

## Evaluation of Heterocyclic Compounds (NSO-Het) and Reference Values (GFS) for the Management of Groundwater Contaminations

Results of the LAWA\*-Subcommittee „GFS for NSO-Het“ from 2009-10

Theo von der Trenck<sup>1</sup>, Hermann Dieter<sup>2</sup>, Rainer Konietzka<sup>2</sup>, Brigitte Moll<sup>3</sup>

<sup>1</sup>LUBW, Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg, Karlsruhe

<sup>2</sup>UBA, Umweltbundesamt (German Federal Environment Agency), Dessau, Berlin

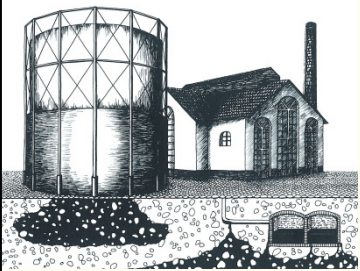
<sup>3</sup>BSU-HH, Freie und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt, Chair person of  
the Board "Groundwater and Water Supply" of the German States' Water Consortium (LAWA)

\*German Federal States' Water Consortium, LAWA (2010) online available at:

[http://www.lawa.de/documents/Bericht\\_NS\\_O\\_Heterozyklen\\_9f8.pdf](http://www.lawa.de/documents/Bericht_NS_O_Heterozyklen_9f8.pdf)



Baden-Württemberg



### German Federal Soil Protection Ordinance (1999)

BBodSchV

III – 5.2.1

Organic Substances	Trigger Value
Organische Stoffe	Prüfwert [ $\mu\text{g/l}$ ]
Mineralölkohlenwasser- stoffe <sup>1)</sup>	200
BTEX <sup>2)</sup>	20
Benzol	1
LHKW <sup>3)</sup>	10
Aldrin	0,1
DDT	0,1
Phenole	20
PCB, gesamt <sup>4)</sup>	0,03
PAK, gesamt <sup>5)</sup>	0,20
Naphthalin	2

<sup>5)</sup> PAK, gesamt: Summe der polycyclischen aromatische Kohlenwasserstoffe ohne Naphthalin und Methylnaphthaline; in der Regel Bestimmung über die Summe von 15 Einzelsubstanzen gemäß Liste der US Environmental Protection Agency (EPA) ohne Naphthalin; ggf. unter Berücksichtigung weiterer relevanter PAK (z.B. Chinoline).

3.2 Anwendung der Prüfwerte

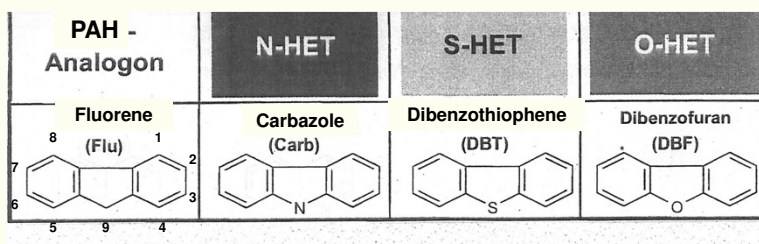
**Manufactured Gas Plant**

Path: soil → groundwater

**total PAH**

**PAH-sum including relevant NSO-Het**

## NSO-heterocyclic Hydrocarbons and their PAH-Analogen



„KORA - Kontrollierter natürlicher Rückhalt und Abbau von Schadstoffen bei der Sanierung kontaminierter Grundwässer und Böden“

**Joint effort: KORA = Controlled natural attenuation  
for the remediation of contaminated groundwater and soil**

Starting in 2003, the German Ministry of Research (BMBF) **financed** 74 projects (KORA) as a **joint effort** to investigate **natural attenuation processes** on sites contaminated with **tar oil**.

In the course of KORA **NSO-Het** were also analyzed besides PAH.

For the contaminant **plume 20 priority pollutants (NSO-Het)** were identified according to the properties of substance and site (ARCADIS, 2007).

