

4. Influence of Monitored Environmental Burdens on Groundwater and Surface Water Quality – General Results

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Abstract: Since 2012, the State Geological Institute of Dionýz Štúr has been carrying out tasks related to the monitoring of contaminated sites, so-called environmental burdens, currently at 309 sites. The aim of the work is to monitor the release of pollutants into the environment (especially groundwater and surface water) and to assess trends in the development of contamination. A large number of data on groundwater and surface water quality are collected and analysed as part of the monitoring work.

The chemical composition of water is often changed around environmental burdens and is shifting from standard types, such as Ca-HCO₃ and Ca-Mg-HCO₃, to types with a higher proportion of substances of secondary origin (Na⁺, Cl⁻, SO₄²⁻), which is reflected in the frequent occurrence of anthropogenically modified water types such as Ca-Na-Cl-HCO₃, Ca-Mg-HCO₃-SO₄, etc. Pollution is also often manifested by an increase in the total dissolved solids and high conductivity values. Due to contamination from landfills as well as some other types of contamination, frequent occurrence of increased contents of boron, Cl⁻, NH₄⁺, SO₄²⁻ and increased conductivity values are observed. Concerning the organic compounds, chlorinated hydrocarbons, especially cis-1,2-dichloroethene, dichloromethane, tetrachloroethene, trichloroethene, chloroethene, appear to be the most problematic at the sites of concern. Regarding the mining sites monitoring, elevated concentrations of some trace inorganic elements, especially As, Cu, Zn, Cd, Sb, were found above the quality criteria. The results show that up to 56 sites (approx. 18%) of environmental burdens are characterized by a significant impact on the quality of groundwater or surface waters from the point of view of contents that do not meet IT criteria according to the MoE SR Directive No. 1/2015-7 for the preparation of risk analysis of contaminated area and do not meet criteria according the Government Regulations no. (EC) No 269/2010 laying down requirements for the achievement of good water status. Up to 78 sites of EB did not detect the spread of groundwater or surface water pollution – no indicator exceeded the IT criterion according to the MoE SR Directive No. 1/2015-7 or the limit value according to Government Regulation no. 269/2010.

Key words: monitoring, environmental burdens, chemical composition, quality, groundwater, surface water

4.1 Introduction

Since 2012, the State Geological Institute of Dionýz Štúr (SGIDŠ) has been carrying out tasks related to the monitoring of contaminated sites, so-called environmental burdens (EB), currently at 309 sites (Fig. 1.1, article 1 of this volume). The aim of the work is to monitor the release of pollutants into the environment (especially groundwater and surface water) and to assess trends in the development of contamination. The sites concerned are areas of various industrial enterprises, railway areas, abandoned and buried

waste dumps, unsecured pesticide and other hazardous substance storages, military areas, sites affected by mineral extraction and their processing and others.

In recent years, the systematic attention has been paid to the issue of EB both in Slovakia and abroad. Quite complexly, the issue of exploration, monitoring and remediation of EB is described in the work Šottník et al. (2015). Between 2012 and 2015, a number of detailed geological investigations of selected EB were carried out which also included an assessment of the risk analysis of the polluted area, such as works of Urban et al. (2015): Vrakunská cesta – CHZJD landfill; Tupý et al. (2015a): Martin – SNP army barracks; Pramuk et al. (2015a): Žilina – eastern industrial zone; Pospiechová et al. (2015): Krompachy – Kovohuty. In the mining areas survey was carried out, for example, in locations Poproč – Petrova dolina Valley (Auxt et al., 2015a), Smolník – mining of pyrite ores (Auxt et al., 2015b), Rudňany – ore mining and treatment (Pramuk & Matiová, 2015), Pezinok – the area of ore mines and old mining works (Tupý et al., 2015b), Slovinky – ore mining and treatment (Pramuk et al., 2015b).

One of the pilot works in monitoring of the EB was the geological task titled “Monitoring of impact of EB on geological factors of the environment in selected Western Carpathians regions” (Vybiral et al., 2005). The aim of this task was to use new methodologies and techniques of exploration and monitoring, to assess impacts of anthropogenic sediments to environment, to determine qualitative and quantitative parameters of pollution, extent and degree of pollution of the rock environment and to establish temporal and spatial trends in pollution spread. Among other works related to monitoring of the EB impact can be mentioned, for example, at the site Bekaert Hlohovec, joint stock company (Pospiechová et al., 2014), pollution monitoring in ENO Nováky (Ingár & Auxt, 2017) and monitoring in TESLA Stropkov, joint stock company (Bachňák, 2019). The system for the detection and monitoring of environmental damage arising from mining activities was developed by Vrana et al. (2005). Abroad, the issue of the EB monitoring is described, for example, in works by Akankpo & Igboekwe (2011), Golder Associates (2010), Narany et al. (2014), Texas Groundwater Protection Committee (2013), Brown et al. (2014), DSITI (2017), McLean et al. (2019).

Monitoring of environmental burdens in Slovakia follows the results of several geological tasks of the

Ministry of Environment of the Slovak Republic. In 2006 – 2008 the geological task of Systematic Identification of Environmental Burdens of the Slovak Republic (Paluchová et al., 2008; www.enviroportal.sk) was carried out. The results of the above project were followed in 2009 by the project “Regional Studies of Impact of Environmental Burdens to Environment” (Helma, 2010), the aim of which was a detailed assessment of the impact of environmental burdens to environment in individual self-governing regions of the Slovak Republic. Since 2016, monitoring of EB in Slovakia is carried out mainly in connection with the projects financed from the Operational Programme Environment:

- Monitoring of Environmental Burdens at Selected Sites in Slovakia (Kordík & Slaninka et al., 2015).
- Investigation of Environmental Burdens at Selected Sites in the Slovak Republic – 54 sites (2012 – 2015).
- Probable environmental burdens – investigation at selected sites in the Slovak Republic – 87 sites (2014 – 2015).
- Projects of Remediation of Environmental Burdens at Selected 19 sites (2013 – 2015).

By carrying out these geological tasks, detailed data on pollution, spatial development and pollution changes, natural attenuation of contamination and detailed interpretation of the data were obtained.

In the article, attention is paid to selected results of monitoring of environmental burdens focused on groundwater and surface water. The basic statistical processing of selected physico-chemical indicators determined in waters and the comparison of analytical results with legislation (in particular with the Directive of the Ministry of Environment of the Slovak Republic No. 1/2015-7 on elaboration of the risk analysis of contaminated

area, or Government Regulation No. 269/2010 laying down requirements for achieving good water status) are stated.

4.2 Methods

Monitoring of groundwaters and surface waters in areas of environmental burdens is a systematic observation of time changes of concentrations of selected pollutants indicative for a given site. Monitoring of EB is carried out in accordance with EU legislation, in particular Directive 2000/60/EC of the European Parliament and of the Council of 28 October 2000 establishing a framework for Community action in the field of water policy and Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration.

Implementation of the monitoring itself is preceded by the establishment of a **monitoring programme**, in which field measurements, sampling and laboratory work carried out in a defined monitoring network were carried out. The monitoring programme is reviewed and updated annually based on new results and information. **Water sampling** is performed on the basis of the procedures specified in the relevant Slovak Technical Standards (STN) of the STN EN ISO 5667 series. The following physico-chemical properties are usually determined directly in the field: water temperature, air temperature, pH, specific electrolytic conductivity (at 25 °C), dissolved oxygen content, percentage oxygen saturation, groundwater level (if relevant), or other indicators. An overview of realized field measurements in groundwaters and surface waters for the period 2012 – 2018 is given in Tab. 4.1.

Laboratory analyses of water samples are implemented according to a proposed monitoring programme and are carried out in the Geoanalytical Laboratories of

Tab. 4.1 Number of realized field measurements in groundwaters and surface waters for the period 2012 – 2018

	Boreholes drilled in 2014 – 2015	Reconstructed boreholes	Old boreholes	Other groundwater sources – house-hold wells, springs	Surface water	Total
Groundwater level	12,357	1,692	2,178	217	-	16,454
pH	10,806	1,296	1,580	471	1,719	15,872
Specific electrolytic conductivity	13,060	1,695	2,323	633	2,340	20,051
Dissolved oxygen	11,598	1,421	1,798	523	2,033	17,373
Oxygen saturation	10,409	1,313	1,459	464	1,775	15,420
Water temperature	13,129	1,652	2,287	629	2,330	20,027
Air temperature	11,515	1,533	1,859	566	2,158	17,631
Eh	6,670	439	998	273	996	9376
Sensorial properties (descriptive)	11,157	1,406	1,705	514	1,924	16,706

SGIDŠ (GALs), Regional Centre Spišská Nová Ves. The GALs performs a complete service of analytical, physico-chemical and mineralogical works for the needs of geological research and investigation, exploration of mineral resources, regional geology, hydrogeology, geochemical mapping and environmental monitoring. The GALs are an accredited testing laboratory in accordance with ISO/IEC 17025: 2005 and were established in 1997 as the Reference Laboratory of the Ministry of the Environment of the Slovak Republic for geology and analysis of geological materials and the rock environment. The quality assurance and quality control system in the laboratory are designed to ensure that the tests performed give correct results with declared accuracy. The control system includes, in particular, internal and external control analyses, the use of certified reference materials, repetition of tests by different analytical methods, operator verification, regular participation in interlaboratory comparisons and proficiency testing programs, testing long-term stability of measuring systems.

Overview of the number of the most frequently determined chemical indicators in waters in 2012 – 2018 is presented together with the basic statistical parameters of selected physico-chemical indicators analysed in waters in Tab. 4.2.

The results of analytical analyses of groundwaters and surface waters (selected physico-chemical indicators) are **statistically processed and compared with legislation** (for groundwater with indicating and intervention criteria given in the Directive of the Ministry of Environment of the Slovak Republic No. 1/2015-7 on elaboration of the risk analysis of contaminated area and for surface water with the limit values given in the Government Regulation No. 269/2010 laying down requirements for achieving good water status).

Methodological procedures used in the groundwater and surface water monitoring in the areas of EB are in more details listed in the article 1 of this issue of the journal and in Kordík & Slaninka et al. (2015).

4.3 Results

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. Tab. 4.2 shows the basic statistical parameters of selected physico-chemical parameters determined in waters, Tab. 4.3 shows a number of exceedances of IT and ID values of selected indicators in groundwater according to the Directive of the Ministry of Environment of the Slovak Republic No. 1/2015-7 and Tab. 4.4 shows a number of exceedances of limit values of selected indicators in surface waters pursuant to the Government Regulation No. 269/2010 laying down requirements for the achievement of good water status.

