

BILAG

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STOFFERNES FYSISKE-KEMISKE EGENSKABER

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Chloridazon

Previously also called pyrazon (PubChem 2023f)

Physical-chemical properties - chloridazon

Property	Value	Source
ISO common name	Chloridazon	(EFSA 2007)
Chemical name (IUPAC)	5-amino-4-chloro-2-phenylpyridazin-3(2H)-one	(EFSA 2007)
Chemical name (CA)	5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone	(EFSA 2007)
CAS number	1698-60-8	(EFSA 2007)
Molecular formula	C ₁₀ H ₈ ClN ₃ O	(EFSA 2007)
Molecular mass	221.6 g/mol	(EFSA 2007)
Structural formula		(EFSA 2007)
Melting point	205.9 – 206.8 °C (99.9 %)	(EFSA 2007)
Boiling point	No boiling point < 360 °C	(EFSA 2007)
Vapor pressure	1 · 10 ⁻⁹ Pa at 20 °C (based on calculation)	(EFSA 2007)
Henry's law constant	5.3 · 10 ⁻¹⁰ Pa m ³ mol ⁻¹	(EFSA 2007)
Solubility in H ₂ O	0.410 g/L at 20 °C (pH 4) (99.9 %) 0.422 g/L at 20 °C (pH 7) (99.9 %)	(EFSA 2007)
Solubility in organic solvents	Solubility at 20 °C in g/L (99.8 %) Methanol 15.1 Ethylacetate 3.7 Acetone 12.4 Octanol 3.1 Acetonitrile 8.4 Dichloromethane 1.9 Isopropanol 5.4 Toluene 0.1	(EFSA 2007)
Partition coefficient (octanol-water coefficient)	1.2 at 25 °C (high purity solvent grade water) (98.8 % radio purity)	(EFSA 2007)
Dissociation	No dissociation takes place in water.	(EFSA 2007)
Property	Value	Source
K _{foc}	199 L/kg (arithmetic mean)	(EFSA 2007)
1/n	0.845 (Arithmetic mean)	(EFSA 2007)

Summary of behaviour in the environment - chloridazon

DT ₅₀ soil – aerobic	Laboratory: 43.1 days (geometric mean, FOCUS reference conditions) Field: 19 days (geometric mean)	(EFSA 2007)
DT ₅₀ soil – anaerobic	Laboratory: 370 – 607 days	(EFSA 2007)
Hydrolytic degradation	No hydrolyses occurred at 25 °C and pH 5,7, and 9	(EFSA 2007)
Photolytic degradation	Theoretical DT ₅₀ : March 75.6 days, April 36.8 days, May 25.9 days, June 21.6 days	(EFSA 2007)

Mineralization and non-extractable residues in soil - chloridazon

Property	Value	Source
Mineralization – aerobic soil	Pyridazinone-14C-labelled chloridazon <u>Sandy loam:</u> 5.6 % AR after 120 days 18.6 % AR after 373 d (study end) <u>Sandy clay loam:</u> 2.2 % AR after 124 days 3.9 % AR after 367 days (study end)	(EFSA 2007)
Mineralization – anaerobic soil	Chloridazon (tested: 14C-chloridazon): <u>Sandy loam:</u> 3.5% after 90 days <u>Sandy clay loam:</u> 1.2% after 91 days	(EFSA 2007)
Non-extractable residues aerobic soil	Pyridazinone-14C-labelled chloridazon <u>Sandy loam:</u> 9.3 % AR after 120 days 12.7 % AR after 373 days (study end) <u>Sandy clay loam:</u> 13.3 % AR after 124 days 19.0 % AR after 367 days (study end)	(EFSA 2007)
Non-extractable residues anaerobic soil	Chloridazon (tested: 14C-chloridazon): <u>Sandy loam:</u> 6.2 % after 90 days <u>Sandy clay loam:</u> 9.7 % after 91 days	(EFSA 2007)

Degradation in aerobic soil - chloridazon

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy clay loam	7.7	25	75	187.6	(EFSA 2007)
Laboratory	Sandy loam	5.9	25	75	154.9	(EFSA 2007)
Laboratory	Loam	7.2	20	40	10.7	(EFSA 2007)
Laboratory	Loamy sand	6.7	20	40	8.6	(EFSA 2007)
Laboratory	Clay	7.4	20	40	82.1	(EFSA 2007)
Laboratory	Loamy sand	5.6	20	40	43	(EFSA 2007)
Field (Sweden)	Silty sand (bare soil)	6	-	-	16	(EFSA 2007)
Field (Germany)	Sandy loam (bare soil)	6.5	-	-	6	(EFSA 2007)

Field (Germany)	Clayey sand (bare soil)	4.6	-	-	55	(EFSA 2007)
Field (Germany)	Heavy loam sand (bare soil)	5.1	-	-	10	(EFSA 2007)
Field (Germany)	Loam (bare soil)	7.1	-	-	16	(EFSA 2007)
Field (Germany)	Loam (bare soil)	6.8	-	-	3	(EFSA 2007)
Field (USA)	Clay (pre-emergence, sugar beet)	7.3	-	-	105	(EFSA 2007)
Field (USA)	Sandy loam (pre-emergence, - sugar beet)	6.6	-	-	42	(EFSA 2007)
Field (Italy)	Sandy loam (bare soil)	6.5	-	-	20	(EFSA 2007)
Field (Spain)	Clay silt loam (bare soil)	8.1	-	-	22	(EFSA 2007)

Degradtion in anaerobic soil - chloridazon

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy clay	-	25	-	370	(EFSA 2007)
Laboratory	Sandy loam	-	25	-	607	(EFSA 2007)

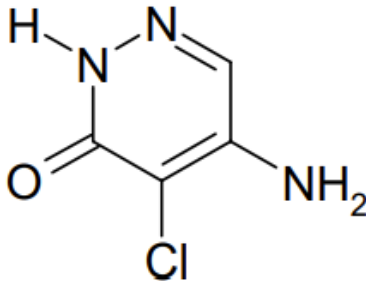
Soil adsorption - chloridazon

Soil type	OC %	pH	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
Sandy loam	-	-	0.2	89	0.568	(EFSA 2007)
Sandy loam	-	-	0.69	128	0.914	(EFSA 2007)
Sand	-	-	0.25	220	1.030	(EFSA 2007)
Silty loam	-	-	1.0	220	0.836	(EFSA 2007)
Clay	-	-	3.6	340	0.877	(EFSA 2007)

Desphenyl Chloridazon, DPC

Physical-chemical properties - DPC

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	5-amino-4-chloro-pyridazine-3-one	(PPDB 2023b)
	4-amino-5-chloro-1H-pyridazin-6-one	(PubChem 2023d)
Chemical name (CA)		

CAS number	6339-19-1	(PubChem 2023d)
Molecular formula	C ₄ H ₄ ClN ₃ O	(PPDB 2023b)
Molecular mass	145.55	(PPDB 2023b)
Molar volume	81 cm ³ (predicted average)	(EPA 2023f)
Structural formula		(EFSA 2007)
Melting point	<300 °C	(SCBT n.d.)
Boiling point	279 °C (predicted average) 236 – 363 °C (predicted range)	(EPA 2023f)
Vapor pressure	4.47 x 10 ⁻³ mmHg (predicted average) = 595.95 mPa	(EPA 2023f)
Henry's law constant	1.36 x 10 ⁻⁸ atm m ³ mol ⁻¹ (predicted average) = 0.00138 Pa m ³ mol	(EPA 2023f)
Solubility in H ₂ O	6.531g/L 0.238 mol/ L (predicted average) 9.16x10 ⁻³ - 0.603 mol/L (predicted range, (4))	(Miljøstyrelsen 2022) (p.122) (EPA 2023f)
Partition coefficient (octanol-water coefficient)	Log K _{ow} = - 0.26 Log D _{ow} = -0.78 (Dow used for ionizable compounds?)	(Miljøstyrelsen 2022) (p.122) Reference to the source in (Piai et al. 2020)

Summary of behaviour in the environment - DPC

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{foc} = 50 L/kg (arithmetic mean) K _f = 0.48 L/kg K _d = 0.53 L/kg	(EFSA 2007) (PPDB 2023b) (Miljøstyrelsen 2022)(p.135)
1/n	K _{oc} = 63.8 L/kg (predicted average) 0.834 (arithmetic mean)	(EPA 2023f) (EFSA 2007)
pH sensitivity	No pH decency	(EFSA 2007)
GUS index	5.46 (calculated)	(PPDB 2023b)
DT ₅₀ soil – aerobic	Laboratory: 108.0 days (geometric mean, FOCUS reference conditions) Field: 235.5 days 106 days	(EFSA 2007) (PPDB 2023b) (Miljøstyrelsen 2022)(p.122)
Hydrolytic degradation	Atmospheric hydroxylation rate (predicted average) 3.95 x 10 ⁻¹² = cm ³ /molecule*sec	(EPA 2023f)
Photolytic degradation	<u>direct photolysis</u> : Theoretical DT ₅₀ April, May, June, July, August: 8.72, 6.96, 6.25, 6.95, 7.0 days (calculation on algorithms by Frank and Klöpfer, information on quantum yield, absorption spectrum used) Aqueous hydrolysis at pH 7: DT ₅₀ = 7.18 days	(EFSA 2007) (PPDB 2023b)

Degradation in aerobic soil - DPC

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy loam	-	20	40	80	(EFSA 2007)
Laboratory	Loamy sand	-	20	40	93	(EFSA 2007)
Laboratory	Sandy loam	-	20	40	132	(EFSA 2007)
Laboratory	Loamy sand	-	20	40	120	(EFSA 2007)
Field	-	-	-	-	130 – 360	(PPDB 2023b)

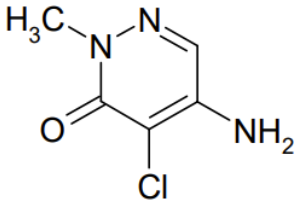
Soil adsorption - DPC

Soil type (% particles < 0.02 mm)	OC %	pH Soil	K_f (K_d) [L/kg]	K_{foc} [L/kg]	1/n	Source
- (10.7)	0.7	7.0	0.34	49	0.804	(EFSA 2007)
- (23.2)	0.9	7.3	0.42	46	0.819	(EFSA 2007)
- (40.0)	0.6	7.3	0.43	74	0.844	(EFSA 2007)
- (14.9)	2.4	6.0	0.71	29	0.868	(EFSA 2007)
Aquifer Sand	0.2	7.7	$K_d = 0.08$	-	-	(Krog Nielsen 2021)
Silty clay	0.31	7.4	$K_f = 0.37 - 0.57$	-	0.83 - 0.98	(Krog Nielsen 2021)
Clayey tills	0.07 - 0.21	7.1 - 8.1	$K_f = 0.81 - 2.14$	-	0.60 - 0.88	(Krog Nielsen 2021)
-	-	-	$K_d = 0.53$	-	-	(Miljøstyrelsen 2022) (p.122)

Methyl Desphenyl Chloridazon, MDPC

Other names: chloridazon-metabolite B1, 5-amino-4-chloro-2-methyl-3(2H)-pyridazinone (PPDB 2021c)

Physical-chemical properties - MDPC

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	5-amino-4-chloro-2-methylpyridazin2-3-one	(PPDB 2021c)
Chemical name (CA)		
CAS number		
Molecular formula	C ₅ H ₆ ClN ₃ O	(PPDB 2021c)
Molecular mass	159.57	(PPDB 2021c)
Molar volume	102 cm ³ (predicted value)	(EPA 2023p)
Structural formula		(EFSA 2007)
Melting point	194 °C (predicted value)	(EPA 2023p)
Boiling point	227 °C (predicted average)	(EPA 2023p)
Vapor pressure	0.145 mmHg (predicted value) = 19331.7 mPa	(EPA 2023p)
Henry's law constant	1.16 x 10 ⁻⁸ atm m ³ mol ⁻¹ (predicted value) =0.00117 Pa m ³ mol ⁻¹	(EPA 2023p)
Solubility in H ₂ O	0.623 mol/L (predicted average)	(EPA 2023p)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log P _{OW} = -1.38 (unverified) Log K _{ow} = -0.428 (predicted average)	(PPDB 2021c) (EPA 2023p)
Dissociation		

Summary of behaviour in the environment - MDPC

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{foc} = 92 L/kg (arithmetic mean)	(EFSA 2007)
	K _f = 1.67 L/kg	(PPDB 2021c)
	K _{oc} = 35.9 L/kg (predicted value)	(EPA 2023p)
1/n	0.867 (arithmetic mean)	(EFSA 2007)
pH sensitivity	No pH dependency	(EFSA 2007)
DT ₅₀ soil - aerobic	Laboratory: 144.6 days (geometric mean, FOCUS reference conditions)	(EFSA 2007)
	Laboratory: 143.8 days; typical 145 days	(PPDB 2021c)
Hydrolytic degradation		
Photolytic degradation		

Degradation in aerobic soil - MDPC

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy loam	-	20	40	135	(EFSA 2007)
Laboratory	Loamy sand	-	20	40	118	(EFSA 2007)
Laboratory	Sandy loam	-	20	40	152	(EFSA 2007)

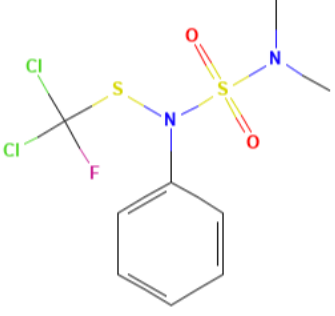
Laboratory	Loamy sand	-	20	40	170	(EFSA 2007)
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Soil adsorption - MDPC

Soil type	OC %	pH	K_f [L/kg]	K_{foc} [L/kg]	1/n	Source
Loamy sand	-	-	0.40	100	0.794	(EFSA 2007)
Loamy sand	-	-	0.43	39	0.861	(EFSA 2007)
Sandy loam	-	--	0.50	33	0.851	(EFSA 2007)
Loam	-	-	0.68	136	0.915	(EFSA 2007)
Sand /loamy sand	-	-	0.68	27	0.907	(EFSA 2007)
Sandy clay loam	-	-	7.34	216	0.871	(EFSA 2007)

Dichlofluamid

Physical-chemical properties - dichlofluamid

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	N-dichlorofluoromethylthio-N',N'-dimethyl-N-phenylsulfamide	(PPDB 2023g)
Chemical name (CA)		
CAS number	1085-98-9	(PPDB 2023g)
Molecular formula	C ₉ H ₁₁ Cl ₂ FN ₂ O ₂ S ₂	(PPDB 2023g)
Molecular mass	333.23	(PPDB 2023g)
Molar volume	214 cm ³ (predicted average)	(EPA 2023k)
Structural formula		(PubChem 2023g)
Melting point	106°C (unverified)	(PPDB 2023g)
Boiling point	353 °C (predicted average)	(EPA 2023k)
Vapor pressure	3.79 x 10 ⁻⁰² mPa 1.12 10 ⁻⁷ mmHg	(PPDB 2023g) (EPA 2023k)
Henry's law constant	3.60 x 10 ⁻⁰³ Pa m ³ mol ⁻¹ (at 25°C) unverified 1.69 x 10 ⁻⁷ atm m ³ mol ⁻¹ (predicted)	(PPDB 2023g) (EPA 2023k)
Solubility in H ₂ O	1.3 mg/L 3.90 10 ⁻⁶ mol/L (experimental average)	(PPDB 2023g) (EPA 2023k)
Solubility in organic solvents	At 20 °C (unverified) Dichloromethane 200 g/L Hexane 2.6 g/L Toluene 145 g/L Isopropanol 10.8 g/L	(PPDB 2023g)
Partition coefficient (octanol-water coefficient)	Log K _{ow} = 3.7	(PPDB 2023g) (EPA 2023k)
Dissociation		

Summary of behaviour in the environment - dichlofluanid

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc} pH sensitivity	K _{oc} = 1100 L/kg	(PPDB 2023g)
DT ₅₀ soil - aerobic	Laboratory: 2.5 days Typical: 3.5 days	(PPDB 2023g)
Hydrolytic degradation Photolytic degradation	DT ₅₀ = 7.5 days (at 20 °C and pH 7)	(PPDB 2023g)

Degradation in aerobic soil - dichlofluanid

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	20	-	2.5	(PPDB 2023g)
-	-	-	-	-	2 - 3	(PPDB 2023g)

Soil adsorption - dichlofluanid

Soil type	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
-	-	-	-	-	-	1100	-	(PPDB 2023g)

Tolyfluanid

Physical-chemical properties - Tolyfluanid

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	N-dichlorofluoromethylthio-N',N'-dimethyl-Np-tolylsulfamide	(EFSA 2005)
Chemical name (CA)	Methanesulfenamide, 1,1-dichloro-N-[(dimethylamino)sulfonyl]-1-fluoro-N-(4-methylphenyl)-	(EFSA 2005)
CAS number	731-27-1	(EFSA 2005)
Molecular formula	C ₁₀ H ₁₃ Cl ₂ FN ₂ O ₂ S ₂	(EFSA 2005)
Molecular mass	347.3	(EFSA 2005)
Molar volume	231 cm ³ (predicted average)	(EPA 2023s)
Structural formula		(EFSA 2005)
Melting point	93 °C	(EFSA 2005)
Boiling point	Not measurable, decomposition above 200 °C	(EFSA 2005)
Vapor pressure	2 · 10 ⁻⁴ Pa at 20 °C (extrapolated)	(EFSA 2005)
Henry's law constant	7.7 · 10 ⁻² at 20 °C Pa m ³ mol ⁻¹	(EFSA 2005)
Solubility in H ₂ O	0.90 mg/L at 20 °C	(EFSA 2005)
Solubility in organic solvents	At 20 °C n-heptane 54 g/L acetone > 250 g/L xylene 190 g/L acetonitrile > 250 g/L dichloromethane >250 g/L 2-propanol 22 g/L dimethylsulfoxide > 250 g/L 1-octanol 16 g/L ethylacetate > 250 g/L Polyethylene glycol (PEG) 56 g/L	(EFSA 2005)
Partition coefficient (octanol-water coefficient)	Log P _{ow} = 3.9 (at 21°C) (not dependent on pH)	(EFSA 2005)
Dissociation	Tolyfluanid shows in aqueous solvents neither acidic nor basic properties. pK value not possible to specify.	(EFSA 2005)