ARCADIS (2007): **Heterozyklische Aromaten** und andere teerölytypische Schadstoffe im Grundwasser – **Bewertung** der Stoffeigenschaften und des Vorkommens im Hinblick auf das Potenzial an natürlichem **Rückhalt und Abbau**. Bearbeiter: J. Blotevogel, T. Held, G. Rippen, P. Wiesert, ARCADIS Consult GmbH, Darmstadt. Abschlussbericht im Förderschwerpunkt **KORA**, Themenverbund 2, 1.Projekt, Teil A im Auftrag des BMBF, Bonn, 31. 3. 2007

## Significance Thresholds (GFS) for NSO-Heterocycles

- **KORA** (BMBF - *joint effort*)
  - 256 Heterocycles including isomers
  - Groundwater *plume*
    - 20 Priority *pollutants* + 31 Isomers = 51 Substances
- **Altlastenforum** (*working group*)
  - *Center of contamination*
    - Expanded to 26 *priority pollutants* + isomers
- **In total (including isomers): 71 *priority pollutants***
- **Subcommittee:** revised method of selection according to **LAWA-criteria** of deriving **significance thresholds** (only properties, not frequency in GW)
  - added 10 pollutants ranked **highest** + isomers → **92 Substances**
- **Search for data → 12 GFS + 1 cumulative value**

Altlastenforum (2008): NSO-Heterocyclen: Vorkommen, Analytik, Beurteilung – Hinweise für die Praxis –. Bearbeiter: Kern, F.; Möhser, H.; Reinhard, M.; Sagner, A.; Sorg, K.-P.; Tiehm, A.. Altlastenforum Baden-Württemberg e.V., Schriftenreihe Heft 12

**Table 1: Pollutant Priority According to Mobility, Persistence, and Toxicity for Humans and the Ecosystem**














Block of Criteria (BC)	Parameter	Weighting factor		Unity	Points				
		C	BC		5	4	3	2	1
Chemico-physical parameters/ Mobility	Odor threshold	0	6	µg/m³	<1	1 - < 10	10 - < 100	100 - < 1000	≥ 1000
	Water solubility	2		mg/l	≥ 10.000	1.000 - < 10.000	100 - < 1.000	10 - < 100	< 10
	Henry-Coefficient	1			>4* 10 <sup>-2</sup>	4*10 <sup>-3</sup> - <4*10 <sup>-2</sup>	4*10 <sup>-4</sup> - <4*10 <sup>-3</sup>	4*10 <sup>-5</sup> - <4*10 <sup>-4</sup>	>4*10 <sup>-6</sup>
	Koc	2			< 10	10 - < 100	100 - < 1.000	1.000 - < 10.000	≥ 10.000
Microbial degradation/ Persistence	Degradation aerobic	0,2	6		Persistence demonstrated		Degradation not determined	Both, degradation and persistence found	Degradation demonstrated
	Degradation denitrifying	0,1			Persistence demonstrated		Degradation not determined	Both, degradation and persistence found	Degradation demonstrated
	Degradation Fe-reducing	0,3			Persistence demonstrated		Degradation not determined	Both, degradation and persistence found	Degradation demonstrated
	Degradation sulfate-reducing	0,3			Persistence demonstrated		Degradation not determined	Both, degradation and persistence found	Degradation demonstrated
	Degradation methane-reducing	0,1			Persistence demonstrated		Degradation not determined	Both, degradation and persistence found	Degradation demonstrated
Toxicity for humans	Carcinogenic in humans	3	6		positive		data lacking or insufficient		negative
	Genotoxic (only the higher one of the two „KORA“-values for „mutagenicity“ and „genotoxicity“ is considered)	3			(5 Points are not assigned)	positive (even if only in one test system)	negative and positive in the same test system	no data	negative
Ecotoxicity	Fish	1	5	mg/l	<1	1 - < 10	10 - < 100	100 - < 1.000	≥ 1.000
	Green algae	1		mg/l	<1	1 - < 10	10 - < 100	100 - < 1.000	≥ 1.000
	Bacteria	1		mg/l	<1	1 - < 10	10 - < 100	100 - < 1.000	≥ 1.000
	Crustaceans	2		mg/l	<1	1 - < 10	10 - < 100	100 - < 1.000	≥ 1.000
Site assessment	Frequency in groundwater	0							

## Significance Thresholds (GFS) for NSO-Heterocycles

### Result of Ranking:

- The list of **priority** pollutants for the contamination **center** (Altlastenforum) and the contaminant **plume** (ARCADIS) was not adopted unchanged,
- but **expanded** by substances of a **high hazard potential** according to their toxicological properties.
- Only the 10 highest ranked substances were added** (plus isomers and substances of equal rank).

