Meuse since 2021 is 1,6 µg/L
PFPrA	422-64-0	Monitoring data	Project Evides- detected in Meuse
PFPrS	423-41-6	Joerss et al. 2022, Monitoring data	Level 2a, present in Rhine River; Project Evides- detected in Meue
ritalinic acid	19395-41-6	List 2a (2021)	Max. conc. In Meuse since 2021 is 0,03 µg/L

Table 9 - Information on the parameters that define the total score for the candidate drinking water relevant substances (List 2a)

Substance name	Total score	(p) GLV (µg/L)	BQ	BQ score	Log K_{ow}		VP (mm Hg)		BIOWIN3		Excee-dance taste/ odour threshold	Excee-dance legal stan-dard	Reference (p)GLV
1,2,4-triazole	11	161	0,006	0	-0,58	3	6,0E-01	3	3,0	2	0	3	EFSA
1,2-dimethoxyethane (monoglyme)	14	39	0,03	6	-0,20	3	4,8E+01	3	3,0	2	0	0	REACH file
adamantan-1-amine	13	4,9	0,02	6	2,44	2	4,0E-03	3	2,7	2	0	0	Khan and Nicell
bisphenol-F	13	28	0,04	6	2,91	2	3,8E-07	3	2,8	2	0	0	EFSA
chlorothalonil R471811	12	105	0,01	0	-4,70	3	6,2E-20	3	1,9	3	0	3	EFSA
fexofenadine	14	12	0,01	6	2,81	2	5,0E-04	3	2,0	3	0	0	DDD
flecainide	19	10	0,01	12	3,78	1	2,4E-08	3	1,1	3	0	0	https://tdm-monografie.org/flecainide
levocetirizine	20	0,5	0,20	12	1,70	2	3,0E-11	3	2,0	3	0	0	https://www.farmaco-therapeutischkompas.nl/
MGDA	10	287	0,003	0	-9,66	3	6,0E-10	3	3,6	1	0	3	NICNAS, 2004
oxipurinol	20	8,0	0,20	12	-0,28	3	9,9E-08	3	3,0	2	0	0	RIVM
PFPrA	13	3,5	0,29	6	1,47	2	1,9E-01	3	2,5	2	0	0	ORD Human Health Toxicity Value for Perfluoropropanoic Acid (CASRN 422-64-0 | DTXSID8059970) | Risk Assessment Portal | US EPA
PFPrS	26	0,1	10	18	1,15	2	7,5E-02	3	1,9	3	0	0	TTC
ritalinic acid	20	0,25	0,12	12	-1,07	3	6,2E-10	3	3,1	2	0	0	Khan and Nicell

(p)GLV=provisional guideline value; BQ = benchmark quotient; VP= vapor pressure; TTC = threshold of toxicological concern. Log K_{ow} and VP values in bold are experimental values, otherwise they are estimated. Values in black are from the EPI Suite database, values in red are estimated but the model is not valid for these substances.

I.4 Background information on substances List 2b

Table 10 - Information on the candidate drinking water relevant substances (List 2b). Source refers to either literature, monitoring data or screening data from where the candidate substance was selected

Substance name	CAS	Source	Remarks
((perfluorododecyl)methyl)oxirane	94158-66-4	Ng et al. 2022	Present in Danube river water, risk score >1
10-hydroxy-amitriptyline	1246833-15-7	List 2b (2021)	
1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-he-nicosafluoro-12-iodoheptadecane	129838-39-7	Ng et al. 2022	Present in Danube river water, risk score >1
1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-he-nicosafluoro-12-iodooctadecane	129838-40-0	Ng et al. 2022	Present in Danube river water, risk score >1
1,3-dicyclohexylurea	2387-23-7	Kang et al. 2024	Confidence level 1 in effluent
1-phenyl-1,2-propanediol	1855-09-0	Van Leerdam et al. 2022	Relevant for drinking water quality
2,4-dimethylaniline	95-68-1	Yang et al. 2022	Confidence level 1 in surface water
2-methyl-2H-benzotriazole	16584-00-2	Been et al. 2021 screening	Possibly hazardous alerts. Suspect exceeded 0,1 µg/L, categorized as medium priority
2-phenylquinoline	612-96-4	Cao et al. 2023	Surface water Yellow River Estuary
3-Bromo-5-chloro-2- hydroxybenzoic acid	4068-58-0	Ciccarelli et al. 2023	Level 1 municipal drinking water
4-amino-3-hydroxybenzoic acid	2374-03-0	List 2b (2021)	
4-hydroxy-omeprazole	301669-82-9	Derksen 2022	Danube - prioritization NORMAN