Summary of behaviour in the environment - tolylfuanid

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} = 2200 L/kg (value estimated using HPLC method)	(EFSA 2005)
pH sensitivity	No pH dependence observed	
DT ₅₀ soil - aerobic	Laboratory: 1.8 days (geometric mean) Field: 6 days	(EFSA 2005) (PPDB 2023I)
Hydrolytic degradation	<u>pH 4:</u> DT ₅₀ = 11.7 days (22°C, extrapolated); 5.6 days (30 °C) <u>pH 7:</u> DT ₅₀ = 42.5 h (20°C); 29.1 h (22 °C, extrapolated), 7.9 h(30 °C) <u>pH 9:</u> << 10 min (20 °C)	(EFSA 2005)
Photolytic degradation (aqueous)	DT ₅₀ = 1.9 days (20°C, pH 7); Direct photodegradation is not expected to contribute to the elimination in the environment (no absorbance above 290 nm).	(PPDB 2023I) (EFSA 2005)
Soil photolysis	Mineralisation 2.8 % after 18 d [phenyl-UL-14C]-label Non-extractable residues 39.3 % after 18 d [phenyl-UL- 14C]-label	(EFSA 2005)

Mineralization and non-extractable residues in soil - tolylfuanid

Property	Value	Source
Mineralization – aerobic soil at 22°C	24.7-40.0 % after 99 d, [phenyl-UL-14C]-label (n = 4); 64.8-76.7 % after 65 d, [dichlorofluoromethyl-13,14C]- label (n = 2) Sterile conditions: no studies provided nor required	(EFSA 2005)
Non-extractable residues aerobic soil at 22°C	56.0-72.3 % after 99 d, [phenyl-UL-14C]-label (n = 4); ~7- ~23 % after 65 d, [dichlorofluoromethyl-13,14C]-label (n = 2) Sterile conditions: no studies provided nor required	(EFSA 2005)

Degradation in aerobic soil - tolylfluamid

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	n=4	-	20	-	0.5 – 2.6 Mean 1.8	(EFSA 2005)

Soil adsorption - tolylfluamid

Soil type	OC %	pH	K _f [L/kg]	K _{oc} [L/kg]	1/n	Source
-	-	-	-	2200	-	(EFSA 2005)

DMS

Physical-chemical properties - DMS

Property	Value	Source
ISO common name	N,N-dimethylsulfoamide (N,N-DMS)	(EU 2014)
Chemical name (IUPAC)	[methyl(sulfamoyl)amino]methane	(PubChem 2023h)
Chemical name	Sulfamide, N,N-dimethyl	(EU 2014)
CAS number	3984-14-3	(PubChem 2023h)
Molecular formula	C ₂ H ₈ N ₂ O ₂ S	(PubChem 2023h)
Molecular mass	124.17	(PubChem 2023h)
Molecular structure		(EPA 2023q)
Molar volume	93.5 cm ³ (predicted average)	(EPA 2023q)
Melting point	73.4 °C (predicted average)	(EPA 2023q)
Boiling point	232 °C (predicted average) 217 - 260 °C (predicted range)	(EPA 2023q)
Vapor pressure	1.8 x 10 ⁻⁶ hPa at 20°C 7.2 x 10 ⁻⁶ hPa at 25°C (98.1%) 0.100 mmHg (predicted average) = 13.33 Pa	(EU 2014) (EPA 2023q)
Henry's law constant	1.34 x 10 ⁻⁷ Pa m ³ mol ⁻¹ (pH 5), 1.60 x 10 ⁻⁷ Pa m ³ mol ⁻¹ (pH 7), 1.35 x 10 ⁻⁷ Pa m ³ mol ⁻¹ (pH 9) 1.86 10 ⁻⁷ atm m ³ mol ⁻¹ (predicted average)	(EU 2014) (EPA 2023q)
Solubility in H ₂ O	173 mg/L (much lower than in other sources) pH 5: 167 g/L at 20 °C pH 9: 165 g/L at 20 °C pH 7: 140 g/L at 20 °C (98.1%) 0.163 mol/L (predicted average)	(Miljøstyrelsen 2022) (p. 22) (<i>not original source</i>) (EU 2014)(p55) (EPA 2023q)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log K _{OW} = 0.53; -0.98 Log K _{OW} pH 5: -0.8 at 20 °C pH 9: -0.9 at 20 °C pH 7: -0.8 at 20 °C (98.1 %) Log K _{OW} = -0.999 (predicted average) Log K _{OW} = -1.50 – 0.278 (predicted range)	(Miljøstyrelsen 2022)(p. 22) (<i>not original source</i>) (EU 2014) (EPA 2023q)
Partition coefficient (octanol-air)	Log K _{OA} = 3.85 (predicted average)	(EPA 2023q)
Dissociation	pK _a = 10.6 (98.1%) (non-GLP study)	(EU 2014)

Summary of behaviour in the environment - DMS

Property	Value	Source
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<p>$K_d, K_f, K_{oc}, K_{foc}$</p> <p>pH sensitivity GUS</p>	<p>$K_{oc}/ K_{foc} = 0$ l/kg</p> <p>No adsorption to soil, the determination of K_{oc} and K_d values was not possible, $K_{aoc} = 0$</p> <p>$K_{oc} = 7.46$ l/kg (predicted average)</p> <p>1.5</p>	<p>(Miljøstyrelsen 2022)(p. 22) (<i>not original source</i>) (EU 2014) (p.64)</p> <p>(EPA 2023q)</p> <p>(<i>not original source</i>) (from Excelsheet. 'Pesticider-overblik_BEHYL_med macroer_juli 2022')</p>
<p>DT₅₀ soil - aerobic</p> <p>DT₅₀ soil - anaerobic</p>	<p>699 days</p> <p>47 – 699 days (20°C) 153 days (20°C, geometric mean) 1325 days at 12 °C</p>	<p>(Miljøstyrelsen 2022)(p. 22) (<i>not original source</i>) (EU 2014) (p.63)</p>
<p>Hydrolytic degradation Photolytic degradation</p>	<p>N,N-DMS is hydrolytically stable</p>	<p>(EU 2014) (p.62)</p>

Bentazon

Physical-chemical properties - bentazon

Property	Value	Source
ISO common name	Bentazone	(EFSA 2015)
Chemical name (IUPAC)	3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide	(EFSA 2015)
Chemical name (CA)	3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide	(EFSA 2015)
CAS number	25057-89-0	(EFSA 2015)
Molecular formula	C ₁₀ H ₁₂ N ₂ O ₃ S	(EFSA 2015)
Molecular mass	240.3 g/mole	(EFSA 2015)
Molecular Volume	179 cm ³	(EPA 2023i)
Md (molecule diameter)	0.53 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(EFSA 2015)
Melting point	139 °C (99.8% onset temperature)	(EFSA 2015)
Boiling point	Decomposition prior to boiling (99.8%)	(EFSA 2015)
Vapor pressure	4.9 x 10 ⁻⁴ Pa at 20°C (99.6 %) 1.7 x 10 ⁻⁴ Pa at 20°C (100 %)	(EFSA 2015)
Henry's law constant	2.108·10 ⁻⁶ Pa·m ³ ·mol ⁻¹ 7.2·10 ⁻⁵ Pa·m ³ ·mol ⁻¹	(EFSA 2015)
Solubility in H ₂ O	(99.8 %): (99.9 %) pH 4: 3.0 g/L at 20°C pH 4: 1837 mg/L at 20°C pH 7: 7.7 g/L at 20°C pH 7: 7112 mg/L at 20°C pH 9: 17 g/L at 20°C pH 9: 5627 mg/L at 20°C 570 mg/L at 20 °C	(EFSA 2015) (Rügge, Tsitonaki, and Tuxen 2011)

Solubility in organic solvents	(96.9-99.8 %): (99 %):	(EFSA 2015)
All in g/L at 20° C	methanol: 1061 556	
	dichloromethane: 206	
	1,2-dichloroethane 88	
	n-heptane: 0.11 0.018	
	ethylacetate: 582 388	
	acetone: 1387 604	
	toluene 24.5	
	xylene 8.3	
Partition coefficient (octanol-water coefficient)	<u>(99.6 %)</u>	
	deionized water: log P _{OW} : 1.49 at 20° C	(EFSA 2015)
	pH 4: log P _{OW} : 1.54 at 20° C	
	pH 7: log P _{OW} : -0.94 at 20° C	
	pH 9: log P _{OW} : -1.32 at 20° C	
	<u>(99.5 %):</u>	
	pH 5: log P _{OW} : 0.77 at 22° C	
	pH 7: log P _{OW} : -0.46 at 22° C	
	pH 9: log P _{OW} : -0.55 at 22° C	
	log K _{OW} = 2.34	(EPA 2023i)
Dissociation constant	pKa: 3.51	(EFSA 2015)
	pKa: 2.50	

Summary of behaviour in the environment - bentazon

Property	Value	Source
K _{foc}	30.2 L/kg (median pH H ₂ O >6.6)	(EFSA 2015)
1/n	0.97 (Arithmetic mean pH H ₂ O >6.6)	(EFSA 2015)
K _{oc}	33.1 L/kg (1 experiment)	(EPA 2023i)
K _d , K _{oc}	K _d = 0.72 K _{oc} = 55.3	(PPDB 2023d)
GUS	1.95 (calculated)	(PPDB 2023d)
pH sensitivity	no	(PPDB 2023d)
DT ₅₀ soil - aerobic	Laboratory: 20.1 days (median, FOCUS reference conditions) Field: 7.5 days (norm. ; geometric mean)	(EFSA 2015)
DT ₅₀ soil - anaerobic	Laboratory: >1000 days	(EFSA 2015)
Hydrolytic degradation	At 25 °C bentazone is hydrolytically stable at pH 5, 7 and 9. At 25 °C pH 4 = 87 days, pH 7 = 77 days, pH 9 = 58 days	(EFSA 2015) (Song et al. 2019)
Photolytic degradation	DT ₅₀ : pH 5: 122 h at 25 °C pH 7: 93 h at 25 °C pH 9: 14 h at 25 °C pH 4: 5.7 h (mercury); 7.5 h (xenon lamp) pH 7 : 5.3 h(mercury); 6.8 h (xenon lamp) pH 9: 2.3 h (mercury); 3.5 h (xenon lamp)	(EFSA 2015)

Mineralization and non-extractable residues in soil - bentazon

Property	Value	Source
Mineralization – aerobic soil	8.2-10.6 % after 91-120 d, [¹⁴ C-phenyl]-label (n ¹² = 2) 14.9 % after 117 d, [¹⁴ C-]-label unknown (n= 1)	(EFSA 2015)
Mineralization – anaerobic soil	6.5 % after 120 d, [¹⁴ C-phenyl]-label (n= 1)	(EFSA 2015)
Non-extractable residues aerobic soil	64.3 - 73.4 % after 91-120 d, [¹⁴ C-phenyl]-label (n= 2) 53.5 % after 117 days [label position unknown] (n=1)	(EFSA 2015)
Non-extractable residues anaerobic soil	40.5 % after 120 d, [¹⁴ C-phenyl]-label (n= 1)	(EFSA 2015)

Degradation in aerobic soil - bentazon

Study type	Soil type	pH	Temperature[°C] / Depth [cm]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy loam	7.9	20 °C	40	45.1	(EFSA 2015)

Laboratory	Sandy loam	7.8	20 °C	40	33.0	(EFSA 2015)
Laboratory	Loamy sand	6.8	20 °C	40	43.4	(EFSA 2015)
Laboratory	Loamy sand	6.2	20 °C	40	30.9	(EFSA 2015)
Laboratory	Sandy loam	7.4	20 °C	40	49.1	(EFSA 2015)
Laboratory	Loamy sand	6.3	20 °C	40	16.9	(EFSA 2015)
Laboratory	Sand	6.4	15 °C	pF 2.17	32	(EFSA 2015)
Laboratory	Sand	5.6	15 °C	pF 2.17	13	(EFSA 2015)
Laboratory	Sand	5.8	15 °C	pF 2.17	18.6	(EFSA 2015)
Laboratory	Loamy sand	5.8	15°C	pF 2.17	20.9	(EFSA 2015)
Laboratory	Sand	6.1	15 °C	pF 2.17	16.9	(EFSA 2015)
Laboratory	Loamy sand	5.6	20 °C	40	9.6	(EFSA 2015)
Field (Germany)	Loamy sand (bare soil)	5.5	0 – 40 cm	-	8.9	(EFSA 2015)
Field (Germany)	Silt loam (bare soil)	6.9	0 – 30 cm	-	5.7	(EFSA 2015)
Field (France)	Loam (bare soil)	4.7	0 – 20 cm	-	3.9	(EFSA 2015)
Field (Italy)	Silt loam (bare soil)	8.3	0 – 30 cm	-	6.7	(EFSA 2015)
Field (Germany)	Silt loam (bare soil)	6.3	0 – 30 cm	-	9.4	(EFSA 2015)
Field (France)	Silt loam (bare soil)	8.1	0 – 45 cm	-	10.5	(EFSA 2015)
Field (Spain)	Sand (bare soil)	7.6	0 – 15 cm	-	26.4	(EFSA 2015)
Field (France)	Sandy loam (bare soil)	6.4	0 – 40 cm	-	5.4	(EFSA 2015)

Degradation in anaerobic soil - bentazon

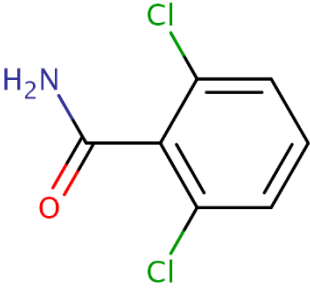
Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Sandy loam	7.9	20	40	>1000	(EFSA 2015)

Adsorption to soil - bentazon

Soil type	OC %	pH	K _f [L/kg]	K _{foc} [L/kg]	K _{f,oc} corr.	1/n	Source
Loam	0.6	7.8	0.22	37.1	19.5	0.99	(EFSA 2015)
Sand	0.5	7.5	0.24	46.5	26.2	1.13	(EFSA 2015)
Loamy Sand	2.7	7.7	0.35	13.3	9.2	1.03	(EFSA 2015)
Clay	2.9	8.2	0.38	13.2	13.2	0.70	(EFSA 2015)
Loamy sand	0.7	6.8	0.02	3.0	3.0	0.85	(EFSA 2015)
Stagnic cambisol	3.4	6.7	1.40	41.0	39,1	1.00	(EFSA 2015)
Calcaric regosol 2	3.3	8.2	1.20	36.0	34,1	0.99	(EFSA 2015)
Calcaric regosol	2.1	7.9	1.20	63,0	59.7	1.00	(EFSA 2015)
Calcaric calcisol	2.1	8.1	1.30	55.0	52.3	1.00	(EFSA 2015)
Vertical stagnic cambisol	2.0	7.0	1.20	63.0	59.7	1.00	(EFSA 2015)
Cambic stagnic vertic calcisol	1.6	8.0	1.30	79.0	75.2	1.00	(EFSA 2015)
Lonnstrop	1.8	6.7	0.32	17.9	15.1	0.98	(EFSA 2015)
Heavy clay	1.7	4.9	3.06	175.6	175.6	0.70	(EFSA 2015)
Clay	1.8	6.0	0.42	23.4	23.4	0.66	(EFSA 2015)
Loamy sand	0.6	5.6	0.45	77.6	77.6	0.70	(EFSA 2015)
Loamy sand	1.2	6.3	0.007	5.9	5.9	0.98	(EFSA 2015)
Dystic cambisol	3.5	5.3	1.90	55.0	55.0	0.99	(EFSA 2015)
Fluvic Gleyic Cambisol	2.8	6.2	1.50	54.0	54.0	1.00	(EFSA 2015)
Eutric cambisol2	2.1	6.2	1.30	60.0	57.1	1.00	(EFSA 2015)
Stagnic luvisol	1.6	5.9	1.40	93.0	88.7	1.00	(EFSA 2015)
Fluvic stagnic cambisol	0.9	5.8	1.40	137.0	130.7	1.00	(EFSA 2015)
Eutric cambisol	0.8	6.4	1.20	158.0	149.8	0.99	(EFSA 2015)
Fluvic cambisol	1.1	5.5	1.50	144.0	144.0	0.99	(EFSA 2015)
Ultuna	2.0	5.3	0.48	24.3	25.0	0.80	(EFSA 2015)
Saby	2.8	5.6	0.37	13.5	13.2	0.86	(EFSA 2015)
N = 7	-	-	Kd 0.72 0.22 – 2.99	Koc 55.3 13 - 176			

BAM

Physical-chemical properties - BAM

Property	Value	Source
ISO common name	2,6-dichlorobenzamide	(PPDB 2021a)
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number	2008-58-4	(PPDB 2021a)
Molecular formula	C ₇ H ₅ Cl ₂ NO	(PPDB 2021a)
Molecular mass	190.03	(PPDB 2021a)
Molar volume	132 cm ³ (predicted value)	(EPA 2023b)
Md (molecule diameter)	0.47 nm	(Miljøstyrelsen 2021) (p28)
Structural formula		(EPA 2023b)
Melting point	198 °C	(EPA 2023b)
Boiling point	296 °C (predicted value)	(EPA 2023b)
Vapor pressure	2.0 x 10 ⁻⁰² mPa (at 20 °C)	(PPDB 2021a)
	3.13 10 ⁻³ mmHg (predicted value)	(EPA 2023b)
Henry's law constant	2.92 10 ⁻⁹ atm m ³ mol ⁻¹ (predicted value)	(EPA 2023b)
	2.96 10 ⁻⁴ Pa m ³ mol ⁻¹	
Solubility in H ₂ O	18.30 g/L	(PPDB 2021a)
	1.28 10 ⁻² mol/L	(EPA 2023b)
	27.30 g/L	(Geyer et al. 1981)
Partition coefficient (octanol-water coefficient)	Log P _{OW} = 0.38	(PPDB 2021a)
	Log K _{ow} = 0.777	(EPA 2023b)
Dissociation	pK _a = not applicable	(PPDB 2021a)
	pK _a = 13 – 14	(Jensen et al. 2009)
	pK _a = 13.3 (not original source)	(Miljøstyrelsen 2021) (p13)

