The state of contaminated sites issues in Slovenia

NATO CCMS Pilot Study Meeting

5 – 7th June, 2006, Athens, Greece

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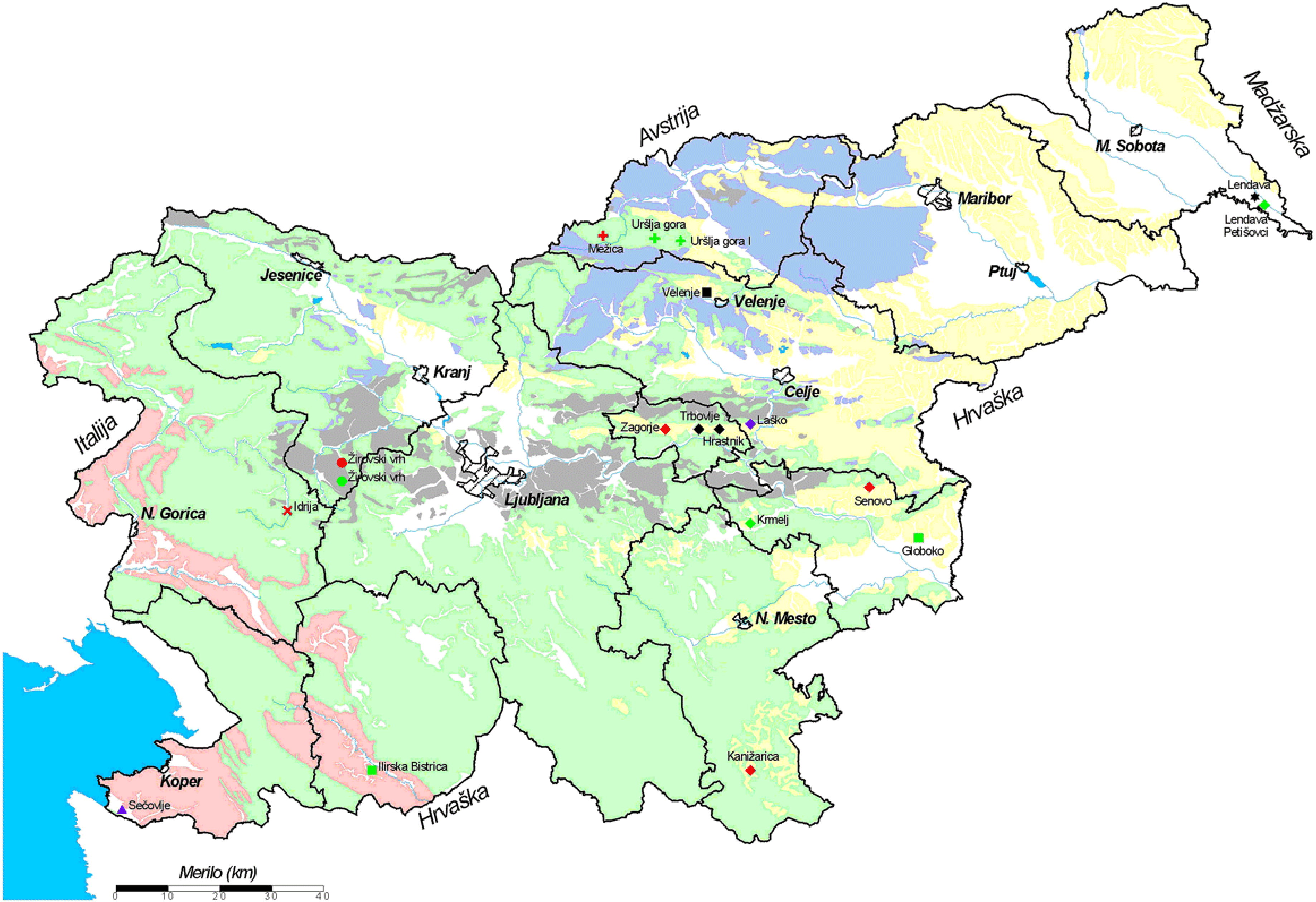
SLOVENIA
Ljubljana
Adriatic Sea

Five sites polluted with heavy metals

- The five sites polluted with heavy metals – Figure 1 – developed through the long centuries or deecades resp. of the operation of mines and/or metal foundries. The mercury mine in Idrija was operating for more than 500 years, the zinc and lead mine in Mežica for more than 300 years, the ironworks in Jesenica for more than 200 years, therefore there are several disposal sites in the surroundings of these places.

