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Groundwater fauna in an urban area – natural or affected?

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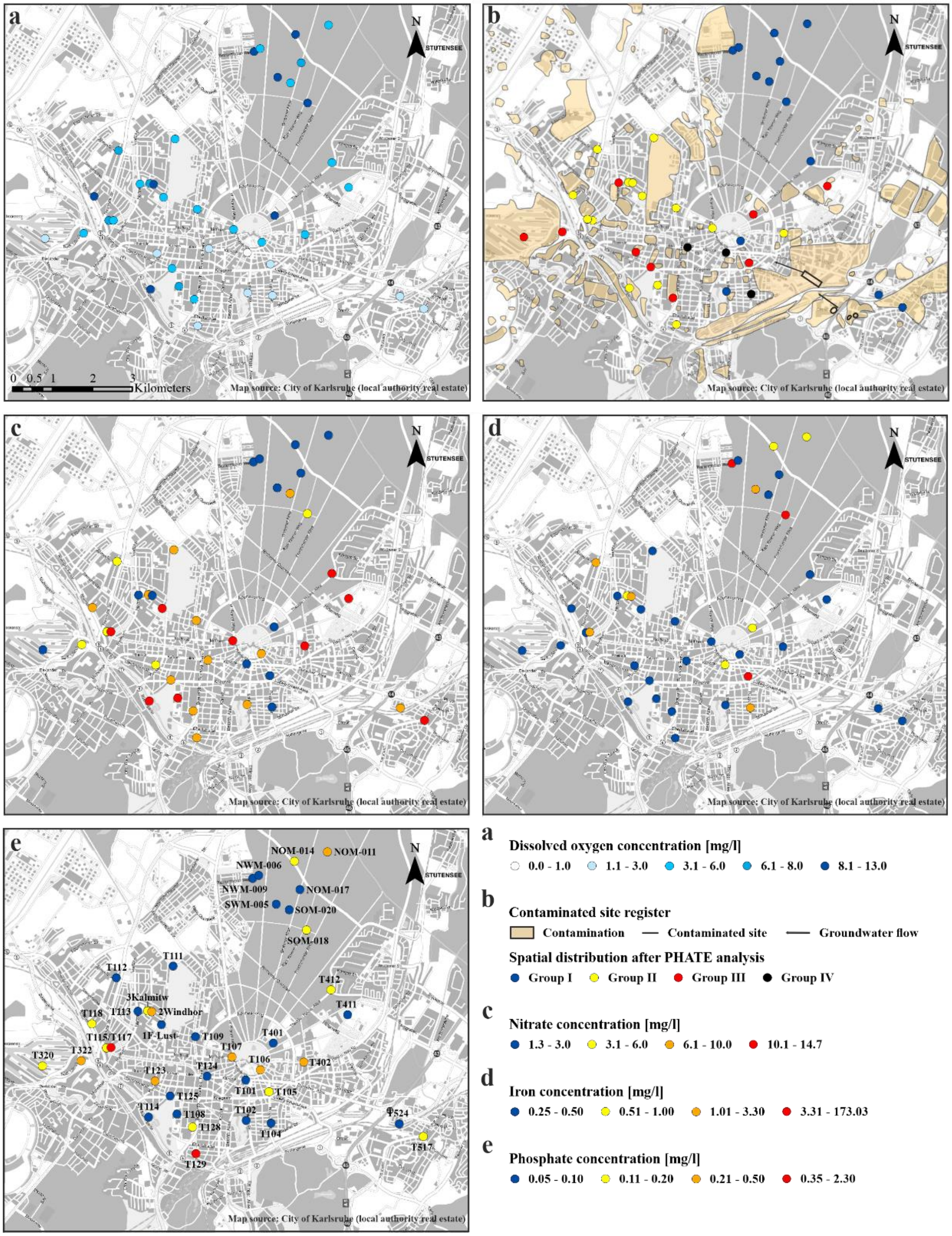

Figure S1: Overview map of Karlsruhe: (a) the average content of dissolved oxygen of the multiple measurements [mg/l]; (b) contaminated sites of the soil protection and contaminated site register (Bodenschutz- und Altlastenkataster) of Karlsruhe (modified after Stadt Karlsruhe, 2006; Kühlers et al., 2012; Wickert et al., 2006) and the spatial distribution after the PHATE analysis; (c) average nitrate concentration [mg/l] of the repeated measurements; (d) iron concentration [mg/l] of the repeated measurements and (e) the phosphate concentration [mg/l] of the repeated measurements at the bottom of the measurement wells.