6PPD-quinone	2754428-18-5	Kang et al. 2024	Confidence level 1 in effluent
abacavir	136470-78-5	Abafe et al. 2023	Confirmed; confidence level 1
acetamiprid	160430-64-8	Finckh et al. 2022	Wastewater Treatment Plant (WWTP) effluent/ present in EU watch list
altrenogest	850-52-2	KIWK, 2022	Substances with high risk (PMT), relatively extensive knowledge available
benserazide	14919-77-8	Nikolopoulou et al. 2023	Highest concentrations in sewage sludge
benzothiazole-2-sulfonic acid	941-57-1	Derksen 2022; Krettek 2017	Requires attention, suspect detected
benzylchloride	100-44-7	Van Leerdam et al. 2022	Relevant for drinking water quality
betamethasone	378-44-9	Yang et al. 2022	Confidence level 1 in surface water
carprofen	53716-49-7	KIWK, 2022	Widely used, high risk (PMT), but relatively little knowledge and measurements available
chlortetracycline	57-62-5	KIWK, 2022	Widely used, high risk (PMT), but relatively little knowledge and measurements available
cotinine N-oxide	36508-80-2	Wang et al. 2022	
DMMM	2415923-14-5	screening QTOF Aqualab Zuid	Detected in >75% of the samples
dicyclohexylamine	101-83-7	Kang et al. 2024	
DDAC	20256-56-8	Derksen 2022	Requires attention
dioxoaminopyrine	519-65-3	Chou et al. 2023	First time in tap water Yangtze River China
doxycycline	564-25-0	KIWK, 2022veterinary medicines 2022	Present in manure after storage period
EDDP	106293-55-4	Derksen 2022	Danube - prioritization NORMAN
emtricitabine	143491-57-0	Wang et al. 2022	
florfenicol	73231-34-2	KIWK, 2022	Frequently detected abroad, widely used in the Netherlands, but not investigated
flubendazol	31430-15-6	KIWK, 2022	Substances with both high risk (PMT) and relatively extensive knowledge available (factsheet in Knowledge Synthesis), present in manure after storage
fluopyram-7-hydroxy	856699-69-9	Dekker et al. 2024	
fluralaner	864731-61-3	KIWK, 2022	Widely used, high risk (PMT), but relatively little knowledge and measurements available
haloaniline	39885-50-2	Dekker et al. 2024	
HYPA	60016-62-8	Dekker et al. 2024	
lauryl guanidine	135-42-2	Abafe et al. 2023	
levofloxacin	100986-85-4	Fabregat-safont et al. 2023	Aquatic environment Peru
losartan carboxylic acid	124750-92-1	BTO 2023.070	Formed in WWTP
mesterolone	1424-00-6	Nikolopoulou et al. 2023	Highest concentrations in sewage sludge
metamitron-desamino	36993-94-9	Houthuijs et al. 2023	OMP identified in Dutch surface water
monensin	17090-79-8	KIWK, 2022; Delgado et al. 2023	Frequently detected abroad, widely used in the Netherlands, but not investigated
MMMM	4261-70-5	screening QTOF Aqualab Zuid	Detected in >75% of the samples
PMMM	3169-30-0	screening QTOF Aqualab Zuid	Detected in >75% of the samples
PFECHS	646-83-3	Li et al. 2023; Joerss et al. 2022	Most prevalent in tap water in South Florida (NTS); level 1 in Ruhr
phthalic anhydride	85-44-9	Huang et al. 2023	High concentrations in drinking water (up to 15 µg/L)
simetone	673-04-1	Yang et al. 2022	Confidence level 1 in surface water
tenofovir	147127-20-6	Abafe et al. 2023	Confirmed; confidence level 3
toltrazuril	69004-03-1	KIWK, 2022	Risk previously identified in groundwater measurements
TMMM	2420-27-1	screening QTOF Aqualab Zuid	Detected in >75% of the samples
triaprost (iliren)	71116-82-0	Abafe et al. 2023	Were not detected in the influent from LWWTP but were detected in the effluent
tributyl citrate acetate	77-90-7	Krettek, 2017	dentified level 1, river surface water, toxic
xylazine	7361-61-7	KWR 2023.070	>0,5 µg/L in effluent