- In the past, the dumping of waste materials was spontaneous and where some place was at disposal. The five disposal sites were unregulated and unprotected. With meteoric water metals washed away from the tailings and wastes and today it is known that a huge quantity of mercury from the disposal site of tailings in the surroundings of the mercury mine Idrija has migrated to the Adriatic Sea.


Avstrija
Madžarska
Italija
Hrvaška
Hrvaška
M. Sobota
Lendava
Lendava Petišovci
Maribor
Ptuj
Mežica
Uršlja gora
Uršlja gora I
Jesenice
Velenje
Velenje
Kranj
Celje
Zagorje
Trbovlje
Hrastnik
Laško
Žirovski vrh
Žirovski vrh
Idrija
N. Gorica
Ljubljana
Senovo
Krmelj
Globoko
N. Mesto
Kanižarica
Ilirska Bistrica
Koper
Sečovlje
Merilo (km)
0
10
20
30
40

2.1. Waste disposal site of the lead and zinc mine at Mezica

- Tailing dumps represent a great burden for the environment because of their number and size. Tailing was dumped into valleys and partly on the slopes in the vicinity of the mine.

- These tailing dumps are not planted; there are 31 of them in the mine area, spreading over 100 km2. The estimated amount of tailing is around 20 million tons; the dump area is around 400,000 m2. The tailing represents carbon material (mainly limestone and dolomite) with traces of ore and metal remains – the lead content is up to 3.8 %, zinc from 0.65 % to 7.7 %. The dump area is full of water, with numerous streams and springs, and even drinking water sources, as is evident from Table 1 (Presecnik, 2003).

- At the Mezica mine, waste was created at first only because of extraction and the processing of ore in the smelting plant. After 1965, waste was also created as a result of the manufacturing of lead used in lead batteries. After 1989, the creation of waste was only the result of processing secondary materials.

- According to Slovenian legislation, waste is dangerous if the values of zinc exceed 10,000 mg/kg; that is why seven of the old dumps are categorised as dumps with hazardous waste, and it is thus necessary to analyze out-going fluids constantly.

- According to data about the production of refined lead and the amount of created waste (scoria, gypsum, brick, hard rubber which amounts to about 5,763 tons of waste from 15,000 tons of pure lead), in the old dumps, it was calculated to be about 20 millions tons of waste

- At that time, tailings were used for several purposes. Because of the appropriate grange and structure of the material, people removed it and used it for filling up sinking in the mine or even in construction of residential housing, for maintaining roads, etc. Usage of this material was the cause for analyses of contamination by natural radionuclides. Due to the dolomite basis, the content of radionuclides in tailings is relatively low, as shown in Table 2 (Presecnik, 2003).

Table 1. Zinc content in old dumps in the mine area.

Name	% lead	% zinc
Zerjavska halda	0.85	3.24
Stoparjeva halda	0.80	2.86
Andrejeva in Lukrecija halda	0.66	0.56
Halda na Zackovih peskih	3.84	7.67
Hildegardina halda	1.12	4.45
Terezija halda	1.95	3.96
Terezija podkop halda	1.95	3.96
Srce halda	1.35	3.17
Fridrih halda	1.0	2.0
Igrceva halda	1.0	2.0
Kavsakova halda	0.15	0.65

Table 2. Content of radionuclides in tailings.

Location	226Ra (Bq/kg)	238U (Bq/kg)	232Th (Bq/kg)	40K (Bq/kg)
Separation Zerjav	10	10	1-3	10
Tailing Kavsak	10	10	1-3	10
Pit Topla below Peca	30	30	4	74
Scoria from Zerjav	6	6	2.8	25

2.2. Waste and tailings disposal site of the mercury mine in Idrija

- The mercury mine in Idrija belongs to the greatest Hg mines in the world. Some 70 % of the ore is cinnabar and 30 % is native mercury.