Groundwater Fauna Index (GFI)

The Groundwater-Fauna-Index (GFI), introduced by Hahn (2006), quantifies the ecological relevant conditions in the groundwater as a result of hydrological exchange between surface and groundwater. It incorporates ecologically important groundwater parameters such as relative amount of detritus, variation of groundwater temperature and concentration of dissolved oxygen (Hahn, 2006) and is calculated by using Equation 1:

$$\textbf{GW Fauna Index} = \sqrt{\boldsymbol{Dissolved\ Oxygen}\left(\frac{\boldsymbol{mg}}{\boldsymbol{l}}\right)} \times \sqrt{\boldsymbol{Relative\ Amount\ of\ Detritus}} \times \boldsymbol{Standard\ deviation\ Temperature} \quad (\mathbf{1})$$

The determined average GFI of all sampled wells is 6.0 ± 2.8 with a total variation between 0 and 14 and a heterogeneous distribution of the GFI-values. High GFI values (> 10, Type III), indicating hydrological exchange with the surface (Hahn, 2006), were only found in three wells which share a high standard deviation of GWT (2.6 to 3.5 °C), higher dissolved oxygen (5.5 to 5.8 mg/l) as well as nitrate concentrations (7.7 up to 12 mg/l). These specific well locations have mainly no or minor sealed surfaces. Overall, 82 % of the measurement wells showed meso-alimonic conditions (GFI > 2-10, Type II) and therefore indicate a medium level of surface influence, at diverse urban and forested locations. Only four wells in this study were well insulated from surface influences (GFI < 2), with three wells located in densely built-up surroundings with sealed surfaces. Moreover, the average GFI in the forested area is 4.5 ± 1.9 and in the urban area 6.2 ± 2.7.

Shannon diversity index

The Shannon-Index, introduced by Shannon and Weaver (1949) is an established standard method to quantify the ecological diversity of e.g. bacterial or faunistic communities. The index describes the diversity by including the number of species and the relative frequency of individuals. The sampled wells in the forested area show the highest balance (median EH = 0.47) and Shannon diversity index (median HS = 0.74). The maximum diversity (median H_{max} = 1.58) is the same in both the forested and the urban area. The balance (median EH = 0.42) and Shannon diversity index (median HS = 0.52) are only a little bit lower in the urban area. These results are comparable with the study of Brielmann et al. (2009), where the Shannon diversity index of an anthropogenically influenced groundwater of an aquifer downstream of an industrial facility varies between 0.20 and 1.45. Nevertheless, no clear distribution pattern according to faunal diversity is recognizable. Thus, the Shannon diversity index was not considered further.

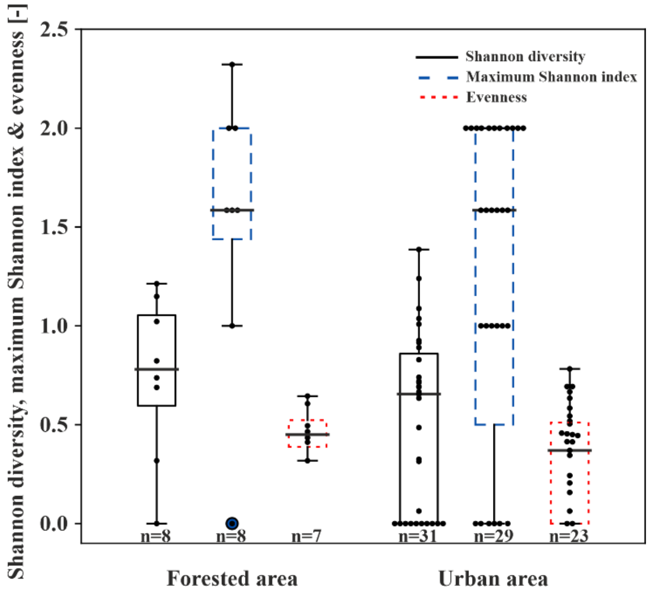

Figure S2. Boxplots of the Shannon diversity index, maximum Shannon index and evenness, divided in forested and urban area (n = number of wells, or number of wells at which the evaluation is applicable).

Urban impacts on groundwater quality

Urban impacts on groundwater systems can be manifold, such as increasing temperatures (urban heat islands (Menberg et al., 2013)), contaminants (Kuroda and Fukushi, 2008), changes in the precipitation discharge due to sealing, falling water levels due to groundwater withdrawal (Foster, 1990). In our study we intend to provide a first impression of the situation in Karlsruhe and therefore focus on the standard parameters. A first overview is given by the LUBW continuous monitoring program of groundwater wells (Landesanstalt für Umwelt Messungen und Naturschutz Baden-Württemberg, 2020), which provides profound groundwater analysis in Karlsruhe. Some of the considered measurement wells are close to the measurement wells of this study. Assessing the evaluation period of this study (2011-2014), most of the wells of the monitoring program show values within the range of the local background or below the thresholds of the drinking water ordinance of Germany and therefore no contamination.

