

In most cases, groundwater or surface waters are the most important transport medium when monitoring EB. For this reason, in the EB monitoring, sampling and analytical work concentrate on the aquatic environment. In general, in the chemical composition of groundwater and surface water, the presence of calcium predominates in the case of macro-element cations, followed by sodium, magnesium and potassium. The anions are dominated by bicarbonates, followed by sulphates, chlorides and nitrates. The basic chemical composition of water is often changed in the areas of environmental burdens and is shifted from standard types (e.g. Ca-Mg-HCO₃ type) to those with a higher proportion of substances of secondary origin (Na⁺, Cl⁻, SO₄²⁻). There is a clear variability of the values of all mentioned indicators reflecting very different conditions of formation of chemical composition of groundwaters and surface waters.

Pollution often occurs in areas of environmental burdens by increasing the values of **total dissolved solids**. The average **conductivity** in water reflecting the solute content was calculated at 118 mS.m⁻¹, which means an increased value compared to waters with a dominant natural formation of chemical composition. The occurrence of extreme conductivity values above 300 mS.m⁻¹ (884 measurements) or above 1,000 mS.m⁻¹ (117 measurements) is quite frequent (the maximum measured value reached 28,600 mS.m⁻¹; Ružomberok – SCP site). Sites with the highest conductivity values in water (above 1,000 mS.m⁻¹) are Ružomberok – SCP site (loc. no. 303), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165), Komárno – Harčáš (loc. no. 212), Nižný Hrabovec – Bukocel (loc. no. 28), Lednické Rovne – landfill Podstránie (loc. no. 66), Trnovec nad Váhom – RSTO dump (loc. no. 49), Čičava – area of agricultural cooperative (loc. no. 324), Bojná – landfill – part A (loc. no. 85).

The **pH value** of the polluted areas may vary. On average, groundwater pH was found close to neutral (7.25), but in extreme cases it reached very low values below 5 (21 measurements) or very high values above 9.5 (122 measurements). Strongly basic environment was found especially at the sites Istebné – OFZ – slug piles (loc. no. 50; maximum 13.25), Prešov – Duklianske barracks

(loc. no. 235; maximum 13.6), Žiar nad Hronom – ZSNP, a.s. – sludge field (loc. no. 142; maximum 12.267), Medzibrodie nad Oravou – landfill Široká (loc. no. 51; maximum 10.69). On the other hand, strongly acidic pH values were measured mainly at the Predajná – landfill sites (locs. no. 58, 59; minimum 1.4), Smolník – pyrite ore extraction (loc. no. 207; minimum 2.79), Polomka – wood-logging plant (loc. no. 101; minimum 3.67).

Concentrations of the group organic pollution indicator (**COD_{Mn}**) were observed in values above IT criteria at 53 sites (Tab. 4.3). Extremely high levels of COD_{Mn} (above 50 mg.l⁻¹) were found at the sites Lednické Rovne – Podstránie dump (loc. no. 66), Bojná – landfill – part A (loc. no. 85), Plešivec – retention reservoirs (loc. no. 104), Hnúšťa – former SLZ factory (loc. no. 116), Žiar nad Hronom – ZSNP sludge field (loc. no. 142), Hrabovčik – landfill (loc. no. 160), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165), Jestice – pesticide storage (loc. no. 305), Jarabina – storage of agrochemicals (loc. no. 314), Komárany – storage of agrochemicals (loc. no. 326).

Pollution from landfills as well as some other types of contamination is associated with the occurrence of high levels (above IT) of **boron** (11 sites), **chlorides** (40 sites), **NH₄⁺** (87 sites) and **conductivity** (52 sites).

Extremely high contents of **boron** (above 5 mg.l⁻¹) were observed especially at the sites Medzibrodie nad Oravou – landfill Široká (loc. no. 51), Snina – dump (loc. no. 64), Bojná – landfill – part A (loc. no. 85), Trnovec nad Váhom – pond America I (loc. no. 137), Žakovce – dump Úsvit (loc. no. 155), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165). Extremely high levels of **chlorides** (above 2000 mg.l⁻¹) were observed mainly at sites Nováky – Chemical plants (loc. no. 1), Trnovec nad Váhom – RSTO dump (loc. no. 49), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165), Prešov – Solivary (loc. no. 298). Extremely high levels of **NH₄⁺** (above 100 mg.l⁻¹) were monitored at sites Trnovec nad Váhom – RSTO dump (loc. no. 49), Lednické Rovne – Podstránie dump (loc. no. 66), Bojná – landfill – part A (loc. no. 85), Komárno – Madzagoš (loc. no. 109), Šaľa – Duslo – production of LAD and ammonium nitrate (loc. no. 149), Komárno – Harčáš (loc. no. 212), Bošany