- In the past the content of mercury in the ore was essentially higher. The greatest production, 820 tons of mercury, was reached in 1913. In the past the yield of winning was low, up to 75 % till 1948 and approximately 90 % after 1961. The burnt cinnabar was disposed near the devices. During the 500 years over 12 mio tons of the ore were dug up and 153,000 tons of mercury were won, out of which 4,500 tons have contaminated the environment between Idria and the Gulf of Trieste (Dizdarevič, 2001).

- During the operation of the mine the emissions in the atmosphere were approximately 7 to 10 tons yearly.

The procedure of closing works can be divided into three steps:

1. Filling of mine objects (galleries, shafts, gravity-feed pipes, working sites given up) with pneumatic dyke and the use of lean concrete (Rezun et al., 1999),.

2. Injecting of inaccessible areas of old ore bodies. If necessay, also inaccessible galleries and blind shafts are injected with a special injecting mass (Rezun et al., 1999). Reinforcing of coagaluted dykes and destroyed stoneware by injecting is technically-technologically and also financially a very demanding part of closing the mine of Idrija. In 1991 a test-injecting on the third floor was performed. The injecting blend. 44 % of electro-filter ashes, 6 % of lime and 50 % of water.

3. On the final step single floors are gradually poured with water under constant control of the closing works (Rezun et al., 1999).

- The bottom of the landfill was covered with a layer of clay and a drainage for meteoric waters was made. Into the landfill 7,180 m3 of the material polluted with native mercury was put and covered with 710 m3 of humus.

River transport – entry of Hg into the rivers and sea

- *Hydrology*

  The hydrology of the Idrijca and Soaa river and of the Gulf of Trieste is important for understanding the transport and distribution of mercury in the river basin and the gulf. The quantity of atmospheric precipitations in the river basin of the Idrijca and Soca rivers is high and varies strongly. Due to the configuration of the area the erosion is rather great, however, the transport of particles is limited because of thee dams on the Soca river (Doblar, Plave, Solkan) – Figure 2.