Summary of behaviour in the environment - BAM

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _f = 0.95 L/kg K _{foc} = 40.98 L/kg 1/n = 0.92	(PPDB 2021a)
pH sensitivity	No	(PPDB 2021a)
GUS leaching potential index	5.11	(PPDB 2021a)
DT ₅₀ soil - aerobic	Laboratory: 1194 days Field: 137.7 days	(PPDB 2021a)
Hydrolytic degradation	Stable	(PPDB 2021a)
Photolytic degradation	Stable	(PPDB 2021a)

Degradation in anaerobic soil - BAM

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	-	-	808-1848	(PPDB 2021a)
Field	-	-	-	-	73 – 256.7	(PPDB 2021a)

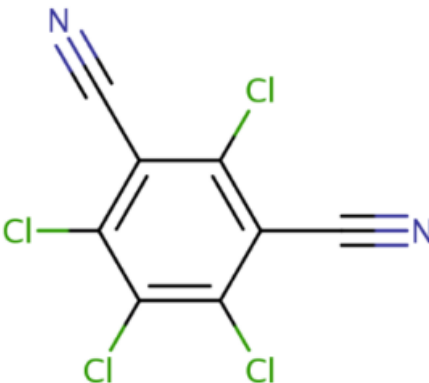
Soil adsorption - BAM

Soil type	OC %	pH	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
N = 5	-	-	0.21 – 1.76	31 - 51	0.809 - 0.972	(PPDB 2021a)

Chlorothalonil

Also known as: TPN, tetrachloroisophthalonitrile; m-TPCN; HSR002825 (PPDB 2023f)

Physical-chemical properties - chlorothalonil

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	tetrachloroisophthalonitrile	(PPDB 2023f)
Chemical name (CAS)	2,4,5,6-tetrachloro-1,3-benzenedicarbonitrile	(PPDB 2023f)
CAS number	1897-45-6	(PPDB 2023f)
Molecular formula	C ₈ Cl ₄ N ₂	(PPDB 2023f)
Molecular mass	265.91	(PPDB 2023f)
Molar volume	155 cm ³ (predicted value)	(EPA 2023j)
Structural formula		(EPA 2023j)
Melting point	252.1 °C	(PPDB 2023f)
Boiling point	347 °C	(PPDB 2023f)
Vapor pressure	0.076 mPa (at 20 °C)	(PPDB 2023f)
Henry's law constant	2.50 x 10 ⁻⁰² Pa m ³ mol ⁻¹	(PPDB 2023f)
Solubility in H ₂ O	0.81 mg/L at 25°C	(PPDB 2023f)
Solubility in organic solvents	Ethyl acetate 13800 mg/L (at 20°C) Acetone 18000 mg/L (at 25°C) Methanol 1700 mg/L (at 25°C) Xylene 74400 mg/L (at 20°C)	(PPDB 2023f)
Partition coefficient (octanol-water coefficient)	Log P _{ow} = 2.94	(PPDB 2023f)
Dissociation	No dissociation	(PPDB 2023f)

Summary of behaviour in the environment - chlorothalonil

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _d = 42.99 L/kg K _{oc} = 2632 L/kg K _f = 27.2 K _{foc} = 1288 L/kg 1/n = 0.90	(PPDB 2023f)
pH sensitivity	None	(PPDB 2023f)
GUS leaching potential index	1.12	(PPDB 2023f)
DT ₅₀ soil - aerobic	Laboratory: 3.53 days Field: 17.9 days	(PPDB 2023f)
Hydrolytic degradation	DT ₅₀ = 29.6 days (at 20 °C and pH 7) Stable at pH4 to pH7	(PPDB 2023f)
Photolytic degradation	DT ₅₀ = 0.72 days at pH 7	(PPDB 2023f)

Degradation in aerobic soil - chlorothalonil

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	N = 18	-	-	-	0.256 – 19.0	(PPDB 2023f)
Field	-	-	-	-	7.44 -28.4	(PPDB 2023f)

Soil adsorption - chlorothalonil

Soil type	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
N = 9	-	-	7.7- 153	300 - 6154	-	-	-	(PPDB 2023f)
N = 12	-	-	-	-	3.0 – 74.1	330 - 7000	0.83 – 0.95	(PPDB 2023f)
N=8	-	-	-	-	96.3 - 1357	13462 - 52585	0.48 – 0.69	(PPDB 2023f)
N = 1	-	-	-	1820	-	-	-	(EPA 2023j)

R417888

Other names: 2-amido-3,5,6-trichlo-4-cyanobenzenesulphonic acid, chlorothalonil sulphonic acid, SDS 3701 (PPDB 2021b)

Physical-chemical properties - R417888

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	2-carbamoyl-3,5,6-trichloro-4-cyanobenzenesulfonic acid	(PubChem 2023b)
Chemical name (CA)		
CAS number	1418095-02-9	(EPA 2023c)
Molecular formula	C ₈ H ₃ Cl ₃ N ₂ O ₄ S	(EPA 2023c)
Molecular mass	329.5	(PPDB 2021b)
Molar volume	167 cm ³ (predicted value)	(EPA 2023c)
Structural formula		(EPA 2023c)
Melting point	177 °C (predicted value)	(EPA 2023c)
Boiling point	289 °C (predicted value)	(EPA 2023c)
Vapor pressure	5.03 10⁻¹⁰ mmHg (predicted value) = 6.71 10 ⁻⁰⁵ mPa	(EPA 2023c)
Henry's law constant	1.56 10 ⁻¹⁰ atm m ³ mol ⁻¹ (predicted value) 1.58 10 ⁻⁵ Pa m ³ mol ⁻¹	(EPA 2023c)
Solubility in H ₂ O	18 g/L 1.52 mol /L (predicted average)	(PPDB 2021b) (EPA 2023c)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log K _{ow} =1.30 (predicted average)	(EPA 2023c)
Dissociation		

Summary of behaviour in the environment - R417888

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _d = 0.113 L/kg K _{oc} = 7.5 L/kg K _f = 0.10 K _{foc} = 8.34 1/n = 1.01 K _{oc} = 813 (predicted value)	(PPDB 2021b) (EPA 2023c)
pH sensitivity	none	(PPDB 2021b)
GUS leaching potential index	7.76	(PPDB 2021b)
DT ₅₀ soil - aerobic	Laboratory: 332 days	(PPDB 2021b)
Hydrolytic degradation Photolytic degradation		

Degradation in aerobic soil - R417888

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	N = 20	-	-	-	61-6-1000	(PPDB 2021b)

Soil adsorption - R417888

Soil type	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
N = 11	-	-	0.012 – 0.28	1.3 – 14.0	-	-	-	(PPDB 2021b)
N = 14	-	-	-	-	0.012 – 0.36	0 – 17.2	0.82 – 1.08	(PPDB 2021b)

R471811

Other names: ,4-bis-amido-3,5,6-trichlorobenzenesulfonate (PPDB 2023e); sodium 2,4-dicarbamoyl-3,5,6-trichlorobenzene-1-sulfonate (EPA 2023r)

Physical-chemical properties - R471811

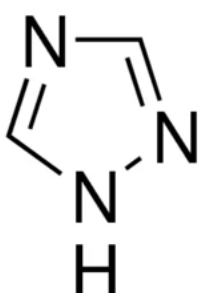
Property	Value	Source
ISO common name		
Chemical name (IUPAC)		
Chemical name	Sodium 2,4-dicarbamoyl-3,5,6-trichlorobenzene-1-sulfonate	(EFSA 2018)
CAS number		
Molecular formula	C ₈ H ₄ Cl ₃ N ₂ NaO ₅ S	(EPA 2023r)
Molecular mass	369.53	(EPA 2023r)
Structural formula		(EPA 2023r)
Melting point		
Boiling point		
Vapor pressure		
Henry's law constant		
Solubility in H ₂ O		
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log Dow = - 1.7 (pH 7)	(Kiefer et al. 2020)
Dissociation	pKa = -4.3	(Kiefer et al. 2020)

Summary of behaviour in the environment – R471811

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}		
pH sensitivity		
GUS leaching potential index		
DT ₅₀ soil - aerobic	Laboratory: 97.0 - > 1000 days	(EFSA 2018)
Hydrolytic degradation		
Photolytic degradation		

1,2,4- Triazol

Physical-chemical properties -1,2,4-triazol

Property	Value	Source
ISO common name		
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number	288-88-0	(SigmaAldrich 2023)
Molecular formula	C ₂ H ₃ N ₃	(SigmaAldrich 2023)
Molecular mass	69.07	(SigmaAldrich 2023)
Structural formula		(SigmaAldrich 2023)
Melting point	121 °C (not verified)	(PPDB 2023a)
Boiling point		
Vapor pressure	0.00022 mPa	(PPDB 2023a)
Henry's law constant	0.155 Pa m ³ mol ⁻¹ (at 25°C, unverified)	(PPDB 2023a)
Solubility in H ₂ O	730 g/L	(PPDB 2023a)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log P _{OW} = -1.0 (at pH7, 20 °C)	(PPDB 2023a)
Dissociation	pK _a = 2.2 (at 25 °C) (not verified) pK _a = 10.3 (not original source)	(PPDB 2023a) (Miljøstyrelsen 2021)(p13)

Summary of behaviour in the environment - 1,2,4-triazol

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _f = 0.719 L/kg K _{foc} = 112 L/kg	(PPDB 2023a)
1/n	0.91	(PPDB 2023a)
pH sensitivity	no	(PPDB 2023a)
GUS leaching potential	1.78 (calculated)	(PPDB 2023a)
DT ₅₀ soil - aerobic	Typical: 10 days Laboratory: 8.2 days	(PPDB 2023a)
Hydrolytic degradation	Stable at pH 5 to pH 9, 25°C	(PPDB 2023a)
Photolytic degradation	Aqueous: stable	(PPDB 2023a)

Degradation in aerobic soil - 1,2,4-triazol

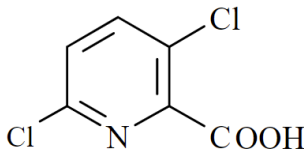
Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	-	-	5.0 – 9.9 days	(PPDB 2023a)

Soil adsorption - 1,2,4-triazol

Soil type	OC %	pH	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
N = 5	-	-	0.234 – 0.833	43 - 202	0.827 – 1.016	(PPDB 2023a)

Clopyralid

Physical-chemical properties -clopyralid

Property	Value	Source
ISO common name	Clopyralid	(EFSA 2006)
Chemical name (IUPAC)	3,6-dichloropyridine-2-carboxylic acid	(EFSA 2006)
Chemical name (CA)	3,6-dichloro-2-pyridinecarboxylic acid	(EFSA 2006)
CAS number	1702-17-6	(EFSA 2006)
Molecular formula	C ₆ H ₃ Cl ₂ NO ₂	(EFSA 2006)
Molecular mass	191.96	(EFSA 2006)
Structural formula		(EFSA 2006)
Melting point	149.6 °C (998 g/kg)	(EFSA 2006)
Boiling point	Not measurable, decomposes	(EFSA 2006)
Vapor pressure	1.36 x 10 ⁻³ Pa at 25 °C (extrapolated from 36 – 65 °C) (996 g/kg)	(EFSA 2006)
Henry's law constant	Unbuffered 3.3 x 10 ⁻¹⁰ Pa m ³ mol ⁻¹ at 20 °C pH 5 2.2 x 10 ⁻¹¹ Pa m ³ mol ⁻¹ at 20 °C pH 7 1.8 x 10 ⁻¹¹ Pa m ³ mol ⁻¹ at 20 °C pH 9 1.6 x 10 ⁻¹¹ Pa m ³ mol ⁻¹ at 20 °C	(EFSA 2006)
Solubility in H ₂ O	Unbuffered: 7.85 g/L at 20 °C H pH 5 : 118 g/L at 20 °C pH 7 : 143 g/L at 20 °C pH 9 : 157 g/L at 20 °C	(EFSA 2006)
Solubility in organic solvents	<u>964 g/kg:</u> acetonitrile: 12.1 wt% at 20 °C n-hexane: 0.6 wt% at 20 °C methanol: 10.4 wt% at 20 °C <u>959 g/kg:</u> acetone: >250 g/L at 20 °C, ethyl acetate: 102 g/L at 20 °C, xylene: 4.6 g/L at 20 °C 1,2-dichlorethane: 20.7 g/L at 20 °C	(EFSA 2006)
Partition coefficient (octanol-water coefficient)	pH 5: - 1.81 at 20 °C pH 7: - 2.63 at 20 °C pH 9: - 2.55 at 20 °C (all 992 g/kg) logP _{ow} = -2.53 Estimation by the Leo-Hansch method	(EFSA 2006)
Dissociation	2.01 at 25 °C (996 g/kg)	(EFSA 2006)

Summary of behaviour in the environment - clopyralid

Property	Value	Source
K _{oc}	5.15 L/kg, (arithmetic mean. European soils)	(EFSA 2006)

1/n	4.64 L/kg (arithmetic mean. American soils) 0.6473 (European soils) 0.875 (American soils)	(EFSA 2006)
pH dependence	Yes, limited evidence that clopyralid is less mobile in acidic soil: K _{oc} was 98.64 at pH 4.06 and 4.76 at pH 5.34 in different horizons of Kaldenkirchen soil; 14.61 at pH 6.21 and 11.25 at pH 6.68 in Lanna soil (n=4)	(EFSA 2006)
DT ₅₀ soil - aerobic	Laboratory: 34 days (mean, 20 °C), 124 days (mean, 10 °C) Field: 11 days (geometric mean)	(EFSA 2006)
DT ₅₀ soil - anaerobic	Laboratory: > 365 days	(EFSA 2006)
Hydrolytic degradation	pH 4-9: No hydrolysis	(EFSA 2006)
Photolytic degradation	DT ₅₀ : 261 days in sterile aqueous pH 7 buffer solution at a concentration of 2.0 ppm clopyralid under natural sunlight at 25°C.	(EFSA 2006)

Mineralization and non-extractable residues in soil - clopyralid

Property	Value	Source
Mineralization – aerobic soil	CO ₂ : 47.5 – 65.5 % of AR after 92 days, 72.9 – 83.3 % of AR after 374 days at 20 °C, [2,6-pyridinyl- ¹⁴ C]-label (n=5) Sterile conditions: no studies provided nor required	(EFSA 2006)
Mineralization – anaerobic soil	No mineralization,	(EFSA 2006)
Non-extractable residues aerobic soil	11.2 – 35.1 % of AR after 92 days at 20 °C, [2,6-pyridinyl- ¹⁴ C]-label (n=5) Sterile conditions: no studies provided nor required	(EFSA 2006)
Non-extractable residues anaerobic soil	NER max 13.4 % of AR after 30 days, no metabolites at 20 °C, [2,6-pyridinyl- ¹⁴ C]-label (n=1)	(EFSA 2006)

Degradation in aerobic soil - clopyralid

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	20	-	13	(EFSA 2006)
Laboratory	-	-	20	-	16	(EFSA 2006)
Laboratory	-	-	20	-	28	(EFSA 2006)
Laboratory	-	-	20	-	36	(EFSA 2006)
Laboratory	-	-	20	-	45	(EFSA 2006)
Laboratory	-	-	20	-	65	(EFSA 2006)
Laboratory	-	-	10	-	73	(EFSA 2006)
Laboratory	-	-	10	-	100	(EFSA 2006)
Laboratory	-	-	10	-	198	(EFSA 2006)
Field (UK)	(bare soil)	-	-	-	8	(EFSA 2006)
Field (Denmark)	(bare soil)	-	-	-	24	(EFSA 2006)
Field (France)	(bare soil)	-	-	-	2	(EFSA 2006)
Field (France)	(bare soil)	-	-	-	7	(EFSA 2006)
Field (Germany)	(bare soil)	-	-	-	16	(EFSA 2006)

Degradation in anaerobic soil - clopyralid

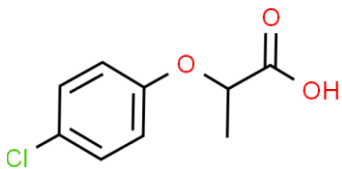
Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	20	-	> 365	(EFSA 2006)

Soil adsorption - clopyralid

Soil origin	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	1/n	Source
Europe	-	-	0.032	3.43	0.6473 (n=4)	(EFSA 2006)
Europe	-	-	0.048	4.76		(EFSA 2006)
Europe	-	-	0.051	5.04		(EFSA 2006)
Europe	-	-	0.151	7.34		(EFSA 2006)
America	-	-	0.0094	0.40	0.875 (n=4)	(EFSA 2006)
America	-	-	0.020	2.12		(EFSA 2006)
America	-	-	0.042	3.15		(EFSA 2006)
America	-	-	0.0935	12.90		(EFSA 2006)