One exception is a measurement well in the Kapellen-Street (next to T105), which shows higher ammonium (average: 0.55 mg/l, threshold drinking water ordinance: 0.5 mg/l), iron (5.1 mg/l, threshold value of the German drinking water ordinance: 0.2 mg/l) and manganese concentrations (0.55 mg/l, threshold drinking water ordinance: 0.05 mg/l). Moreover, this well has a noticeable concentration of arsenic (8.7 µg/l, threshold drinking water ordinance: 10 µg/l) and of the herbizide CGA 369873 (0.1 µg/l, threshold: 0.1 µg/l). This well is at the margin of one of the largest contaminated sites in Karlsruhe, the former gas plant.

Three other wells, which contain contaminants are in the Kaiserallee, Mathy-Street (next to T124) and near the municipal hospital. They showed noticeable concentrations of volatile hydrocarbons of up to 13 µg/l during the evaluation period (in detail at the hospital: 3-6 µg/l; Kaiserallee: 5-8 µg/l; Mathy Street: about 3 µg/l). In comparison, the German threshold value of the drinking water ordinance is 20 µg/l.

The groundwater of one measurement well in the Hardtwald (next to SWM-005/SOM-020) has a different chemical composition than the wells in the urban area. It shows lower concentrations of boron (30-45 µg/l, compared to the other wells: 50-98 µg/l), calcium (100-110 mg/l, compared to the other wells of up to 150 mg/l), chloride (25.5 mg/l in 2014 compared to the other wells: > 50 mg/l), potassium (3.2 mg/l) and sodium (11.3 mg/l). Furthermore, the content of dissolved oxygen is higher than in the wells of the urban area (average with 4.8 mg/l).

This overview indicates that beside one larger and two smaller contaminations, the groundwater beneath Karlsruhe contains only minor pollution. Groundwater fauna can usually cope well with short-term changes of chemical-physical parameters (Griebler et al., 2016). Previous studies showed that some species can even benefit from pollutants (Matzke, 2006; Zuurbier et al., 2013). Thus, the main documented impacts on groundwater quality in the study area are related to groundwater temperature, oxygen and nitrate concentration.

Table S1: Estimation of the relative amounts of sediment per sample (modified after Hahn, 2006).

Scale	Description	Characterisation
0	Absent	No sediments in the sampling vessel
1	Little	Bottom of the sampling vessel (Ø ¼ 7.6 cm) slightly covered by sediment
2	Much	Bottom of the sampling vessel covered by several millimetres of sediment
3	Very much	Bottom of the sampling vessel covered by one or more centimetres of sediment

Table S2: Well locations, information, sampled properties and result of the evaluation (GWT=groundwater temperature, *sampling 2011-2012: 6 times, † sampling 2014: 3 times).

Measuring point	Location		Area classification	Depth [m]	Average GWT [°C]	SD GWT [-]	Relative amount of detritus [-]	Average dissolved oxygen [mg/l]	Average GFI [-]	Amount crustaceans (acc. to Griebler et al. (2014)) [%]	Amount oligochaetes (acc. to Griebler et al. (2014)) [%]	Total amount of individuals [-]	Numbers of taxa [-]	Ecological condition (acc. to Griebler et al. (2014))
T101	Lammstr. No.7	*	Urban area	39.0	14.4	0.05	3	0.97	0	0	0	0	0	Faunistic evaluation not possible
T102	Tulla Bad	*	Urban area	10.0	14.0	2.99	2	1.45	5	100	0	4	2	Natural
T104	Arbeitsamt - Rankestr.	*	Urban area	15.8	12.5	1.28	3	1.07	2	0	0	0	0	Faunistic evaluation not possible
T105	Fritz-Erler-Str. No.21	*	Urban area	9.3	14.4	3.29	3	1.29	6	0	100	1	1	Faunistic evaluation not possible
T106	Schloßplatz / Schloßbezirk	*	Urban area	11.0	14.2	2.60	3	4.02	9	86	14	7	3	Natural
T123	Sophienstr. - Grillparzerstr.	*	Urban area	14.0	12.8	1.65	1	2.18	2	0	100	3	2	Affected
T124	Kaiserplatz	*	Urban area	13.0	14.9	1.95	3	1.97	5	0	0	2	1	Affected
T125	Kriegsstr. No.141	*	Urban area	11.8	15.0	2.32	1	3.64	4	0	100	103	3	Affected
T128	Südendstr. - Brauerstr.	*	Urban area	9.5	13.2	3.21	2	5.50	11	0	100	13	2	Affected
T129	Schule Beiertheim	*	Urban area	8.5	12.2	3.67	1	2.31	6	91	9	124	4	Natural
T320	Südbeckenstr. No.16	*	Urban area	9.0	12.6	3.43	1	2.62	6	0	100	252	1	Affected
T322	Rheinhafenbad	*	Urban area	10.0	15.9	2.99	2	3.45	8	0	100	6	2	Affected
T402	Am Fasanengarten - Parkstr.	*	Urban area	9.0	12.4	3.43	2	3.68	9	50	50	4	4	Affected
T411	Gewann Blösse	*	Urban area	10.9	11.3	2.64	3	5.74	11	0	100	34	2	Affected
T412	Theodor- Heuss - Allee	*	Urban area	10.0	11.4	2.99	1	4.47	6	100	0	6	4	Natural
T517	Auer Str. - Reichenbachstr.	*	Urban area	9.0	12.8	3.43	2	2.84	8	100	0	5	1	Natural
T524	Dornwaldstr.	*	Urban area	9.0	11.5	3.43	2	1.77	6	99	1	275	2	Natural
T401	Area next to the Wildpark-Stadion	†	Urban area	11.0	14.2	2.60	2	8.90	10	0	100	8	1	Affected
T109	Erzbergerstr.	†	Urban area	13.7	14.1	1.76	1	4.86	4	92	8	38	4	Natural
T108	Edgar-von-Gierke-Str. - Siegfried-Kühn-Str.	†	Urban area	12.0	14.9	2.26	2	6.12	8	79	21	25	4	Affected
T114	Allotment garden at the Alb	†	Urban area	12.8	15.4	2.01	1	8.25	6	13	88	171	4	Affected