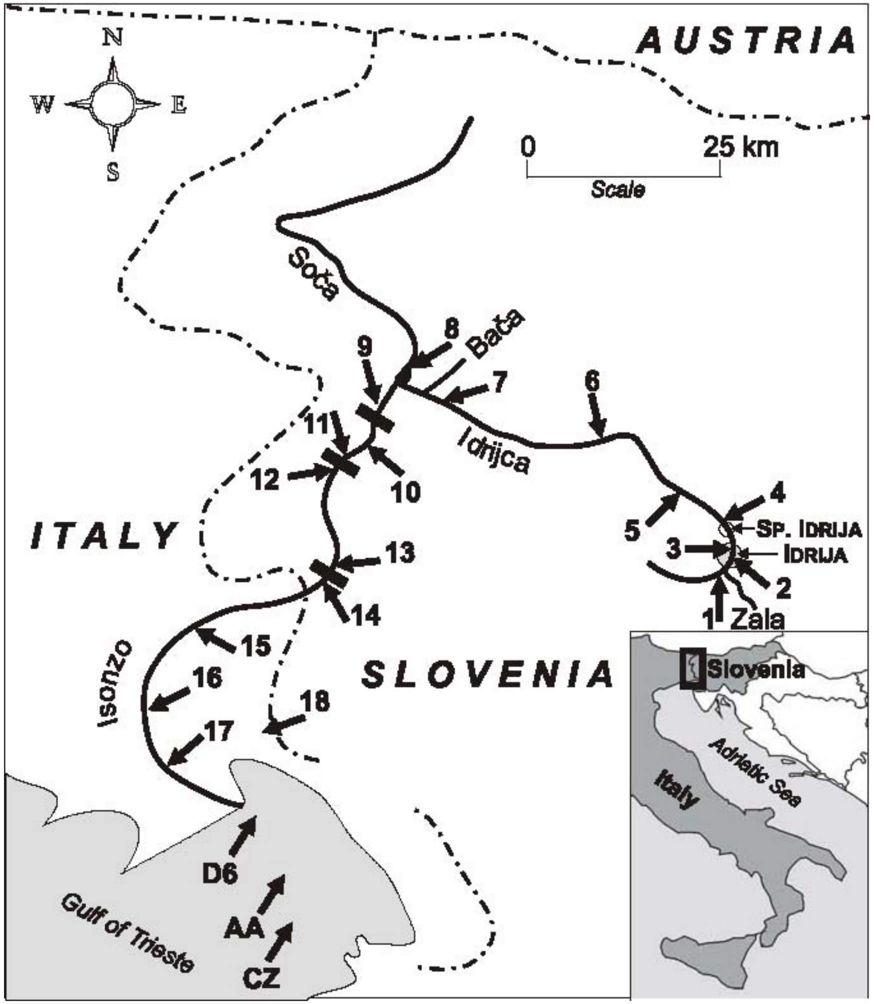


Figure 2. Leaching of Hg from disposal sites of the mercury mine in Idrija and migrating of Hg to Adriatic Sea

- The measurements show a great variability of Hg concentrations, which is connected with the flow, hydrometeorologic parameters and sites. The Hg values mentioned in several reports and between <10 and up to 80 mg/kg of the suspended material.

- In 2002, when systematic measurements in moderate and low waters were carried out, the values varied between 1 and 4.5 mg/kg of sediment. The share of the methylated Hg is 0.2 to 3 % of the total Hg. The quantity of the average yearly entry of Hg over the Idrijca river is 1500 kg.

- Anyway, it should be mentioned that occurences of extreme events (large flood waves) can be essentially more fatal, namely in a period of 5 to 10-year waters great quantities of Hg can enter the waters, as the case was in november 1997 when at the time of the flood wave in the course of 8 days the river Soca brought 4700 kg of mercury into the Gulf of Trieste.

2.3. Tailings disposal site of the uranium mine at Zirovski Vrh

- In Slovenia there are four locations where radioactive waste is disposed. This waste has been generated chiefly by the research, healthcare and industrial activities. The waste is kept in temporary storage facilities, whose technical features are not appropriate for the storage of the type of waste deposited.

- The largest volume of waste was generated primarily by a uranium mine and coal-fired power station (coal, ash) and aluminium processing plant. These locations are in the vicinity of Zirovski Vrh (uranium mine), Sostanj (coal-fired power station), Kidricevo (aluminium processing plant) and Kocevje (from other origins) (Druzina, 2004).

- Slovenia used to have active uranium mine – Zirovski Vrh; it is now in the phase of closure and remediation of the landfill. There are now two landfills for radioactive waste from past mining activities and the processing of uranium ore:
  - - the first contains tailings produced in the uranium ore processing plant. This landfill covers an area of 4 hectares and contains around 600,000 tonnes of material containing 80 g U_3O_8/t and 8.6 Bq/kg Ra-226,
  - - the second contains waste with red mud from ore pšrocessing. It contains around 1,500,000 tonnes of material with an average content of 70 g U_3O_8/t and total radioactivity of 15,200 GBq (Druzina, 2004).