### Additional Priority Pollutants

Formula	Rank	Name	Product Priority / 100	GFS [µg/l]
	1	Desazopyron-2-one (C-mesuraxin)	161	4,7
	1	2-Propylpyridine	161	
	1	3-Propylpyridine	115	
	1	4-Propylpyridine	115	
	2	2,3-Dihydroxypyridine	96	
	2	2,6-Dihydroxypyridine	159	
	4	2,5-Dihydroxypyridine	144	
	5	3,4-Dihydroxypyridine	134	
	6	2,4-Dihydroxypyridine	133	
	3	3-Hydroxyindol	153	
	7	Trinitrothiophene	128	
	7	2-Ethylthiophene	128	
	8	1-Methylpyrrole	125	
	9	Piperazine	123	(14)
	10	Benzo(b)thiophene-4,5-dioxide	122	
	10	2,4-Dimethylfuran	122	
	10	2,5-Dimethylfuran	122	
	10	4-Acridinol	122	

## How to derive *Significance Thresholds* (GFS) as **Criteria** for **Contaminated Groundwater**

The **significance threshold** (GFS) **substantiates** for single substances or groups of substances the concept of „**damage**“ in the German Water Act (WHG, 2009\*).

### Section 1

**§ 1 Purpose** It is the purpose of this law **to protect** through sustainable water resources management the **water bodies**

- as elements of the **ecosystem**,
- as **natural basis** of **human life**,
- as **habitat** for **animals and plants** and
- as **usable resource**.

\*BGBl I, S. 2585ff

## German Water Act (WHG, 2009)\*

**§ 3 Definitions** 10. **Damaging alteration of the water:** Changes of the properties of a body of water, which **impair** the **public welfare**, especially the **public water supply**...

### § 6 General Principles of Water Management

1. **Purpose:** ...**to protect** a body of water against **detrimental changes** of its properties...
2. ...**to compensate** as much as possible **impairments**, that are **not insignificant**...

### § 48 Groundwater pollution abatement

- (1) ..permission to discharge and **introduce chemical substances** into the groundwater may **not** be **granted**, **unless** a **detrimental change** of the water quality is **not** to be **feared** ...
- (2) **Chemical substances** may only be **stored** in such a way that a **detrimental change** of the water quality is **not to be feared** ...

### § 62 ...handling of **substances hazardous to water**

- (1) ... a **detrimental change** of the properties of water bodies is **not** to be **feared** ...

\*BGBl I, S. 2585ff

## Significance Threshold\*

What magnitude of groundwater impairment is ,not insignificant'?

Concentrations in groundwater (exceeding background)  
can be classified as **insignificant** only if

- no relevant **ecotoxicological** effects are exerted in or due to the groundwater, and
- the groundwater complies with the requirements of the German Drinking Water Ordinance (or values derived correspondingly).

\*LAWA (2004)

## Criteria for the Significance Threshold

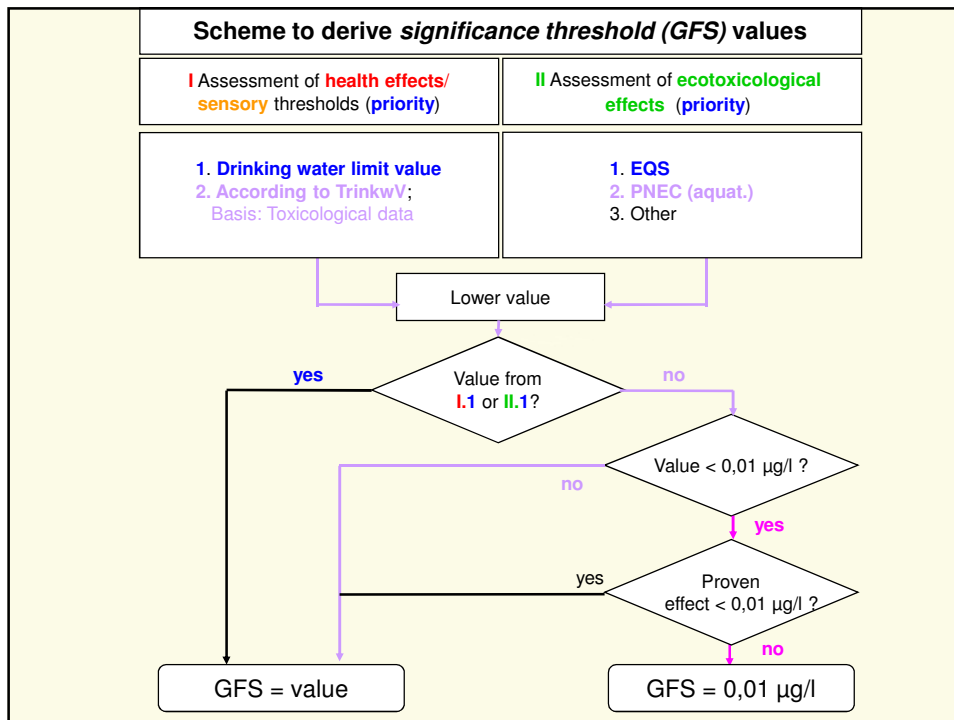
according to the German Drinking Water Ordinance\*