4-CPP

Physical-chemical properties - 4-CPP

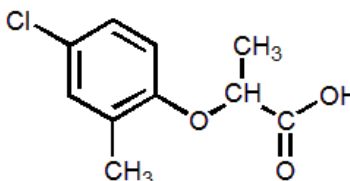
Property	Value	Source
ISO common name		
Chemical name (IUPAC)	2-(4-chlorophenoxy)propanoic acid	(PubChem 2023a)
Chemical name (CA)		
CAS number	3307-39-9	(PubChem 2023a)
Molecular formula	C ₉ H ₉ ClO ₃	(PubChem 2023a)
Molecular mass	200.62	(PubChem 2023a)
Molar volume	153 cm ³ (predicted value)	(EPA 2023d)
Md (molecule diameter)	0.62 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		
Melting point	106 °C (predicted value)	(EPA 2023d)
Boiling point	300 °C (predicted average)	(EPA 2023d)
Vapor pressure	7.57 x 10 ⁻⁵ mmHg (predicted average) = 10.09 mPa	(EPA 2023d)
Henry's law constant	6.94 x 10 ⁻⁹ atm m ³ mol ⁻¹ (predicted value) = 7.03 x 10 ⁻⁴ Pa m ³ mol ⁻¹	(EPA 2023d)
Solubility in H ₂ O	1.148 g / L 7.37 mol /L	(Miljøstyrelsen 2022) (EPA 2023d)
Partition coefficient (octanol-water coefficient)	Log K _{OW} = 2.3	(Miljøstyrelsen 2022) (EPA 2023d)
Dissociation	pKa = 3.1 (not original source)	(Miljøstyrelsen 2021) (p.12)

Summary of behaviour in the environment - 4-CPP

Property	Value	Source
K _{oc}	K _{oc} =30.86 L/kg K _{oc} =52.5 L/kg (predicted value)	(Miljøstyrelsen 2022) (EPA 2023d)
pH dependence		
DT ₅₀ soil - aerobic	20 – 50 days	(Miljøstyrelsen 2022)
DT ₅₀ soil - anaerobic	500 days	(Miljøstyrelsen 2022)
Hydrolytic degradation		
Photolytic degradation		

MCPP

Physical-chemical properties - MCPP

Property	Value	Source
ISO common name	Mecoprop	(SegesInnovation 2023)
Chemical name (IUPAC)	(RS)-2-(4-chloro-o-tolyloxy)propionic acid	(PPDB 2023j)
Chemical name (CAS)	2-(4-chloro-2- methylphenoxy)propanoic acid	(Rügge, Tsitonaki, and Tuxen 2011)
CAS number	7085-19-0	(PPDB 2023j)
Alternative /old CAS number	93-65-2	(PPDB 2023j)
Molecular formula	C ₁₀ H ₁₁ ClO ₃	(PPDB 2023j)
Molecular mass	214.65	(Miljøstyrelsen 2022) (p139)
Molar volume	170 cm ³	(EPA 2023a)
Md (molecule diameter)	0.62 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(SegesInnovation 2023)
Melting point	94 °C 106 °C	(PPDB 2023j) (EPA 2023a)
Boiling point	298 °C	(EPA 2023a)
Vapor pressure	1.6 mPa (at 20 °C)	(PPDB 2023j)
Henry's law constant	2.20 x 10 ⁻⁴ Pa m ³ mol ⁻¹	(PPDB 2023j)
Solubility in H ₂ O	250 g/L in 20°C	(PPDB 2023j)
Solubility in organic solvents	At 20 °C n-Heptane: 4.11 mg/L Methanol: 1000 mg/L Xylene: 126 mg/L Ethyl acetate: 469 mg/L	(PPDB 2023j)
Partition coefficient (octanol-water coefficient)	Log P _{OW} = -0.19 (at pH 7, 20 °C) Log K _{ow} = 3.13 Log K _{ow} = 0.10 (at pH7)	(PPDB 2023j) (EPA 2023a) (Rügge, Tsitonaki, and Tuxen 2011)
Dissociation	pK _a =3.11 (at 25 °C) pK _a = 3.7 (not original source)	(PPDB 2023j) (Miljøstyrelsen 2021) (p12)

Summary of behaviour in the environment - MCPP

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} /K _{foc} = 60 L/kg K _{oc} = 47 L/kg (unverified)	(Miljøstyrelsen 2022)(p22) (PPDB 2023j)

	$K_f = 0.41$ L/kg $K_{foc} = 31$ L/kg	
pH sensitivity	Adsorption higher at lower pH	
DT ₅₀ soil - aerobic	Laboratory: 20 days 8 days	(PPDB 2023j) (Miljøstyrelsen 2022)(p22)
DT ₅₀ soil - anaerobic	10000 days	(Miljøstyrelsen 2022)(p140)
Hydrolytic degradation	Stable. Stable pH 5 to pH 9 up to 70 °C, 8 days	(PPDB 2023j)
Photolytic degradation (aqueous)	DT ₅₀ = 44 days, at pH 7 pH sensitive: DT ₅₀ 42 days at pH 5, 44 days at pH 7, 32 days at pH 9	(PPDB 2023j)

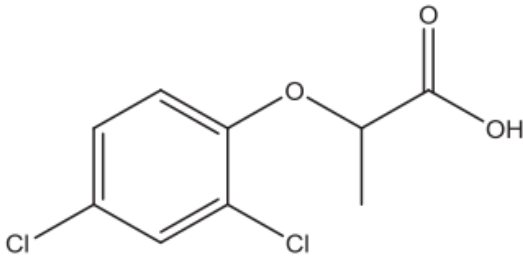
Soil adsorption - MCPP

Soil type	OC %	pH	K_d [L/kg]	K_{oc} [L/kg]	K_f [L/kg]	K_{foc} [L/kg]	1/n	Source
-	-	-	-	47	-	-	-	(PPDB 2023j)
-	-	-	-	-	0.41	31	-	(PPDB 2023j)
N = 4	-	-	-	-	0.2 – 0.69	20 - 43	-	(PPDB 2023j)
N = 1	-	-	-	20.0	-	-	-	(EPA 2023a)

Dichlorprop

Other names: : 2-(2,4-Dichlorophenoxy)propanoic acid, 2-(2,4-Dichlorophenoxy)propionic acid

Physical-chemical properties - dichlorprop

Property	Value	Source
ISO common name	Dichlorprop	(PPDB 2023h)
Chemical name (IUPAC)	(RS)-2-(2,4-dichlorophenoxy)propionic acid	(PPDB 2023h)
Chemical name (CA)		
CAS number	120-36-5	(PPDB 2023h)
Molecular formula	C ₉ H ₈ Cl ₂ O ₃	(PPDB 2023h)
Molecular mass	235.06	(PPDB 2023h)
Md (molecule diameter)	0.62 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(EFSA 2018)
Melting point	117 °C	(PPDB 2023h)
Boiling point		
Vapor pressure	0.01 mPa (at 20 °C)	(PPDB 2023h)
Henry's law constant	8.80 x 10 ⁻⁶ Pa m ³ mol ⁻¹	(PPDB 2023h)
Solubility in H ₂ O	350 mg/L at 20 °C	(PPDB 2023h)
Solubility in organic solvents	At 20 °C	(PPDB 2023h)
	Ethyl acetate 689 g/L	
	Acetone 1265 g/L	
	Hexane 3.030 g/L	
	Toluene 61.2 g/L	
Partition coefficient (octanol-water coefficient)	LogK _{ow} =2.29	(PPDB 2023h)
Dissociation	1.42 (at 25 °C)	(PPDB 2023h)
	3.0	(Miljøstyrelsen 2021)

Summary of behaviour in the environment - dichlorprop

Property	Value	Source
K_{foc}	41.2 L/kg (arithmetic mean)	(PPDB 2023h)
1/n	0.87 (arithmetic mean)	(PPDB 2023h)
pH dependence		
DT ₅₀ soil - aerobic	Laboratory: 10 – 14 days Field: 10 days	(PPDB 2023h)
Hydrolytic degradation	stable	(PPDB 2023h)
Photolytic degradation		

Degradation in aerobic soil - dichlorprop

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	20	-	14	(PPDB 2023h)
Laboratory	-	-	-	-	10	(PPDB 2023h)
-	-	-	-	-	21 - 25	(PPDB 2023h)
Field	-	-	-	-	10	(PPDB 2023h)

Soil adsorption - dichlorprop

Soil type	OC %	pH	K_f [L/kg]	K_{foc} [L/kg]	1/n	Source
-	-	-	0.67	34.4	0.86	(PPDB 2023h)
-	-	-	0.86	47.9	0.88	(PPDB 2023h)
-	-	-	-	$K_{oc} = 74$		(PPDB 2023h)
-	-	-	-	$K_{oc} = 12.0$ – 170		(PPDB 2023h)

AMPA

Other names: AMPA, Aminomethylphosphonic acid, phosphoglycine, 1-aminomethylphosphonic acid (PPDB 2022)

Physical-chemical properties - AMPA

Property	Value	Source
ISO common name	aminomethylphosphonic acid	(PPDB 2022)
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number	1066-51-9	(PPDB 2022)
Molecular formula	CH ₆ NO ₃ P	(PPDB 2022)
Molecular mass	111.04	(PPDB 2022)
Molar volume	67.9 cm ³	(EPA 2023h)
Md (molecule diameter)	0.53 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(PubChem 2023e)
Melting point	122 °C (predicted average)	(EPA 2023h)
Boiling point	317 °C (predicted average)	(EPA 2023h)
Vapor pressure	2.16 x 10 ⁻⁶ mmHg (predicted average)	(EPA 2023h)
Henry's law constant	0.16 Pa m ³ mol ⁻¹ (at 25 °C) (unverified)	(PPDB 2022)
	1.06 x 10 ⁻⁸ atm m ³ mol ⁻¹ (predicted)	(EPA 2023h)
Solubility in H ₂ O	1466.561 g/L (unverified)	(PPDB 2022)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log K _{ow} = - 1.63 (unverified)	(PPDB 2022)
	Log K _{ow} = -2.2	(Degenhardt et al. 2012)
	Log K _{ow} = -2.42 (predicted average)	(EPA 2023h)
Dissociation	pK _a = 1.8 / 5.4 / 10.0 (not original source)	(Miljøstyrelsen 2021) (p13)

Summary of behaviour in the environment - AMPA

Property	Value	Source
K_d , K_f , K_{oc} , K_{foc}	K_{oc} = 2002 L/kg (unverified) K_f = 197.5 L/kg K_{foc} = 9664.5 L/kg $1/n$ = 0.81 K_{oc} = 4.20 L/kg	(PPDB 2022) (EPA 2023h)
pH sensitivity	No	(PPDB 2022)
GUS leaching potential index	0.04	(PPDB 2022)
DT ₅₀ soil - aerobic	Typically 234 days Laboratory: 234.07 days Field: 419 days	(PPDB 2022)
Hydrolytic degradation		
Photolytic degradation		

Degradation in aerobic soil - AMPA

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	N = 6	-	-	-	28.6 – 1000	(PPDB 2022)
Field	N= 5	-	-	-	283.6 – 633.1	(PPDB 2022)

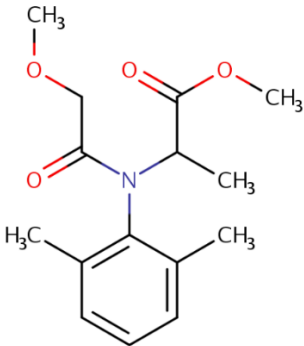
Soil adsorption - AMPA

Soil type	OC g/kg	pH	K_f [L/kg]	K_{foc} [L/kg]	1/n	Source
N= 17	-	-	10.0 -1570	1119 - 11100	0.55 – 0.98	(PPDB 2022)
N= 17	7.2 – 23.1 Mean 6.1		33 – 392 Mean 164		0.72 – 0.82 Mean 0.78	(Sidoli, Baran, and Angulo-Jaramillo 2016)

Metalaxyl

Other names: CGA 48988

Physical-chemical properties - metalaxyl

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	methyl N-(methoxyacetyl)-N-(2,6-xylyl)-DL-alaninate	(PPDB 2023k)
Chemical name (CAS)	methyl N-(2,6-dimethylphenyl)-N-(methoxyacetyl)-DL-alaninate	(PPDB 2023k)
CAS number	57837-19-1	(PPDB 2023k)
Molecular formula	C ₁₅ H ₂₁ NO ₄	(PPDB 2023k)
Molecular mass	279.33	(PPDB 2023k)
Molar volume	250 cm ³ (predicted value)	(EPA 2023o)
Md (molecule diameter)	0.62 nm	(Miljøstyrelsen 2021) (p27) (EPA 2023o)
Structural formula		
Melting point	72 °C	(EPA 2023o)
Boiling point	354 °C (predicted value)	(EPA 2023o)
Vapor pressure	0.75 mPa	(PPDB 2023k)
Henry's law constant	1.60 x 10 ⁻⁵ Pa m ³ mol ⁻¹	(PPDB 2023k)
Solubility in H ₂ O	8400 mg/L (at 22°C and pH 5.2)	(PPDB 2023k)
Solubility in organic solvents	Benzene 550000 mg/L (at 20 °C) Hexane 9100 mg/L (at 20 °C) Methanol 650000 mg/L (at 20 °C) Toluene miscible (at 20 °C)	(PPDB 2023k)
Partition coefficient (octanol-water coefficient)	Log P _{OW} = 1.75 (at 25 °C) Log K _{ow} = 1.65	(PPDB 2023k)
Dissociation	pK _a = 0 (very strong acid)	(PPDB 2023k)

Summary of behaviour in the environment - metalaxyl

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} = 162 L/kg K _f = 2.49 L/kg K _{foc} = 162.3 L/kg 1/n = 0.98	(PPDB 2023k)
pH sensitivity	No	(PPDB 2023k)
GUS leaching potential index	2.06	(PPDB 2023k)
DT ₅₀ soil - aerobic	Typical: 36 days Laboratory: 7.1 days Field: 14.1 days	(PPDB 2023k)
Hydrolytic degradation	DT50 = 106 days (at 20° and pH 7) pH sensitive (all at 20°C) DT50 = 200 days at pH 1 DT50 = 115 days at pH 9 DT50 = 12 days at pH 10	(PPDB 2023k)
Photolytic degradation	Stable (at pH 7)	(PPDB 2023k)

Degradation in aerobic soil - metalaxyl

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	-	-	-	-	2.6 -73	(PPDB 2023k)

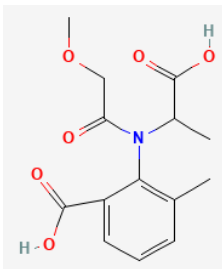
Soil adsorption - metalaxyl

Soil type	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
N = 4	-	-	-	-	0.4 – 1.4	29.6 – 283.8	0.766 – 1.257	(PPDB 2023k)
N = 27	-	-	-	-	0.01 – 8.01	28 - 284	0.57 – 1.32	(PPDB 2023k)
N = 1	-	-	-	37.2	-	-	-	(EPA 2023o)

CGA 108906

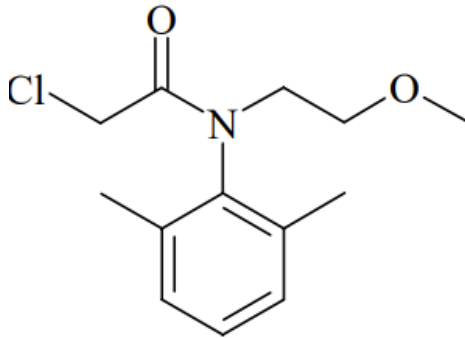
Other names: 2-[N-(1-carboxyethyl)-2-methoxyacetamido]-3-methylbenzoic acid (PubChem 2023c)

Physical-chemical properties - CGA 108906

Property	Value	Source
ISO common name		
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number	104390-56-9	(EPA 2023e)
Molecular formula	C ₁₄ H ₁₇ NO ₆	(PubChem 2023c)
Molecular mass	295.29 g/mol	(PubChem 2023c)
Molar volume		
Structural formula		(PubChem 2023c)
Melting point		
Boiling point		
Vapor pressure		
Henry's law constant		
Solubility in H ₂ O		
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)		
Dissociation		

Dimethachlor

Physical-chemical properties - dimethachlor

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	2-chloro-N-(2-methoxyethyl)acet-2',6'-xylylidide	(EFSA 2008)
Chemical name (CA)	2-chloro-N-(2,6-dimethylphenyl)-N-(2-methoxyethyl)- acetamide	(EFSA 2008)
CAS number	50563-36-5	(EFSA 2008)
Molecular formula	C ₁₃ H ₁₈ ClNO ₂	(EFSA 2008)
Molecular mass	255.8	(EFSA 2008)
Molar volume	224 cm ³	(EPA 2023I)
Structural formula		(EFSA 2008)
Melting point	45.8 – 46.7 °C	(EFSA 2008)
Boiling point	Approx. 320 °C	(EFSA 2008)
Vapor pressure	6.4 x 10 ⁻⁴ Pa at 20 °C (extrapolated) (99.4 %) 1.5 x 10 ⁻³ Pa at 25 °C (extrapolated) (99.4 %)	(EFSA 2008)
Henry's law constant	1.7 x 10 ⁻⁴ Pa m ³ mol ⁻¹ at 25 °C	(EFSA 2008)
Solubility in H ₂ O	2.3 g /L at 25 °C	(EFSA 2008)
Solubility in organic solvents	acetone > 500 g/L ethyl acetate > 500 g/L hexane 42 g/L methanol > 500 g/L dichloromethane > 500 g/L octanol 440 g/L toluene > 500 g/L all at 25 °C	(EFSA 2008)
Partition coefficient (octanol-water coefficient)	Log Pow=2,17 at 25 °C No dependence on pH	(EFSA 2008)
Dissociation	No dissociation in an accessible pH- range	(EFSA 2008)