Table 11 - Information on the parameters that define the total score for the candidate drinking water relevant substances (List 2b)

Substance name	Total score	(p) GLV (µg/L)	BQ	BQ score	Log K_{ow}		VP (mm Hg)		BIO-WIN3		Excee-dance taste/ odour threshold	Excee-dance legal stan-dard	Reference (p)GLV
((perfluorododecyl) methyl)oxirane	24	0,1	10	18	8,94	0	1,9E+00	3	-1,2	3	0	0	TTC
10-hydroxy-amitriptyline	24	0,1	10	18	3,41	1	2,4E-09	3	2,4	2	0	0	TTC
1,1,1,2,2,3,3,4,4,5,5, 6,6,7,7, 8,8,9,9,10,10 -henicosafluoro -12-iodoheptadecane	24	0,1	10	18	11,69	0	1,0E-03	3	-0,6	3	0	0	TTC
1,1,1,2,2,3,3,4,4,5,5, 6,6,7,7,8,8,9,9,10,10 -henicosafluoro -12-iodooctadecane	24	0,1	10	18	12,18	0	4,1E-04	3	-0,6	3	0	0	TTC
1,3-dicyclohexylurea	24	0,1	10	18	3,92	1	8,8E-06	3	2,7	2	0	0	EFSA
1-phenyl-1,2-propanediol	13	63	0,02	6	0,90	2	2,7E-04	3	3,2	2	0	0	TTC (Cramer II)
2,4-dimethylaniline	13	13	0,08	6	1,70	2	1,3E-01	3	2,6	2	0	0	Comptox EPA
2-methyl-2H-benzotria-zole	10	350	0,003	0	1,64	2	1,0E-02	3	2,9	2	0	3	RIVM value for 4-methyl-1H-benzotriazole
2-phenylquinoline	24	0,1	10	18	3,90	1	1,7E-05	3	2,8	2	0	0	TTC
3-Bromo-5-chloro-2-hydroxybenzoic acid	24	0,1	10	18	3,78	1	2,2E-06	3	2,5	2	0	0	TTC
4-amino-3-hydroxyben-zoic acid	25	0,1	10	18	0.5	2	4.6E-07	3	2,9	2	0	0	TTC
4-hydroxy-omeprazole	19	2,0	0,50	12	1,51	2	2,8E-13	3	2,4	2	0	0	Not an active metabolite: DDD of omeprazole used (https://atcddd.fhi.no)
6PPD-quinone	12	42	0,02	6	3,98	1	4,3E-08	3	2,4	2	0	0	Comptox EPA
abacavir	13	30	0,03	6	1,22	2	3,1E-13	3	2,5	2	0	0	https://www.farmaco-therapeutischkompas.nl/
acetamiprid	13	35	0,03	6	2,55	2	4,4E-05	3	2,3	2	0	0	EFSA
altrenogest	25	0,01	71	18	3,71	1	7,8E-09	3	2,1	3	0	0	Australian Pesticides and Veterinary Medicines Authority (APVMA)
benserazide	20	5,0	0,20	12	-1,50	3	2,0E-13	3	2,7	2	0	0	https://www.farmaco-therapeutischkompas.nl/
benzothiazole-2-sulfo-nic acid	26	0,1	10	18	-0,99	3	5,9E-09	3	2,9	2	0	0	Landesamt fÜr Natur, Umwelt und Verbrau-cherschutz Nordr-hein-Westfalen (LANUV)
benzylchloride	25	0,04	24	18	2,30	2	1,2E+00	3	2,8	2	0	0	https://www.rivm.nl/bibliotheek/rappor-ten/601714016.pdf
betamethasone	26	0,04	25	18	1,90	2	5,8E-14	3	1,8	3	0	0	https://atcddd.fhi.no
carprofen	12	35	0,03	6	3,79	1	1,7E-08	3	2,5	2	0	0	APVMA
chlortetracycline	15	21	0,05	6	-0,62	3	5,8E-22	3	1,5	3	0	0	European Medicines Agency (EMA) and APVMA
cotinine N-oxide	14	5,6	0,02	6	-1,80	3	1,7E-08	3	2,7	2	0	0	EFSA
DMMM	15	9,1	0,02	6	?	3	?	3	?	3	0	0	Based on HMMM as derived by RIVM
dicyclohexylamine	12	70	0,01	6	4,37	1	3,4E-02	3	2,8	2	0	0	REACH file
DDAC	11	70	0,01	6	6,66	0	7,5E-11	3	3,1	2	0	0	EFSA
dioxoaminopyrine	26	0,1	10	18	-0,76	3	2,9E-08	3	2,6	2	0	0	TTC
doxycycline	15	21	0,05	6	-0,02	3	1,4E-23	3	2,1	3	0	0	EMA
EDDP	19	2,5	0,40	12	4,94	1	3,3E-06	3	2,2	3	0	0	Not an active metabolite: DDD of methadon used (https://atcddd.fhi.no)
emtricitabine	14	20	0,05	6	-0,40	3	8,1E-09	3	2,8	2	0	0	https://atcddd.fhi.no
florfenicol	21	7,0	0,14	12	-0,04	3	1,4E-12	3	2,2	3	0	0	APVMA
flubendazol	14	91	0,01	6	2,91	2	2,2E-11	3	2,0	3	0	0	APVMA
fluopyram-7-hydroxy	13	84	0,01	6	3,30	1	3,3E-11	3	1,0	3	0	0	EFSA
fluralaner	13	70	0,01	6	5,21	1	1,9E-14	3	0,1	3	0	0	EMA
haloaniline	14	35	0,03	6	2,70	2	9,7E-02	3	1,9	3	0	0	EFSA
HYPA	25	0,1	10	18	1,10	2	2,6E-04	3	2,7	2	0	0	TTC
lauryl guanidine	24	0,1	10	18	**4,52**	1	**1,2E-10**	3	**2,6**	2	0	0	TTC
levofloxacin	27	0,98	1,0	18	-0,39	3	9,8E-13	3	1,5	3	0	0	Khan Nicell Appendix O
losartan carboxylic acid	24	0,25	4,0	18	4,81	1	4,1E-17	3	2,3	2	0	0	Khan Nicell Appendix O
mesterolone	19	4,2	0,24	12	3,48	1	3,5E-09	3	2,2	3	0	0	REACH file
metamitron-desamino	25	0,1	10	18	1,43	2	3,4E-09	3	2,8	2	0	0	TTC
monensin	13	21	0,05	6	5,43	1	5,2E-23	3	1,5	3	0	0	EFSA
MMMM	15	9,1	0,02	6	-0,10	3	1,2E-05	3	2,2	3	0	0	Based on HMMM as derived by RIVM
PMMM	14	9,1	0,02	6	1,30	2	5,9E-08	3	1,5	3	0	0	Based on HMMM as derived by RIVM
PFECHS	25	0,1	10	18	4,42	1	5,4E-04	3	0,4	3	0	0	TTC
phthalic anhydride	10	14000	<0,001	0	1,60	2	5,2E-04	3	2,9	2	0	3	EPA risk screening level
simetone	26	0,1	10	18	2,70	2	2,4E-06	3	2,2	3	0	0	TTC
tenofovir	26	0,1	10	18	-1,87	3	6,1E-11	3	2,4	2	0	0	TTC
toltrazuril	12	14	0,07	6	6,50	0	2,2E-13	3	1,6	3	0	0	EMA and APVMA
TMMM	14	9,1	0,02	6	0,60	2	1,8E-06	3	2,0	3	0	0	Based on HMMM as derived by RIVM
triaprost (iliren)	24	0,1	10	18	3,13	1	2,6E-16	3	3,1	2	0	0	TTC
tributyl citrate acetate	11	35	0,03	6	4,29	1	4,6E-06	3	3,6	1	0	0	Comptox EPA
xylazine	24	0,1	17	18	4,52	1	2,4E-03	3	2,4	2	0	0	Food and Agriculture Organization of the United Nations (FAO)

(p)GLV=provisional guideline value; BQ = benchmark quotient; VP= vapor pressure; TTC = threshold of toxicological concern. Log K_{ow} and VP values in bold are experimental values, otherwise they are estimated. Values in black are from the EPI Suite database, values in red are estimated but the model is not valid for these substances

I.5 Considered candidate substances with a score below 10

Table 12 - Information on the parameters that define the total score for the candidate drinking water relevant substances. None of the substances had an exceedance of the taste- or odour threshold or the legal standard, therefore the score is always 0 and not included in the table.