**Groundwater contaminants** without a drinking water limit value  
must meet 3 criteria.

Their concentration must be:

Harmless for human health [TrinkwV § 6(1)],  
minimized at reasonable expense according to  
the best available technology [TrinkwV § 6(3)], and  
aesthetically unobjectionable [TrinkwV § 4(1)].

\*TrinkwV (2001)




**2<sup>nd</sup> Priority Basis for Significance Threshold** (LAWA, 2004)  
 for NSO-Het (case I.2 or II.2)

- **PNEC** (*predicted no effect concentration*); **NOEC<sub>min</sub>** (*no observed effect concentration* of the most sensitive species: Algae, Crustaceans, Fish);  
**NOEC<sub>min</sub>/AF = PNEC** (AF ≥ 10 according to data gaps)
- **according to DRINKING WATER ORD.**
  - **TDI** (tolerable daily intake for non-carcinogens)
  - **added life time risk of 10<sup>-6</sup>** (for carcinogens)
  - **odor detection threshold**

LAWA (2004) online available at: [http://www.lawa.de/documents/GFS-Bericht-DE\\_a8c.pdf](http://www.lawa.de/documents/GFS-Bericht-DE_a8c.pdf)

## Example: Benzothiophene data sheet

### Benzo(b)thiophene

Substanzname	Benzo(b)thiophene
CAS-Nr.	95-15-8
Synonyme	Thionaphthen, 1-Benzothiophen, Benzo(b)thiophen, Thianaphthen, 1-Thiainden, 2,3-Benzothiophen, Benzothiofuran
Strukturformel	
Significance Threshold (µg/l)	0,3
Maßgebliche Basis für den Vorschlag	<input type="checkbox"/> TrinkwV <input type="checkbox"/> Analog TrinkwV o <input checked="" type="checkbox"/> Ökotoxizität <input type="checkbox"/> Basiswert / Untergrenze
Grenzwert der TrinkwV (µg/l)	-
Vorschlag analog TrinkwV (µg/l)	
Humantoxikologisch begründeter Wert	
Ästhetisch begründeter Wert	
Ökotoxikologische Kriterien (µg/l):	Umweltqualitätsnorm PNEC (aquat.) 0,3* LAWA ZV MPA Sonstige
Basiswert (µg/l)	

#### Explanation

Ausschlaggebend für die Festlegung des Geringfügigkeitsschwellenwertes ist der ökotoxikologisch begründete Wert. Ob ein GFS-Wert in Höhe der PNEC auch das Schutzgut Trinkwasser ausreichend schützt, wurde nach dem Konzept der Bewertung der Anwesenheit humantoxikologisch nur teil- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht (UBA, 2003) geprüft. Aussagekräftige experimentell-humantoxikologische Daten liegen nicht vor. Damit ergibt sich ein gesundheitlicher Orientierungswert (GOV) von 0,1 µg/l. Es kann daher angenommen werden, dass eine geringfügig höhere GFS von 0,3 µg/l das Grundwasser auch ausreichend als Trinkwasserressource schützt.

#### Toxicological Assessment

Es liegen keine oder keine ausreichend bewertbaren Daten für die humantoxikologische Begründung einer GFS vor.

#### Odor- and Taste-Threshold

In den zur Überprüfung der sensorischen Wahrnehmungsschwelle herangezogenen Referenzwerken ist der Stoff nicht aufgeführt (Rippen, 2010) oder es wird keine sensorische Schwelle genannt (Brauer, 2002).