– tannery dump I (loc. no. 229), Žilina – Eastern Industrial Zone (loc. no. 251), Šurice – pesticide storage (loc. no. 281), Jarabina - agrochemical storage (loc. no. 312), Sačurov – old steam mill (loc. no. 327).

Among the organic substances, chlorinated hydrocarbons appear to be the most problematic within monitored EB, especially **cis- 1,2-dichloroethene** (29 sites above the IT value), **dichloromethane** (12 sites above the IT value), **tetrachloroethene** (39 sites above the IT value), **trichloroethene** (21 sites above the IT value) and **chloroethene** (26 sites above IT value).

Very high contents of cis- 1,2-dichloroethene (above 1 mg.l⁻¹) were found at the sites Zlaté Moravce – Calex (loc. no. 35), Banská Bystrica – Uľanka – chemical plant (loc. no. 38), Detva – PPS Group (loc. no. 40), Lučenec – laundries and dry cleaners (loc. no. 71), Žilina – east industrial zone (loc. no. 251), Pukanec – sludge dump Hampoch (loc. no. 254), Prešov – former ZPA plant (loc. no. 296).

Very high contents of dichloromethane (above 0.02 mg.l⁻¹) were observed at the sites Nováky – Chemical plants (loc. no. 1), Bratislava – CHZJD chemical plants (loc. no. 6), Piešťany – Chirana (loc. no. 22), Banská Bystrica – Uľanka – Chemika (loc. no. 38), Lučenec – laundries and dry cleaners (loc. no. 71), Bratislava – Vrakuňa – landfill CHZJD (loc. no. 203), Levice – laundries and dry cleaners (loc. no. 217), Považská Bystrica – area of former Považské Engineering Works (loc. no. 227), Žilina – east industrial zone (loc. no. 251).

Very high levels of tetrachloroethene (above 1 mg.l⁻¹) were found at the sites Zlaté Moravce – Calex (loc. no. 35), Detva – PPS Group (loc. no. 40), Lučenec – laundries and dry cleaners (loc. no. 71), Banská Bystrica – former LOBB galvanizing plant (loc. no. 96), Rožňava – chlorinated hydrocarbon cloud at barracks (loc. no. 103), Pukanec – sludge dump Hampoch (loc. no. 254).

Very high contents of trichloroethene (above 1 mg.l⁻¹) were observed at the sites Zlaté Moravce – Calex (loc. no. 35), Banská Bystrica – Uľanka – chemical plant (loc. no. 38), Detva –

PPS Group (loc. no. 40), Lučenec - laundries and dry cleaners (loc. no. 71), Žilina - eastern industrial zone (loc. no. 251), Pukanec – sludge dump Hampoch (loc. no. 254), Šurany – former ELITEX and STS area (loc. no. 293), Nováky – Military Repair Company (loc. no. 294).

Very high contents of chloroethene (above 0.1 mg.l^{-1}) were found at the sites Nováky – Chemical plants (loc. no. 1), Piešťany – Chirana (loc. no. 22), Piešťany – Tesla (loc. no. 26), Kežmarok – OKTAN (loc. no. 31), Zlaté Moravce – Calex (loc. no. 35), Banská Bystrica – Uľanka – Chemika (loc. no. 38), Detva – PPS Group (loc. no. 40), Rimavská Sobota – area after Soviet Army (loc. no. 240), Žilina – east industrial zone (loc. no. 251), Pukanec – sludge dump Hampoch (loc. no. 254).

Substances from the PAH group (**polycyclic aromatic hydrocarbons**) were monitored over ID or IT criteria mainly at the sites Zvolen – Bučina – Black Impregnation (loc. no. 36), Zvolen – Bučina – Old Depot (loc. no. 81) and Medzev – Strojsmalt (loc. no. 81).