T115	Sonnenstr. – Zietenstr.	†	Urban area	13.5	14.8	1.81	1	4.83	4	89	11	23	4	Natural
T117	Sonnenstr. – Zietenstr.	†	Urban area	13.0	17.0	1.95	3	6.24	8	92	8	76	5	Natural
T118	Schoemperlenstr.	†	Urban area	13.7	16.1	1.76	1	8.45	6	38	63	11	4	Affected
T112	Wattstr. – Annweilerstr.	†	Urban area	12.0	14.5	2.26	2	6.87	8	100	0	204	4	Natural
T111	Field near Kaiserslauterner-Str.	†	Urban area	8.9	13.4	3.48	3	5.75	14	77	23	96	4	Affected
T113	Hertzstr. – St. Barbara-Weg	†	Urban area	11.0	17.5	2.60	1	3.35	5	0	100	1	1	Affected
3Kalmitw	Kalmitweg No.3	†	Urban area	15.5	15.3	1.34	1	6.44	3	77	23	13	3	Affected
2Windhor	Wilhelm-Windhorststr. - Schänzle	†	Urban area	15.2	15.8	1.34	2	8.64	6	20	80	353	4	Affected
1F-Lust-	Franz-Lust-Str. – Kußmaulstr.	†	Urban area	15.2	17.3	1.34	2	5.95	5	65	35	630	3	Affected
T107	Molkestr. – Willy-Brandt-Allee	†	Urban area	10.1	16.2	2.95	1	4.90	7	66	34	130	3	Affected
NOM-011		†	Forested area	14.9	10.7	1.47	1	3.42	3	100	0	15	1	Natural
NOM-017		†	Forested area	15.0	10.9	1.45	3	7.20	7	97	3	506	6	Natural
SOM-020		†	Forested area	15.0	10.7	1.45	1	5.81	3	50	50	9	4	Affected
SOM-018		†	Forested area	27.0	10.3	0.26	3	12.75	2	90	10	31	2	Natural
SWM-005	Hardtwald	†	Forested area	15.5	10.5	1.34	2	8.72	6	26	74	358	3	Affected
NWM-009		†	Forested area	15.0	10.8	1.45	2	10.69	7	43	57	90	4	Affected
NWM-006		†	Forested area	14.8	10.7	1.49	1	5.00	3	86	14	16	3	Natural
NOM-014		†	Forested area	15.0	10.5	1.45	1	9.92	5	67	33	23	3	Affected

Table S3: Taxa-site matrix of the invertebrate fauna of each water gauge.