In general, in the chemical composition of groundwater and surface water, the presence of calcium predominates in the case of macro-element cations, with an average content of 120 mg.l⁻¹, followed by sodium (average 58.5 mg.l⁻¹), magnesium (average 35.6 mg.l⁻¹)

and potassium (mean 16.3 mg.l⁻¹) – Tab. 4.2. The anions are dominated by bicarbonates (average 400 mg.l⁻¹), followed by sulphates (average 135 mg.l⁻¹), chlorides (average 110 mg.l⁻¹) and nitrates (average 24.9 mg.l⁻¹). 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⁻). As shown in Tab. 4.2, 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 EB 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 (Tab. 4.2). 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 (producer of paper and pulp, loc. no. 303), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165; maximum 3,230 mS.m⁻¹), Komárno – Harčáš (loc. no. 212; maximum 2,719 mS.m⁻¹), Nižný Hrabovec – Bukocel (loc. no. 28; maximum 2,870 mS.m⁻¹), Lednické Rovne – landfill Podstránie (loc. no. 66; maximum 2,130 mS.m⁻¹), Trnovec nad Váhom – RSTO dump (loc. no. 49; maximum 1,539 mS.m⁻¹), Čičava – area of agricultural cooperative (loc. no. 324; maximum 1,340 mS.m⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 1,227 mS.m⁻¹).

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). However, extreme pH values are usually limited spatially, as processes in the rock environment have the potential to adjust the pH in the waters towards neutral values.

From Tab. 4.3 it is evident that the most exceedances of IT value was found in the case of **TOC** (2,004 determinations at 103 sites), which is also influenced by the strict (low) IT limit for TOC (5 mg.l⁻¹). Pollution with organic substances (which is indicated by TOC) is relatively frequent in Slovakia, especially at sites such as municipal landfills and oil pollution areas or other contamination sources. The highest content of TOC (1,460 mg.l⁻¹) was found at the

site Komárno – area after the Soviet Army (loc. no. 253). Extremely high levels of TOC (above 50 mg.l⁻¹) were also determined at the Predajná – industrial landfill Predajná I. (loc. no. 59; maximum 253.8 mg.l⁻¹), Krompachy – Kovohuty (former smelting plant, loc. no. 314; maximum 395 mg.l⁻¹), Lednické Rovne – Podstránie dump (loc. no. 66; maximum 1,300 mg.l⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 296 mg.l⁻¹), Komárno – Madzagoš (loc. no. 109; maximum 104 mg.l⁻¹), Hnúšťa – former SLZ factory (loc. no. 116; maximum 83.5 mg.l⁻¹), Bratislava – Vrakuňa – CHZJD landfill (loc. no. 203; maximum 218,8 mg.l⁻¹).

Similarly to TOC, concentrations of the next group organic pollution indicator (**COD_{Mn}**) were observed in values above IT 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; maximum 408 mg.l⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 150.1 mg.l⁻¹), Plešivec – retention reservoirs (loc. no. 104; maximum 118 mg.l⁻¹), Hnúšťa – former SLZ factory (loc. no. 116; maximum 104.5 mg.l⁻¹), Žiar nad Hronom – ZSNP sludge field (loc. no. 142; maximum 95 mg.l⁻¹), Hrabovčik – landfill (loc. no. 160; maximum 81 mg.l⁻¹), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165; maximum 95.8 mg.l⁻¹), Jestice – pesticide storage (loc. no. 305; maximum 88.5 mg.l⁻¹), Jarabina – storage of agrochemicals (loc. no. 314; maximum 99.2 mg.l⁻¹), Komárany – storage of agrochemicals (loc. no. 326; maximum 1,176 mg.l⁻¹).

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), **Cl⁻** (40 sites), **NH₄⁺** (87 sites) and **conductivity** (52 sites) – Tab. 4.3.

Extremely high contents of B (above 5 mg.l⁻¹) were observed especially at the sites Medzibrodie nad Oravou – landfill Široká (loc. no. 51; maximum 68 mg.l⁻¹), Snina – dump (loc. no. 64; maximum 123.8 mg.l⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 7.84 mg.l⁻¹), Trnovec nad Váhom – pond America I (loc. no. 137; maximum 6.39 mg.l⁻¹), Žakovce – dump Úsvit (loc. no. 155; maximum 10.35 mg.l⁻¹), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165; maximum 9.67 mg.l⁻¹). Extremely high levels of Cl⁻ (above 2,000 mg.l⁻¹) were observed mainly at sites Nováky – Chemical plants (loc. no. 1; maximum 4,140 mg.l⁻¹), Trnovec nad Váhom – RSTO dump (loc. no. 49; maximum 4,557 mg.l⁻¹), Hlohovec – Šulekovo – Fe-sludge (loc. no. 165; maximum 13,000 mg.l⁻¹), Prešov – Solivary (loc. no. 298; maximum 7,750 mg.l⁻¹). Extremely high levels of NH₄⁺ (above 100 mg.l⁻¹) were monitored at sites Trnovec nad Váhom – RSTO dump (loc. no. 49; maximum 185 mg.l⁻¹), Lednické Rovne – Podstránie dump (loc. no. 66; maximum 852 mg.l⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 779 mg.l⁻¹), Komárno – Madzagoš (loc. no. 109; maximum 259 mg.l⁻¹), Šaľa – Duslo – production of LAD and ammonium nitrate (loc. no. 149; maximum 164 mg.l⁻¹), Komárno – Harčáš (loc. no. 212; maximum 271 mg.l⁻¹), Bošany – tannery dump I (loc. no. 229; maximum 1,158 mg.l⁻¹), Žilina – Eastern Industrial Zone (loc. no. 251; maximum 353 mg.l⁻¹), Šurice – pesticide storage (loc. no. 281; maximum 558 mg.l⁻¹), Jarabina – agrochemical storage (loc. no. 312;

maximum 247 mg.l⁻¹), Sačurov – old steam mill (loc. no. 327; maximum 879 mg.l⁻¹).

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) – Tab. 4.3.

Very high contents of cis- 1,2-dichloroethene (above 1 mg.l⁻¹) were found at the sites Zlaté Moravce – Calex (loc. no. 35; maximum 34.19 mg.l⁻¹), Banská Bystrica – Uľanka – chemical plant (loc. no. 38; maximum 64.911 mg.l⁻¹), Detva – PPS Group (loc. no. 40; maximum 6.144 mg.l⁻¹), Lučenec – laundries and dry cleaners (loc. no. 71; maximum 2.53 mg.l⁻¹), Žilina – east industrial zone (loc. no. 251; maximum 27.33 mg.l⁻¹), Pukanec – sludge dump Hampoch (loc. no. 254; maximum 2.488 mg.l⁻¹), Prešov – former ZPA plant (loc. no. 296; maximum 2.357 mg.l⁻¹).

Very high contents of dichloromethane (above 0.02 mg.l⁻¹) were observed at the sites Nováky – Chemical plants (loc. no. 1; maximum 0.048 mg.l⁻¹), Bratislava – CHZJD chemical plants (loc. no. 6; maximum 0.6 mg.l⁻¹), Piešťany – Chirana (loc. no. 22; maximum 0.0565 mg.l⁻¹), Banská Bystrica – Uľanka – Chemika (loc. no. 38; maximum 0.6 mg.l⁻¹), Lučenec – laundries and dry cleaners (loc. no. 71; maximum 0.06 mg.l⁻¹), Bratislava – Vrakuňa – landfill CHZJD (loc. no. 203; maximum 0.6 mg.l⁻¹), Levice – laundries and dry cleaners (loc. no. 217; maximum 0.0259 mg.l⁻¹), Považská Bystrica – area of former Považské Engineering Works (loc. no. 227; maximum 0.064 mg.l⁻¹), Žilina – east industrial zone (loc. no. 251; maximum 0.0363 mg.l⁻¹).

Very high levels of tetrachloroethene (above 1 mg.l⁻¹) were found at the sites Zlaté Moravce – Calex (loc. no. 35; maximum 6.482 mg.l⁻¹), Detva – PPS Group (engineering industry, loc. no. 40; maximum 6.312 mg.l⁻¹), Lučenec – laundries and dry cleaners (loc. no. 71; maximum 35.105 mg.l⁻¹), Banská Bystrica – former LOBB galvanizing plant (loc. no. 96; maximum 3.364 mg.l⁻¹), Rožňava – chlorinated hydrocarbon cloud at barracks (loc. no. 103; maximum 1.706 mg.l⁻¹), Pukanec – sludge dump Hampoch (loc. no. 254; maximum 23.159 mg.l⁻¹).

Very high contents of trichloroethene (above 1 mg.l⁻¹) were observed at the sites Zlaté Moravce – Calex (loc. no. 35; maximum 85.2 mg.l⁻¹), Banská Bystrica – Uľanka – chemical plant (loc. no. 38; maximum 64.4 mg.l⁻¹), Detva – PPS Group (loc. no. 40; maximum 14.475 mg.l⁻¹), Lučenec – laundries and dry cleaners (loc. no. 71; maximum 7.056 mg.l⁻¹), Žilina – eastern industrial zone (loc. no. 251; maximum 8.215 mg.l⁻¹), Pukanec – sludge dump Hampoch (loc. no. 254; maximum 1.74 mg.l⁻¹), Šurany – former ELITEX and STS area (loc. no. 293; maximum 2.32 mg.l⁻¹), Nováky – Military Repair Company (loc. no. 294; maximum 40.67 mg.l⁻¹).

Very high contents of chloroethene (above 0.1 mg.l⁻¹) were found at the sites Nováky – Chemical plants (loc. no. 1; maximum 6.973 mg.l⁻¹), Piešťany – Chirana (producer of medical devices, loc. no. 22; maximum 0.76 mg.l⁻¹),

Piešťany – Tesla (loc. no. 26), Kežmarok – OKTAN (loc. no. 31; maximum 0.477 mg.l⁻¹), Zlaté Moravce – Calex (engineering, production of refrigerators, loc. no. 35; maximum 5.186 mg.l⁻¹), Banská Bystrica – Uľanka – Chemika (loc. no. 38; maximum 9.84 mg.l⁻¹), Detva – PPS Group (loc. no. 40; maximum 0.38 mg.l⁻¹), Rimavská Sobota – area after Soviet Army (loc. no. 240; maximum 0.206 mg.l⁻¹), Žilina – east industrial zone (loc. no. 251; maximum 37.983 mg.l⁻¹), Pukanec – sludge dump Hampoch (loc. no. 254; maximum 0.42 mg.l⁻¹).