Substance name	CAS	Total score	(p)GLV (µg/L)	BQ	BQ score	Log K_{ow}		VP (mm Hg)		BIO-WIN3		Reference (p)GLV
1,2-diacetylbenzene	704-00-7	7	210	0,005	0	1,35	2	7,2E-03	3	2,8	2	Comptox EPA
1-chloro-2,2,3,3-tetrafluorocyclobutane (C4H3ClF4)	558-61-2	4	-	-	-	3,32	1	3,9E+04	0	2,2	3	Substances is excluded due to itsphysico-chemical properties.
2,2'-dimorpholinyldiethyl-ether	6425-39-4	9	7000	<0,001	0	-1,31	3	7,7E-05	3	2,1	3	Comptox EPA
2-[4-(diethylamino)-2-hydroxybenzoyl]benzoic acid	5809-23-4	6	350	0,003	0	3,79	1	1,7E-10	3	2,4	2	https://chemview.epa.gov/chemview/
2'-methoxycinnamaldehyde/cassiastearoptene	1504-74-1	7	1925	0,001	0	1,90	2	1,2E-02	3	2,8	2	EFSA
benzyldimethyltetradecylammonium	16287-71-1	6	700	0,001	0	5,91	1	2,0E-09	3	2,8	2	https://www.eurl-pesticides.eu/userfiles/file/EurlSRM/EurlSrm_Observation_QAC_V6.pdf
butan-2-one O,O',O''-(methylsilanetriyl)oxime	22984-54-9	5	203	0,005	0	9,83	0	4,1E-04	3	2,5	2	REACH file
caprolactam	105-60-2	7	59850	<0,001	0	0,66	2	1,6E-03	3	2,9	2	REACH file
clopidol	2971-90-6	8	280	0,004	0	2,70	2	1,2E-06	3	2,1	3	FAO/WHO
cloxacilline	61-72-3	8	1400	0,001	0	2,48	2	1,4E-15	3	2,0	3	APVMA
diethyl-2-phenylacetamide	2431-96-1	7	210	0,005	0	2,40	2	3,8E-04	3	2,7	2	TTC
dimethyl octadecylphosphonate	25371-54-4	5	2100	0,000	0	7,76	0	1,4E-06	3	2,7	2	REACH file
diundecyl phthalate (DUP)	3648-20-2	5	336	0,003	0	11,5	0	1,2E-09	3	3,0	2	REACH file
dodecylbenzene sulfonic acid	27176-87-0	9	3500	0,000	0	4,78	1	7,9E-11	3	2,8	2	US EPA, 2019
dotarem (Gd-DOTA)	92943-93-6	8	-	-	-	**-6,58**	3	**2,7E-16**	3	**2,7**	2	Monitoring data show presence < 0,1 µg/L
erucamide	112-84-5	5	49000	<0,001	0	8,44	0	8,3E-08	3	2,7	2	RIVM mededeling
fenbendazol	43210-67-9	6	350	0,003	0	3,90	1	4,3E-11	3	2,5	2	APVMA
gadovist (Gd-BT-DO3A)	770691-21-9	8	-	-	-	**-6,79**	3	**3,3E-23**	3	**2,8**	2	Monitoring data show presence < 0,1 µg/L
helional	1205-17-0	7	1190	0,001	0	2,50	2	8,1E-04	3	2,6	2	REACH file
isosafrol	120-58-1	6	154	0,006	0	3,40	1	2,3E-02	3	2,7	2	EFSA
magnevist (Gd-DTPA),	86050-77-3	8	-	-	-	-	3	-	3	-	2	Monitoring data show presence < 0,1 µg/L.
metamizol	50567-35-6	8	224	0,004	0	-3,08	3	5,1E-13	3	2,8	2	https://ec.europa.eu/health/documents/community-register/2019/20190320143604/anx_143604_en.pdf (DDD)
metofluthrin	240494-70-6	7	113,4	0,009	0	5,52	1	2,0E-05	3	0,7	3	https://www3.epa.gov/pesticides/chem_search/reg_actions/registration/fs_PC-109709_01-Sep-06.pdf
monepantel	887148-69-8	7	210	0,005	0	5,10	1	5,5E-10	3	0,6	3	APVMA
monochloramine	10599-90-3	8	700	0,001	0	-1,19	3	1,2E-09	3	3,1	2	REACH file
multihance (Gd-BOPTA)	127000-20-8	8	-	-	-	-	3	-	3	-	2	Monitoring data show presence < 0,1 µg/L.
N-(2-carboxyethyl)-N-octyl-β-alanine	52663-87-3	7	301	0,003	0	-0,82	3	5,1E-10	3	3,4	1	Comptox EPA
N,N-dimethyldodecylamine	112-18-5	6	350	0,003	0	5,44	1	1,6E-02	3	2,8	2	REACH file
n,n-dimethyldodecylamine n-oxide (DDAO)	1643-20-5	9	280	0,004	0	4,67	1	1,6E-07	3	3,0	2	https://fragrancematerialsafetyresource.elsevier.com/sites/default/files/1643-20-5.pdf
sabinene	3387-41-5	6	1554	0,001	0	4,69	1	7,4E+00	3	2,7	2	EFSA
safrol	94-59-7	6	154	0,006	0	3,50	1	6,2E-02	3	2,6	2	EFSA
tetrabroombisfenol A	79-94-7	6	112	0,009	0	7,20	0	3,5E-11	3	1,4	3	Comptox EPA
tilmicosine	108050-54-0	7	280	0,004	0	3,80	1	4,6E-32	3	1,5	3	https://apps.who.int/food-additives-contaminants-jecfa-database/Home/Chemical/514
triethyl citrate	77-93-0	7	145600	<0,001	0	0,33	2	6,9E-04	3	2,8	2	REACH file
trimellitic anhydride	552-30-7	7	3500	<0,001	0	1,95	2	9,9E-06	3	2,9	2	REACH file

Max = maximum concentration in the Meuse in 2019-2023; (p)GLV=provisional guideline value; BQ = benchmark quotient; VP= vapor pressure; TTC = threshold of toxicological concern. Log K_{ow} and VP values in bold are experimental values, otherwise they are estimated. Values in red are estimated but the model is not valid for these substances.