#### Ecotoxicological Assessment

Chronische bzw. Langzeit-NOEC-Werte fehlen. Akute LC<sub>50</sub>-Werte liegen für alle drei Trophiestufen vor. Am empfindlichsten erweisen sich Fische (Danio rerio, Fischeltest, 48 h) mit LC<sub>50</sub> = 0,29 mg/l (Sagner, 2009). Bei Anwendung eines Sicherheitsfaktors von 1000 auf dieses Testergebnis ergibt sich eine PNEC von (aufgerundet) 0,3 µg/l.

#### Literature

Brauer, L. (2002): Gefahrstoffsensibilis - Farbe, Geruch, Geschmack, Reizwirkung gefährlicher Stoffe, Geruchsschwellenwerte. Loseblattwerk, 48. Erg.-Lfg. 2/2002, ecomed Verlag, Landsberg (Das Werk wurde mit der 48. Erg.-Lfg. eingestellt).

Rippen, G. (2010): Handbuch Umweltschadstoffe - Stoffdaten, Prüfverfahren, Vorschriften. Loseblattwerk, 90. Erg.-Lfg. 2/2010, ecomed Verlag, Landsberg.

Sagner, A. (2009): Vorkommen, Toxizität, mikrobiologischer Abbau heterozyklischer Kohlenwasserstoffe. Dissertation, (Hrsg.: Technologiezentrum Wasser Karlsruhe (TZW)).

UBA (2003): Bewertung der Anwesenheit teil- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht. Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz 46, 249-251.

#### Analytical Methods

Methode	BG (µg/l)	Literatur Fundstelle
HPLC-DAD	0,5-7,2 nach KORA 1,2-7,2 nach Blotvogel	Störke und Hübner (2006) S. 217-219 (sawag ES.1) Reineke (2008) Blotvogel (2008)
HPLC-MS-MS (nach KORA)	0,018-0,13 nach Blotvogel	Störke und Hübner (2006) S. 217-219 (sawag ES.1) Reineke (2008) Blotvogel (2008)
GC-MS (nach KORA)	0,01-1,5 nach Blotvogel	Störke und Hübner (2006) S. 236-240 (im Linienberg ES.6) Meyer (2006) Blotvogel (2008)
GC-MS	0,05 nach Johansen	Johansen et al. (1997) (Rings, Dänemark)

## Significance Thresholds for NSO-Het

- Data search for 92 substances (46 plus 46 isomers)
- Result:  
Ecotox-data for 24 substances  
Human tox-data for 8 substances
- ➔ in principle, GFS possible for 24 substances,
- but...



## Check PNEC by means of HRIV (health related indication value for non-assessables)

Results of **human-** and **ecotoxicological** assessments **may be very far apart** from each other, e.g.:

**Piperazine** human tox value  
(14 µg/l, uncertain, AF = 6000)      90 → PNEC  
1250 µg/l

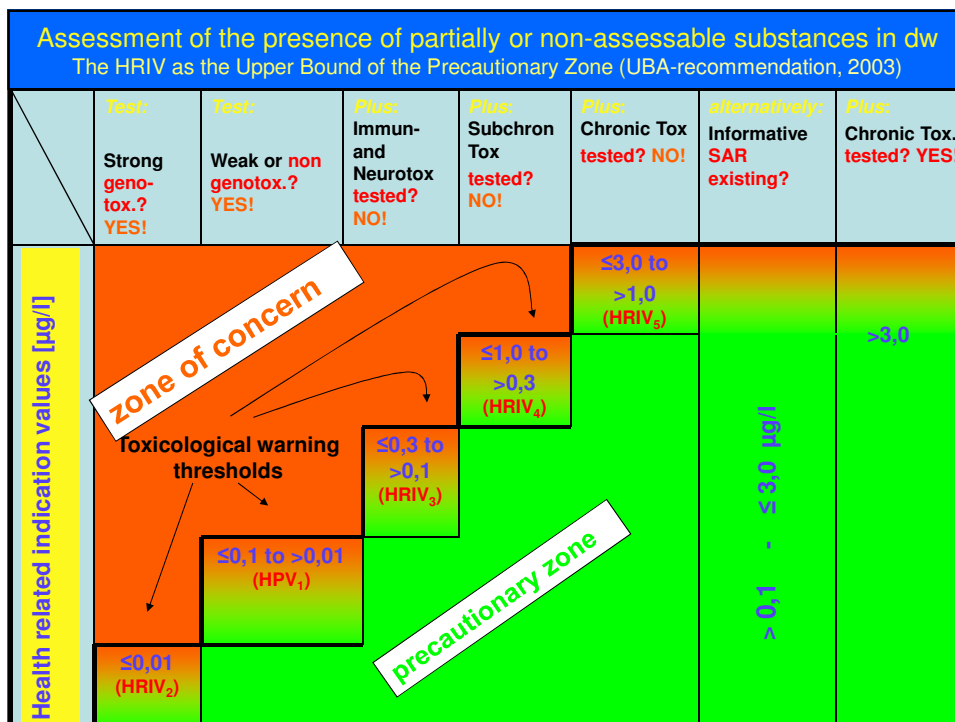
Compliance with the piperazine-PNEC obviously does **not sufficiently protect** the gw **as dw-resource**.