Summary of behaviour in the environment - dimethachlor

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _f = 4.20 L/kg K _{foc} = 69 L/kg 1/n = 0.91	(EFSA 2008)
pH sensitivity		
DT ₅₀ soil - aerobic	Laboratory: 7.3 days (geometric mean) Field: 3.2 days	(EFSA 2008)
DT ₅₀ soil - anaerobic	Laboratory: 11.3 – 19.4 days	(EFSA 2008)
Hydrolytic degradation	pH 1, 5, 7 & 9 hydrolytically stable (DT ₅₀ >200d)	(EFSA 2008)
Photolytic degradation	Stable (for natural light, 40°N, pH 7)	(EFSA 2008)

Mineralization and non-extractable residues in soil - dimethachlor

Property	Value	Source
Mineralization – aerobic soil	9.6 – 39.9 % after 120 days; 24.3 % after 85 days	(EFSA 2008)
Mineralization – anaerobic soil	0.7 % after 180 days, 2.2 % (total) after 7 + 180 days	(EFSA 2008)
Non-extractable residues aerobic soil	33.4 – 56.8 % after 120 days, 41.3 % after 85 days	(EFSA 2008)
Non-extractable residues anaerobic soil	23 % after 180 days, 50.5 % after 7 + 180 days	(EFSA 2008)

Degradation in aerobic soil - dimethachlor

Study type	Soil type	pH	Temperatur e[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Silt loam	7.5	20	75 % FC	6.6	(EFSA 2008)
Laboratory	Loamy sand	7.4	20	75 % FC	6.3	(EFSA 2008)
Laboratory	Clay loam	7.5	25	75% FC	8.1	(EFSA 2008)
Laboratory	Silt loam	7.4	20	40 % MWHC	3.9	(EFSA 2008)
Laboratory	Loamy sand	5.7	20	40% MWHC	7.7	(EFSA 2008)
Laboratory	Silt loam	7.8	20	40 % MWHC	4.6	(EFSA 2008)
Laboratory	Silt loam	7.5	20	60 % FC	4.8	(EFSA 2008)
Laboratory	Silt loam	7.5	10	60 % FC	12.7	(EFSA 2008)
Laboratory	Silt loam	7.5	20	30 % FC	8.1	(EFSA 2008)
Laboratory	Silt loam	7.5	20	60 % FC	3.3	(EFSA 2008)
Laboratory	sand	6.8	22	40 % MWHC	14.3	(EFSA 2008)
Laboratory	Loamy sand	5.2	22	40 % MWHC	19.8	(EFSA 2008)
Laboratory	Sandy loam	6.4	25	6 % w/w	21.4	(Walker and Brown 1985)
Laboratory	Sandy loam	6.4	25	9% w/w	9.8	(Walker and Brown 1985)
Laboratory	Sandy loam	6.4	25	12% w/w	7.4	(Walker and Brown 1985)
Laboratory	Sandy loam	6.4	25	15% w/w	5.8	(Walker and Brown 1985)
Laboratory	Sandy loam	6.4	15	12% w/w	14.4	(Walker and Brown 1985)

Laboratory	Sandy loam	6.4	5	12% w/w	35.7	(Walker and Brown 1985)
Field	-	-	-	-	Circa 15 - 20	(Walker and Brown 1985)
Field	clay	6.6	-	-	3.2	(EFSA 2008)

Degradation in anaerobic soil - dimethachlor

Study type	Soil type	pH	Temperature[°C]	% MWHC	DT ₅₀ [days]	Source
Laboratory	Clay loam soil	7.5	25	25% MWHC	11.3	(EFSA 2008)
Laboratory	Silt loam	7.5	20	20 %MWHC	19.4	(EFSA 2008)
Laboratory	Sandy loam	8.5	20 - 25	14 % humidity	64.0 – 67.1	(López-Ruiz et al. 2020)
Laboratory	loam	8.4	20 - 25	34% humidity	50.7 – 57.0	(López-Ruiz et al. 2020)

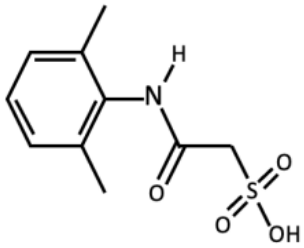
Soil adsorption - dimethachlor

Soil type	OC %	pH	K _f [L/kg]	K _{foc} [L/kg]	1/n	Source
Loamy sand	1.17	7.3	1.12	95.37	0.9052	(EFSA 2008)
Loamy sand	0.81	7.4	0.46	56.65	0.90	(EFSA 2008)
Silty loam	2.1	7.3	1.47	69.97	0.8444	(EFSA 2008)
Silty loam	1.5	6.2	1.18	62	0.92	(EFSA 2008)
Silty loam	4.39	7.1	1.3	29.72	0.7598	(EFSA 2008)
Silty loam	5.4	7.3	3.72	69	0.92	(EFSA 2008)
Silty loam	19.34	6.6	13.3	68.77	0.9392	(EFSA 2008)
Silty loam	25.0	6.9	18.4	73.6	0.95	(EFSA 2008)
Sand	0.66	5.5	0.32	48.72	0.8515	(EFSA 2008)
?	0.56	6.5	0.76	128	0.90	(EFSA 2008)

(2,6-dimethyl-phenylcarbamoyl)-methansulfonsyre

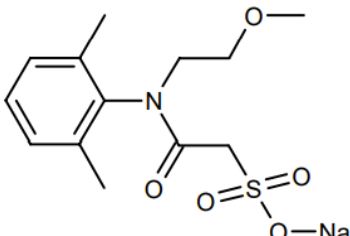
Relevant information: the dimethachlor degradation compound CGA 369873 is the sodium salt of this compound

Physical-chemical properties - (2,6-dimethyl-phenylcarbamoyl)-methansulfonsyre

Property	Value	Source
ISO common name		
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number		
Molecular formula		
Molecular mass		
Structural formula		(Rasmussen, Sonne, and Tsitonaki 2021)
Melting point		
Boiling point		
Vapor pressure		
Henry's law constant		
Solubility in H ₂ O		
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)		
Dissociation		

Dimethachlor ESA

Physical-chemical properties - dimethachlor ESA

Property	Value	Source
(ISO) common name	Dimethachlor ESA ; CGA 354742	
Chemical name	(2,6-dimethylphenyl)-(2-methoxyethyl)carbamoyl]methanesulfonic acid sodium salt	(EFSA 2008)
Chemical name (CA)		
CAS number		
Molecular formula	C ₁₃ H ₁₈ N ₂ O ₅ S	(EFSA 2021)
Molecular mass	323	(EFSA 2021)
Molar volume	232 cm ³ (predicted value)	(EPA 2023m)
Md (molecule diameter)	0.66 nm	(Miljøstyrelsen 2021) (p28)
Structural formula		(EFSA 2008)
Melting point	182 °C (predicted)	(EPA 2023m)
Boiling point	315 °C (predicted)	(EPA 2023m)
Vapor pressure	8.51 x 10 ⁻⁸ mmHg (predicted) =0.0113 mPa	(EPA 2023m)
Henry's law constant	4.56 x 10 ⁻¹⁰ atm m ³ mol ⁻¹ (predicted) =4.62 x 10 ⁻⁵ Pa m ³ mol ⁻¹	(EPA 2023m)
Solubility in H ₂ O	1000 g/L 5.57 x 10 ⁻² mol/L (predicted)	(EFSA 2008) (EPA 2023m)
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log K _{ow} = 0.397 (predicted)	(EPA 2023m)
Dissociation		

Summary of behaviour in the environment - dimethachlor ESA

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} = 3.7 L/kg (arithmetic mean) 1/n = 1.0 K _{oc} = 83.8 L/kg (predicted)	(EFSA 2008) (EPA 2023m)
pH sensitivity	no	(EFSA 2008)
DT ₅₀ soil - aerobic	Laboratory: 15.1 days (geometric mean)	(EFSA 2008)
Hydrolytic degradation	Stable at pH 4 - pH 9, 50 °C	(EFSA 2021)
Photolytic degradation	Aqueous photolysis: stable (29 days at pH4)	(EFSA 2021)

Degradation in aerobic soil - dimethachlor ESA

Study type	Soil type	pH	Temperature [°C]	% MWHC	DT ₅₀ [days]	Source

Laboratory	Silt loam	7.5	20	75% FC	13.1	(EFSA 2008)
Laboratory	Loamy sand	7.4	20	75% FC	11.4	(EFSA 2008)
Laboratory	Sandy clay loam	5.6	20	pF2	23.2	(EFSA 2008)
Geometric mean					15.1	(EFSA 2008)

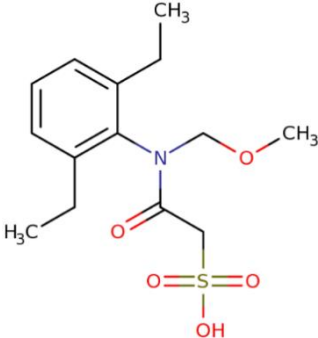
Soil adsorption - dimethachlor ESA

Soil type	OC %	pH	K _d [L/kg]	K _{oc} [L/kg]	1/n	Source
Loamy sand	1.17	7.3	0.05	4.0	-	(EFSA 2008)
Silty loam	2.1	7.3	0.1	3.4	-	(EFSA 2008)
Silty loam	4.39	7.1	0.1	3.6	-	(EFSA 2008)
Arithmetic mean				3.7		(EFSA 2008)

Alachlor ESA

Other names: Alachlor ethane sulphonate (PPDB 2023c); 2-[(2,6-Diethylphenyl)(methoxymethyl)amino]-2-oxoethane-1-sulfonic acid (EPA 2023g)

Physical-chemical properties - alachlor ESA

Property	Value	Source
ISO common name		
Chemical name (IUPAC)		
Chemical name (CA)		
CAS number	142363-53-9	(EPA 2023g)
Molecular formula	C ₁₄ H ₂₁ NO ₅ S	(EPA 2023g)
Molecular mass	315.38	(EPA 2023g)
Molar volume	248 cm ³ (predicted average)	(EPA 2023g)
Md (molecule diameter)	0.64 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(EPA 2023g)
Melting point	182 °C (predicted average)	(EPA 2023g)
Boiling point	392 °C (predicted average)	(EPA 2023g)
Vapor pressure	4.98 x 10 ⁻⁸ mmHg (predicted) 0.00664 mPa	(EPA 2023g)
Henry's law constant	5.62 x 10 ⁻¹⁰ atm m ³ mol ⁻¹ (predicted) 5.70 x 10 ⁻⁰⁵ Pa m ³ mol ⁻¹	(EPA 2023g)
Solubility in H ₂ O		
Solubility in organic solvents		
Partition coefficient (octanol-water coefficient)	Log K _{OW} =1.27 (predicted average)	(EPA 2023g)
Dissociation		

Summary of behaviour in the environment - alachlor ESA

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} =302 L/kg (predicted)	(EPA 2023g)
pH sensitivity		
DT ₅₀ soil - aerobic		
DT ₅₀ soil - anaerobic		
Hydrolytic degradation		
Photolytic degradation		

Hexazinon

Other names: DPX A3674, Hexazinone (PPDB 2023i)

Physical-chemical properties - hexazinon

Property	Value	Source
ISO common name		
Chemical name (IUPAC)	3-cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	(PPDB 2023i)
Chemical name (CAS)	3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	(PPDB 2023i)
CAS number	51235-04-2	(PPDB 2023i)
Molecular formula	C ₁₂ H ₂₀ N ₄ O ₂	(PPDB 2023i)
Molecular mass	252.31	(PPDB 2023i)
Molar volume	198 cm ³ (predicted)	(EPA 2023n)
Md (molecule diameter)	0.63 nm	(Miljøstyrelsen 2021) (p27)
Structural formula		(EPA 2023n)
Melting point	113.5 °C	(PPDB 2023i)
Boiling point	Decomposes on distillation 353 °C (predicted)	(PPDB 2023i) (EPA 2023n)
Vapor pressure	2.25 x 10 ⁻⁷ mmHg = 0.03 mPa	(EPA 2023n)
Henry's law constant	1.08 x 10 ⁻⁶ atm m ³ mol ⁻¹ (predicted value) = 0.1094 Pa m ³ mol ⁻¹	(EPA 2023n)
Solubility in H ₂ O	33000 mg/L (at 20 °C)	(PPDB 2023i)
Solubility in organic solvents	Acetone 626 g/L Toluene 334 g/L Methanol 2146.5 g/L Benzene 837 g/L	(PPDB 2023i)
Partition coefficient (octanol-water coefficient)	Log K _{OW} = 1.85	(EPA 2023n)
Dissociation	pK _a = 1.7	(Miljøstyrelsen 2021) (p12, not original source)

Summary of behaviour in the environment - hexazinon

Property	Value	Source
K _d , K _f , K _{oc} , K _{foc}	K _{oc} = 1.95 L/kg	(EPA 2023n)
pH sensitivity		
DT ₅₀ soil - aerobic		
Hydrolytic degradation		
Photolytic degradation		

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BILAG

2

SAMMENFATNING AF LITTERATUR- GENNEMGANGEN FOR FOKUSSTOFFERNE

BILAG 2

SAMMENFATNING AF LITTERATURGENNEMGANGEN FOR FOKUSSTOFFERNE

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1. Prioritet

Desphenyl Chloridazon

Technology	Medium	Details	Comment/ Critique	Source
Adsorption (GAC) + bioremediation	Water (DWTP)	Laboratory experiment Adsorption of 10 micro pollutants (mixture) onto GAC, bGAC (with biofilm) and autoclaved bCAG; For desphenyl-chloridazon no trends indicating biodegradation; Higher adsorption at lower temperatures, removal better with fresh GAC (removal rate of used GAC only 67% of that of fresh GAC); initial concentrations in experiments 25 µM-69µM	Used concentrations are higher than observed in groundwater	(Piai et al. 2020)
Ozonation	Water (DWTP)	the ozonation products for DPC and MDPC are described and the reaction pathways are given; for DPC the product 6-azauracil is of concern as it is known to have adverse effects on plants, animals and humans	<i>No focus on removal efficiency</i>	(Schatz 2012)
AOPs (Ozonation, O ₃ +UV, O ₃ + H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe)	Water (DWTP)	Pilot scale experiment with several AOPs; inlet concentration 0.14 µg/L DPC and 0.046 µg/L BAM, flow rate of about 250 L/h; all ozonation methods could completely remove both compounds, no additional effect of addition of UV or H ₂ O ₂ ; fenton removal rate of around 40 % (but not more than the control)		(Naturstyrelsen 2013)
AOP (H ₂ O ₂ + UV)	Water (DWTP)	Pilot study and full-scale mobile test; In pilot study removal of 61 %, 3.5 ppm H ₂ O ₂ ; In full scale test 100% possible with 15 ppm H ₂ O ₂ ; initial concentration 0.14 µg/L	<i>UV strength not named</i>	(Miljøstyrelsen 2020)

AOP , synergetic dual-electrodes electrocatalytic (SDEs) system	Water (synthetic wastewater)	Laboratory experiment comparing different electrocatalytic systems; DPC mineralization of up to 91 % (150 min treatment, initial DPC concentration 17.5 ppm, current density 11.94 mA/cm ²)	<i>Tested concentrations higher than concentrations in typical point source</i>	(Zhao et al. 2021)
Adsorption (pillared smectite clay)	Water	Laboratory experiment: Synthesis of Cu ²⁺ @POSS_SWy-2 nanocomposite for adsorption; sorption experiments in ethanol/water mixture (30/70 v/v) for 24 hr with concentrations of 5 - 25 ppm of desphenyl-chloridazon with 2 materials; Kf 17.15 - 81.29 L/kg N 0.892 - 1.262	<i>Concentrations used (5 - 25 ppm) are possibly higher than concentrations in groundwater; suspensions are ethanol/water mixture (30/70 v/v)</i>	(Yan et al. 2020)
Adsorption (to graphene oxide)	Water (Milli-Q)	Laboratory experiment with chloridazon, desphenyl-chloridazon and methyl-desphenyl chloridazon and graphene oxide; Adsorption capacities decrease with increasing temperature (25-65 oC); removal efficiency for DPC in this range was 16.7 - 19.2 % ; Adsorption isotherms (determined at concentrations 5 - 125 mg/L) Freundlich: Kf = 1296 L/kg, n = 1.509, R2=0.797 Langmuir: qm (maximum adsorption capacity) = 34299 mg/kg; Kl= 0.0195 L/mg, R2 = 0.992 Chloridazon has highest affinity to graphene oxide	<i>Concentrations used in temperature experiment (5 - 125 ppm) are possibly higher than concentrations in groundwater; the initial concentration for the temperature experiments is not given (only the removal efficiency) ;</i>	(Yan et al. 2021)
Adsorption (to activated carbon)	Water (Groundwater)	Technically possible to clean groundwater polluted with desphenyl-chloridazon and methyl-desphenyl chloridazon with activated carbon	<i>No information about the experiments given</i>	(Altomteknik n.d.)