I.6 Candidate substances to keep in sight (parking list)

Table 13 – Candidate substances on the parking list

Substance	CS RN	Category	Score	Previous List	Reason
1,3-di-o-tolylguanidine	97-39-2	industrial	12	2a	Analytical method unavailable
4-aminophenol	123-30-8	industrial	13	2a	Analytical method unavailable
4-mesyl-2-nitrotoluene	1671-49-4	industrial	13	2a	Analytical method unavailable
fluconazole	86386-73-4	pharmaceutical	20	2a	Analytical method unavailable
(9E)-9-octadecenamide	4303-70-2	Industrial/natural	23	New	Natural substance
aflatoxin B1	1162-65-8	natural	25	New	Natural substance
Indolebutyric acid	133-32-4	Natural/plant growth regulator	25	New	Natural substance
pelargonic acid	112-05-0	biocide/ natural	11	New	Natural substance

I.7 Substances which no longer meet the criteria list 3

Table 14 - Complete list of no longer drinking water relevant substances (including the substances from the previous evaluations)

Substance name	CAS	List 2021
1,2-Benzisothiazol-3(2H)-one	2634-33-5	List 3
1,2-Diacetylbenzene	704-00-7	New
1,3-Diethyldiphenylurea	85-98-3	List 3
1,3-Diphenylguanidine	0102-06-07	List 3
10,11-Dihydro-10,11-dihydroxycarbamazepine	58955-93-4	List 3
1-Chloro-2,2,3,3-tetrafluorocyclobutane (C4H3ClF4)	558-61-2	New
1H-Benzotriazole	95-14-7	List 3
2-(Methylthio)benzothiazole	615-22-5	List 3
2,2,6,6-Tetramethyl-4-oxopiperidinonoxy	2896-70-0	List 3
2,2'-Dimorpholinyldiethyl-ether	6425-39-4	New
2,3,3,3-Tetrafluoro-2-(heptafluorpropoxy) propanoate (GenX substance)	62037-80-3	List 3
2,4-D (2,4-dichlorophenoxyacetic Acid)	94-75-7	List 3
2-[4-(Diethylamino)-2-hydroxybenzoyl]benzoic acid	5809-23-4	New
2'-Aminoacetophenone	551-93-9	List 3
2'-Methoxycinnamaldehyde/cassiastearoptene	1504-74-1	New
3,5,6-Trichloro-2-pyridinol (TCP)	6515-38-4	List 3
4-Methylbenzotriazole	29878-31-7	List 3
4-n-Nonyl phenol	104-40-5	List 3
Acesulfame-K	55589-62-3	List 3
Acetaminophen (paracetamol)	103-90-2	List 3
Acetone	67-64-1	List 3
AHTN (6-acetyl-1,1,2,4,4,7-hexamethyltetraline)	1506-02-01	List 3
Amidotrizoic acid	117-96-4	List 3
Amoxicillin	26787-78-0	List 3
Anti-androgenic activity (expressed in flutamide-equivalents)	N/A	List 3
Aspirin (acetylsalicylic acid)	50-78-2	List 3
Azelaic acid	123-99-9	List 3
BAM (2,6-dichlorobenzamide)	2008-58-4	List 3
Barbital	57-44-3	List 3
BBP (butylbenzylphtalate)	85-68-7	List 3
Benzo(a)pyrene	50-32-8	List 3
Benzothiazole	95-14-7	List 1
Benzyldimethyltetradecylammonium	16287-71-1	New
Bis(2-chloroisopropyl) ether	39638-32-9	List 3
BPS (4,4'-sulfonyldiphenol)	80-09-1	List 3
Butan-2-one O,O',O''-(methylsilanetriyl)oxime	22984-54-9	New
Caffeine	58-08-2	List 3
Caprolactam	105-60-2	New
Carbamazepine	298-46-4	List 3

Substance name	CAS	List 2021
Carbendazim	10605-21-7	List 3
Cetirizine	83881-51-0	List 3
Chloridazon	1698-60-8	List 3
Chloridazone-desphenyl	6339-19-1	List 1
Chlorotoluron	15545-48-9	List 3
Ciprofloxacin	85721-33-1	List 3
Citalopram	59729-33-8	List 3
Clarithromycin	81103-11-9	List 3
Clindamycin	18323-44-9	List 3
Clopidol	2971-90-6	New
Cloxacilline	61-72-3	New
DBP (dibutyl phthalate)	84-74-2	List 3
DEP (diethyl phthalate)	84-66-2	List 3
DIBP (di-(2-methyl-propyl)phthalate)	84-69-5	List 3
Diclofenac	15307-86-5	List 3
Diethyl-2-phenylacetamide	2431-96-1	New
Diglyme (bis(2-methoxyethyl)ether)	111-96-6	List 3
Diisopropyl ether (DIPE)	108-20-3	List 1
Dimethenamid	87674-68-8	List 3
Dimethyl octadecylphosphonate	25371-54-4	New
Dimethyldisulfide	624-92-0	List 3
Di-n-butyltin	1002-53-5	List 1
Diundecyl phthalate (DUP)	3648-20-2	New
Diuron (DMCU)	330-54-1	List 3
DMSA (N,N-dimethylaminosulfanilide)	4710-17-2	List 3
Dodecylbenzene sulfonic acid	27176-87-0	New
Dotarem (Gd-DOTA)	92943-93-6	New
Erucamide	112-84-5	New
Erythromycin	0114-07-08	List 3
Estrone	53-16-7	List 3
ETBE (ethyl-tertiairy-butyl-ether)	637-92-3	List 3
Ethyl sulphate	540-82-9	List 3
fenbendazol	43210-67-9	List 3
Fluoride	16984-48-8	New
Gabapentin	60142-96-3	List 1
Gadolinium (containing contrast agents)	7440-54-2	List 3
Gadovist (Gd-BT-DO3A)	770691-21-9	New
Galaxolide (HHCB)	1222-05-05	New
Helional	1205-17-0	New
Hexa(methoxymethyl)melamine	68002-20-0/ 3089-11-0	List 3
Ibuprofen	15687-27-1	List 3
Iohexol	66108-95-0	List 3
Iomeprol	78649-41-9	List 3
Iopamidol	60166-93-0	List 3
Iopromide	73334-07-03	List 3
Ioxaglic acid	59017-64-0	List 3