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

Strong oil pollution caused by high **hydrocarbon index** (C₁₀-C₄₀) above the IT criterion (0.5 mg.l⁻¹) was found at 35 sites (Tab. 4.3). Extremely high levels of C₁₀-C₄₀ (above 10 mg.l⁻¹) were observed especially at the sites Bratislava – Chemika (loc. no. 4; maximum 4,715 mg.l⁻¹), Bratislava – Gumon (loc. no. 5; maximum 1,410 mg.l⁻¹), Kežmarok – OKTAN (loc. no. 31; maximum 126 mg.l⁻¹), Kysucké Nové Mesto – NN Slovakia (loc. no. 33; maximum 206 mg.l⁻¹), Zvolen – Bučina – black impregnation (loc. no. 36; maximum 227 mg.l⁻¹), Ružomberok – brick factory (loc. no. 113; maximum 30.8 mg.l⁻¹), Medzev – Strojsmalt (loc. no. 156; maximum 302 mg.l⁻¹), Kysucké Nové Mesto – municipal landfill (loc. no. 210; maximum 21.6 mg.l⁻¹), Kuchyňa – airport (loc. no. 219; maximum 5,110 mg.l⁻¹), Čierna nad Tisou – transshipment station (loc. no. 248; maximum 689 mg.l⁻¹), Komárno – area after Soviet Army (loc. no. 253; maximum 1,730 mg.l⁻¹), Trstená – former fuel store Hámričky (loc. no. 319; maximum 18.4 mg.l⁻¹), Žilina – ZVL area (loc. no. 331; maximum 23.3 mg.l⁻¹).

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 (Tab. 4.3).

Very high concentrations of As (above 0.5 mg.l⁻¹) are mainly associated with industrial activity, these are the sites Itebné – OFZ – slug piles (loc. no. 50; maximum 2.054 mg.l⁻¹), Medzibrodie nad Oravou – landfill Široká (loc. no. 51; maximum 7.8 mg.l⁻¹), Svät – landfill Chemosvit (loc. no. 56; maximum 1.25 mg.l⁻¹), Bojná – landfill – part A (loc. no. 85; maximum 2.3 mg.l⁻¹), Bystričany – ENO – temporary tailings (loc. no. 139; maximum 3.047 mg.l⁻¹), Žiar nad Hronom – ZSNP sludge field (loc. no. 142; maximum 1.494 mg.l⁻¹), Bratislava – Vračuňa – CHZJD landfill (loc. No. 203; maximum 1.31 mg.l⁻¹), Žilina – east industrial zone (loc. no. 251; maximum 1.96 mg.l⁻¹), Kropachy – Kovohuty (loc. no. 314; maximum 2.01 mg.l⁻¹). From mining sites, the highest concentrations of As were found at the sites Poproč – Petrova dolina Valley (loc. no. 213; maximum 7.25 mg.l⁻¹) and Pezinok – ore and old mining area (loc. no. 231; maximum 0.645 mg.l⁻¹).

Very high concentrations of Sb (above 0.3 mg.l⁻¹) were observed at the sites Lazisko – Liptovská Dúbrava (loc. no. 13; maximum 0.49 mg.l⁻¹), Dúbrava – galleries and heaps

at Liptovská Dúbrava (loc. no. 14; maximum 11.3 mg.l⁻¹), Banská Bystrica – Uľanka – Chemika (loc. no. 38; maximum 0,326 mg.l⁻¹), Partizánska Ľupča – galleries and heaps at Magurka (loc. no. 78; maximum 0.642 mg.l⁻¹), Poproč – Petrova dolina Valley (loc. no. 213; maximum 7.176 mg.l⁻¹), Pezinok – ore and old mining area (loc. no. 231; maximum 0.518 mg.l⁻¹), Kropachy – Kovohuty (loc. no. 314; maximum 2.2 mg.l⁻¹).

Exceedance the IT criterion for **aluminum** was found in groundwater at 16 sites (Tab. 4.3). The IT criterion for Al³⁺ (0.4 mg.l⁻¹) seems to be too strict, as in Slovakia the natural concentration of Al³⁺ up to 0.5 mg.l⁻¹ is quite common. Very high levels of aluminum in groundwater (above 2 mg.l⁻¹) were measured at the sites Krásny Brod – Monastýr dump (loc. no. 132; maximum 7.64 mg.l⁻¹), Smolník – pyrite ores (loc. no. 207; maximum 110 mg.l⁻¹), Poproč – Petrova dolina Valley (loc. no. 213; maximum 30.48 mg.l⁻¹), Dežerice – VAB sludge basin (loc. no. 261; maximum 8.33 mg.l⁻¹).

Less problematic indicators in our monitored sites include some trace elements (Co, Cr, Cu, Hg, Mo, Pb, V), fluorides, nitrites, cyanides, phenols, chlorobenzenes, substances of BTEX and PCB.

From the point of view of physico-chemical indicators measured in situ in **surface waters**, a rather frequent phenomenon is the deteriorated quality of surface water caused by the deterioration of oxygen regime (38 sites) and occurrence of high values of conductivity (46 sites) and pH (45 sites) – Tab. 4.4. Pollution from landfills as well as some other types of contamination (e.g. agriculture) is associated with increased levels of Cl⁻ (16 sites), NH₄⁺ (35 sites), SO₄²⁻ (19 sites), Na⁺ (22 sites), Ca²⁺ (37 sites), Mn²⁺ (32 sites), NO₃⁻ (24 sites) and conductivity (46 sites). Among the trace elements in surface waters, above-limit contents of As (29 sites), Cr (15 sites), Al³⁺ (26 sites), Cu (19 sites) and Zn (14 sites) were observed.

Specific organic substances were found in **surface water** at above-limit concentrations as follows:

cis- 1,2-dichloroethene (18 sites) – the most: Lučenec – laundries and dry cleaners (loc. no. 71; maximum 0.26 mg.l⁻¹), Zubrohlava – sludge field – heavy engineering factories Námestovo (loc. no. 15; maximum 0.0766 mg.l⁻¹), Zlaté Moravce – Calex (loc. no. 35; maximum 0.281 mg.l⁻¹), Banská Bystrica – Uľanka – chemical plant (loc. no. 38; maximum 0.0365 mg.l⁻¹), chlorobenzene: Bratislava – CHZJD chemical plants (loc. no. 6; maximum 0.053 mg.l⁻¹),

- dichlorobenzene: Predajná – industrial dump Predajná I. (loc. no. 59; maximum 0.0088 mg.l⁻¹),
- benzene, toluene and xylenes: Pozdišovce – former state material reserves (loc. no. 221; maximum 0.198 mg.l⁻¹ for benzene; maximum 0.549 mg.l⁻¹ for toluene; maximum 0.556 mg.l⁻¹ for xylenes),
- substances from the PAH group (acenaphthene, anthracene, dibenzo(a,h)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, phenanthrene, fluoranthene, fluorene, chrysene, indeno(1,2,3-c,d)pyrene, naphthalene, pyrene): Zvolen – Bučina – black impregnation (loc. no. 36), Predajná – industrial

dump Predajná II. (loc. no. 58), Zvolen – Bučina – old depot (loc. no. 81), Polomka – woodworking plant (loc. no. 101),

- dichloromethane: Piešťany – Chirana (loc. no. 22; maximum 0.0825 mg.l⁻¹), Rimavská Sobota – Gemer nákup (loc. no. 112; maximum 0.0233 mg.l⁻¹),
- tetrachloroethene: Zlaté Moravce – Calex (loc. no. 35; maximum 0.818 mg.l⁻¹), Bratislava – Petržalka – Matador (loc. no. 48; maximum 0.0177 mg.l⁻¹), Lučenec – laundry and dry cleaning (loc. no. 71; maximum 0.407 mg.l⁻¹),
- trichloroethene: Stropkov – TESLA (loc. no. 20; maximum 0.0139 mg.l⁻¹), Zlaté Moravce – Calex

(loc. no. 35; maximum 8.517 mg.l⁻¹), Banská Bystrica – Uľanka – Chemika (loc. no. 38; maximum 0.0106 mg.l⁻¹), Predajná – industrial dump Predajná II. (loc. no. 58; maximum 0.059 mg.l⁻¹), Lučenec – laundries and dry cleaners (loc. no. 71; maximum 0.066 mg.l⁻¹), Rožňava – cloud of chlorinated hydrocarbons at the barracks (loc. no. 103; maximum 0.0132 mg.l⁻¹), Strážske – Chemko – waste channel (loc. no. 222; maximum 0.0243 mg.l⁻¹),

- polychlorinated biphenyls (PCB): Strážske – Chemko – waste channel (loc. no. 222).

Tab. 4.2 Basic statistical parameters of selected physico-chemical parameters determined in waters

	unit	mean	median	standard deviation	minimum	maximum	number of measurements / analyses
pH	-	7.25	7.16	0.61	1.171	13.76	15,858
water temperature	°C	11.99	12	3	0	32.5	20,021
specific electrolytic conductivity	mS.m ⁻¹	118	84	305	0.609	28,600	19,987
dissolved O ₂	mg.l ⁻¹	3.71	2.76	3.63	0	22.70	17,335
Eh	mV	132	137	164	-978	2,016	9,370
NH ₄ ⁺	mg.l ⁻¹	3.94	0.1	31.20	<0.005	1,158	9,987
NO ₂ ⁻	mg.l ⁻¹	0.28	0.02	4.52	<0.005	164	2,777
NO ₃ ⁻	mg.l ⁻¹	24.9	4.98	127	0.046	8,012	9,412
PO ₄ ³⁻	mg.l ⁻¹	0.22	0.03	1.34	<0.01	50	3,284
F ⁻	mg.l ⁻¹	1.62	0.1	29.5	<0.01	975	1,378
Cl ⁻	mg.l ⁻¹	110	28.8	463	0.43	13,000	9,661
SO ₄ ²⁻	mg.l ⁻¹	135	59.2	431	<0.5	23,064	9,647
HCO ₃ ⁻	mg.l ⁻¹	400	371	292	0	5,673	8,155
TOC	mg.l ⁻¹	7.24	2.31	33.1	0.1	1,460	8,902
COD _{Mn}	mg.l ⁻¹	5.51	1.6	29.70	0.03	1,466	6,647
Na ⁺	mg.l ⁻¹	58.5	21.0	189.00	0.09	5,300	8,209
K ⁺	mg.l ⁻¹	16.3	3.29	95.50	0.1	2,980	8,169
Ca ²⁺	mg.l ⁻¹	120	102	169	2.4	5,470	8,161
Mg ²⁺	mg.l ⁻¹	35.6	24.5	45.70	0.04	2,100	8,153
Fe _{total}	mg.l ⁻¹	2.74	0.046	24.10	<0.001	1,040	8,504
Mn	mg.l ⁻¹	1.37	0.10	25.0	<0.001	1,560	8,586
SiO ₂	mg.l ⁻¹	20.0	13.0	80.0	0.04	2,052	3,769
Li ⁺	mg.l ⁻¹	0.04	0.01	0.63	<0.001	38	3,691
Ba	mg.l ⁻¹	0.17	0.079	3.74	<0.005	317	7,776
Sr	mg.l ⁻¹	0.49	0.375	0.63	0.015	14.30	7,709
B	mg.l ⁻¹	0.37	0.064	6.88	0.006	620	8,354
Al	mg.l ⁻¹	0.14	0.02	2.36	<0.005	110	7,824
As	µg.l ⁻¹	27.1	1.2	245	<0.1	7,800	8,520
Sb	µg.l ⁻¹	16.7	1	244	<0.1	11,300	8,039
Se	µg.l ⁻¹	1.83	1	6.86	<1	140	868
Be	µg.l ⁻¹	0.14	0.1	1.99	<0.1	121	3,680
Cr	µg.l ⁻¹	47.1	2	963	<0.1	35,000	8,412
Cd	µg.l ⁻¹	5.59	0.3	157	<0.1	6,680	8,067
Cu	µg.l ⁻¹	40.1	2	455	<0.01	15,200	8,324
Ni	µg.l ⁻¹	61.1	2	1,3970	<0.1	80,523	8,292