Strong oil pollution caused by high **hydrocarbon index** ($C_{10}\text{-}C_{40}$) above the IT criterion (0.5 mg.l^{-1}) was found at 35 sites. Extremely high levels of $C_{10}\text{-}C_{40}$ (above 10 mg.l^{-1}) were observed especially at the sites Bratislava – Chemika (loc. no. 4), Bratislava – Gumon (loc. no. 5), Kežmarok – OKTAN (loc. no. 31), Kysucké Nové Mesto – NN Slovakia (loc. no. 33), Zvolen – Bučina – black impregnation (loc. no. 36), Ružomberok – brick factory (loc. no. 113), Medzev – Strojsmalt (loc. no. 156), Kysucké Nové Mesto – municipal landfill (loc. no. 210), Kuchyňa – airport (loc. no. 219), Čierna nad Tisou – transshipment station (loc. no. 248), Komárno – area after Soviet Army (loc. no. 253), Trstená – former fuel store Hámričky (loc. no. 319), Žilina – ZVL area (loc. no. 331).

Slovakia is also characterized by exceeding the quality criteria for some trace inorganic elements. **Arsenic and antimony**, especially due to the inclusion of mining sites in monitoring, exceed IT criteria in groundwater at 26 sites (As) and 13 sites (Sb), respectively.

Very high concentrations of As (above 0.5 mg.l⁻¹) are mainly associated with industrial activity, these are the sites Istebné – OFZ – slug piles (loc. no. 50), Medzibrodie nad Oravou – landfill Široká (loc. no. 51), Svit – landfill Chemosvit (loc. no. 56), Bojná – landfill – part A (loc. no. 85), Bystričany – ENO – temporary tailings (loc. no. 139), Žiar nad Hronom – ZSNP sludge field (loc. no. 142), Bratislava – Vrakuňa – CHZJD landfill (loc. No. 203), Žilina - east industrial zone (loc. no. 251), Krompachy – Kovohuty (loc. no. 314). From mining sites, the highest concentrations of As were found at the sites Poproč – Petrova dolina Valley (loc. no. 213) and Pezinok – ore and old mining area (loc. no. 231).

Very high concentrations of Sb (above 0.3 mg.l⁻¹) were observed at the sites Lazisko – Liptovská Dúbrava (loc. no. 13), Dúbrava – galleries and heaps at Liptovská Dúbrava (loc. no. 14), Banská Bystrica – Uľanka – Chemika (loc. no. 38), Partizánska Ľupča – galleries and heaps at Magurka (loc. no. 78), Poproč – Petrova dolina Valley (loc. no. 213), Pezinok – ore and old mining area (loc. no. 231), Krompachy – Kovohuty (loc. no. 314).

List of environmental burdens with a significant impact on the quality of groundwater and/or surface waters from the point of view of contents that do not meet IT criteria according to the Directive of the Ministry of Environment of the Slovak Republic No. 1/2015-7, resp. the Government Regulations of the Slovak Republic no. 269/2010.

ID	Environmental burden	Indicators exceeding the IT values
1	Nováky – Chemical plants	As, Cl ⁻ , NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , conductivity, pH, benzene, chlorobenzene, dichlorobenzene, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene cis, dichloromethane, tetrachloroethene, carbon tetrachloride, trichloroethene, vinyl chloride
4	Bratislava – Chemika	NH ₄ ⁺ , COD _{Mn} , TOC, conductivity, anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, phenanthrene, chrysene, indeno(1,2,3-c,d)pyrene, dichloromethane, tetrachloroethene
5	Bratislava – Gumon	NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , anthracene, chrysene, carbon tetrachloride
6	Bratislava – Chemical plants of Juraj Dimitrov	Cl ⁻ , NH ₄ ⁺ , COD _{Mn} , TOC, pH, benzene, ethylbenzene, chlorobenzene, dichlorobenzene, trichlorobenzene, dichloromethane, tetrachloroethene, carbon tetrachloride, trichloroethene, vinyl chloride
8	Bardejov – Heavy engineering factory	1,2-dichloroethene cis, dichloromethane, tetrachloroethene, trichloroethene
20	Stropkov – TESLA	NH ₄ ⁺ , 1,2-dichloroethene cis, trichloroethene