Substance name	CAS	List 2021
Ioxitalamic acid	28179-44-4	List 3
Irbesartan	138402-11-6	List 3
Isoproturon	34123-59-6	List 3
Isosafrol	120-58-1	New
Lincomycin	154-21-2	List 3
Magnevist (Gd-DTPA),	86050-77-3	New
MCPA (4-chloro-2-methylphenoxyacetic acid)	94-74-6	List 3
Mecoprop (MCPP)	93-65-2	List 3
Metamizol	50567-35-6	New
Metazachlor	67129-08-02	List 3
Metazachlor-ethane sulfonic acid	172960-62-2	List 3
Metazachlor-oxanilic acid	1231244-60-2	List 3
Methoxymethyltriphenylphosphonium	4009-98-7	List 3
Methyl-desfenylchloridazon	17254-80-7	List 3
Metofluthrin	240494-70-6	New
Metoprolol	37350-58-6	List 3
Monepantel	887148-69-8	New
Monobromoacetic acid	79-08-3	List 1
Monochloramine	10599-90-3	New
MTBE (methyl-tert-butylether)	1634-04-04	List 3
Multihance (Gd-BOPTA)	127000-20-8	New
Musk (ketone)	81-14-1	List 3
Musk (xylene)	81-15-2	List 3
N-(2-carboxyethyl)-N-octyl-β-alanine	52663-87-3	New
N,N-Dimethyldodecylamine	112-18-5	New
N,N-Dimethyldodecylamine n-oxide (DDAO)	1643-20-5	New
N,N-dimethylsulfamid (DMS)	3984-14-3	List 3
N-butylbenzenesulphonamide	3622-84-2	List 3
NDMA (nitrosodimethylamine)	62-75-9	List 3
Nicosulfuron	111991-09-4	List 3
O-desmethylvenlafaxine	93413-62-8	List 3
Oxadiazon	19666-30-9	List 3
Pentobarbital	76-74-4	List 3
Phenanthrene	85-01-8	List 3
Phenazone	60-80-0	List 3
Phenobarbital	50-06-6	List 3
Pyrazole	288-13-1	List 3
Sabinene	3387-41-5	New
Safrol	94-59-7	New
Salicylic Acid	69-72-7	List 3
Sebuthylazine	7286-69-3	List 3
Sotalol	3930-20-9	List 3
Sucralose	56038-13-2	List 3
Sulfamethoxazole	723-46-6	List 3
Surfynol 104	126-86-3	List 3
TBP (tributylphosphate)	126-73-8	List 3

Substance name	CAS	List 2021
TCEP (tris(2-chloroethyl) phosphate)	115-96-8	List 3
TCPP (tri-(2-chloroisopropyl) phosphate)	13674-84-5	List 3
Telmisartan	144701-48-4	List 3
Terbuthylazine	5915-41-3	List 1
Tetrabroombisfenol A	79-94-7	New
Tetrachloroethene	127-18-4	List 3
Tetrahydrofuran	109-99-9	List 3
Thiabendazole	148-79-8	List 3
Tilmicosine	108050-54-0	New
Triamcinolonehexacetonide	5611-51-8	List 3
Trichloroethene	79-01-6	List 3
Trichloromethane	67-66-3	List 3
Triethyl citrate	77-93-0	New
Trifluoromethanesulfonic acid (F3-MSA)	1493-13-6	List 3
Triflusulfuron-methyl	126535-15-7	List 3
Triisobutyl phosphate	126-71-6	List 3
Trimellitic anhydride	552-30-7	New
Triphenylphosphine oxide (TPPO)	791-28-6	List 3
Venlafaxine	93413-69-5	List 3
Vinylchloride	75-01-4	List 3

I.8 Available analytical techniques for substances List 2

Table 15 – List of candidate substances along with the laboratories equipped with an available analytical technique.

Substance name	CAS	Analytical technique available
1,2,4-Ttriazole	288-88-0	TZW
1,2-Dimethoxyethane (monoglyme)	110-71-4	AQZ
Adamantan-1-amine	768-94-5	AQZ/HWL
Bisphenol-F	620-92-8	-
Chlorothalonil R471811	geen CAS	TZW
Fexofenadine	83799-24-0	AQZ
Flecainide	54143-55-4	AQZ
Levocetirizine	130018-77-8	HWL
MGDA	164462-16-2	TZW
Oxipurinol	2465-59-0	AQZ/HWL
PFPrA	422-64-0	AQZ
PFPrS	423-41-6	AQZ
Ritalinic acid	19395-41-6	AQZ/HWL