Tab. 4.2 – continue

	unit	mean	median	standard deviation	minimum	maximum	number of measurements / analyses
Pb	µg.l ⁻¹	5.85	5	91.0	<0.1	7,810	8,503
Mo	µg.l ⁻¹	9.64	4	48.9	<0.1	956.8	7,515
Ag	µg.l ⁻¹	1.06	1	0.70	<1	15	3,714
Co	µg.l ⁻¹	4.07	2	25.7	<1.5	1,089	7,413
Sn	µg.l ⁻¹	30.4	30	10.0	<0.5	300	3,667
V	µg.l ⁻¹	4.58	3	29.8	<1	1,590	7,482
Zn	µg.l ⁻¹	5213	5	165,207	<0.01	7,090,000	8,443
COD_{Cr}	mg.l ⁻¹	41.3	11	172	<0.5	4,188	1,651
P-total	mg.l ⁻¹	0.21	0.02	2.37	<0.01	118	3,990
surfactants	mg.l ⁻¹	3.04	0.07	72.8	<0.01	2,200.00	915
Hg	µg.l ⁻¹	7.99	0.1	529	<0.01	36,000	4,636
CN⁻_{total}	mg.l ⁻¹	0.04	0.005	1.12	<0.002	44.6	1,597
phenol index	mg.l ⁻¹	0.05	0.01	0.43	<0.01	11.4	1,698
adsorbable organic halogens	mg.l ⁻¹	0.13	0.03	0.45	<0.004	6.59	624
extractable organic halogens	mg.l ⁻¹	1.59	0.005	30.5	<0.001	775	1,029
hydrocarbon index (C₁₀₋₄₀)	mg.l ⁻¹	6.72	0.02	149	<0.005	6,350	7,087
1,1,1 – trichloroethane	µg.l ⁻¹	0.33	0.2	3.03	<0.1	137	4,375
1,1 – dichloroethene	µg.l ⁻¹	0.94	0.2	11.7	<0.1	754	5,559
1,2 cis – dichloroethene	µg.l ⁻¹	154	0.2	5,293	<0.1	374,065	5,490
1,2 trans – dichloroethene	µg.l ⁻¹	1.73	0.2	44.1	<0.1	3,071	5,492
1,2 – dichloroethane	µg.l ⁻¹	1.62	0.2	47.1	<0.1	2,530	3,023
dichloromethane	µg.l ⁻¹	3.30	0.2	33.6	<0.1	600	2,912
tetrachloroethene	µg.l ⁻¹	161	0.2	1307	<0.1	35,105	5,520
carbon tetrachloride	µg.l ⁻¹	3.22	0.2	60.6	<0.1	2,068	3,087
trichloroethene	µg.l ⁻¹	171	0.2	2,497	<0.03	85,200	5,546
chloroethene	µg.l ⁻¹	21.4	0.2	582	<0.1	37,983	5,050
chloroform	µg.l ⁻¹	1.33	0.2	12.1	<0.1	456	3,237
1,2 – dichlorobenzene	µg.l ⁻¹	0.37	0.2	2.22	<0.1	65.3	2,949
1,3 – dichlorobenzene	µg.l ⁻¹	0.31	0.2	1.34	<0.1	52.6	2,946
1,4 – dichlorobenzene	µg.l ⁻¹	0.50	0.2	3.4	<0.1	104	2,947
benzene	µg.l ⁻¹	17.4	0.2	235	<0.1	9,367	4,041
ethylbenzene	µg.l ⁻¹	15.6	0.2	271	<0.1	9,780	4,042
chlorobenzene	µg.l ⁻¹	72.1	0.2	929.97	<0.1	28,700	2,939
toluene	µg.l ⁻¹	23.4	0.2	647.58	<0.01	28,550	4,041
styrene	µg.l ⁻¹	0.70	0.2	17.14	<0.1	975	3,307
xylene	µg.l ⁻¹	14.4	0.2	182.98	<0.1	7,186	3,949
acenaphthene	µg.l ⁻¹	6.70	0.03	149.20	<0.002	5,679	3,336
anthracene	µg.l ⁻¹	0.73	0.003	21.96	<0.001	887	3,910
dibenzo(a,h)anthracene	µg.l ⁻¹	0.05	0.03	1.07	<0.002	60.6	3,341
benzo(a)pyrene	µg.l ⁻¹	0.52	0.005	20.33	<0.001	1,122	3,946
benzo(b)fluorantene	µg.l ⁻¹	1.61	0.03	69.29	<0.001	3,794	3,935
benzo(g,h,i)perylene	µg.l ⁻¹	0.12	0.03	2.94	<0.001	137	3,938
benzo(k)fluoranthene	µg.l ⁻¹	0.20	0.03	6.90	<0.001	373	3,938
phenanthrene	µg.l ⁻¹	6.48	0.02	181.04	<0.001	7,681	3,946
fluoranthene	µg.l ⁻¹	4.24	0.003	133.88	<0.001	5,072	3,947
fluorene	µg.l ⁻¹	6.71	0.015	181.74	<0.001	7,000	3,360
chrysene	µg.l ⁻¹	0.92	0.003	30.04	<0.001	1,326	3,946

Tab. 4.2 – continue

	unit	mean	median	standard deviation	minimum	maximum	number of measurements / analyses
indeno(1,2,3-c,d)pyrene	µg.l ⁻¹	0.16	0.03	5.08	<0.001	284	3,940
naphthalene	µg.l ⁻¹	6.73	0.04	150.20	<0.001	8,451	4,000
pyrene	µg.l ⁻¹	4.09	0.006	127.97	<0.001	5,527	3,923
PCB28	µg.l ⁻¹	0.04	0.003	0.38	<0.001	4	1,007
PCB52	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,027
PCB101	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,028
PCB118	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,028
PCB138	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,028
PCB153	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,028
PCB180	µg.l ⁻¹	0.04	0.003	0.37	<0.001	4	1,028
acenaphthylene	µg.l ⁻¹	0.19	0.03	4.08	<0.002	178	3,191
benzo(a)anthracene	µg.l ⁻¹	3.45	0.003	118.06	<0.001	5,061	3,329

Tab. 4.3 Number of exceedances of IT and ID values of selected indicators in groundwater according to the Directive of MoE SR No. 1/2015-7

Parameter	ID value (mg.l ⁻¹)	IT value (mg.l ⁻¹)	Number of exceedances of ID value	Number of analyses with exceedance of IT value	Number of sites with exceedances of IT value
Al ³⁺	0.25	0.4	93	154	16
As	0.05	0.1	105	224	26
Cd	0.005	0.02	75	57	7
Ni	0.1	0.2	33	105	6
Sb	0.025	0.05	75	185	13
Zn	1.5	5	46	36	5
B	0.5	5	729	44	11
Cl ⁻	150	250	413	653	40
NH ₄ ⁺	1.2	2.4	412	1,091	87
COD _{Mn}	5	10	617	482	53
TOC	2	5	2,083	2,004	103
hydrocarbon index (C ₁₀ -C ₄₀)	0.25	0.5	165	346	35
specific electrolytic conductivity (mS.m ⁻¹)	200	300	885	884	52
pH	6.0 – 6.5 and 8.5 – 9.0	less than 6.0 and more than 9.0	784	302	29
phenol index	0.015	0.06	69	52	8
benzene	0.015	0.03	30	101	15
polycyclic aromatic hydrocarbons – sum	0.06	0.12	21	54	7
chlorobenzene	0.015	0.03	20	74	5
dichlorobenzene	0.0015	0.003	21	47	6
1,2- dichloroethene cis	0.025	0.05	89	452	29
dichloromethane	0.015	0.03	25	23	12
tetrachloroethene	0.01	0.02	174	603	39
trichloroethene	0.025	0.05	103	360	21
chloroethene (vinyl chloride)	0.005	0.01	90	227	26

Tab. 4.4 Number of exceedances of limit values of selected indicators in surface waters according to the Government Regulation of the SR no. 269/2010

Parameter	Unit	Limit value (mg.l ⁻¹)	Number of analyses with exceedance of limit value	Number of sites with exceedances of limit value
dissolved O ₂	mg.l ⁻¹	more than 5	192	38
pH	-	6 – 8.5	209	45
specific electrolytic conductivity	mS.m ⁻¹	110	379	46
COD _{Cr}	mg.l ⁻¹	35	87	9
TOC	mg.l ⁻¹	11	167	24
Mn	mg.l ⁻¹	0.3	152	32
Ca ²⁺	mg.l ⁻¹	100	220	37
Cl ⁻	mg.l ⁻¹	200	79	16
SO ₄ ²⁻	mg.l ⁻¹	250	83	19
Na ⁺	mg.l ⁻¹	100	107	22
F ⁻	mg.l ⁻¹	1.5	31	10
N-NH ₄ ⁺	mg.l ⁻¹	1	188	35
N-NO ₂ ⁻	mg.l ⁻¹	0.02	87	24
N-NO ₃ ⁻	mg.l ⁻¹	5.0	126	23
Al ³⁺	mg.l ⁻¹	0.2	59	26
As	mg.l ⁻¹	7.5*	152	29
Cr _{total}	mg.l ⁻¹	9*	29	15
Cu	mg.l ⁻¹	8.8*	58	19
Zn	mg.l ⁻¹	52*	66	14
1,2- dichloroethene cis	mg.l ⁻¹	0.4	40	18
tetrachloroethene	mg.l ⁻¹	10**	11	3
trichloroethene	mg.l ⁻¹	10**	14	7

Notes:

* To the values stated in the Government Regulation of the SR no. 269/2010, it is necessary to add the background concentration values for a given surface water body of Slovakia as specified in a separate document (Bodiš et al., 2010)

** average value

List of EB sites with a significant impact on the quality of groundwater 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, is shown in Tab. 4.5. These are 56 sites representing a wide range of economic activities that have been carried out in the past.

In particular, various industrial activities, waste facilities and some mining sites are represented. Several of the sites listed in Tab. 4.5 are subject to a more detailed assessment in the article 1 of the next issue of this journal.

Spread of contamination in groundwaters or surface waters was not found at the 81 EB sites (Tab. 4.6). However, this does not mean that there is no risk of contamination of the natural environment, especially where the source of pollution has not been removed.