## → Review of PNEC by means of HRIV (UBA, 2003)

The **HRIV** (upper bound of precautionary zone) is **as high as possible** and **as low as necessary** to compensate the lack of data. With the **HRIV** the Federal Environment Agency has created a criterion, that includes

- **Precautionary** aspects and the
- Experience from **assessments** of dw-contaminants **conducted earlier** to bridge the data gap.

UBA (2003) Bundesgesundheitsblatt 46, 249-251



1. Significance threshold (+ basis + value suggested by KORA)						
Nr.	Name	KORA	GFS [µg/l]	Basis [µg/l]		
				Human tox.	Sensory	Ecotox.
1	Acridine		0,08	(HRIV: 0,1 - 0,3)	--	0,08
2	Benzo(b)thiophene		0,3	(HRIV: 0,1)	--	0,3
3	Benzofuran	0,01*	1,8	2,7	--	1,8
4	Benzotriazole und Me-Benzotriazoles		40	-	--	40
5	Carbazole	0,1*	0,2	10	--	0,2
6 →	Quinoline	0,01*	0,01	0,002	16	0,4
7 →	Coumarin		4,7	4,7	50	8
8 →	Dibenzofuran	0,01**	0,4	(HRIV: 0,3)	120	0,4
9	Dibenzothiophene		--	(HRIV: 0,1)	--	0,6
10	2,6-Dimethylquinoline	0,01**	--	(HRIV: 0,1 - 0,3)	--	1,9
11	Furan		0,35	0,35	50 000	--
12	2-Hydroxybiphenyl	0,1*	0,7	100	400	0,7
13	Indole		--	(HRIV: 0,1)	300	0,9
14	Isoquinoline	0,01**	--	(HRIV: 0,1 - 0,3)	--	4
*Genotoxicity **High toxic potential						

2. Significance threshold (+ basis + value suggested by KORA)						
Nr.	Name	KORA	GFS [µg/l]	Basis [µg/l]		
				Human tox.	Sensory	Ecotox.
15	Me-Quinolines	0,01**	--	(HRIV: 0,1)	--	2,2
16	Piperazine		--	(14)	--	1250
17 →	Pyridine		0,5	3,5	0,5	1,1
18	Pyrrol		--	--	10 000	-
19	Thiophene		--	(HRIV: 0,3)	--	13
20	Xanthene		--	(HRIV: 0,1)	--	0,4
21 →	2,3-Dimethylbenzofuran	0,01**	0,3	(HRIV: 0,1)	--	0,3
22 →	2-Methylbenzofuran	0,01**	--	(HRIV: 0,1)	--	3,2
23a →	3-Methylbenzothiophene	0,01**	--	(HRIV: 0,1)	--	2,6
23b →	5-Methylbenzothiophene	0,01**	--	(HRIV: 0,1)	--	14
24 →	Benzo(b)thiophene-1,1-dioxide		--	(HRIV: 0,1)	--	14
	Σ		12	7-8 → 8	8 → 1	24 → 8
25	Σ PAH (incl. NSO-Het without value)		0,2	(HRIV: 0,1 - 0,3)		
26	Acridinone	0,01**	--			
27	Benzo(b)thiophene	0,01**	--			
28	Quinolinones	0,01**				
*Genotoxicity **High toxic potential						

### 3. Significance threshold (+ basis + value suggested by KORA)

Nr.	Name	KORA	GFS [µg/l]			
30	Me-Quinolinones	0,01**	--			
31	Me-Dibenzofurans	0,01**	--			
32	Me-Isoquinolinones	0,01**	--			
33	Phenanthridinone	0,01**	--			
34	Xanthenone	0,01**	--			

\*Genotoxicity \*\*High toxic potential

### Evaluation of NSO-Het and Significance Thresholds (GFS) for the Management of Groundwater Contaminations

#### Summary (1)

The German States' Water Consortium (LAWA) derived **significance thresholds** to assess **groundwater** contaminated with **heterocyclic compounds**.