	Official designation of the water gauges	T101	T102	T104	T105	T106	T123	T124	T125	T128	T129	T320	T322	T402	T411	T412	T517	T524	Number of individuals	Percentage	T401	T109	T108
Crustacea	*Amphipoda*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	6	0
	Cyclopoida	0	0	0	0	5	0	0	0	0	76	0	0	1	0	0	5	0	87	10	0	27	14
	Harpacticoida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Parastenocaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
	Bathynelleacea	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	272	274	33	0	0	1
	Nauplia	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0
	Amount *Crustacea*	0	2	0	0	6	0	0	0	0	77	0	0	1	0	3	5	272	366	44	0	33	15
	Amount *Crustacea* %	0	50	0	0	86	0	0	0	0	62	0	0	25	0	50	100	99			0	87	60
	Amount *Amphipoda* %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0			0.0	15.8	0.0
	Amount *Cyclopoida* %	0.0	0.0	0.0	0.0	71.4	0.0	0.0	0.0	0.0	61.3	0.0	0.0	25.0	0.0	0.0	100.0	0.0			0.0	71.1	56.0
	Amount *Harpacticoida* %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
	Amount *Parastenocaris* %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0			0.0	0.0	0.0
	Amount *Bathynellacea* %	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.9			0.0	0.0	4.0
	Amount *Nauplia* %	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
	Nematoda	0	2	0	0	0	0	2	65	5	0	0	0	1	0	1	0	0	76	9	0	2	6
	Oligochaeta	0	0	0	1	1	2	0	37	8	8	252	3	1	33	0	0	3	349	42	8	3	4
	Acari	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0
	Mikturbellaria	0	0	0	0	0	0	0	1	0	39	0	3	0	1	2	0	0	46	5	0	0	0
	Amount others	0	2	0	1	1	3	2	103	13	47	252	6	3	34	3	0	3	473	56	8	5	10
	Total amount	0	4	0	1	7	3	2	103	13	124	252	6	4	34	6	5	275	839	100	8	38	25
	Amount *Oligochaeta* %	0.0	0.0	0.0	100.0	14.3	66.7	0.0	35.9	61.5	6.5	100.0	50.0	25.0	97.1	0.0	0.0	1.1			100.0	7.9	16
	Amount *Nematoda* %	0.0	50.0	0.0	0.0	0.0	0.0	100.0	63.1	38.5	0.0	0.0	0.0	25.0	0.0	16.7	0.0	0.0			0.0	5.3	24
	Amount *Acari* %	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0			0.0	0.0	0
	Amount *Microturbellaria* %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	31.5	0.0	50.0	0.0	2.9	33.3	0.0	0.0			0.0	0.0	0

	Official designation of the water gauges	T114	T115	T117	T118	T112	T111	T113	3Kalm itw	2Wind hor	1F-Lust-	T107	NOM-011	NOM-017	SOM-020	SOM-018	SWM-005	NWM-009	NWM-006	NOM-014	Number of individuals	Percentage	Number of all individuals	Percentage of all
Crustacea	*Amphipoda*	2	0	0	0	0	0	0	0	0	10	0	0	41	3	0	0	2	0	0	64	2.3	66	1.8
	Cyclopoida	6	15	64	2	171	0	0	8	19	0	84	15	299	1	28	76	36	12	12	889	31.4	976	26.6
	Harpacticoida	0	0	2	1	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	33	1.2	33	0.9
	Parastenocaris	0	0	0	0	0	11	0	2	48	402	0	0	119	0	0	16	0	0	0	598	21.2	599	16.3
	Bathynelleacea	0	2	1	0	31	62	0	0	0	0	0	0	0	0	0	0	0	0	0	97	3.4	371	10.1
	Nauplia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	2	0.1
	Amount *Crustacea*	8	17	67	3	202	73	0	10	67	412	84	15	489	4	28	92	38	12	12	1681	59.5	2047	55.8
	Amount *Crustacea* %	5	74	88	27	99	76	0	77	19	65	65	100	97	44	90	26	42	75	52				
	Amount *Amphipoda* %	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	8.1	33.3	0.0	0.0	2.2	0.0	0.0				
	Amount *Cyclopoida* %	3.5	65.2	84.2	18.2	83.8	0.0	0.0	61.5	5.4	0.0	64.6	100.0	59.1	11.1	90.3	21.2	40.0	75.0	52.2				
	Amount *Harpacticoida* %	0.0	0.0	2.6	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0				
	Amount *Parastenocaris* %	0.0	0.0	0.0	0.0	0.0	11.5	0.0	15.4	13.6	63.8	0.0	0.0	23.5	0.0	0.0	4.5	0.0	0.0	0.0				
	Amount *Bathynellacea* %	0.0	8.7	13	0.0	15.2	64.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Amount *Nauplia* %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Nematoda	107	4	3	3	1	1	0	0	12	0	2	0	2	1	0	0	1	2	5	152	5.4	228	6.2
	Oligochaeta	56	2	6	5	1	22	1	3	274	218	44	0	15	4	3	266	51	2	6	994	35.2	1343	36.6
	Acari	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	2	0.1
	Mikturbellaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	46	1.3
	Amount others	163	6	9	8	2	23	1	3	286	218	46	0	17	5	3	266	52	4	11	1146	40.5	1619	44.2
	Total amount	171	23	76	11	204	96	1	13	353	630	130	15	506	9	31	358	90	16	23	2827	100.0	3666	100
	Amount *Oligochaeta* %	32.7	8.7	7.9	45.5	0.5	22.9	100.0	23.1	77.6	34.6	33.8	0.0	3.0	44.4	9.7	74.3	56.7	12.5	26.1				
	Amount *Nematoda* %	62.6	17.4	3.9	27.3	0.5	1.0	0.0	0.0	3.4	0.0	1.5	0.0	0.4	11.1	0.0	0.0	1.1	12.5	21.7				
	Amount *Acari* %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
	Amount *Microturbellaria* %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				

Table S4: Average and standard deviation of faunistic, chemical and physical parameters with regard to the four groups (result of the PHATE analysis).