Tab 4.5 Overview of the occurrence of pollutants at the most contaminated monitored localities of environmental burdens from the point of view of contents not meeting the IT criteria according to the Directive of the MoE of the SR No. 1/2015-7

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

Tab 4.5 – continue

ID	Environmental burden	Indicators exceeding the IT values
20	Stropkov – TESLA	NH ₄ ⁺ , 1,2-dichloroethene cis, trichloroethene
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

Tab 4.5 – continue

ID	Environmental burden	Indicators exceeding the IT values
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, 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-IČ, 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	Krompachy – 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

Tab. 4.6 Sites where no spread of contamination in groundwater or surface water has been detected (in brackets is the site identification number)

Udavské – Coating of bitumen blends (11)	Stropkov – Coating (16)
Nesluša – landfill (18)	Žiar nad Hronom – ZSNP – former factory area (45)
Bratislava – Slovak Gas Company (46)	Komárno – Slovak Gas Company (47)
Bardejov – electric station (52)	Haniska pri Košiciach – Slovak Gas Company (61)
Veterná Poruba – landfill (63)	Levice – mall Benzinol (69)
Piešťany – former tractor station (72)	Mád – landfill (73)
Neded – former farm (QUEEN) (74)	Nitra – illegal release of oil substances at the sewage treatment (75)
Veľké Rovné – landfill (80)	Petrovice – Pšurnovice – playground (84)
Pernek – old mining works (86)	Hlboké nad Váhom – landfill II (88)
Dobšiná – landfill Bingarten (93)	Giraltovce – landfill (94)
Hlboké nad Váhom – landfill V (99)	Hlohovec – Šulekovo – landfill (100)
Čierne Kľačany – landfill (105)	Piešťany – oil refuelling station (107)
Zlaté Klasy – landfill (108)	Košice – Eastern Slovakia Engineering Works (110)
Tlmače – SES (141)	Levice – Levitex (129)
Šaľa – Duslo – nitric acid production (150)	Stará Turá – Chirana (145)
Udavské – landfill Janov dol (158)	Banská Belá – tailings Sedem žien (152)
Špačince – landfill (169)	Majcichov – landfill (166)
Hontianske Tesáre – agrochemical warehouse (209)	Bratislava – Central freight station (202)
Kráľova Lehota – landfill III (215)	Kysucké Nové Mesto – landfill at Secondary school (211)
Michalovce – city barracks (220)	Bielovce – pesticide storage (216)
Zemianske Kostolany – army area (228)	Nové Zámky – traction power station (225)
Prešov – Sokolovské barracks (234)	Pezinok – Rudné bane – tailings (232)
Utekáč – former Clara glassworks (239)	Poprad – Railway station (237)
Čel'ovce – pesticide storage (247)	Boldog – pesticide storage (243)
Nemšová – military unit (257)	Fačkov – landfill (250)
Nižná Polianka – stock of agrochemicals (260)	Bratislava – Ružinov – chemical dry cleaner (258)
Bytča – KK NEFT (266)	Bytča – former Slovak bus transportation (265)
Čadca – Slovak bus transportation (267)	Ošadnica – FRACHO (268)
Malé Dvorníky – pesticide storage (271)	Košarovce – Pastovník – fuel storage (273)
Ľubiša – farm area (274)	Udavské – railway station (275)
Dubnica nad Váhom – ZVS (277)	Liptovský Mikuláš – Locomotive depo (282)
Levice – Slovak Railways – surroundings of aboveground reservoirs (285)	Pohronský Ruskov – black oil industry of former sugar refinery (286)
Trenčianske Bohuslavice – Hydrostav (291)	Partizánske – ZDA – store of chemicals (295)
Poprad – fuel pump station (299)	Ľubochňa – forest area (302)
Soboš – stock of agrochemicals (310)	Stročín – former chemical cleaning (311)
Osadné – pesticide storage (315)	Strihovce – stock of chemicals of former farm Podvihorlat (316)
Trenčín – Air Repair Shops (317)	Trenčín – Slovak bus transportation (318)
Veľká Čalomija – pesticide storage (321)	Žilina – Trnové – fly ash dump (332)
Žilina – locomotive depo (333)	Hodruša-Hámre – Sandrik (334)
Bratislava – Devínska Nová Ves – quarry Srdce (339)	Plešivec – locomotive depo (342)
Dubová – stock of agrochemicals (309)	

Conclusion

Since 2012, the State Geological Institute of Dionýz Štúr has been carrying out tasks related to the monitoring of environmental burdens, currently at 309 sites. The aim of the work is to monitor the release of pollutants into the environment (especially groundwater and surface water) and to assess trends in the development of contamination.

Water sampling is performed on the basis of the procedures specified in the relevant Slovak technical standards (STN) of the STN EN ISO 5667 series. Physico-chemical properties are determined directly in the field: water temperature, air temperature, pH, specific electrolytic conductivity (at 25 °C), dissolved oxygen content, percentage oxygen saturation, groundwater level (if relevant), or other indicators. A total of 15,000 to 20,000 field measurements of various indicators were implemented. Laboratory analyses of water are carried out in the Geoanalytical Laboratories of SGIDŠ (GALs), Regional Centre Spišská Nová Ves using standard methodological procedures.

In general, in the chemical composition of groundwater and surface water, the presence of calcium predominates in the case of macroelement 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⁻). Pollution often occurs in areas of environmental burdens by increasing the values of total dissolved solids and conductivity.

Pollution from landfills as well as some other types of contamination is associated with the occurrence of high concentrations of boron, Cl⁻, NH₄⁺ and SO₄²⁻. Due to the inclusion of mining sites in monitoring, the elevated contents of some trace inorganic elements, especially As, Cu, Zn, Cd, Sb occurred in waters. Among the organic substances, chlorinated hydrocarbons appear to be the most problematic within monitored environmental burdens, especially cis 1,2-dichloroethene, dichloromethane, tetrachloroethene, trichloroethene and chloroethene. Strong oil pollution caused by high hydrocarbon index (C₁₀-C₄₀) above the IT criterion (0.5 mg.l⁻¹) was found at 35 sites. Substances from the PAH group were monitored over ID or IT criteria only at the sites Zvolen – Bučina – Black Impregnation, Zvolen – Bučina – Old Depot and Medzev – Strojsmalt. Less problematic indicators in our monitored sites include some trace elements (Co, Cr, Cu, Hg, Mo, Pb, V), fluorides, nitrites, cyanides, phenols, chlorobenzenes, substances of BTEX and PCB.

From the point of view of physico-chemical indicators measured in situ in surface waters, a rather frequent phenomenon is the deteriorated quality of surface water caused by the deterioration of oxygen regime and occurrence of high values of conductivity and pH.

List of environmental burdens with a significant impact on the quality of groundwaters 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, or the Government Regulations of the Slovak Republic no. 269/2010, includes 56 sites. These sites represent a wide range of economic activities that have been carried out in the past. In particular, various industrial activities, waste facilities and some mining sites are represented. Spread of contamination in groundwaters or surface waters was not found at the 81 EB sites.

The data obtained and the results of extensive monitoring contribute to the overall awareness of the effects of environmental burdens on the quality of groundwater or surface water. In other words, the public awareness of the risks associated with threats of EBs to human health or environment is improving.

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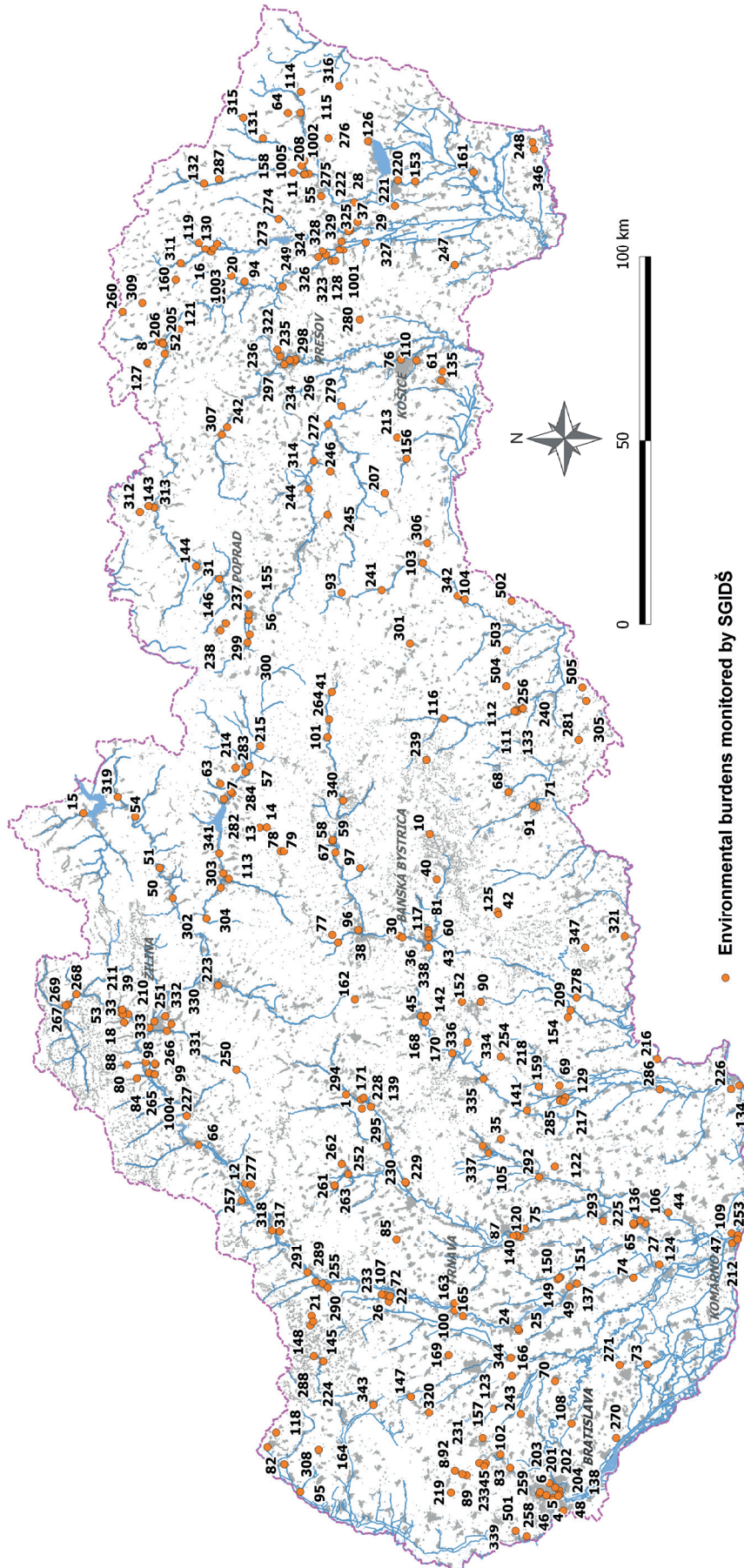
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ANNEX



● Environmental burdens monitored by SGIDŠ

Annex

List of 309 monitored environmental burdens (at SGIDŠ)