ID	Environmental burden	Indicators exceeding the IT values
21	Nové Mesto nad Váhom – landfill Mnešice – Tušková	Cl ⁻ , NH ₄ ⁺ , TOC, conductivity, 1,2-dichloroethene cis, tetrachloroethene
22	Piešťany – Chirana	NH ₄ ⁺ , 1,2-dichloroethene cis, dichloromethane, trichloroethene, vinyl chloride
24	Sereď – Nickel plant – landfill dump	Cd, Ni
25	Sereď – Nickel plant – former factory area	Cd, Co, Ni, Zn, NH ₄ ⁺ , conductivity
26	Piešťany – Tesla – contamination plume under the housing estate	1,2-dichloroethene cis, vinyl chloride
27	Nové Zámky – Real H.M. – terminal	NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , benzene
30	Sliač – airport – south	As, COD _{Mn} , TOC, C ₁₀ -C ₄₀ , naphthalene, dichlorobenzene, tetrachloroethene
33	Kysucké Nové Mesto - NN Slovakia	Cl ⁻ , C ₁₀ -C ₄₀ , benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene
35	Zlaté Moravce – Calex	NH ₄ ⁺ , COD _{Mn} , 1,2-dichloroethene cis, 1,2-dichloroethene trans, tetrachloroethene, trichloroethene, vinyl chloride
36	Zvolen – Bučina – black impregnation	COD _{Mn} , TOC, C ₁₀ -C ₄₀ , FNI, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, fluoranthene, phenanthrene, chrysene, indeno(1,2,3-c,d)pyrene, naphthalene, pyrene
38	Banská Bystrica – Chemika	As, Sb, NH ₄ ⁺ , COD _{Mn} , TOC, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene cis, 1,2-dichloroethene trans, dichloromethane, tetrachloroethene, trichloroethene, vinyl chloride
40	Detva – PPS Group	COD _{Mn} , TOC, C ₁₀ -C ₄₀ , 1,1-dichloroethene, 1,2-dichloroethene cis, 1,2-dichloroethene trans, tetrachloroethene, trichloroethene, vinyl chloride
41	Pohorelá – Strojsmalt Holding	COD _{Mn} , tetrachloroethene
43	Zvolen – Bučina – white impregnation	NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , pH, FNI, naphthalene, tetrachloroethene
50	Istebné – OFZ – heap of debris	As, Cr, Mo, NH ₄ ⁺ , TOC, conductivity, pH
51	Medzibrodie nad Oravou – landfill Široká	As, B, Cl ⁻ , F ⁻ , NH ₄ ⁺ , TOC, conductivity, pH
58	Predajná – industrial landfill Predajná II.	Al ³⁺ , Sb, TOC, conductivity
59	Predajná – industrial landfill Predajná I.	Sb, NO ₂ ⁻ , COD _{Mn} , TOC
65	Nové Zámky – locomotive depo – diagnostic centre	conductivity, 1,2-dichloroethene cis, tetrachloroethene, vinyl chloride
71	Lučenec – Laundry and dry cleaning	NH ₄ ⁺ , pH, 1,1-dichloroethene, 1,2-dichloroethene cis, dichloromethane, tetrachloroethene, trichloroethene, vinyl chloride
81	Zvolen – Bučina – old depot	NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , anthracene, benzo(a)pyrene, benzo(k)fluoranthene, fluoranthene, phenanthrene, chrysene, naphthalene
85	Bojná – landfill – part A (old)	As, Ba, B, Cl ⁻ , NH ₄ ⁺ , COD _{Mn} , TOC, conductivity
96	Banská Bystrica – former galvanizing shop LOBB	Mo, 1,2-dichloroethene cis, tetrachloroethene, trichloroethene
103	Rožňava – plume of chlorinated hydrocarbons at barracks	Cl ⁻ , COD _{Mn} , tetrachloroethene, trichloroethene, vinyl chloride
106	Nové Zámky – Former Barracks of the Soviet Army – Novocentrum	1,2-dichloroethene cis, tetrachloroethene, trichloroethene, vinyl chloride
116	Hnúšťa – former SLZ	As, NH ₄ ⁺ , COD _{Mn} , TOC, C ₁₀ -C ₄₀ , FNI, tetrachloroethene
137	Trnovec nad Váhom – tailings Amerika I	B, Cl ⁻ , F ⁻ , NH ₄ ⁺ , TOC, conductivity
142	Žiar nad Hronom – sludge field ZSNP	As, Mo, V, F ⁻ , NH ₄ ⁺ , COD _{Mn} , TOC, conductivity, pH
147	Smolenice – Chemolak	COD _{Mn} , TOC, C ₁₀ -C ₄₀ , FNI, benzene, ethylbenzene, toluene, xylene, styrene
156	Medzev – Strojsmalt	COD _{Mn} , TOC, C ₁₀ -C ₄₀ , benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-c,d)pyrene
201	Bratislava – Ružinov – Čierny les	NH ₄ ⁺ , COD _{Mn} , TOC, conductivity, benzo(b)fluoranthene,