I.9 Literature list

Table 16 – List of consulted publications

Author	Year	Title	Link
Abafe et al.	2023	Non-targeted screening of emerging contaminants in South African surface and wastewater	https://doi.org/10.1016/j.emcon.2023.100246
Adviesgroep Waterkwaliteit	2022	Mailing over tetrafosfor	
Arcadis	2022	Brononderzoek drinkwaterrelevante stoffen - Tien stoffen in het Rijnstroomgebied - Rijkswaterstaat WVL	
Arp et al.	2023	A prioritization framework for PMT/vPvM Substances under REACH for registrants, regulators, researchers and the water sector	
Arp et al.	2023	PMT/vPvM assessment of REACH registered Substances Detected in Wastewater Treatment Plant Effluent, Freshwater Resources and Drinking Water	
Arp et al.	2023	Prioritised PMT/vPvM substances in the REACH registration database	
Bauerlein et al.	2024	Verhulde organische stoffen: een blik op wat (nog) niet gemeten wordt	
Béen et al.	2021	Risk-based prioritization of suspects detected in riverine water using complementary chromatographic techniques	https://doi.org/10.1016/j.watres.2021.117612
BTO 2022.044	2022	Tekst-mining voor vroege detectie van relevante waterverontreinigingen	
BTO 2022.053	2022	Final report HRMS data science PoC	
BTO 2023.015	2023	Evaluation of QSAR tools in combination with bioassays for transformation prodcuts and emerging substances	
BTO 2023.047	2023	PFAS in sea-spray aerosols	
BTO 2023.063	2023	Onthullen van verhulde stoffen in de waterketen	
BTO 2024.012	2024	Zeer zorgwekkende stoffen in het milieu (deel 3) - Literature mining	
Bugsel et al.	2023	Nontarget screening strategies for PFAS prioritization and identification by high resolution mass spectrometry: A review	https://doi.org/10.1016/j.teac.2023.e00216
Cao et al.	2023	Comprehensive investigation and risk assessment of organic contaminants in Yellow River Estuary using suspect and nontarget screening strategies	https://doi.org/10.1016/j.envint.2023.107843
Chou et al.	2023	Identification of high-concern organic pollutants in tap waters from the Yangtze River in China based on combined screening strategies	https://doi.org/10.1016/j.scitotenv.2022.159416
Ciccarelli et al.	2023	Enhanced selectivity for acidic contaminants in drinking water: From suspect screening to toxicity prediction	https://doi.org/10.1016/j.jhazmat.2023.130906
CLM, WUR en Arcadis	2024	Milieubelasting van gewasbeschermingsmiddelen in Noord-Brabant	
Dekker et al.	2022	Tackling the increasing contamination of the water supply by iodinated contrast media	https://doi.org/10.1186/s13244-022-01175-x
Dekker et al.	2024	PFAS-pesticiden en grondwater	CLM rapport - 1193
Dekker et al.	2024	Review of strategies to reduce the contamination of the water environment by gadolinium-based contrast agents	https://doi.org/10.1186/s13244-024-01626-7
Delgado et al.	2023	Veterinary pharmaceutical as emerging contaminants in wastewater and surface water: An overview	https://doi.org/10.1016/j.jhazmat.2023.132431
Deltares	2022	NORMAN prioritering Nederlandse waterkwaliteitsdata	https://publications.deltares.nl/11206216_010_0001.pdf
Derksen	2022	Aandachtvragende stoffen in rwzi-effluent- Samenvatting van de huidige stand van de kennis	Hier horen ook twee Excelbestanden bij!
DVGW-Technologiezentrum Wasser	2021	Measurement and evaluation of analytical data of metabolites of the fungicide chlorothalonil in drinking water samples	
Emke et al. (KWR)	2023	Influenten en effluenten in de Provincie Utrecht. Chemische screening van alle rioolwaterzuiveringen	KWR 2023.070
Etteieb et al.	2020	Monitoring and analysis of selenium as an emerging contaminant in mining industry: A critical review	https://doi.org/10.1016/j.scitotenv.2019.134339
Fabregat-Safont et al.	2023	Searching for pharmaceutically active products and metabolites in environmental waters of Peru by HRMS-based screening: Proposal for future monitoring and environmental risk assessment	https://doi.org/10.1016/j.chemosphere.2023.139375
Finckh et al.	2024	Mapping chemical footprints of organic micropollutants in European streams	https://doi.org/10.1016/j.envint.2023.108371
Finckh et al.	2022	A risk based assessment approach for chemical mixtures from wastewater treatment plant effluents	https://doi.org/10.1016/j.envint.2022.107234
Frokjaer et al.	2023	Non-targeted and suspect screening analysis using ion exchange chromatography-Orbitrap tandem mass spectrometry reveals polar and very mobile xenobiotics in Danish drinking water	https://doi.org/10.1016/j.chemosphere.2023.139745
Gao et al.	2024	Advances in the analysis of disinfection by-products with mass spectrometry: Sample preparation and target/non-target screening	https://doi.org/10.1016/j.trac.2024.117621
Göckener et al.	2023	Tracking down unknown PFAS pollution – The direct TOP assay in spatial monitoring of surface waters in Germany	https://doi.org/10.1016/j.scitotenv.2023.165425
Gutierrez et al.	2024	A thorough analysis of the occurrence, removal and environmental risks of organic micropollutants in a full-scale hybrid membrane bioreactor fed by hospital wastewater	https://doi.org/10.1016/j.scitotenv.2023.169848
Hale et al.	2022	Getting in control of persistent, mobile and toxic (PMT) and very persistent and very mobile (vPvM) substances to protect water resources: strategies from diverse perspectives	https://doi.org/10.1186/s12302-022-00604-4
Han et al.	2024	Machine learning coupled with causal inference to identify COVID-19 related chemicals that pose a high concern to drinking water	https://doi.org/10.1016/j.isci.2024.109012
Hernández et al.	2024	High resolution mass spectrometry-based screening for the comprehensive investigation of organic micropollutants in surface water and wastewater from Pasto city, Colombian Andean highlands	https://doi.org/10.1016/j.scitotenv.2024.171293
Houthuijs et al.	2023	Identification of organic micro-pollutants in surface water using MS-based infrared ion spectroscopy	https://doi.org/10.1016/j.chemosphere.2023.140046
Huang t al.	2023	Chemical characterization and source attribution of organic pollutants in industrial wastewaters from a Chinese chemical industrial park	https://doi.org/10.1016/j.envres.2023.115980
IWB	2023	2-Methoxy-1,4-dioxan KI 675	ppt.slide
Joerrs et al.	2022	Beyond the Tip of the Iceberg: Suspect Screening Reveals Point Source-Specific Patterns of Emerging and Novel Per- and Polyfluoroalkyl Substances in German and Chinese Rivers	https://doi.org/10.1021/acs.est.1c07987
Kang et al.	2024	Profiling emerging micropollutants in urban stormwater runoff using suspect and non-target screening via high-resolution mass spectrometry	https://doi.org/10.1016/j.chemosphere.2024.141402
Khan et al.	2022	Emerging contaminants of high concern for the environment: Current trends and future research	https://doi.org/10.1016/j.envres.2021.112609
Kirmit en Hanenberg	2023	Opkomende stoffen - hoe krijgen we er grip op. H20-artikel	
KIWK Diergeneesmiddelen	2022	Veterinary pharmaceuticals recommended by KIWK (Foundation for Applied Water Research STOWA)	KIWK-project Diergeneesmiddelen (Veterinary Pharmaceuticals)