Adsorption (to activated carbon)	Water (Groundwater)	Laboratory experiment with 10 - 20 minutes contact time; water from Lolland water abstraction well, in best case DPC under detection limit	<i>No data about the experiments given</i>	(Pedersen 2018)
Adsorption (to activated carbon)	Water (Surface and groundwater)	Removal from surface and groundwater, DPC concentration of 1 µg/L, removal efficiency 96-98 %	<i>Original article/source was not read during this review</i>	(Konradt et al. 2021)
Filtration (Reverse osmosis)	Water (Groundwater)	Filter type = LPRO (, DPC concentration of 1 µg/L, removal efficiency 88-92 %	<i>Original article/source was not read during this review</i>	(Konradt et al. 2021)
Filtration (Reverse osmosis)	Water (Groundwater)	Pilot scale with reverse osmosis, permeate flow of 12.9 - 14.0 L/min, DPC was abated by 87 - 98 % (raw water: 440-560 ngL-1; permeate: 30 - 63 ngL-1); Removal of chlorothalonil TP higher		(Kiefer et al. 2020)
Filtration (Nano filtration)	Water	Estimation based on weight of the molecule; NF not suitable for DPC removal DPC has molecular weight < 200 Da, which is the estimated MWCO (molecular weight cut-off) for NF membranes	<i>Only 'desk-exercise', no experiments</i>	(Miljøstyrelsen 2021)
AOP Electro-oxidation process	Water (Soil wash water after EKSW)	Laboratory experiment; initial chloridazon, DPC and MDPC of 0.4 mg/L; different current densities tested Complete degradation of DPC e.g. after 180 min at 10 mA cm-2		(Jorge Vidal et al. 2022)

Technologies that didn't work

Technology	Medium	Details	Comment/ Critique	Source
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Bioremediation	Water (DWTP)	Laboratory experiment investigating the potential of methane oxidizing bacteria in sand filters to remove DMS, DPC and bentazone through co-metabolism with copper; Copper addition (1-1000µg/L) showed no significant effect on the removal of pesticides; DPC and DMS not degradable by methane oxidizing bacteria		(Hummelshøj 2021)
Biodegradation	Water	Microbial degradation in water with fixed bed bioreactor and spiked (n-chloridazon)water from a WWTP: degradation product DPC was resistant for degradation throughout the 98 day experiment		(Buttiglieri et al. 2009)
Bioremediation (and co-metabolic degradation)	Water (DWTP)	Laboratory and pilot scale experiments; a minor biodegradation in laboratory experiment was observed but could not be attributed to co-metabolism; For both DMS and DPC co-metabolism stimulation in sand filter in water works is not a viable path for degradation		(DANVA 2023)
Aquifer Storage Transfer and Recovery (ASTR)	Water (Groundwater) / Soil	Field experiment : Injection of fresh tile drainage did not enhance degradation, half lifes were at least 141 days of the 9 studied compounds (including bentazon, chloridazon, DPC and MDPC)		(Kruisdijk, Stuyfzand, and van Breukelen 2022)

Methyl desphenyl chloridazon

Technology	Medium	Details	Comment / Critique	Source
Adsorption (pillared smectite clay)	Water	Laboratory experiment: Synthesis of Cu ²⁺ @POSS_SWy-2 nanocomposite for adsorption; sorption experiments in ethanol/water mixtures (30/70 v/v) for 24 hr with concentrations of 5	<i>Concentrations used (5 - 25 ppm) are probably higher than concentrations</i>	(Yan et al. 2020)

		- 25 ppm of methyl-desphenyl-chloridazon with 2 materials; Kf 10.55 - 25.68 L/kg n 0.861 - 0.934	<i>in groundwater; suspensions are ethanol/water mixture (30/70 v/v); removal efficiencies not given</i>	
Adsorption (to graphene oxide)	Water (Milli-Q)	Laboratory experiment with chloridazon, desphenyl-chloridazon and methyl-desphenyl chloridazon and graphene oxide; Adsorption capacities decrease with increasing temperature (25-65 °C); removal efficiency for DPC in this range was 23.6-26.1 % ; Adsorption isotherms (determined at concentrations 5 - 125 mg/L) Freundlich: Kf = 1214.76 L/kg, n = 1.315, R ² =0.998 Langmuir: qm (maximum adsorption capacity) = 36849 mg/kg; KI= 0.0267 L/mg, R ² = 0.982 Chloridazon has highest affinity to graphene oxide	<i>Concentrations used in temperature experiment (5 - 125 ppm) are probably higher than concentrations in groundwater; the initial concentration for the temperature experiments is not given (only the removal efficiency) ;</i>	(Yan et al. 2021)
Adsorption (to activated carbon)	Water (Groundwater)	Technically possible to clean groundwater polluted with desphenyl-chloridazon and methyl-desphenyl chloridazon with activated carbon	<i>No information about the experiments given</i>	(Altomteknik n.d.)
Adsorption (to activated carbon)	Water	Removal with activated carbon should be possible (based on theory and on experimentally found physical-chemical properties e.g. the adsorption capacity in soil)	<i>Only 'desk-exercise', no experiments</i>	(Miljøstyrelsen 2021)
Filtration (RO)	Water (Groundwater)	Pilot plant reverse osmosis: Permeate flow rate 12.9 - 14.0 L min ⁻¹ Chloridazon-desphenyl-methyl were not detectable in the permeate (raw water 30-33 ng/L)	<i>The concentration in the raw water is very low (30-33 ng/L)</i>	(Kiefer et al. 2020)

AOP Electro-oxidation process	Water (Soil wash water after EKSW)	Laboratory experiment; initial chloridazon, DPC and MDPC of 0.4 mg/L; different current densities tested Complete degradation of MDPC e.g. after 150 min at 10 mA cm ⁻²		(Jorge Vidal et al. 2022)
Ozonation	Water	Ozonation of MDPC leads to a broad spectrum of oxidation products	<i>removal rate not mentioned</i>	(Schatz 2012)

Technologies that did not work:

Technology	Medium	Details	Comment / Critique	Source
Aquifer Storage Transfer and Recovery (ASTR)	Water (Groundwater) / Soil	Field experiment : Injection of fresh tile drainage did not enhance degradation, half-lives were at least 141 days of the 9 studied compounds (including bentazon, chloridazon, DPC and MDPC)		(Kruisdijk, Stuyfzand, and van Breukelen 2022)
Filtration (NF and RO)	Water	Removal with NF most likely not possible, with RO there could be challenges in removing MDPC (based on theory and on estimated properties through e.g. dansk-(Q)SAR)	<i>Only 'desk-exercise', no experiments</i>	(Miljøstyrelsen 2021)

Chloridazon

Technology	Medium	Details	Comment / Critique	Source
Bioremediation	Soil	Bacterium that degrades chloridazon was isolated; gram-negative rods or coccal rods, need vitamin B12 as a growth factor, optimal growth on chloridazon, antipyrin, pyramidon and L-phenylalanine; species <i>Phenylobacterium immobile</i>	<i>Potential for bioremediation/ bioaugmentation but no experiments on the degradation potential in soil was conducted</i>	(Lingens, Blecher, and Blecher 1985)

<p>Electro-remediation (Electro-kinetic soil washing)</p>	<p>Soil</p>	<p>Laboratory experiment; initial chloridazon concentration of 14 µg/kg wet soil; duration 15 days and electric field of 1 V cm⁻¹ In clay removal of 100 % with direct polarity (DP) and of 63 % at alternating polarity (AP), In MET soil (high organic carbon) removal of 51 % at AP</p>		<p>(Vidal et al. 2022)</p>
<p>Adsorption (pillared smectite clay)</p>	<p>Water</p>	<p>Laboratory experiment: Synthesis of Cu²⁺@POSS_SWy-2 nanocomposite for adsorption; sorption experiments in ethanol/water mixture (30/70 v/v) for 24 hr with concentrations of 5 - 25 ppm of methyl-desphenyl-chloridazon with 3 materials; 58.22 - 471.07 L/kg N 0.900 - 1.305 Thermal treatment (4 cycles) lowered the adsorption capacity for chloridazon by 32.%, to 3260 mg/kg</p>	<p><i>Concentrations used (5 - 25 ppm) (5 ppm for desphenyl-chloridazon = 40 mg/L) are higher than concentrations in groundwater, maybe obtained at some point sources?; suspensions are ethanol/water mixture (30/70 v/v) --> might be cost intensive for larger scale (?); removal efficiencies not given</i></p>	<p>(Yan et al. 2020)</p>
<p>Adsorption (to graphene oxide)</p>	<p>Water (Milli-Q)</p>	<p>Laboratory experiment with chloridazon, desphenyl-chloridazon and methyl-desphenyl chloridazon and graphene oxide; Adsorption capacities decrease with increasing temperature (25-65 °C); removal efficiency for DPC in this range was 42.5 - 44.9 % ; Adsorption isotherms (determined at concentrations 5 - 125 mg/L)</p>	<p><i>Concentrations used in temperature experiment (5 - 125 ppm) (5 ppm for desphenyl-chloridazon = 40 mg/L) are higher than concentrations</i></p>	<p>(Yan et al. 2021)</p>

		<p>Freundlich: $K_f = 3671.19 \text{ L/kg}$, $n = 1.494$, $R^2=0.997$ Langmuir: q_m (maximum adsorption capacity) = 67.180 g/kg; $K_L = 0.0406 \text{ L/mg}$, $R^2 = 0.993$</p> <p>Chloridazon has highest affinity to graphene oxide</p>	<p><i>in groundwater, maybe obtained at some point sources?; the initial concentration for the temperature experiments is not given (only the removal efficiency) ;</i></p>	
Fenton and photo-Fenton	Water	<p>Laboratory experiment ; Photo-Fenton process was superior over Fenton process (with regards to removal efficiencies), optimal conditions for Fenton 7.5 mg/L Fe(II), $50 \text{ mg/L H}_2\text{O}_2$, $40 \text{ mg/L initial CLZ}$, $\text{pH } 3$ and 20°C; optimal conditions of photo-Fenton 5 mg/L Fe^{2+}, $50 \text{ mg/L H}_2\text{O}_2$, $60 \text{ mg/L initial CLZ}$, $\text{pH } 3$ and 20°C; removal efficiencies $>99\%$ possible for both processes; desphenyl chloridazon can be formed</p>	<p><i>Initial Chloridazon concentrations (20-60 mg/L) much higher than in point sources; only the chloridazon removal is given and not the mineralization rate (also unknown how much DPC and MDPC are formed under the varying conditions)</i></p>	(Ulu, Değermenci, and Dilek 2020)
AOP UV/H ₂ O ₂	Water (Wastewater)	<p>Laboratory experiment; 100% disappearance after 1 h with $20 \text{ mg/L H}_2\text{O}_2$; $20 \text{ mg/L initial chloridazon}$, $\text{pH } 3$</p>	<p><i>tested for wastewaters and thus on high concentrations; the mineralization rate was not named</i></p>	(Ulu 2019)
AOP Electro-oxidation process	Water (Soil wash water after EKSW)	<p>Laboratory experiment; initial chloridazon, DPC and MDPC of 0.4 mg/L; different current densities tested Complete degradation of chloridazon e.g. after 120 min at 10 mA cm^{-2}</p>		(Jorge Vidal et al. 2022)

AOP (TiO ₂ photocatalyst)	Water (Double-Distilled)	Laboratory experiment; 3 different TiO ₂ tested as well as influence of pH, TiO ₂ concentration, initial herbicide concentration, electron acceptors); degradation of 62% of chloridazon observed with an initial concentration of 0.18 mM chloridazon, pH 6.2, 1 g/L TiO ₂ (Degussa P25), 125 W medium pressure mercury lamp, constant stirring and aeration	<i>Only results from chloridazon degradation not from the mineralization shown</i>	(Khan et al. 2012)
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Technologies that did not work:

Technology	Medium	Details	Comment / Critique	Source
Aquifer Storage Transfer and Recovery (ASTR)	Water (Groundwater) / Soil	Field experiment: Injection of fresh tile drainage did not enhance degradation, half-lives were at least 141 days for the 9 studied compounds (including bentazon, chloridazon, DPC and MDPC)		(Kruisdijk, Stuyfzand, and van Breukelen 2022)

DMS

Technology	Medium	Details	Critique	Source
AOP (UV + H ₂ O ₂)	Water	Pilot study with UV+H ₂ O ₂ ; Removes DMS (from around 0.6 µg/L) down to 0.025 µg/L with 15 ppm H ₂ O ₂ and UV-dose of 75; NDMA was under detection limit (0.02 µg/L); technology called RemUve	<i>only presentation is available, details about the experiments missing; initial DMS concentration < 0.06µg/L</i>	(Schouw, Rahbek, and Bymose n.d.)
AOP (UV + H ₂ O ₂)	Water	Pilot study: UV + H ₂ O ₂ : For DMS it was found that removal is possible by applying a UV/H ₂ O ₂ process, but that this will require a relatively high UV dose (about 800 mJ/cm ² ; other compounds require around		(KWR 2015)

		350 mJ/cm ²) to remove the DMS to a level below the reporting limit.		
AOP (UV+H ₂ O ₂)	Water (DWTP)	Full-scale test: DMS removal of 76 % (initial DMS concentration 0.46 µg/L), 10 ppm H ₂ O ₂ ; no NDMA detected; technology called RemUve	<i>Strength of UV light not given</i>	(Miljøstyrelsen 2020)
AOP (UV + H ₂ O ₂)	Water (DWTP)	Laboratory experiment: Initial DMS concentration circa 1µg/L; different H ₂ O ₂ concentrations and UV energy doses tested; E.g. EEO for 40 mg/L H ₂ O ₂ is 1.4 kWh/m ³ ; No NDMA detection; nitrite formation was observed		(Kaarsholm 2020)
Ozone	Water	With bromide and DMS ozonation can lead to the highly toxic NDMA	<i>Focus not on removal of DMS but on formation pathway of NDMA</i>	(Trogolo et al. 2015)
Ozone	Water	Laboratory experiment, initial DMS concentration of 20 µg/L ; applied ozone 0.5 and 5 mg/L and contact time of 2 hr; full conversion of DMS, but formation of NDMA; NDMA is biodegradable		(Schmidt and Brauch 2008)
Ozone	Water	Laboratory experiments; initial DMS concentration 2-42 µg/L; DMS was reduced to below the detection limit with 1.7 mg/L ozone (detection limit 50 ng/L); 74% of DMS moles were transformed into NDMA		(Kaarsholm 2019)
Disinfection (Cl ₂)	Water	Laboratory experiment; initial DMS concentration of 20 µg/L; applied free chlorine of 0.2 and 1.2 mg//L and contact time of 96 hr; Full conversion of DMS; No UDMH formation observed		(Schmidt and Brauch 2008)

Filtration (RO)	Water (DWTP)	Pilot scale experiment; Initial concentration of DMS 0.05 µg/L ; end concentration < 0.01 µg/L	<i>Very short summary of the experiment; concentrations of DMS very low</i>	(Hedegaard n.d.)
Filtration (NF)	Water (DWTP)	Laboratory experiment, NF-90 (molecular cutoff value of 200 Da); initial DMS 20 µg/L; flux 70 L m ⁻² h ⁻¹ ; rejection of 76% Conclusion: no major adsorption of DMS to membrane, DMS removal limited and not sufficient for drinking water treatment		(Schmidt and Brauch 2008)
Filtration (RO, LPRO)	Water (Surface and groundwater)	initial DMS concentration 1 µg/L, removal of 95-97 %	<i>Original article/ source was not read during this review</i>	(Konradt et al. 2021)
Filtration (VRO-SE4040)	Water (Groundwater)	Initial concentration of DMS 0.1 - 10 µg/L, removal rate 84%	<i>Original article/ source was not read during this review</i>	(Hedegaard and Quinzanos 2020)
Adsorption (AC)	Water (DWTP)	Full scale experiment; Initial DMS concentration close to quality criteria, production of 36 m ³ /h; In the first 2 month outlet concentrations below the detection limit; After 5 month >70% break through; Conclusion that AC filters for DMS are cost-intensive	<i>Very short summary of the experiments</i>	(Hedegaard n.d.)
Adsorption (AC, GAC)	Water	Small - scale filter column test (laboratory experiment); initial concentration DMS 25 µg/L ; removal possible but very fast breakthrough (less than 5000 bed volumes treated BVT)		(Schmidt and Brauch 2008)
Adsorption (AC)	Water	Surface and groundwater, initial DMS concentration 1 µg/L, removal rate 8 - 85 %	<i>Original article/ source was not read during this review</i>	(Konradt et al. 2021)

Technologies that did not work:

Technology	Medium	Details	Comment/ Critique	Source
Bioremediation	Water (DWTP)	Laboratory experiment investigating the potential of methane oxidizing bacteria in sand filters to remove DMS, DPC and bentazone through co-metabolism with copper; Copper addition (1-1000µg/L) showed no significant effect on the removal of pesticides; DPC and DMS not degradable by methane oxidizing bacteria; no significant removal was found after 30 days		(Hummelshøj 2021)
Bioremediation (and co-metabolic degradation)	Water (DWTP)	Laboratory and pilot scale experiments; a minor biodegradation in laboratory experiment was observed but could not be attributed to co-metabolism; For both DMS and DPC co-metabolism stimulation in sand filter in water works is not a viable path for degradation		(DANVA 2023)
Biodegradation	Soil / Groundwater	Field study: No sorption / degradation of N,N-DMS in subsoil suggests long-term presence in groundwater		(Albers et al. 2023)
Flocculation, Riverbank Filtration, Disinfection with ClO ₂ , H ₂ O ₂ , KMNO ₄ and UV	Water	Laboratory experiment, initial concentration of DMS 20 µg/L ; no significant elimination by any of the used technologies		(Schmidt and Brauch 2008)

Dichlorfluorid

Technology	Medium	Details	Comment / Critique	Source
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Photocatalyzation (light + TiO ₂)	Water	Laboratory experiment; xenon lamp (1500W), average irradiation intensity 750 W/m ² ; TiO ₂ concentration 500 mg/L , initial dichlofluamid concentration 2.0 mg/L; Without UV 75% were absorbed after 180 min; light + TiO ₂ : complete transformation after 20 min; light+TiO ₂ : 78 % mineralization after 240 min ; inorganic products such as NO ₃ ⁻ /NH ₄ ⁺ were formed		(Sakkas and Albanis 2003)
Hydrolysis	Water (deionized water and coastal water)	Laboratory experiment; initial concentration 250 µg/L dichlofluamid, complete transformation after 24 hr, half-time of 1.6 hr in costal water; degradation products are DMST and DMSA	No remediation technologies	(Cai et al. 2021)

Tolyfluamid

Technology	Medium	Details	Comment / Critique	Source
Hydrolysis	Water (deionized water and coastal water)	Laboratory experiment; initial concentration 250 µg/L dichlofluamid, complete transformation after 24 hr, half-time of 2.7 hr in costal water; degradation products are DMST and DMSA	No remediation technologies	(Cai et al. 2021)