ID	Environmental burden	Coord x_jtsk	Coord y_jtsk	ID Slovak Environmental Agency
1	Nováky – Chemical plants (2)	-463209	-1228520	SK/EZ/PD/626
4	Bratislava – Chemika (2)	-572101	-1280930	SK/EZ/B1/116
5	Bratislava – Gumon (2)	-571942	-1281047	SK/EZ/B2/122
6	Bratislava – Juraj Dimitrov chemical plants (2)	-570457	-1277293	SK/EZ/B3/138
7	Liptovský Mikuláš – Leather plants (2)	-379688	-1193613	SK/EZ/LM/406
8	Bardejov – Heavy engineering factory (2)	-256943	-1173508	SK/EZ/BJ/22
10	Hriňová - Heavy engineering factory (2)	-390812	-1247203	SK/EZ/DT/209
11	Udavské – Coating of bitumen blends (7)	-211218	-1213290	SK/EZ/HE/261
12	Dubnica nad Váhom – Heavy engineering factory (2)	-485976	-1197183	SK/EZ/IL/271
13	Lazisko – tailings of Liptovská Dúbrava (6)	-389017	-1201131	SK/EZ/LM/397
14	Dúbrava – galleries and heaps of Liptovská Dúbrava (6)	-388923	-1202967	SK/EZ/LM/390
15	Zubrohlava – sludge field – Heavy engineering factory Námestovo (2)	-385085	-1153122	SK/EZ/NO/541
16	Stropkov – Coating (7)	-232387	-1187919	SK/EZ/SP/917
18	Nesluša – landfill (1)	-442288	-1163974	SK/EZ/KM/321
20	Stropkov – TESLA (2)	-231488	-1188491	SK/EZ/SP/915
21	Nové Mesto nad Váhom – landfill Mnešice – Tušková (1)	-512735	-1216258	SK/EZ/NM/533
22	Piešťany – Chirana (2)	-516851	-1236436	SK/EZ/PN/676
24	Sereď – Nickel plant – landfill dump (2)	-525645	-1271459	SK/EZ/GA/222
25	Sereď – Nickel plant – former factory area (2)	-526082	-1271801	SK/EZ/GA/221
26	Piešťany – Tesla – contamination plume under the housing estate (2)	-518189	-1236114	SK/EZ/PN/675
27	Nové Zámky – Real H.M. – terminal (4)	-497372	-1302917	SK/EZ/NZ/588
28	Nížný Hrabovec – tailings Bukocel (2)	-226076	-1225790	SK/EZ/VT/1026
29	Poša – tailings of Chemko Strážske (2)	-224087	-1227840	SK/EZ/VT/103
30	Sliač – airport – south (4)	-419167	-1239838	SK/EZ/ZV/1128
31	Kežmarok – OKTAN (3)	-321490	-1190097	SK/EZ/KK/295
33	Kysucké Nové Mesto – NN Slovakia (2)	-440059	-1163866,4	SK/EZ/KM/315
35	Zlaté Moravce – Calex (2)	-475816	-1261651	SK/EZ/ZM/111
36	Zvolen – Bučina – black impregnation (2)	-417966	-1246810	SK/EZ/ZV/1132
37	Nížný Hrabovec – landfill (1)	-226429	-1225920	SK/EZ/VT/1027
38	Banská Bystrica – Chemika (2)	-420550	-1222360	SK/EZ/BB/6
39	Kysucké Nové Mesto – KINEX-KLF (2)	-439621	-1163443	SK/EZ/KM/312
40	Detva – PPS Group (2)	-403084	-1249160	SK/EZ/DT/207
41	Pohorelá – Strojsmalt Holding (2)	-352179	-1220658	SK/EZ/BR/69
42	Lešť (military district) – garage yards (5)	-411828	-1265912	SK/EZ/ZV/1123
43	Zvolen – Bučina – white impregnation (2)	-417437	-1246916,8	SK/EZ/ZV/1131
44	Bajč – landfill (1)	-493881	-1312319	SK/EZ/KN/324
45	Žiar nad Hronom – ZSNP – former factory area (2)	-440551	-1244825	SK/EZ/ZH/1102
46	Bratislava – Slovak Gas Company – Votrubova street (3)	-571557	-1281119,9	SK/EZ/B2/131

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47	Komárno – Slovak Gas Company (3)	-502019	-1329909	SK/EZ/KN/337
48	Bratislava – Matador – former factory area (2)	-575067	-1283587	SK/EZ/B5/161
49	Trnovec nad Váhom – RSTO landfill (1)	-514165	-1285472	SK/EZ/SA/804
50	Istebné – OFZ – slag piles (1)	-408170	-1177459	SK/EZ/DK/178
51	Medzibrodie nad Oravou – landfill Široká (1)	-399976	-1173867	SK/EZ/DK/180
52	Bardejov – electric station (2)	-260273	-1175202	SK/EZ/BJ/26
53	Kysucké Nové Mesto – KLF – Energetics (2)	-439176	-1162934	SK/EZ/KM/313
54	Nižná – OTF – sludge field Malá Orava (2)	-385880	-1167131	SK/EZ/TS/969
55	Myslina – old landfill (1)	-217156	-1218009	SK/EZ/HE/254
56	Svit – Chemosvit landfill (1)	-336559	-1198390	SK/EZ/PP/710
57	Podtureň – Žadovica landfill (1)	-373938	-1197231	SK/EZ/LM/417
58	Predajná – industrial landfill Predajná II. (1)	-392716	-1220871	SK/EZ/BR/74
59	Predajná – industrial landfill Predajná I. (1)	-392377	-1220881	SK/EZ/BR/73
60	Zvolen – Railway repair shops and machinery (4)	-418816	-1246965	SK/EZ/ZV/1135
61	Haniska – Slovak Gas Company (3)	-265049	-1250782	SK/EZ/KS/346
63	Veterná Poruba – landfill I. (1)	-377193	-1190354	SK/EZ/LM/424
64	Snina – old landfill (1)	-194572	-1208987	SK/EZ/SV/929
65	Nové Zámky – locomotive depo – diagnostic centre (4)	-496277	-1304462	SK/EZ/NZ/1789
66	Lednické Rovne – Podstránie landfill (1)	-475597	-1184428	SK/EZ/PU/727
67	Nemecká – Petrochema (2)	-395786	-1221633	SK/EZ/BR/67
68	Kalinovo – phenol pit (Žiaromat) (2)	-379412	-1268957	SK/EZ/PT/720
69	Levice – mall Benzinol (3)	-463502	-1282909	SK/EZ/LV/433
70	Veľké Úľany – landfill (1)	-539881	-1281637	SK/EZ/GA/230
71	Lučenec – Laundry and dry cleaning (7)	-383419	-1276561	SK/EZ/LC/371
72	Piešťany – former tractor station (7)	-517234	-1236230	SK/EZ/PN/674
73	Mad – landfill (1)	-535273	-1306724	SK/EZ/DS/194
74	Neded – former farm (QUEEN) (7)	-511712	-1302914	SK/EZ/SA/795
75	Nitra - illegal release of oil substances at the sewage treatment (Horné Krškany) (3)	-498320	-1273381	SK/EZ/NR/557
76	Košice – old gasworks (3)	-261808	-1239439	SK/EZ/K4/364
77	Špania Dolina – flotation treatment plant (6)	-418465	-1220789	SK/EZ/BB/17
78	Partizánska Ľupča – galleries and heaps Magurka (6)	-395402	-1207683	SK/EZ/LM/416
79	Partizánska Ľupča – tailings Magurka (6)	-395413	-1206794	SK/EZ/LM/414
80	Veľké Rovné – landfill I (1)	-453800	-1165018	SK/EZ/BY/113
81	Zvolen – Bučina – old depot (2)	-417080	-1246871	SK/EZ/ZV/1133
82	Skalica – former roller bearing plant (2)	-557783	-1203171	SK/EZ/SI/857
83	Svätý Jur – Brestová – landfill (1)	-563431	-1269360	SK/EZ/PK/665
84	Petrovice – Pšurnovice – playground (1)	-459565	-1168626	SK/EZ/BY/104
85	Bojná – landfill – part A (1)	-501153	-1238308	SK/EZ/TO/961

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86	Pernek – old mining works (6)	-564233	-1254939	SK/EZ/MA/467
87	Nitra – locomotive depo (Cargo) (4)	-500278	-1270600	SK/EZ/NR/559
88	Hlboké nad Váhom – landfill II (1)	-453692	-1172674	SK/EZ/BY/98
89	Pernek – Dolná Karol adit and heap (6)	-565534	-1257410	SK/EZ/MA/466
90	Banská Štiavnica – Lintich tailings (6)	-436679	-1261109	SK/EZ/BS/85
91	Lučenec – Marián Šustek – M Fruit (3)	-383003	-1275550	SK/EZ/LC/370
92	Pernek – Pavol adit and heap (6)	-564910	-1256585	SK/EZ/MA/468
93	Dobšiná – Bingarten landfill (1)	-325221	-1223290	SK/EZ/RV/779
94	Giraltovce – landfill (1)	-240595	-1196972	SK/EZ/SK/866
95	Unín – oil collection centre Cunín (3)	-569888	-1212086	SK/EZ/SI/863
96	Banská Bystrica – former galvanizing shop LOBB (2)	-417238	-1227977	SK/EZ/BB/1
97	Lubietová – Podlipa (6)	-400245	-1228733	SK/EZ/BB/12
98	Kotešová – landfill (1)	-452408	-1169950	SK/EZ/BY/101
99	Hlboké nad Váhom – landfill V (under the birch) (1)	-453439	-1172571	SK/EZ/BY/97
100	Hlohovec – Šulekovo – landfill (1)	-520667	-1253880	SK/EZ/HC/243
101	Polomka – wood plant (2)	-364407	-1219524	SK/EZ/BR/71
102	Pezinok – stream Mahulianka (3)	-559765	-1266747	SK/EZ/PK/663
103	Rožňava – plume of chlorinated hydrocarbons at barracks (2)	-317114	-1245099	SK/EZ/RV/786
104	Plešivec – retention ponds (2)	-327072	-1256755	SK/EZ/RV/785
105	Čierne Kľačany – landfill (under the apple orchard) (1)	-473930	-1266908	SK/EZ/ZM/110
106	Nové Zámky – Former Barracks of the Soviet Army – Novocentrum (5)	-496923	-1306096	SK/EZ/NZ/585
107	Piešťany – oil refuelling station (3)	-516445	-1235095	SK/EZ/PN/678
108	Zlaté Klasy – landfill (1)	-551380	-1286106	SK/EZ/DS/206
109	Komárno – Madzagoš landfill (1)	-499605	-1329581	SK/EZ/KN/336
110	Košice – Eastern Slovakia Engineering Works (2)	-262042	-1243627	SK/EZ/K4/365
111	Rimavská Sobota – Slovak Sugar Factory (3)	-357466	-1271274	SK/EZ/RS/768
112	Rimavská Sobota – Gemer nákup (3)	-357128	-1271009	SK/EZ/RS/767
113	Ružomberok – brick factory (2)	-402964	-1192633	SK/EZ/RK/753
114	Stakčín – landfill (1)	-188832	-1212473	SK/EZ/SV/934
115	Belá nad Cirochou – landfill (1)	-198738	-1215177	SK/EZ/SV/922
116	Hnúšťa – former SLZ factory (2)	-359394	-1251072	SK/EZ/RS/756
117	Sliač – airport – pipeline (3)	-418771	-1239025	SK/EZ/ZV/1129
118	Skalica – landfill Zlatnícka dolina Valley (1)	-553827	-1205583	SK/EZ/SI/860
119	Chotča – landfill (1)	-229758	-1184529	SK/EZ/SP/912
120	Nitra – former fuel depots on the Novozámocká Road (3)	-500162	-1271223	SK/EZ/NR/553
121	Komárov – Lukavica landfill (1)	-253644	-1179249	SK/EZ/BJ/36
122	Vráble – landfill (part Židová) (1)	-481406	-1281569	SK/EZ/NR/567
123	Báhoň – landfill (1)	-547367	-1264735	SK/EZ/PK/640