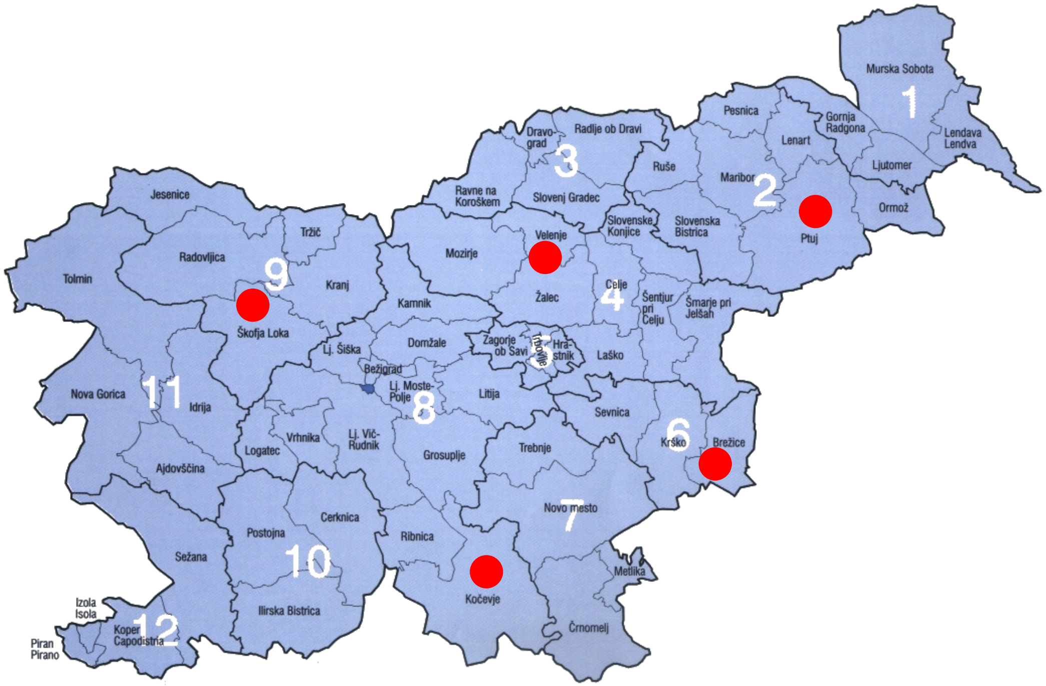


Figure 3 shows the locations listed above.

2.4. Waste disposal site of the Jesenice ironworks

- Iron industry in Jesenice goes back to year 1530, and in 1868 the first smeltery was opened. Since then, the smeltery waste (scoriae) have been deposited in the immediate vicinity of the factory. The present state is alarming first of all because all heavy metals are washed away into the underground water. The floor, where the waste was been deposited, is contaminated with antimony, copper, zinc, chrome, manganese, lead and dioxins.

- At the time of the greatest production the factory deposited some 10,000 tons of scoriae every year; scoriae are actually inert, the only problem are heavy metals. It was estimated that on the disposal sites in the surroundings of ironworks there are some 1,600,000 tons of waste from ironworks.

- The present needs for the disposal sites are some 250,000 tons for the coming years of operating of the smeltery and rolling mill. It is foreseen that yearly some 8700 m3 of place would be needed.

Figure 4 shows disposal site of the Jesenice ironworks

2.5. Waste disposal site of the aluminium processing plant in Kidricevo

- The building of the aluminum processing plant in Kidričevo was started during the second World War, in year 1942. In 1954 the trial production of the plant for the production of metallurgic bauxite was started, and at the end of the same year also the aluminium processing plant. The production was growing from year to year, and with it also waste materials, both gaseous and solid ones, that were deposited on the disposal site inside the factory. The total production of metallurgic bauxite till 1991, when this plant was closed, amounted to some 3.4 mio tons. The total production of aluminium in years 1955 till 2004 was slightly less than 2.6 mio tons.

- During the described production a great number of waste materials was arising, out of them the following one represent the greatest burdening of the environment:
  - fluorides - approx. 1,150 tons yearly,
  - tar – approx. 90 tons yearly,
  - remainders of cathodes - approx 2,500 tons yearly, and
  - tailings of the bauxite ore, from which aluminium was leached – red mud - - 140,000 to 170,000 tons yearly.

- Ash represents a special inert waste, namely as an energy supplier coal was used for years and 60,000 to 70,000 tons of ash were produced yearly.

- Since 1991 approx. 6.5 mio tons of red mud have been produced. This mud contains alkaline metals. It is deposited on a disposal site of some 42 hectares (1 ha is 10,000 m2). The alkaline metals were washed into the underground water and came so also in the sources of drinking water.