Bentazon

Technology	Medium	Details	Comment / Critique	Source
Electrokinetic processes	Soil	Laboratory experiment; initial concentration of circa 50 - 80 µg/g soil; removal efficiency of circa 14 - 41 %	<i>Soil and pore water concentrations were not separately measured</i>	(Ribeiro, Mateus, and Rodríguez-Maroto 2011)
Adsorption (AC)	Water	activated carbon may be effective under certain circumstances		(WHO 2022)

Adsorption (mesoporous silica)	Water (Surface water, waste water)	Laboratory experiment: lake water and wastewater spiked with 2 mg/L bentazone, removal yields of 61 - 73 %		(Bruzzoniti et al. 2016)
Adsorption (AC)	Water	Laboratory experiment with CAT and CARBOPAL, investigated the effect of pH, ionic strength and temperature; CAT carbon has greater capacity; CAT = 392 mg/g ; CARBOPAL = 185 mg/g	<i>high bentazone concentrations tested (> 5 mg/L), no removal efficiency given</i>	(Spaltro et al. 2018)
Adsorption (AC, ACF)	Water (Deionized)	Initial bentazon concentration 20.9 mg/L; Removal capacity 151 mg/g AC	<i>Original source was not read for this review</i>	(Ayranci and Hoda 2004)
Adsorption (AC, ACF)	Water (Distilled)	Removal capacity 167 mg/g AC	<i>Original source was not read for this review</i>	(Njoku et al. 2014)
Adsorption (AC, ACF)	Water (Distilled)	Initial bentazon concentration 50 - 300 mg/L; Removal capacity 86 mg/g AC	<i>Original source was not read for this review</i>	(Salman and Hameed 2010)
Electrosorption on carbon cloth	Water / Wastewater	Laboratory experiment; start concentration of 20 ppm ; comparison of the sorption to an oxidized and non-oxidized carbon surface; higher sorption to the non-oxidized surface; higher sorption at low pH	<i>Original source was not read for this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Ania and Béguin 2007)
Phytoremediation	Soil / Groundwater	Field experiment	<i>Original source was not read for this review & groundwater concentration was not explicitly mentioned thus the</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Begum 1997)

			<i>cleaning effect cannot be evaluated</i>	
Phytoremediation	Groundwater	Outdoor experiment; Load of 150 mg/L for 3 weeks tested on 6 tree species; black willow most promising with 1.0×10^{-3} to 9.0×10^{-4} mg bentazone/mg tree / day; 27 % of applied bentazone was mineralized; mineralization happens most likely by photolysis in the leaves	<i>Groundwater concentrations were really high with 150 mg/L; the groundwater concentration was not tested after the phytoremediation</i>	(Conger and Portier 1997)
Phytoremediation	Groundwater	Site study (full scale) in Louisiana; 438 trees planted on 0.1 hectare and 1000 trees on 0.3 hectares; period over 5 years; initial concentration of below $\mu\text{g/L}$ to 4.8 mg/L; end concentration below 2 mg/L ; statistically tested with DLM analysis and BACIP model		(Conger and Portier 2006)
Natural degradation	Soil	Laboratory experiment; initial concentration 3 mg/kg; high organic content inhibits mineralization under aerobic conditions; 15% was mineralized, formed degradation products include 8-hydroxy-bentazon, 8-methoxy-bentazon, n-methyl bentazon	<i>Original source was not read for this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Knauber, Krotzky, and Schink 2000)
Biodegradation	Water (DWTP)	Laboratory experiment investigating the removal of DPC, DMS and bentazone by methane oxidizing bacteria and the influence of copper addition to it; Addition of copper had no influence, bentazone is degradable in DWTPs sand filter (removal of up to 97% after 8 days and initial concentration of $0.7 \mu\text{g/L}$), more methane can lead to inhibition		(Hummelshøj 2021)
Biodegradation	Water (DWTP)	Laboratory experiments with water and biomass from DWTPs, microbial bentazone degradation is associated	<i>at only 2 out of 4 WWTP with high</i>	(M J Hedegaard et al. 2020)

		with methane oxidation in full-scale drinking water treatment plants; Biological treatment of bentazone contamination in drinking water may be achieved using methanotrophs	<i>methane concentrations also bentazone removal is increased (could be outliers) ; only biodegradation in sand filters is not sufficient - might become sufficient with stimulation or in combination with other technologies</i>	
Biodegradation	Water	Laboratory experiments about co-metabolism of bentazone by methanotrophs; 5 mg/L methane + circa 1.8 mg/L lead to a transformation of 53% of bentazone after 21 days, same set up without methane lead to 31 % transformation; addition of acetylene inhibited methane oxidation and stopped bentazone removal; Methane stimulates formation of hydroxylated bentazone TPs	<i>transformation and not degradation measured; are the TPs more or less problematic?; high bentazone concentrations (>1mg/l) tested</i>	(Hedegaard et al. 2018)
Biodegradation (with fungi)	Water	Laboratory experiment of bentazone remediation by <i>Trametes versicolor</i> ; In batch experiment complete removal of 10 mg/L bentazone within 3 days; Trickle-bed reactor with pine wood chips, average removal of 48% after 30 days; 19 transformation products were identified	<i>transformation and not degradation measured; are the TPs more or less problematic? high bentazone concentrations (10mg/l) tested</i>	(García-Vara et al. 2021)
Biodegradation	Water	Laboratory experiment with groundwater through sand filters; enhanced biodegradation of bentazone was observed with nitrification and also		(Wang et al. 2022)

		methanotrophic activity; dominating species were <i>Nitrosomonas</i> , <i>Nitrospira</i> , <i>Methylobacter</i> , <i>Methylomonas</i> , <i>Methylotenera</i> ; initial concentration was 400 µg/L (mixture of 9 compounds); nitrification activity → removal of 46 % after 737 h ; under methanotrophic activity 53 % of bentazone was removed after 737 h		
AOPs (Ozonation, O ₃ +UV, O ₃ + H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe = Fenton)	Water (DWTP)	Pilot-scale experiment with several AOPs; experiment with 10 pesticides (20 µg/L) bentazone 3.04 µg/L; and on its own 0.2 µg/L; flow rate 250 L/hr; full removal by ozone, ozone + UV, ozone+ H ₂ O ₂ (no increased efficiency by adding UV / H ₂ O ₂) Fenton removal efficiency = 21 %, fenton+UV = 57%		(Naturstyrelsen 2013)
AOP (UV + H ₂ O ₂)	Water (surface)	Bentazone is primarily degraded by hydroxyl radical oxidation; ; removal rate of circa 60%	<i>original source / article not read during this review</i>	(Kruithof and Martijn 2013)
Electrochemical AOP (anodic oxidation AO)	Water	Laboratory experiments: tests of different electrodes; experiments with initial bentazone concentration of 30 mg/L lead to more than 99% of removal after 120 min and 30 mA cm ⁻² ; after 6 h of electrolysis 74% of TOC (initial 14 mg/L) was removed and 31% and 22% of initial N was transformed into NH ₄ ⁺ and NO ₃ ⁻ ions; identified intermediates = oxalic acid, glyoxylic acid, malonic acid, acetic acid	<i>high bentazone concentrations (30 mg/L) tested; are the intermediates formed of concern?</i>	(Liu et al. 2020)
Oxidation (with ClO ₂)	Water (Distilled & Surface water)	Laboratory experiments; tested influence of ClO ₂ concentration, pH, light/dark conditions, humic acids; Optimal conditions for double distilled water (pH 7, ClO ₂ 10 mg/L, 24 hr) lead to 95.63% removal efficiency for bentazone (10 mg/L);	<i>high bentazone concentrations (10 mg/L) tested; are the intermediates formed of concern?</i>	(Pergal et al. 2020)

		In surface water highest removal efficiency of 85.73 % removal (after 24 hr, 10 mg/L bentazone); 4 degradation products identified		
Filtration	Water (Distilled & Groundwater)	Laboratory experiment (with both distilled water and 2 GW samples); distilled water with probably 1 mg/L bentazon: NF99HF, NF99, NF90 removal efficiencies of >95%; XLE and BW30 removal rate circa 100%; Removal efficiencies at GW samples slightly lower but for all filters >95% for bentazone	<i>Not clear if 1 mg/L pesticide solution is a mixture of 4 pesticides, or each pesticide tested separately; concentration of the groundwater samples used for testing are not shown</i>	(Madsen and Søgaard 2014)
Filtration	Water (Distilled)	Membrane type PTFE Initial concentration of 30 mg/L, removal efficiency of 100%	<i>Original article was not read during this review</i>	Mentioned in: (Miljøstyrelsen 2021) original source: (Peydayesh et al. 2015)
Filtration	Water (Distilled)	Initial concentration of 10 µg/L; removal efficiency of 97.9 % with NF270 ; removal efficiency of 87.9 % with N30F	<i>Original article was not read during this review</i>	Mentioned in: (Miljøstyrelsen 2021) original article: (Caus et al. 2009)
Hydrolysis and photolysis	Water	Laboratory experiment; initial bentazone concentration of 1 mg/L; tested different buffer solutions, temperatures and Fe 3+ concentrations for hydrolysis and lead to half-lives of 46 - 99 days; Photolysis tested under different buffer solutions, solvents, solvent concentrations, FE3+ concentrations and mecury and xenon light; photolysis half-lives 2.3 - 7.5 hr;	<i>Hydrolysis and photolysis are no remediation technologies</i>	(Song et al. 2019)

		2 degradation products identified		
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Technologies that did not work

Natural degradation	Groundwater	Field experiment, investigation of degradation of the mixture including MCP, dichlorprop, bentazon, isoproturon, DNOC, BAM; aerobic groundwater; no degradation of bentazon observed	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Broholm et al. 2001)
Aquifer Storage Transfer and Recovery (ASTR)	Water (Groundwater) / Soil	Field experiment : Injection of fresh tile drainage did not enhance degradation, half lives were at least 141 days of the 9 studied compounds (including bentazon, chloridazon, DPC and MDPC)		(Kruisdijk, Stuyfzand, and van Breukelen 2022)

BAM

Technology	Medium	Details	Critique	Source
Bioremediation	Water, sand and soil	Laboratory experiment: Mineralization rate in soil up to 40-60 % (added water concentration of BAM 10 µg/L, 20 °C, 36 days) after bioaugmentation with <i>Aminobacter sp MSH1</i> (in free form or formulated to beads); Other tests included among others higher BAM concentrations and different media (e.g. water)		(Schultz-Jensen, Aamand, and Sørensen 2016)
Bioaugmentation	Soil	Laboratory experiment: Bioaugmentation with bacterium <i>Aminobacter sp MSH1</i> and fungi <i>Mortierella sp. LEJ702</i> ;	Tested BAM concentration of 100 µg/kg	(Knudsen et al. 2013)

		Increased mineralization when both species present: mineralization rates of up to 50% after 60 day (initial BAM concentration 100 µg/kg)		
Bioaugmentation	Water Drinking water	Review paper: Bioaugmentation of DWTP sand filters is promising, but needs further research e.g. in isolation of more BAM-degrading bacteria and sustaining the bacteria in the filter (currently still problems due to loss during backwash and due to starvation)		(Ellegaard-Jensen et al. 2017)
Bioaugmentation	Water Drinking Water	Pilot scale experiment: Pilot waterworks with bioaugmented sand filters: significant BAM degradation observed (to below 0.1 µg/L) but efficient degradation for more than 2-3 weeks difficult to maintain due to the backwash loss (input BAM concentration 0.2 µg/L)	<i>Not fully applicable yet but promising technology</i>	(Albers et al. 2015)
Bioaugmentation & reverse osmosis treatment	Water Drinking Water	Pilot scale experiment: Retenate of reverse osmosis is treated in bioaugmented sand filters; efficient BAM removal for > 100 days; with residence time of 133 min initial BAM degradation >97%, at day 65 88% degradation		(Schostag et al. 2022)
Filtration	Water (Groundwater)	Laboratory experiment and modelling: For BAM rejection rates of >90% were achieved by the membranes types NF90, XLE and BW30; rejection rates increased when using groundwater with higher ionic content probably due to ion adsorption on the membrane (narrowing of the pores)	<i>used concentrations of BAM in the experiment not mentioned</i>	(Madsen and Søgaard 2014)
Filtration	Water	Membrane type XLE, drinking water, BAM concentration 1 mg/L, removal efficiency of 95.8 %		Mentioned in (Miljøstyrelsen 2021) Original source: (Hylling et al. 2019)

Filtration	Water	Membrane type AqP, Milli-Q water, BAM concentration 1-10 mg/L, removal efficiency of > 97 %		Mentioned in (Miljøstyrelsen 2021) Original source: (Henrik T. Madsen et al. 2015)
Filtration	Water	Membrane type RO, LPRO, BW30 or XLE; Milli-Q water; BAM concentration 1 mg/L, removal efficiency of >92 %		Mentioned in (Miljøstyrelsen 2021) Original source: (Fini, Madsen, and Muff 2019)
Adsorption	Water (Groundwater)	Laboratory and pilot scale experiment; Activated carbon, initial BAM concentration 0.27 µg/L , Capacity of 0.048-0.057 mg/g-AC (for groundwater), 2.7 - 3.6 mg/g-AC in mili-Q water		Mentioned in (Miljøstyrelsen 2021) Original source: (Clausen et al. 2003)
Catalyzed oxidation	Water (groundwater)	Field study, removal to below the detection limit	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Petersen 2000)
AOPs (Ozonation, O ₃ +UV, O ₃ + H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe)	Water (DWTP)	Pilot-scale experiment with several AOPs; experiment with 10 pesticides (20µg/L) BAM 2.09 µg/L; flow rate 250 L/hr; Ozone is most effective removal (up to 100%), no increased efficiency by combining ozone with UV/ Or H ₂ O ₂ ; Fenton = 0% removal, Fenton+UV = 41 %		(Naturstyrelsen 2013)
AOP (UV+H ₂ O ₂)	Water (DWTP)	Full-scale test: complete BAM removal (initial concentration 0.12 µg/L), 10 ppm H ₂ O ₂ and 100 % UV; degradation lower for other conditions (down to 30%	<i>Strength of UV light not given</i>	(Miljøstyrelsen 2020)

		reomoval); faster degradation than for DMS; technology called RemUVE		
EO (electrochemical oxidation)	Water	Laboratory experiment: two anode materials (Ti/Pt90-Ir10 and boron doped diamond Si/BDD) were tested; initial BAM concentration = 100 mg/L; Pt-Ir cell: > 95% of transformation after 7 Ah/L & level of stable DIs=54% after 5.7 Ah/L; BDD-cell= >95% of transformation after 7 Ah/L and level of stable DIs=20% after 3 Ah7L	<i>the tested concentration was rather high (100 mg/L)</i>	(Madsen, Søgaard, and Muff 2014)

Technologies that did not work:

Technology	Medium	Details	Critique	Source
Natural degradation	Groundwater	Field experiment, investigation of degradation of the mixture including MCP, dichlorprop, bentazon, isoproturon, DNOC, BAM; aerobic groundwater; no degradation of BAM observed	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) original source: (Broholm et al. 2001)

R417888 / R471811

Technology	Medium	Details	Critique	Source
Activated carbon, Reverse osmosis	Water (Groundwater)	Tested both in different DWTP and laboratory experiments; Possibilities are activated carbon filter and reverse osmosis; not successful were UV irradiation, ozonation and AOPs based on OH-radicals (Reverse osmosis can remove > 98% of both R417888 and R471811 , AC: 80 % with PAC conc. of 25 mg/L, R417888 conc. of natural groundwater, 42h; Fresh AC needed for the removal of R471811-SA)		(Kiefer et al. 2020)
Activated carbon	Water (Groundwater)	Pilot study in Vernaz Switzerland; 3 types of AC tested; initial concentrations R4171811 0.53 - 0.93 µg/L, R417888 0.07 µg/L, DPC 1.17 µg/L, MDPC 0.17 µg/L ; all	<i>not per-reviewed</i>	(Merle, Cardot, and Urfer 2022)

		compounds were able to be removed to either below the detection limit or quality criteria; the filter material had to be replaced after 25-30 m ³ /kg (conventional GAC), 50 - 55 m ³ /kg (GAC LUCA), 35 m ³ /kg (μGAC)		
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Technologies that did not work

Technology	Medium	Details	Critique	Source
UV disinfection, ozonation, AOPs	Water (Groundwater)	Tested both in different DWTP and laboratory experiments; not successful were UV irradiation, ozonation and AOPs based on OH-radicals; Persistent against UV disinfection (for 90% abatement by direct photolysis 380000-640000 Jm ⁻² would be required); Persistent against ozonation and also refractory against OH-radicals		(Kiefer et al. 2020)

Chlorothalonil

Technology	Medium	Details	Comment / Critique	Source
Catalytic degradation (bimetallic irons)	Water	Laboratory experiment; initial concentration chlorothalonil 2.08 μM; with modified zero valent iron (MZVI) containing Fe/Pd complete removal of mother compound after 10 min; with only ZVI it took 2 hr; conclusion from authors: "Combination of MZVI and anaerobic biodegradation processes could be an alternative method for the remediation of chlorothalonil polluted soil and water."	<i>Several degradation products formed during the process (e.g. Fig4)</i>	(Ghauch and Tuqan 2008)
Electrocatalyzation	Water (Wastewater)	Laboratory experiment; simultaneous degradation for the anodic oxidation process was tested for fenitrothion(FTH), trifluralin(CTH), and chlorothalonil(CTH); under optimal conditions complete removal of all compounds possible after	<i>Tested concentrations quite high (e.g. 16 mg L-1 chlorothalonil)</i>	(Dolatabadi et al. 2023)