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124	Kolárovo – landfill Pačérok (1)	-508142	-1309915	SK/EZ/KN/333
125	Lešť (military district) – main camp (5)	-412765	-1266218	SK/EZ/ZV/1124
126	Jovsa – landfill (1)	-202233	-1230702	SK/EZ/MI/485
127	Zlaté – landfill (1)	-262725	-1170369	SK/EZ/BJ/54
128	Čaklov – landfill (1)	-234915	-1221598	SK/EZ/VT/101
129	Levice – Levitex (2)	-462533	-1284520	SK/EZ/LV/432
130	Stropkov – poison cemetery Vojtovce (2)	-230063	-1189420	SK/EZ/SP/916
131	Papín – landfill (1)	-201424	-1202207	SK/EZ/HE/256
132	Krásny Brod – Monastýr landfill (1)	-213557	-1185619	SK/EZ/ML/503
133	Rimavská Sobota – Heavy engineering factory (2)	-357386	-1270577	SK/EZ/RS/766
134	Štúrovo – former JCP, asphalt and oil storage facility (2)	-459362	-1331690	SK/EZ/NZ/595
135	Košice – U.S. Steel (2)	-267680	-1250596	SK/EZ/K2/362
136	Nové Zámky – landfill (1)	-497055	-1303194	SK/EZ/NZ/587
137	Trnovec nad Váhom – tailings Amerika I (2)	-513322	-1287571	SK/EZ/SA/803
138	Bratislava – Malý Dunaj – influx object (2)	-570618	-1282824	SK/EZ/B2/123
139	Bystričany – ENO – temporary tailings (2)	-465166	-1231271	SK/EZ/PD/623
140	Nitra – Katruša landfill (1)	-500586	-1272164	SK/EZ/NR/560
141	Tlmače – SES (2)	-466212	-1273955	SK/EZ/LV/449
142	Žiar nad Hronom – ZSNP sludge field (2)	-442201	-1245889	SK/EZ/ZH/1097
143	Stará Ľubovňa – Skalka landfill (1)	-301601	-1170798	SK/EZ/SL/890
144	Spišská Belá – landfill (1)	-317951	-1183812	SK/EZ/KK/300
145	Stará Turá – Chirana (2)	-523608	-1215630	SK/EZ/NM/534
146	Veľký Slavkov – landfill Under the farm (1)	-333532	-1191871	SK/EZ/PP/716
147	Smolenice – Chemolak (2)	-544186	-1241935	SK/EZ/TT/981
148	Lubina – Palčekové landfill (1)	-522054	-1215173	SK/EZ/NM/526
149	Šaľa – Duslo – production of LAD and ammonium nitrate (2)	-511816	-1282606	SK/EZ/SA/798
150	Šaľa – Duslo – nitric acid production (2)	-511795	-1282628	SK/EZ/SA/797
151	Šaľa – Duslo – production of rubber chemicals (2)	-511805	-1282597	SK/EZ/SA/796
152	Banská Belá – Sedem žien tailings (6)	-436630	-1256014	SK/EZ/BS/79
153	Lastomír – landfill (1)	-213130	-1243545	SK/EZ/MI/486
154	Hontianske Tesáre – landfill (1)	-440933	-1285025	SK/EZ/KA/289
155	Žakovce – Úsvit landfill (1)	-325731	-1197977	SK/EZ/KK/310
156	Medzev – Strojsmalt (2)	-296955	-1239329	SK/EZ/KS/349
157	Modra – Hliny – landfill (1)	-555205	-1261599	SK/EZ/PK/645
158	Udavské – Janov dol landfill (1)	-208867	-1212736	SK/EZ/HE/262
159	Levice – landfill Levitex – Nixbrod (1)	-459394	-1282797	SK/EZ/LV/436
160	Hrabovčák – landfill (1)	-240102	-1178318	SK/EZ/SK/867
161	Vojany – EVO tailings (2)	-210611	-1259356	SK/EZ/MI/498

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162	Kremnické Bane – sheepfold (7)	-436017	-1226911	SK/EZ/ZH/1092
163	Hlohovec – industrial park (2)	-518594	-1254000	SK/EZ/HC/241
164	Unín – landfill (1)	-558302	-1217074	SK/EZ/SI/862
165	Hlohovec – Šulekovo – Fe-sludge (2)	-522099	-1256223	SK/EZ/HC/242
166	Majcichov – landfill (1)	-533491	-1269579	SK/EZ/TT/979
168	Žiar nad Hronom – ZSNP old industrial landfill (1)	-440436	-1246428	SK/EZ/ZH/1101
169	Špačince – landfill (1)	-532746	-1252365	SK/EZ/TT/982
170	Žiar nad Hronom – Horné Opatovce landfill (1)	-440582	-1246537	SK/EZ/ZH/1100
171	Zemianske Kostol'any – Xella (2)	-456973	-1229023	SK/EZ/PD/634
201	Bratislava – Ružinov – Čierny les (2)	-569573	-1282711	SK/EZ/B2/120
202	Bratislava – Ružinov – Central freight station (4)	-568721	-1281604	SK/EZ/B2/133
203	Bratislava – Vrakuňa – CHZJD landfill (1)	-567560	-1280050	SK/EZ/B2/136
204	Bratislava – Ružinov – Harbor (4)	-571007	-1282494	SK/EZ/B2/1904
205	Bardejov – JAS (2)	-257028	-1174540	SK/EZ/BJ/23
206	Bardejov – SNAHA (2)	-257452	-1174748	SK/EZ/BJ/24
207	Smolník – pyrite ores (6)	-298127	-1235055	SK/EZ/GL/237
208	Rovné – farm area (7)	-207513	-1213456	SK/EZ/HE/260
209	Hontianske Tesáre – agrochemical warehouse, poultry house (1)	-438981	-1285777	SK/EZ/KA/1742
210	Kysucké Nové Mesto – city landfill (1)	-440014	-1165330	SK/EZ/KM/314
211	Kysucké Nové Mesto – landfill at Secondary school (1)	-438796	-1163664	SK/EZ/KM/318
212	Komárno – Harčáš (1)	-500080	-1331330	SK/EZ/KN/335
213	Poproč – Petrova dolina Valley (6)	-282993	-1238424	SK/EZ/KS/353
214	Jamník – barracks and Mokrad' airport (5)	-372730	-1194516	SK/EZ/LM/1909
215	Kráľova Lehota – landfill III (1)	-366863	-1201219	SK/EZ/LM/395
216	Bielovce – pesticide storage (1)	-452235	-1309306	SK/EZ/LV/428
217	Levice – laundry and dry cleaning (7)	-463753	-1283881	SK/EZ/LV/434
218	Nová Dedina – pesticide storage (1)	-459758	-1277179	SK/EZ/LV/438
219	Kuchyňa – airport (5)	-570133	-1253016	SK/EZ/MA/459
220	Michalovce – city barracks – autopark (5)	-212816	-1238783	SK/EZ/MI/1905
221	Pozdišovce – objects of former state material reserves (7)	-219751	-1238007	SK/EZ/MI/1913
222	Strážske – Chemko – waste channel (2)	-218806	-1226945	SK/EZ/MI/494
223	Martin – SNP barracks (5)	-432215	-1189765	SK/EZ/MT/512
224	Myjava – dump of galvanic sludge – Holičov vrch (1)	-534450	-1218380	SK/EZ/MY/521
225	Nové Zámky – traction power station (2)	-496879	-1302870	SK/EZ/NZ/1911
226	Štúrovo – main railway station (4)	-460313	-1329431	SK/EZ/NZ/598
227	Považská Bystrica – former Považské Engineering Works (2)	-467678	-1181284	SK/EZ/PB/1894
228	Zemianske Kostol'any – army area (5)	-465686	-1228829	SK/EZ/PD/636
229	Bošany – tannery dump I (2)	-485863	-1240740	SK/EZ/PE/1874