- The trial surface was divided into four parts, in which four different kinds of revitalization were carried out. With revitalization they tried to limit the influence of red mud on the environment, namely dusting and first of all trickling of meteoric waters through the layers of red mud and herewith transporting of alkaline metals and other toxic compounds in the groundwater.

- To the first part or field of 15,000 m2 first uncontaminated soil was carted and uniformly distributed, and then some 3000 young trees were planted in it, first of all Scoth pine, Austrian pine, common spruce, larch and maple.

- On the second field of 10,000 m2 5000 m3 of coal ash was carted and grass was sowed on it. Measurements showed that in one year pH of the surface decreased from 9.9 to 8.5.
- The third trial field of 10,000 m2 was covered with grass.

- The fourth trial field, also 10,000 m2 large, was covered with the mud from the purifying plant for waste technological and communal waters and sowed with gras.

- The results of these trial makings green showed that the most successful possibility of revitalization is covering with a layer of soil and planting of young trees. In this way the alkalinity of the surface of red mud is decreased and meteoric waters are retained in a great extend. Up till now it has succeeded to plant trees and grass on some 200,000 m2 of the disposal site, it is approximately one half of the total surface.

3. Working industrial wastes landfills

- In Slovenia are 10 industrial wastes landfills and one disposal site for hazardous wastes. All site are shown on Figure 5.

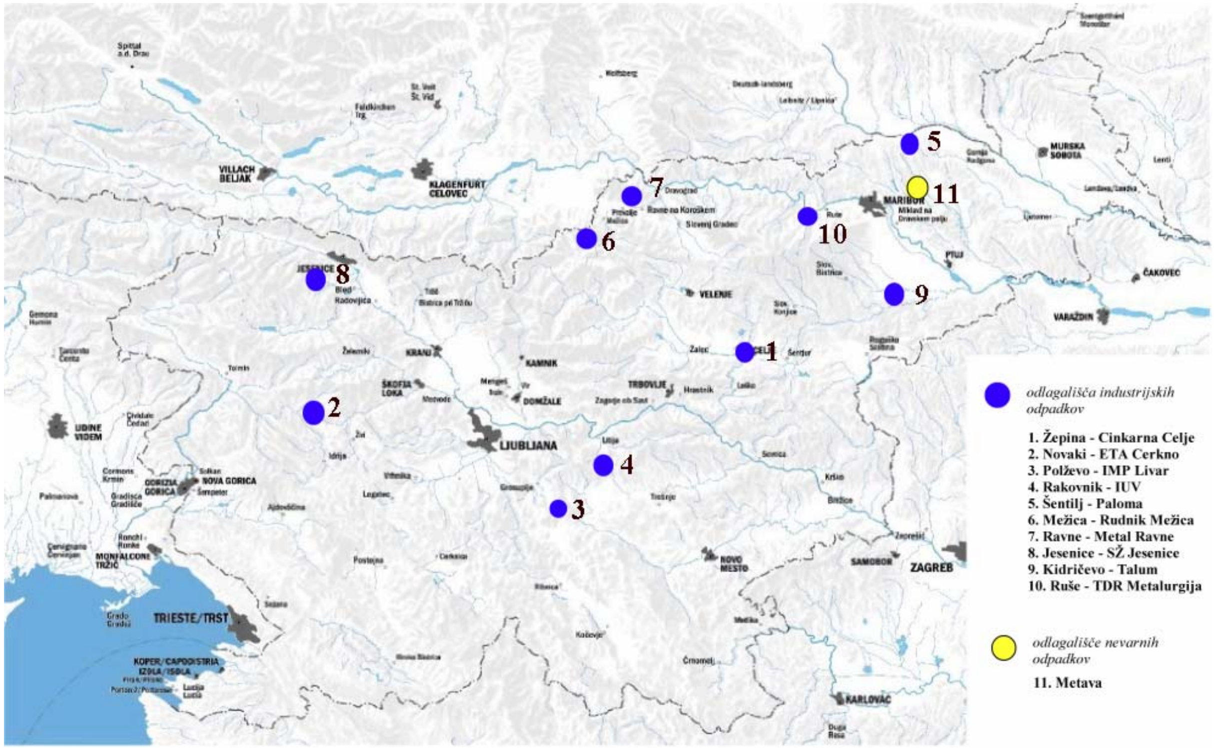


Figure 5

Table 3 shows quantities of wastes on individual of mentioned landfill or disposal site.