	Average amount crustaceans (acc. to Griebler et al. (2014)) [%]	Average amount oligochaetes (acc. to Griebler et al. (2014)) [%]	Average numbers of taxa [-]	Average total amount of individuals [-]	Average Shannon diversity [-]	Average abundance *Amphipoda* [-]	Average abundance *Cyclopoida* [-]	Average abundance *Parastenocaris* [-]	Average abundance *Bathynellacea* [-]
Group I (n = 13)	80.3 (± 24.5)	19.7 (± 24.5)	2.9 (± 1.3)	103.5 (± 159.6)	0.6 (± 0.4)	3.7 (± 10.8)	37.6 (± 78.2)	10.5 (± 31.6)	21.1 (± 72.4)
Group II (n = 14)	67.8 (± 26.7)	32.4 (± 26.9)	3.9 (± 0.5)	135.6 (± 165.9)	0.9 (± 0.3)	1.3 (± 2.9)	34.8 (± 46.9)	33.1 (± 103.1)	6.9 (± 17.2)
Group III (n = 9)	0.0 (± 0.0)	100.0 (± 0.0)	1.7 (± 0.7)	46.8 (± 78.8)	0.2 (± 0.3)	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)
Group IV(n = 3)	0.0 (± 0.0)	0.0 (± 0.0)	0.3 (± 0.5)	0.7 (± 0.9)	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)	0.0 (± 0.0)

	Average geological unit [-]	Average GWT [°C]	Average phosphate concentration[mg/l]	Average nitrate concentration [mg/l]	Average relative amount of detritus [-]	Average depth [m]
Group I (n = 13)	2 (± 1)	11.5 (± 1.3)	0.1 (± 0.1)	5.4 (± 3.9)	1.8 (± 0.8)	13.9 (± 4.5)
Group II (n = 14)	3 (± 1)	15.0 (± 1.5)	0.3 (± 0.6)	9.1 (± 3.7)	1.7 (± 0.7)	12.4 (± 2.3)
Group III (n = 9)	3 (± 1)	14.1 (± 1.8)	0.1 (± 0.1)	4.9 (± 3.9)	1.8 (± 0.8)	10.7 (± 1.5)
Group IV(n = 3)	2 (± 1)	13.9 (± 1.0)	0.1 (± 0.0)	3.9 (± 3.4)	3.0 (± 0.0)	22.6 (± 11.7)

Table S5: Results of the Mann-Whitney-Tests from the four groups of the PHATE analysis.

	Amount crustaceans (acc. to Griebler et al. (2014)) [%]	Amount oligochaetes (acc. to Griebler et al. (2014)) [%]	Numbers of taxa [-]	Total amount of individuals [-]	Shannon diversity [-]	Abundance *Amphipoda* [-]	Abundance *Cyclopoida* [-]	Abundance *Parastenocaris* [-]	Abundance *Bathynellacea* [-]
Group I vs. II (n = 13;14)	1.3×10^{-1}	1.3×10^{-1}	1.5×10^{-2}	2.0×10^{-1}	3.2×10^{-1}	7.4×10^{-1}	5.6×10^{-1}	7.2×10^{-1}	4.0×10^{-1}
Group I vs. III (n = 13;9)	4.0×10^{-6}	4.0×10^{-6}	2.7×10^{-2}	2.4×10^{-1}	3.9×10^{-1}	2.0×10^{-1}	8.9×10^{-4}	3.7×10^{-1}	6.8×10^{-1}
Group IV vs. I (n = 3;13)	3.6×10^{-3}	1.3×10^{-1}	1.1×10^{-2}	3.6×10^{-3}	2.0×10^{-1}	7.9×10^{-1}	7.1×10^{-2}	1.0	1.0
Group II vs. III (n = 14;9)	2.5×10^{-6}	2.5×10^{-6}	9.8×10^{-7}	3.4×10^{-2}	3.3×10^{-2}	4.1×10^{-1}	1.4×10^{-4}	2.3×10^{-1}	1.2×10^{-1}
Group IV vs. II (n = 3;14)	2.9×10^{-3}	1.2×10^{-2}	2.9×10^{-3}	2.9×10^{-3}	2.9×10^{-2}	1.0	2.9×10^{-2}	8.4×10^{-1}	6.5×10^{-1}
Group IV vs. III (n = 3;9)	1.0	9.1×10^{-3}	4.6×10^{-2}	2.7×10^{-2}	7.6×10^{-1}	1.0	1.0	1.0	1.0