Author	Year	Title	Link
KIWK Diergenees-middelen	2022	Monitoringstrategie Diergeneesmiddelen	KIWK-project Dierge-neesmiddelen (Veterina-ry Pharmaceuticals)
Koley et al.	2024	Perspectives and understanding on the occurrence, toxicity and abatement technologies of disinfection by-products in drinking water	https://doi.org/10.1016/j.jenvman.2023.119770
Koronaiou et al.	2022	High-resolution mass spectrometry-based strategies for the target analysis and suspect screening of per- and polyfluoroalkyl substances in aqueous matrices	https://doi.org/10.1016/j.microc.2022.107457
Krettek	2017	Identification of new emerging pollutants in surface water using suspect screening analysis and prioritisation strategies based on regulatory databases	Master thesis
Kumar et al.	2022	A review on emerging water contaminants and the application of sustainable removal technologies	https://doi.org/10.1016/j.cscee.2022.100219
Kumar Mishra et al.	2023	Emerging pollutants of severe environmental concern in water and wastewater: A comprehensive review on current developments and future research	https://doi.org/10.1016/j.wen.2023.08.002
Labad et al.	2022	Occurrence, data-based modelling, and risk assessment of emerging contaminants in an alluvial aquifer polluted by river recharge	https://doi.org/10.1016/j.envpol.2022.120504
Leendertse et al. (CLM)	2022	Herkomst onverwachte gewasbeschermingsmiddelen in water	
Li et al.	2023	Non-targeted analysis for the screening and semi-quantitative estimates of per-and polyfluoroalkyl substances in water samples from South Florida environments	https://doi.org/10.1016/j.jhazmat.2023.131224
Liu et al.	2024	Assessment for the data processing performance of non-target screening analysis based on high-resolution mass spectrometry	https://doi.org/10.1016/j.scitotenv.2023.167967
LUBW Baden-Wür-rtemberg	2023	Spurenstoffinventar der Fließgewässer in Baden-Württemberg	
Meekel et al.	2021	Online Prioritization of Toxic Compounds in Water Samples through Intelligent HRMS Data Acquisition	https://doi.org/10.1021/acs.analchem.0c04473
Meijer et al.	2021	An annotation database for chemicals of emerging concern in exposome research	https://doi.org/10.1016/j.envint.2021.106511
Min IenW	2021	Wegwijzer Opkomende Stoffen in Oppervlaktewater - Op weg naar omgang met opkomende stoffen	
Ng et al.	2022	Target and suspect screening of 4777 per- and polyfluoroalkyl substances (PFAS) in river water, wastewater, groundwater and biota samples in the Danube River Basin	https://doi.org/10.1016/j.jhazmat.2022.129276
Nikolopoulou et al.	2023	Wide-scope target and suspect screening of emerging contaminants in sewage sludge from Nigerian WWTPs by UHPLC-qToF-MS	http://dx.doi.org/10.1016/j.scito-tenv.2022.159529
NORMAN	2023	NORMAN comments on candidate 5th Watch List substances (First outline draft report on Selection of substances for the 5th Watch List under the Water Framework Directive - JRC)	
Pereira et al.	2023	Parabens as environmental contaminants of aquatic systems affecting water quality and microbial dynamics	https://doi.org/10.1016/j.scitotenv.2023.167332
Platform Meetnet-beheerders Grondwater-kwaliteit	2023	Grondwaterkwaliteit Nederland 2021-2022	
Ratchnashree et al.	2023	Advanced technologies for the determination of quantitative structure-activity relationships and degradation efficiency of micropollutants and their removal in water – A review	https://doi.org/10.1016/j.scitotenv.2023.166563
Rijksoverheid	2022	Het nationale waterbeleid en de uitvoering in de rijkswateren: Nationaal Water Programma 2022-2027	
Rijkswaterstaat	2021	Aanvullend onderzoek naar PFAS in afvalwaterlozingen	
Rijkswaterstaat	2023	Jaaroverzicht 2023 - Landelijke Coördinatiecommissie Milieuverontreiniging Water (LCM)	
RIVM	2022	Advies n-heptadecaan (CAS nr. 629-78-7) in de Maas	

Author	Year	Title	Link
RIWA	2024	PFAS in gewasbeschermingsmiddelen en biociden	Pfd en Word
RIWA	2020	List of Micropollutants in European River Basins River Basins Rhine, Elbe, Meuse, Scheldt - list of substances found in exceedance of the target values of the European River Memorandum (ERM) in 2020	
Rocco et al.	2022	Enhanced database creation with in silico workflows for suspect screening of unknown tebuconazole transformation products in environmental samples by UHPLC-HRMS	https://doi.org/10.1016/j.jhazmat.2022.129706
Sadia et al.	2023	Occurrence, Fate, and Related Health Risks of PFAS in Raw and Produced Drinking Water	https://doi.org/10.1021/acs.est.2c06015
Shittu et al.	2023	A rapid systematic scoping review of research on the impacts of water contaminated by chemicals on very young children	https://doi.org/10.1016/j.scitotenv.2023.164604
STOWA	2023	Pilot onderzoek GE(O)ZOND	
STOWA	2021	Literatuuronderzoek naar bronnen en gedrag van PFAS in afvalwater	
STOWA	2021	PFAS in influent, effluent en zuiveringsslib - Resultaten van een meetcampagne op acht RWZI's	
STOWA Deltafact	2022	Antiparasitica, emissies, gedrag en milieueffecten	
Vale et al.	2022	Parabens as emerging contaminants: Environmental persistence, current practices and treatment processes	https://doi.org/10.1016/j.jclepro.2022.131244
Van Leerdam et al. (RIVM)	2022	De gevaren van dumpingen en lozingen van drugsproductieafval voor de kwaliteit van drinkwaterbronnen	
Wang et al.	2024	Application of molecular imprinting for targeted removal of organic contaminants and resistance genes from water: A review	https://doi.org/10.1016/j.jece.2024.112068
Wang et al.	2023	Occurrence of aflatoxins in water and decontamination strategies: A review	https://doi.org/10.1016/j.watres.2023.119703
Wang et al.	2022	Suspect screening to support source identification and risk assessment of organic micropollutants in the aquatic environment of a Sub-Saharan African urban center	https://doi.org/10.1016/j.watres.2022.118706
Wang et al.	2022	Suspect, non-target and target screening of pharmaceuticals and personal care products (PPCPs) in a drinking water system	http://dx.doi.org/10.1016/j.scito-tenv.2021.151866
WLN - water-on-derzoek-advies	2021	Veterinaire geneesmiddelen in grond- en oppervlaktewater	
Yang et al.	2022	Coupling suspect and non-target analytical methods for screening organic contaminants of concern in agricultural & urban impacted waters: Optimization and application	https://doi.org/10.1016/j.scitotenv.2021.151117

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