**12 values** were **derived** plus a **lumped parameter** for PAH including the NSO-Het, which are not characterized sufficiently by (eco)toxicological data.

Based on work completed by the BMBF-joint project **KORA** a LAWA-subcommittee selected **92 priority** pollutants **from 256** single substances according to different criteria such as **mobility, persistence, human- and ecotoxicity**.

**Contaminations** of the groundwater can be classified as **insignificant** only if they are **not ecotoxic** and comply with the requirements of the German **Drinking Water Ordinance** or values derived accordingly: **harmless** for **human health** and **aesthetically unobjectionable**.

**Evaluation of NSO-Het and Significance Thresholds (GFS)  
for the Management of Groundwater Contaminations**

**Summary (2)**

**For all 92** priority pollutants  
**data** for the assessment according to these criteria were searched.

Out of **24** substances, which fully or partially fulfilled the data requirements,  
only **12** passed the test of comparing them with the **HRIV** (health related indication  
values) devised by the German Federal Environment Agency (**UBA**).  
**Significance thresholds were derived for these 12.**

As a result of the data evaluation **less stringent** values could be derived for almost  
all of the NSO-Het (**LAWA, 2011**) than suggested earlier (**ARCADIS, 2007**).

**ARCADIS (2007):** Heterozyklische Aromaten und andere teerötypische Schadstoffe im Grundwasser – Bewertung der Stoffeigenschaften und des Vorkommens im Hinblick auf das Potenzial an natürlichem Rückhalt und Abbau. Bearbeiter: J. Blotvogel, T. Held, G. Rippen, P. Wiesert, ARCADIS Consult GmbH, Darmstadt. **Abschlussbericht im Förderschwerpunkt KORA**, Themenverbund 2, 1. Projekt, Teil A im Auftrag des BMBF, Bonn, 31. 3. 2007

**LAWA (2011):** Ableitung von Geringfügigkeitsschwellenwerten für das Grundwasser – NSO-Heterozyklen. Hrsg.: **Länderarbeitsgemeinschaft Wasser**, [http://www.lawa.de/documents/Bericht\\_NS\\_O\\_Heterozyklen\\_9f8.pdf](http://www.lawa.de/documents/Bericht_NS_O_Heterozyklen_9f8.pdf)

**Evaluation of NSO-Het and Significance Thresholds (GFS)  
for the Management of Groundwater Contaminations**

Compiled by the **Subcommittee “Significance Thresholds for Heterocycles”** of the Permanent Committee „Groundwater and Water Supply” of the German States’ Water Consortium 2009 / 2010

Dieter, PD Dr. Hermann H.

Frank, Dr. Dieter

Herrmann, Dr. Heide

Konietzka, Rainer

Moll, Brigitte (chair)