	Geological unit [-]	GWT [°C]	Phosphate concentration [mg/l]	Nitrate concentration [mg/l]	Relative amount of detritus [-]	Depth [m]
Group I vs. II (n = 13;14)	8.2×10^{-3}	2.0×10^{-5}	5.2×10^{-1}	1.2×10^{-2}	6.1×10^{-1}	2.8×10^{-1}
Group I vs. III (n = 13;9)	1.5×10^{-1}	3.8×10^{-3}	1.0	9.9×10^{-1}	9.7×10^{-1}	7.4×10^{-2}
Group IV vs. I (n = 3;13)	4.8×10^{-1}	2.1×10^{-2}	3.6×10^{-3}	6.1×10^{-1}	7.1×10^{-1}	2.2×10^{-1}
Group II vs. III (n = 14;9)	4.4×10^{-1}	3.2×10^{-1}	7.2×10^{-1}	4.5×10^{-2}	8.5×10^{-1}	9.4×10^{-2}
Group IV vs. II (n = 3;14)	3.5×10^{-1}	2.8×10^{-1}	2.9×10^{-2}	9.1×10^{-2}	2.9×10^{-2}	1.1×10^{-1}
Group IV vs. III (n = 3;9)	8.4×10^{-1}	9.6×10^{-1}	9.1×10^{-3}	1.7×10^{-1}	9.1×10^{-2}	1.8×10^{-2}

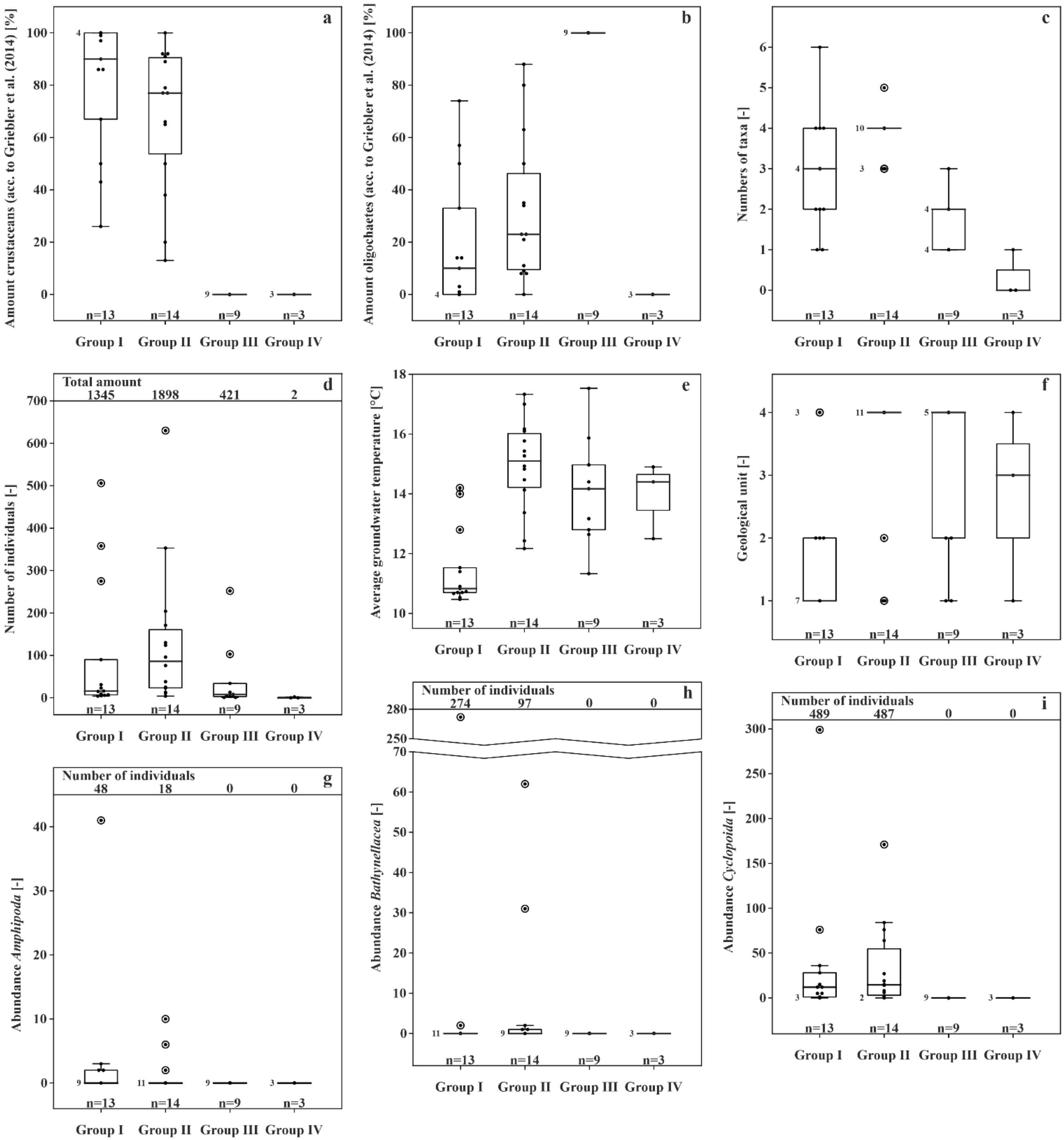

Figure S3. Boxplots of: (a) Amount of crustaceans [%] and (b) oligochaetes [%] according to the scheme of Griebler et al. (2014); (c) numbers of Taxa [-]; (d) number of individuals [-]; (e) average GWT of the repeated measurements at the bottom of the measurement wells [%] and (f) geological unit [-]; (g) Abundance of the order *Amphipoda* [-]; (h) of the order *Bathynellacea* [-] and (i) of the order *Cyclopoida* [-], divided into four groups according to the PHATE visualization (n = number of wells).