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230	Bošany – tannery dump II (2)	-485689	-1240633	SK/EZ/PE/637
231	Pezinok – ore mines and old mines (6)	-562068	-1260702	SK/EZ/PK/654
232	Pezinok – Rudné bane – tailings (6)	-562177	-1262448	SK/EZ/PK/656
233	Piešťany – barracks (5)	-516250	-1234200	SK/EZ/PN/677
234	Prešov – Sokolovské barracks (5)	-263085	-1207752	SK/EZ/PO/1898
235	Prešov – Duklianske barracks (5)	-261949	-1209260	SK/EZ/PO/1899
236	Prešov – airport (4)	-259116	-1205859	SK/EZ/PO/1907
237	Poprad – Railway station (4)	-331146	-1198085	SK/EZ/PP/1447
238	Vysoké Tatry – landfill Pod lesom (1)	-335471	-1190394	SK/EZ/PP/718
239	Utekáč – former Clara glassworks (2)	-370642	-1246340	SK/EZ/PT/1786
240	Rimavská Sobota – area after Soviet Army – Industrial park (5)	-356630	-1272708	SK/EZ/RS/1980
241	Nižná Slaná – mining plant and surroundings (6)	-324549	-1234194	SK/EZ/RV/784
242	Rožkovany – plume of chlorinated hydrocarbons (2)	-280162	-1192249	SK/EZ/SB/811
243	Boldog – pesticide storage (1)	-548730	-1272280	SK/EZ/SC/813
244	Markušovce – ore mining (6)	-297009	-1214298	SK/EZ/SN/898
245	Rudňany – ore mining and processing (6)	-303984	-1219510	SK/EZ/SN/899
246	Slovinky – ore mining and processing (6)	-292219	-1220252	SK/EZ/SN/900
247	Čel'ovce – pesticide storage (1)	-236062	-1254059	SK/EZ/TV/989
248	Čierna nad Tisou – transshipment station (4)	-202487	-1275412	SK/EZ/TV/990
249	Merník – mercury mines (6)	-233904	-1216960	SK/EZ/VT/1024
250	Fačkov – landfill (1)	-455139	-1194777	SK/EZ/ZA/1053
251	Žilina – eastern industrial zone (2)	-441957	-1172400	SK/EZ/ZA/1070
252	Bánovce nad Bebravou – Railway station (4)	-483512	-1225084	SK/EZ/BN/57
253	Komárno – area abandoned by the Soviet Army (5)	-501240	-1331180	SK/EZ/KN/334
254	Pukanec – sludge dump Hampoch (1)	-451591	-1266828	SK/EZ/LV/441
255	Nové Mesto nad Váhom – area of military unit (5)	-514369	-1219550	SK/EZ/NM/530
256	Rimavská Sobota – area abandoned by the Soviet Army (5)	-356675	-1272870	SK/EZ/RS/1979
257	Nemšová – military unit (5)	-490718	-1196176	SK/EZ/TN/945
258	Bratislava – Ružinov – chemical dry cleaner (2)	-570830	-1279200	SK/EZ/B2/124
259	Bratislava – Nové Mesto – Heating plant II (2)	-570000	-1277500	SK/EZ/B3/140
260	Nižná Polianka – stock of agrochemicals (1)	-248833	-1163777	SK/EZ/BJ/44
261	Dežerice – VAB tailings (2)	-486730	-1221445	SK/EZ/BN/1926
262	Horné Naštice – fly ash dump (1)	-480740	-1223337	SK/EZ/BN/55
263	Dežerice – Veronika tailings (1)	-486542	-1221373	SK/EZ/BN/58
264	Závodka nad Hronom – Poľnospol Plus area (7)	-359640	-1219912	SK/EZ/BR/78
265	Bytča – former Slovak bus transportation (4)	-455928	-1170902	SK/EZ/BY/89
266	Bytča – KK NEFT (2)	-456278	-1172377	SK/EZ/BY/93
267	Čadca – Slovak bus transportation (4)	-437334	-1148853	SK/EZ/CA/168

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268	Oščadnica – FRACHO (2)	-434584	-1151254	SK/EZ/CA/173
269	Čadca – AVC – supermarket (2)	-437635	-1148298	SK/EZ/CA/1959
270	Báč – former STS (4)	-555278	-1298205	SK/EZ/DS/182
271	Malé Dvorníky – pesticide storage (1)	-535449	-1299144	SK/EZ/DS/195
272	Margecany – Locomotive depo, Cargo (4)	-279405	-1219708	SK/EZ/GL/1879
273	Košarovce – Pastovník – fuel storage (3)	-223352	-1206421	SK/EZ/HE/249
274	Lubiša – farm area (7)	-210781	-1210384	SK/EZ/HE/251
275	Udavské – railway station (4)	-211094	-1214637	SK/EZ/HE/264
276	Valaškovce (military area) – washbasin (4)	-201425	-1219965	SK/EZ/HE/265
277	Dubnica nad Váhom – ZVS (2)	-486313	-1198723	SK/EZ/IL/272
278	Rykynčice – stock of old agrochemicals (1)	-435510	-1287415	SK/EZ/KA/291
279	Malá Lodina – dam Ružín (7)	-274456	-1223311	SK/EZ/KS/1998
280	Keccerovce – landfill Kecerovské Pekľany II (1)	-250949	-1228231	SK/EZ/KS/347
281	Šurice – former farm – pesticide storage (1)	-365207	-1287990	SK/EZ/LC/373
282	Liptovský Mikuláš – Locomotive depo, Cargo (4)	-381276	-1191351	SK/EZ/LM/1884
283	Liptovský Hrádok – Rettenmeier Tatra Timber (2)	-372362	-1198282	SK/EZ/LM/403
284	Liptovský Mikuláš – Velvetex (2)	-379246	-1193240	SK/EZ/LM/410
285	Levice – Slovak Railways – surroundings of aboveground reservoirs (2)	-463168	-1283167	SK/EZ/LV/437
286	Pohronský Ruskov – black oil industry of former sugar refinery (4)	-460424	-1310037	SK/EZ/LV/440
287	Čabiny – farm area (7)	-212529	-1189893	SK/EZ/ML/500
288	Myjava – former SAM (2)	-533013	-1215748	SK/EZ/MY/519
289	Nové Mesto nad Váhom – locomotive depo (4)	-513288	-1218158	SK/EZ/NM/532
290	Stará Turá – Drahý vrch landfill (1)	-524678	-1214826	SK/EZ/NM/535
291	Trenčianske Bohuslavice – Hydrostav (2)	-510241	-1214040	SK/EZ/NM/536
292	Vráble – Tesla (TESGAL) (2)	-484365	-1277245	SK/EZ/NR/566
293	Šurany – former ELITEX and STS (2)	-496222	-1294619	SK/EZ/NZ/605
294	Nováky – Military repair business (5)	-461850	-1224500	SK/EZ/PD/628
295	Partizánske – ZDA – store of chemicals (3)	-475827	-1235527	SK/EZ/PE/639
296	Prešov – former ZPA (2)	-262377	-1210538	SK/EZ/PO/689
297	Prešov – panel industry (2)	-260942	-1206646	SK/EZ/PO/690
298	Prešov – Solivary (2)	-261737	-1210750	SK/EZ/PO/693
299	Poprad – fuel pump station – Slovak bus transportation (3)	-332711	-1198112	SK/EZ/PP/700
300	Svit – fuel pump station (3)	-338754	-1197768	SK/EZ/PP/709
301	Magnezitovce – pesticide storage (1)	-339036	-1241871	SK/EZ/RA/733
302	Lubochňa – forest area (7)	-414009	-1186614	SK/EZ/RK/742
303	Ružomberok – SCP area – SUPRA plant (2)	-401452	-1191184	SK/EZ/RK/747
304	Ružomberok – area TEXICOM – black oil management (2)	-405359	-1190485	SK/EZ/RK/748
305	Jestice – pesticide storage (1)	-354630	-1290045	SK/EZ/RS/762

Annex

List of 309 monitored environmental burdens (at SGIDŠ)

ID	Environmental burden	Coord x_jtsk	Coord y_jtsk	ID Slovak Environmental Agency
306	Krásnohorské Podhradie – sarcophagus under Kaplna (7)	-311699	-1246575	SK/EZ/RV/783
307	Lipany – ZVL area (2)	-282202	-1190783	SK/EZ/SB/808
308	Holíč – oil-fired boiler room (7)	-562446	-1207768	SK/EZ/SI/852
309	Dubová – stock of agrochemicals (1)	-246399	-1169149	SK/EZ/SK/864
310	Soboš – stock of agrochemicals (1)	-239002	-1193345	SK/EZ/SK/875
311	Stročín – former chemical cleaning (2)	-235623	-1179615	SK/EZ/SK/876
312	Jarabina – stock of agrochemicals (1)	-303251	-1168447	SK/EZ/SL/883
313	Stará Ľubovňa – SKRUTKÁREŇ – EXIM (2)	-302023	-1172391	SK/EZ/SL/891
314	Krompachy – Kovohuty (2)	-289402	-1215735	SK/EZ/SN/897
315	Osadné – pesticide storage (1)	-195862	-1196516	SK/EZ/SV/926
316	Strihovce – stock of chemicals of former farm Podvihorlat (1)	-187300	-1222870	SK/EZ/SV/935
317	Trenčín – Air Repair Shops (4)	-499067	-1206515	SK/EZ/TN/957
318	Trenčín – Slovak bus transportation (4)	-498796	-1204498	SK/EZ/TN/959
319	Trstená – former fuel storage Hámričky (3)	-380720	-1162440	SK/EZ/TS/973
320	Horné Orešany – Majdan – former chemical factory (2)	-548362	-1247043	SK/EZ/TT/977
321	Veľká Čalomija – pesticide storage (1)	-418840	-1300534	SK/EZ/VK/1003
322	Bystré – former brick factory TEMAKO (7)	-241976	-1207333	SK/EZ/VT/1007
323	Čaklov – former farm area (7)	-234973	-1220542	SK/EZ/VT/1009
324	Čičava – farm area (7)	-232083	-1218209	SK/EZ/VT/1011
325	Hencovce – Bukocel – extraction of black oil (2)	-226557	-1225335	SK/EZ/VT/1016
326	Komárany – stock of agrochemicals (1)	-233325	-1219033	SK/EZ/VT/1021
327	Sačurov – old steam mill (2)	-229710	-1230091	SK/EZ/VT/1032
328	Vranov nad Topľou – Čemerné – brick factory (2)	-231842	-1223851	SK/EZ/VT/1042
329	Vranov nad Topľou – Petrol station Dlhá ulica (3)	-229454	-1223467	SK/EZ/VT/1045
330	Rosina – fly ash dump – tailing pond (1)	-442726	-1177075	SK/EZ/ZA/1062
331	Žilina – ZVL (2)	-444569	-1175813	SK/EZ/ZA/1067
332	Žilina – Trnové – fly ash dump (2)	-440570	-1175360	SK/EZ/ZA/1840
333	Žilina – locomotive depo, Cargo (4)	-443734	-1171117	SK/EZ/ZA/1882
334	Hodruša-Hámre – Sandrik (2)	-447688	-1257504	SK/EZ/ZC/1074
335	Nová Baňa – former Technical Glass Works (2)	-457576	-1261832	SK/EZ/ZC/1077
336	Žarnovica – former Preglejka (2)	-450639	-1253362	SK/EZ/ZC/1081
337	Zlaté Moravce – locomotive depo (4)	-477786	-1263337	SK/EZ/ZM/1118
338	Zvolen – army objects (5)	-421876	-1246923	SK/EZ/ZV/1805
339	Bratislava – Devínska Nová Ves – quarry Srdce (2)	-582001	-1273892	SK/EZ/B4/147
340	Brezno – Slovak Railways (4)	-381656	-1223727	SK/EZ/BR/61
342	Plešivec – locomotive depo, Cargo (4)	-326080	-1254853	SK/EZ/RV/1858
343	Jablonica – depo (4)	-546305	-1231942	SK/EZ/SE/831
344	Voderady – landfill (1)	-538372	-1269889	SK/EZ/TT/1847

Annex**List of 309 monitored environmental burdens (at SGIDŠ)**

ID	Environmental burden	Coord x_jtsk	Coord y_jtsk	ID Slovak Environmental Agency
346	Čierna nad Tisou – locomotive depo, Cargo (4)	-204427	-1275767	SK/EZ/TV/1861
501	Bratislava – Devínska Nová Ves – landfill at Volkswagen (1)	-580506	-1270858	SK/EZ/B4/152

Explanations:

1 – waste disposal facilities, 2 – industrial production, 3 – storage and distribution of goods, 4 – transportation, 5 – military base, 6 – mining of mineral resources, 7 – other