ID	Environmental burden	Indicators exceeding the IT values
		benzo(g,h,i)perylene, benzo(k)fluoranthene
203	Bratislava – Vrakuňa – landfill CHZJD	As, F ⁻ , NH ₄ ⁺ , NO ₂ ⁻ , TOC, C ₁₀ -C ₄₀ , conductivity, FNI, benzene, ethylbenzene, toluene, xylene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, phenanthrene, chrysene, naphthalene, pyrene, chlorobenzene, dichlorobenzene, trichlorobenzene, dichloromethane, tetrachloroethene, carbon tetrachloride, vinyl chloride, PCB
207	Smolník – pyrite ores	Al ³⁺ , As, Co, Cu, Ni, Zn, conductivity, pH
213	Poproč – Petrova dolina Valley	Al ³⁺ , As, Cd, Ni, Sb, Zn, pH
214	Jamník – barracks and airport Mokrad'	COD _{Mn} , TOC, C ₁₀ -C ₄₀ , pH, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-c,d)pyrene
223	Martin – SNP barracks	C ₁₀ -C ₄₀ , NEL-IC, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene
236	Prešov – airport	C ₁₀ -C ₄₀ , benzene, ethylbenzene, xylene
248	Čierna nad Tisou – transshipment station	Cl ⁻ , C ₁₀ -C ₄₀ , non-polar extractable substances-UV, benzene, ethylbenzene, toluene, xylene, carbon tetrachloride
251	Žilina – eastern industrial zone	As, NH ₄ ⁺ , benzene, ethylbenzene, toluene, xylene, styrene, 1,2-dichloroethene cis, 1,2-dichloroethene trans, dichloromethane, tetrachloroethene, carbon tetrachloride, trichloroethene, vinyl chloride
252	Bánovce nad Bebravou – Railway station	NH ₄ ⁺ , TOC, 1,2-dichloroethene cis, tetrachloroethene, trichloroethene
253	Komárno – area after the Soviet Army	NH ₄ ⁺ , TOC, C ₁₀ -C ₄₀ , benzene, xylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, phenanthrene, indeno(1,2,3-c,d)pyrene, naphthalene, pyrene, tetrachloroethene
256	Rimavská Sobota – area after the Soviet Army	1,2-dichloroethene cis, tetrachloroethene, trichloroethene, vinyl chloride
259	Bratislava – Nové Mesto – Heating plant II	As, NH ₄ ⁺ , TOC, conductivity, pH, FNI, benzene, chlorobenzene, dichlorobenzene, trichlorobenzene
289	Nové Mesto nad Váhom – locomotive depo	dichlorobenzene, vinyl chloride, PCB
293	Šurany – former ELITEX and STS	1,2-dichloroethene cis, tetrachloroethene, trichloroethene, vinyl chloride
294	Nováky – Military repair business	1,2-dichloroethene cis, trichloroethene
296	Prešov – former ZPA	Cl ⁻ , conductivity, 1,2-dichloroethene cis, vinyl chloride
314	Krupá – Kovohuty	Al ³⁺ , As, Cd, Co, Cu, Hg, Ni, Pb, Sb, Zn, Cl ⁻ , F ⁻ , NH ₄ ⁺ , TOC, conductivity, pH
338	Zvolen – army objects	Hg, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-c,d)pyrene
340	Brezno – Slovak Railways	TOC, C ₁₀ -C ₄₀ , non-polar extractable substances-IR, pH, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-c,d)pyrene

Notes: PAH – polycyclic aromatic hydrocarbons, C₁₀-C₄₀ – hydrocarbon index, PAL – anionic surfactants, FNI – phenol index, PCB – polychlorinated biphenyls