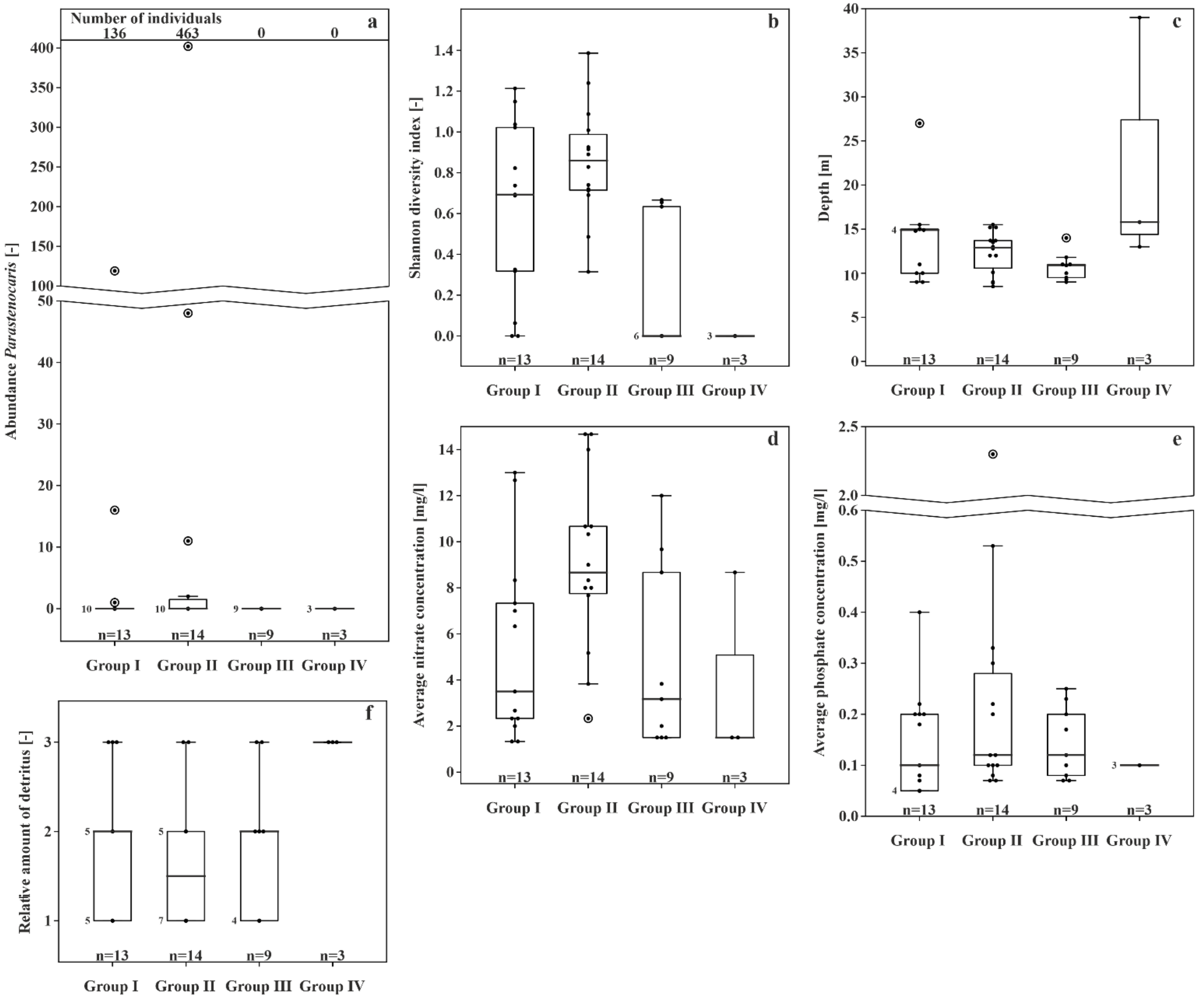

Figure S4. Boxplots of: (a) Abundance of the genus Parastenocaris [-]; (b) Shannon diversity index [-]; (c) depth of the measurement wells [m]; (d) of the average nitrate concentration [mg/l]; (e) average phosphate concentration [mg/l] of the repeated measurements at the bottom of the measurement wells and (f) of the relative amount of detritus [-], divided into four groups according to the PHATE visualization (n = number of wells).

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