Six, Ellen

Stockerl, Dr. Rudolf

von der Trenck, Dr. K. Theo

Federal Environment Agency

Landesamt für Umwelt- und Arbeitsschutz, **Saarland**

**Hessisches** Landesamt für Umwelt und Geologie

Federal Environment Agency

Behörde für Stadtentwicklung und Umwelt, **Hamburg**

Federal Environment Agency

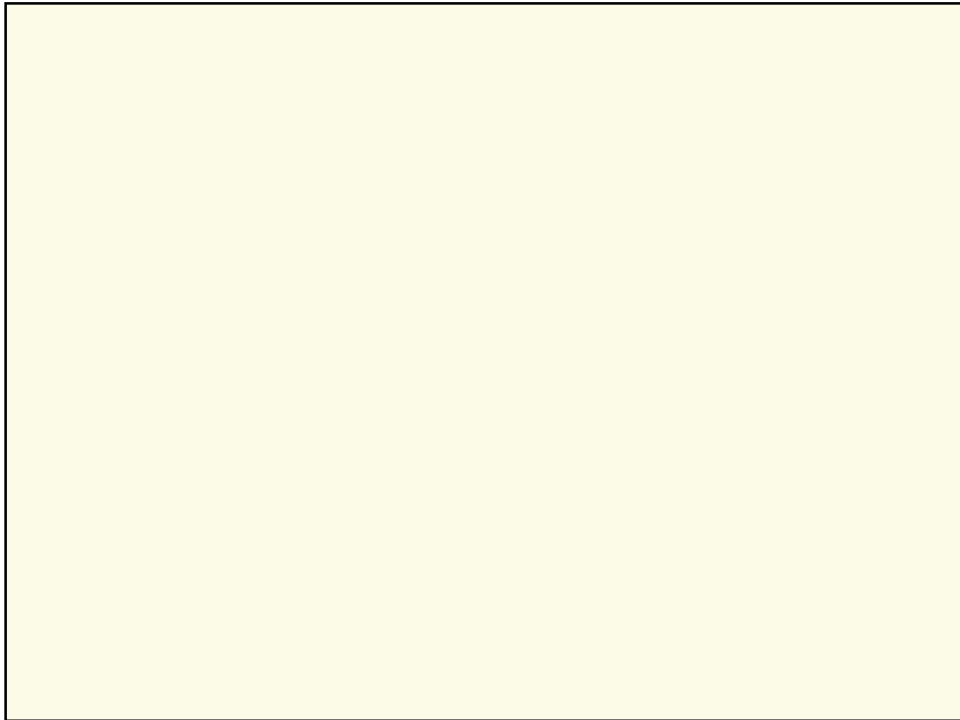
**Bayerisches** Landesamt für Umwelt

Landesanstalt für Umwelt, Messungen und Naturschutz

**Baden-Württemberg**

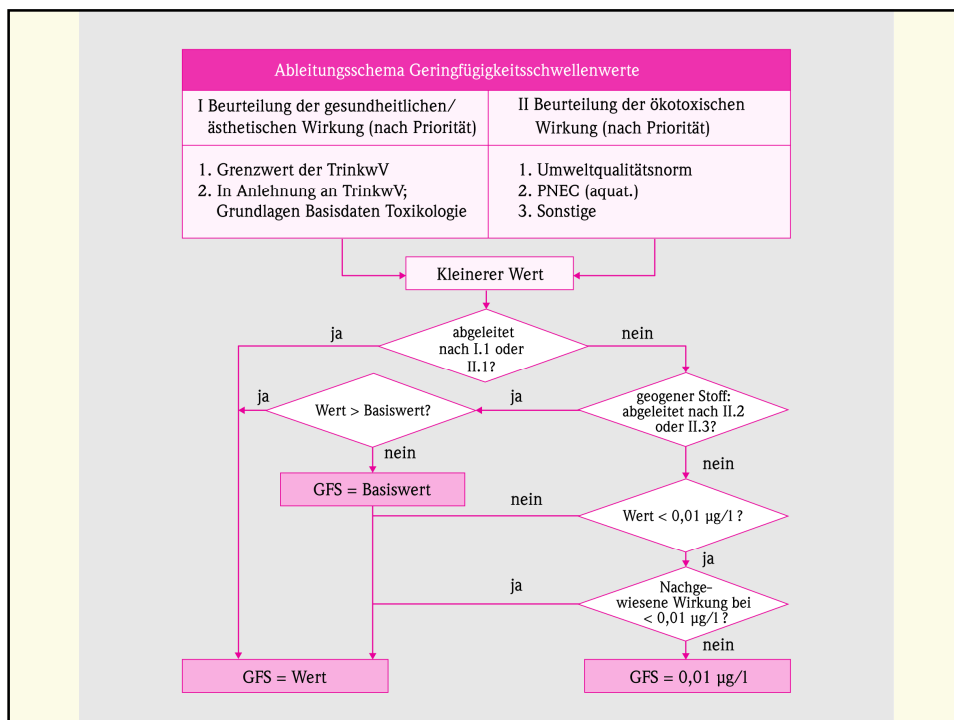


In the name of the subcommittee:  
**Thank you very much for your interest!**



### Deconstruction of the Manufactured Gas Plant in Geislingen/Steige





Bundesgesundheitsbl - Gesundheitsforsch -  
Gesundheitsschutz 2003; 46:249-251  
DOI 10.1007/s00103-002-0576-7

**März 2003**

**Empfehlung des Umweltbundesamtes**

## Bewertung der Anwesenheit teil- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht

Empfehlung des Umweltbundesamtes  
nach Anhörung der Trinkwasserkommission  
beim Umweltbundesamt

<http://www.umweltdaten.de/wasser-e/empfnichtbewertbstoffe-english.pdf>