		60 min: initial concentrations FTH 8.0 mg L-1, TRL 12.0 mg L-1, CHT 16.0 mg L-1, pH 6.0, current density 6.0 mA, using PbO ₂ /Cu; under optimal conditions COD removal of 74.3%; Conclusion from the authors: "The AO technology using Pb=2/Cu electrode could be considered a nice solution to the treatment of pesticide-polluted wastewater"		
Photocatalyzation (light + TiO ₂)	Water	Laboratory experiment; xenon lamp (1500W), average irradiation intensity 750 W/m ² ; TiO ₂ concentration 500 mg/L , initial dichlofluanid concentration 0.54 mg/L; Without light no significant reduction; light + TiO ₂ : complete transformation after 90 min; light +TiO ₂ : complete mineralization after 240 min		(Sakkas and Albanis 2003)
Fenton (H ₂ O ₂ / Fe ²⁺)	Water	Laboratory experiment; 3 pesticides tested individually and as mixture: chlorothalonil, methyl parathion and methamidophos; initial concentration 13 mg/L, pH3, H ₂ O ₂ and Fe ²⁺ tested in different ranges from 400-4000ppm and 100 - 1000 ppm respectively, time span 90 minutes; under optimal conditions after 10 minutes chlorothalonil concentration decreased to 0.1 µg/L, after 90 minutes removal of >98 % active substance and >90% COD; no formation of other organic compounds (including TPs); degradation not affected by the presence of other organophosphorus pesticides	<i>concentration of 13 mg/L rather high, pH 3 very low</i>	(Gutiérrez et al. 2010)
UV Fenton + aerobic sequencing batch reactor	Water (Wastewater)	Laboratory experiment; pesticide wastewater from production site tested; initial concentrations COD 3350 mg L-1, TOC 2960 mg L-1 and chlorothalonil 692 mg L-1 (other pesticides also present); UV Fenton-SBR achieve COD and TOC removal efficiency of 96.2 and 97.4% respectively after 40 d operation at 12 hr HRT	<i>tested for pesticide wastewaters (very high pesticide concentrations of circa 700 mg/L); the pesticides were not tested for separately</i>	(Affam et al. 2014)

Photocatalyzed Ozonation (Ru/TiO ₂)	Water	Combination of Ru/TiO ₂ (photocatalyst) and ozonation could completely mineralize chlorothalonil in water (10 mg/L)	<i>Only the abstract was available; used chlorothalonil concentrations were rather high (10 mg/L)</i>	Maddila et al. 2016)
Phytoremediation / Constructed Wetlands	Water (Run-Off)	Laboratory experiment; initial concentrations 148 - 326 µg/L after 48 hr always below 0.1 µg/L; effective treatment of storm water runoff		(Sherrard et al. 2004)
Biodegradation	Soil	Review article; diverse pure strains capable of degrading chlorothalonil; e.g. 50 mg kg ⁻¹ degraded below detection limit after 3 days when soil was inoculated with <i>Ochrobactrum sp. CTN-11 cells</i> ; <i>O.lupini TP-D1</i> could degrade 95.0% chlorothalonil (50 mg kg ⁻¹) after 3 days and 99.7% after 7 days; 56–95% of 0.432–1.298 µg/g TPN was depleted in biologically active soil microcosms after 25-day incubation; main degradation product is chlorothalonil-OH = more soluble and persistent	<i>Review article, the original articles cited were not read for this review</i>	(Wang et al. 2011)

2.Prioritet

1,2,4 – Triazol

Technology	Medium	Details	Comment / Critique	Source
Adsorption on activated carbons	Water	Adsorption kinetics follow pseudo-second-order Charcoal-powdered activated carbon (CPAC) removed circa 76% of the 1,2,4-Triazole Bovine bone-powdered activated carbon (BPAC) was ineffective in the removal	<i>Only abstract accessible</i>	(Amorim et al. 2013)
Adsorption AC	Water (Drinking water)	Laboratory experiment: initial concentration of 500 µg/L; AC = Filtrasorb 300; 10 % breakthrough after 15000 BVT = = 30		(Scheurer et al. 2016)

		m3 water treated per kg AC(=lower limit of an economical usage of AC in drinking water treatment plants); concluded to be ineffective for removal in DWTP		
Biological removal by biogenic manganese oxides	Water (Industrial waste water)	Biogenic manganese oxides (BioMnOx) were used for the removal of 1,2,4-Triazole in a biological aerated filter (BAF); The dominant bacteria were <i>Pseudomonas</i> and <i>Bacillus</i> (also present were <i>Bdellovibrio</i> , <i>Pedobacter</i> and <i>Sediminbacterium</i>) : Pesticide removal most efficient at slightly acid pH; Removal enhanced when coupled with manganese oxidation	<i>Used for Industrial waste water</i>	(R. Wu et al. 2017)
Biodegradation in wastewater sludge	Synthetic (residual) waste water	Laboratory experiment with activated sludge; Studied the co-metabolic enhancement of 1,2,4-Triazole biodegradation through nitrification; Co-metabolic degradation could result in the enhanced removal of 1,2,4-triazole, TOC and DOM	<i>(synthetic) wastewater was used</i>	(H. Wu et al. 2019)
Conventional drinking water treatment (Brazil)	Drinking water	Conventional DWT methods (conventional in Brazil) are not suitable for the removal of the pesticides/metabolites (removal of 1,2,4-triazole <18%)	<i>Only abstract accessible</i>	(Soares et al. 2013)

Technologies that did not work:

Technology	Medium	Details	Comment / Critique	Source
Ozonation	Water	Laboratory experiment; initial concentration 2 µg/L; ozone concentration 0.5 - 1 mg/L; testing after 2 - 60 min; overall transformation was very limited		(Scheurer et al. 2016)

Clopyralid

Technology	Medium	Details	Cirque	Source
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<p>AOPs UV/TiO₂ UV/H₂O₂ O₃</p>	<p>Water</p>	<p>Laboratory experiment to find optimal removal conditions of UV/TiO₂ and comparison to UV/H₂O₂ and O₃; Three TiO₂ photocatalysts were tested: Optimal conditions: catalyst Degussa P25 with concentration 1 g/L , pH 5 --> pseudo-zero-order kinetics with rate constant $2.1 \times 10^{-6} \pm 4.3 \times 10^{-7} \text{ Mmin}^{-1}$; concentration range of 1,2,4-Triazole of 0.078 - 0.521 mM; Initial removal rates for UV/H₂O₂ and ozone are higher than for UV/TiO₂ but the latter one outperforms over longer time (and can reach complete removal)</p>	<p><i>The number of replicates is not named; the ozone and H₂O₂ concentrations were not varied --> if the optimum was not found how can there be a conclusion be made that they performed worse than TiO₂ ?</i></p>	<p>(Tizaoui, Mezughi, and Bickley 2011)</p>
<p>AOP Electro Fenton</p>	<p>Groundwater (?)</p>	<p>Laboratory experiment: conclusion - groundwater can be used as a sustainable supporting electrolyte; mineral constituents have a significant influence on the degradation 200 mA and 480 min treatment --> degradation of 80% , mineralization of 30%, improvement of the biodegradability (BOD5/COD = 0.48)</p>	<p><i>When the initial clopyralid concentration mentioned (e.g. fig 1,4) then very high = 180 mg/L</i></p>	<p>(Carboneras Contreras et al. 2019)</p>
<p>Electro-kinetic remediation of soils</p>	<p>Soil</p>	<p>Laboratory experiments to find a sustainable and efficient powering solution; Soil from Spain, clopyralid conc. 2 g/kg dry soil, duration of 15 days; Most suitable for remediation is to use constant power gradient (best efficiency and least adverse effects like extreme pH), can achieve removal of 110 g kWh⁻¹</p>	<p><i>Critique: large concentration of pesticide (2g /kg dry soil) was used to simulate an accidental spill</i></p>	<p>(Millán et al. 2020)</p>
<p>Electro-kinetic soil flushing (EKSF) and reactive barriers (RB) from ZVI</p>	<p>Soil</p>	<p>Bench scale experiments (only EKSF, + granular milimetric iron, + nanoparticle iron); One month, electric field of 1.0 V/m, three anodes and cathodes made of graphite rods and initial concentration of 20 mg clopyralid/kg dry soil;</p>		<p>(J. Vidal et al. 2018)</p>

		One month not enough to remove everything BUT the remaining pesticide is precisely located and can be more easily be extrated ; ZVI can achieve larger dehalogenation but it also seriously affects the electrokinetic flushes		
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4-CPP

MCPP

Technology	Medium	Details	Comment / Critique	Source
Bioremediation	Soil	Based on extensive literature review the Miljøstyrelsen recommended further investigations on bioremediation (both monitoring and stimulation) for the remediation of pesticide point sources contaminated with MCPP		(Rügge, Tsitonaki, and Tuxen 2011)
Chemical Oxidation	Soil	Based on extensive literature review the Miljøstyrelsen recommended further investigations on bioremediation (both monitoring and stimulation) for the remediation of pesticide point sources contaminated with MCPP		(Rügge, Tsitonaki, and Tuxen 2011)
Chemical Oxidation (H ₂ O ₂ + Metalporpyriner)		Laboratory experiment; up to 100 % removal, mapping of degradation pathways, very laboratory-oriented	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Rebelo et al. 2009)
Natural degradation	Soil, Aquifer and Sediment	Laboratory experiment MCPP degraded in 7/8 experiments in aerobic sediments; no degradation under anaerobic conditions DT50 = 10- 408 days; Initial concentration of 10 µg/kg in the unsaturated zone, 50 µg/kg in the saturated zone, tested on 8 European soils	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Albrechtsen, Clausen, and Pedersen 2005)

Natural degradation	Aquifer Sediment	Laboratory experiment Removal of up to 31% after 154 days; big vertical variations in degradation potential	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Nygaard 2005)
Natural degradation	Groundwater	Field experiment, investigation of degradation of the mixture including MCP, dichlorprop, bentazon, isoproturon, DNOC, BAM; aerobic groundwater; degradation of MCP observed	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Broholm et al. 2001)
Natural degradation	Groundwater	Field experiment. Degradation of MCP from 100 µg/L to 30 µg/L in 40-60 days, aerobic groundwater	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Agertved, Rügge, and Barker 1992)
Natural degradation	Water	Laboratory experiment; 50 - 75 % mineralization after 1 week	<i>Original article was not read during this review</i>	Mentioned in: (Rügge, Tsitonaki, and Tuxen 2011) Original Source: (Mai, Stig Jacobsen, and Amand 2001)
AOPs (Ozonation, O ₃ +UV, O ₃ + H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe)	Water (DWTP)	Pilot-scale experiment with several AOPs; experiment with 10 pesticides (20µg/L) MCP 3.45 µg/L; flow rate 250 L/hr; Ozone is most effective removal (up to 100%), no increased efficiency by combining ozone with UV/H ₂ O ₂ ; fenton only removal of around 20%, fenton+UV 97 %		(Naturstyrelsen 2013)

Dichlorprop

Technology	Medium	Details	Cirque	Source
Biodegradation Bioaugmentation	Soil (agricultural)	In agricultural soil (R)- and (S)-Dichlorprop are degraded by microorganisms (after 15 days, 20°C, concentration of 10 mg/kg 22.1% and 35.9% respectively, for 30 mg/kg 18.1% and 27.8% respectively); Identified microorganisms (also used for the bioaugmentation of (S)-Dichlorprop with a concentration of 1.0×10^8 CFU g ⁻¹ for each strain): <i>Sphingobium</i> sp. strain SP-2 (enantioselectively transforming (S)-dichlorprop to 2,4-dichlorophenol) and <i>Sphingopyxis</i> sp. strain DP-21 (mineralizing 2,4-dichlorophenol); Bioaugmentation: the 30 mg/kg were removed by day 15.	<i>concentrations of around 10-30mg/kg tested</i>	(Hu et al. 2022)
Biodegradation	Soil (agricultural)	Half-life of racemic DPCC in different soils 10.5-19.8 days (initial concentration of 0.5 mg/kg of R- and S-DPCC, 50% WHC, incubation at 28 °C in the dark for 28 days); DPCC-degrading related families <i>Sphingomonadaceae</i> and <i>Comamonadaceae</i> , enhanced in all soils; Preferential degradation of R- or S-DCPP was detected in all soils and enantiomerization of DPCC was found in both directions; Results suggest a preferential degradation of S-enantiomer in acidic soils		(Youfeng, Dongdong, and Ling 2020)
Bioremediation	Soil	Based on extensive literature review the Miljøstyrelsen recommended further investigations on bioremediation (both monitoring and stimulation) for the remediation of pesticide point sources contaminated with MCP		(Rügge, Tsitonaki, and Tuxen 2011)
(Enhanced) Biodegradation	Soil /Groundwater (Aquifers)	Oxygen addition to anaerobic sediment: degradation of 3-9% dichlorprop after 200 days; no degradation under anaerobic conditions; initial concentration	<i>degradation of 3-9% not sufficient; maybe promising in</i>	(Levi et al. 2014)

			<i>combination with other techniques</i>	
Natural degradation	Groundwater	Field experiment, investigation of degradation of the mixture including MCP, dichlorprop, bentazon, isoproturon, DNOC, BAM; aerobic groundwater; degradation of dichlorprop observed	<i>Original article was not read during this review</i>	Mentioned in:(Rügge, Tsitonaki, and Tuxen 2011) Original source: (Broholm et al. 2001)
Chemical Oxidation	Soil	Based on extensive literature review the Miljøstyrelsen recommended further investigations on bioremediation (both monitoring and stimulation) for the remediation of pesticide point sources contaminated with MCP		(Rügge, Tsitonaki, and Tuxen 2011)
Advanced oxidation process (?)	Water (potentially wastewater)	Efficient enantioselective recognition and controllable degradation of S-DCPP on a photoelectrocatalytic (PEC) surface; Fabricated a (S)-DCPP-molecular-imprinted single-crystalline TiO ₂ photoelectrode in situ; k-value of (S)-DCPP was 0.156 h ⁻¹ after 6 hr (2.6 times greater than for (R)-DCPP); Potential in wastewater treatment	<i>Tested on very high water concentrations (50 mg/L)</i>	(Zhang et al. 2017)
Adsorption	Water (Drinking Water)	Graphene Nanosheets: removal efficiency of 80 % could be achieved after 45 min at pH 3, Adsorption pH dependent (higher adsorption at low pH) and temperature dependent (higher adsorption at higher concentrations)	<i>Materials and Methods part MISSING: e.g. concentration (pesticide and GNs) not mentioned for the pH experiments; error bars seems off (e.g. too even in figure 4) ; maximum removal efficiency obtained at pH 3 (not realistic?) , concentration range</i>	(Kamaraj et al. 2017)

			<i>from 10 - 50 mg/L (high!)</i>	
Chemical Oxidation	Soil	Based on extensive literature review the Miljøstyrelsen recommended further investigations on bioremediation (both monitoring and stimulation) for the remediation of pesticide point sources contaminated with MCPP		(Rügge, Tsitonaki, and Tuxen 2011)
AOPs (Ozonation, O ₃ +UV, O ₃ + H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe)	Water (DWTP)	Pilot-scale experiment with several AOPs; experiment with 10 pesticides (20µg/L) dichlorprop 3.76 µg/L; flow rate 250 L/hr; Ozone is most effective removal (up to 100%), no increased efficiency by combining ozone with UV/H ₂ O ₂ ; Fenton reaction can lead to by product dichlororphenol (from dichlorprop), removal fenton = 20%, fenton+ UV 73%		(Naturstyrelsen 2013)

AMPA

Technology	Medium	Details	Critique	Source
Adsorption	Water and Soil	The collective results from in vitro, in silico, and in vivo studies showed that montmorillonite clay-based strategies may be useful to remediate mixtures of GLP and AMPA in water and soils and to protect aquatic and soil species; sorption follows Langmuir equation		(M. Wang, Rivenbark, and Phillips 2023)
Thermal decomposition		Modeled: The half-life of AMPA at 1000 K is predicted to be 4 ms (readily destroyable via conventional incineration processes); preferred decomposition channel leaves to imine methanimine; decomposition product is expected to react with water vapour and form simple amines and carbonyl compounds	<i>Modeled, not tested.</i>	(Narimani and Da Silva 2020)
Oxidation (?)	Water	Thin films of birnessite: Mineralization of AMPA in water possible; after 48 hr (best case?): 50% of initial AMPA remaining;	<i>high concentrations used for the</i>	(Ndjeri et al. 2013)

		Higher degradation at higher temperatures	<i>experiments (9.3 - 74.3 mg/l)</i>	
Filtration (Nano-)Filtration	Water (Synthetic water)	Rejection percent of nanofilters is 73.5 - 86.7 % in synthetic water (initial concentration of AMPA 0.50 µg/L)		(Narimani and Da Silva 2020)

CGA108906

Technology	Medium	Details	Critique	Source
AOP (UV+H ₂ O ₂)	Water (DWTP)	Full-scale test: complete CGA 108906 removal (initial concentration 0.12 µg/L), 5 ppm H ₂ O ₂ and 70% UV or 10 ppm H ₂ O ₂ and 20% UV; much faster degradation than for DMS and BA; technology called RemUVE	<i>Strength of UV light not given</i>	(Miljøstyrelsen 2020)

Metalaxyl

(2,6-dimethyl-phenylcarbamoyl)-methansulfonsyre

Dimethachlor ESA

Dimethachlor

Alachlor ESA

Hexazinon

Technology	Medium	Details	Comment / Critique	Source
AOPs (Ozonation, O ₃ +UV, O ₃ +	Water (DWTP)	Pilot-scale experiment with several AOPs; experiment with 10 pesticides (20 µg/L) hexazinon 3.04 µg/L; flow rate 250 L/hr; Ozone is most effective removal (up to 100%), no increased efficiency by combining ozone with UV/H ₂ O ₂ ;		(Naturstyrelsen 2013)



H ₂ O ₂ , H ₂ O ₂ + Fe + UV, H ₂ O ₂ + Fe)		Fenton = 10 % removal, fenton + UV = 47 %		
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