Activity	Name of the landfill/dsiposal site	Type of waste	Quantity (t)
DG (On Figure 6 – 1)	Landfill of solid wastes in Zepina	Inert and nonhazardous wastes	220
DJ (On Figure 6 – 2)	Landfill of industrial wastes in Novaki	Inert and nonhazardous wastes	3087,5
DJ (On Figure 6 – 3)	Disposal site in Polzevo	Inert wastes	5790
DC (On Figure 6 – 4)	Disposal of leather working industry in Smartno - Rakovnik	Nonhazardous wastes	4095,2
DE (On Figure 6 – 5)	Landfill of industrial wastes in Paloma	Nonhazardous wastes	10584
DJ (On Figure 6 – 6)	Landfill of metalurgical slag and crushed plastics in Mezica	Inert and nonhazardous wastes	1220
DJ (On Figure 6 – 7)	Tailings disposal site of the lead and zinc mine in Ravne	Inert and nonhazardous wastes	30284
DJ (On Figure 6 – 8)	Tailings disposal site Javornik of the Jesenice ironworks	Inert and nonhazardous wastes	28950
DJ (On Figure 6 – 9)	Ash disposal site of the aluminium processing plant in Kidricevo	Inert wastes	1283,1
DJ (On Figure 6 – 10)	Landfill of industrial wastes in Ruse	Inert and nonhazardous wastes	4475,7

Legend of designations for activities:

DG – Manufacture of chemicals, chemical products and man-made fibers
DJ – Manufacture of metals and metal products
DC – Manufacture of leather and leather products
DE – Manufacture of pulp, paper, cardboard, paper and cardboard products, printing

Table 4. Type and quantity of industrial wastes produced in different activitis for the year 2000

Activity	Quantity of all wastes of industry in the year 2000 (tons)	Quantity of wastes in bigger industrial factories in the year 2000 (tons)
CA	141.151	11.601
CB	43.033	0
DA	126.066	84.576
DB	5.141	406
DC	16.195	426
DD	61.226	0
DE	144.910	115.557
DF	3.143	3.125
DG	221.571	214.448
DH	12.778	3.020
DI	39.269	26.069
DJ	91.238	66.708
DK	41.755	0
DL	41.491	3.370
DM	31.706	0
N	445.620	24.762
Total	1.466.293	554.068

Legend of designations for activities:

CA – Quarrying of energy producing materials
CB – Mining and quarrying except energy producing materials
DA – Manufacture of food products, feeding stuffs, verages and tobacco
DB – Manufacture if textiles and textile and fur products
DC - Manufacture of leather and leather products
DD – Manufacture of wood and wood products
DJ - Manufacture of metals and metal products
DK – Manufacture of machinery and equipment
DL – Manufacture of electrical and optical equipment
DM – Manufacture of transport equipment
DN – Manufacture of furniture and other processing equipment

- In Slovenia there is only one regulated harmful waste disposal site, that is Metava (on the Figure 5, marked with 11). This waste disposal site was built in 1984. Its total capacity is 95,000 m3. For the waste materials deposited on this site there existas the list of kinds, quantities and analyses of assay of individual harmful substances. There prevail scoriae from the aluminum factory containing ammonia compounds, casting sands (containing phenols), remaining of dyes and varnishes (containing various organic solvents) and metallic oxides and slimes (containing chrome, nickel, copper and zinc compounds).

Table 5. shows the quantities of landfilled wastes from 1984 to 2000 on disposal site for harmful and hazardous wastes Metava near Maribor

Year	Quantity (m^3)
1984	755
1985	2531
1986	1520
1987	1696
1988	957
1989	1525
1990	1327
1991	1034
1992	1065
1993	1047
1994	536
1995	547
1996	530
1997	375
1998	549
1999	588
2000	569
TOTAL	**17156**

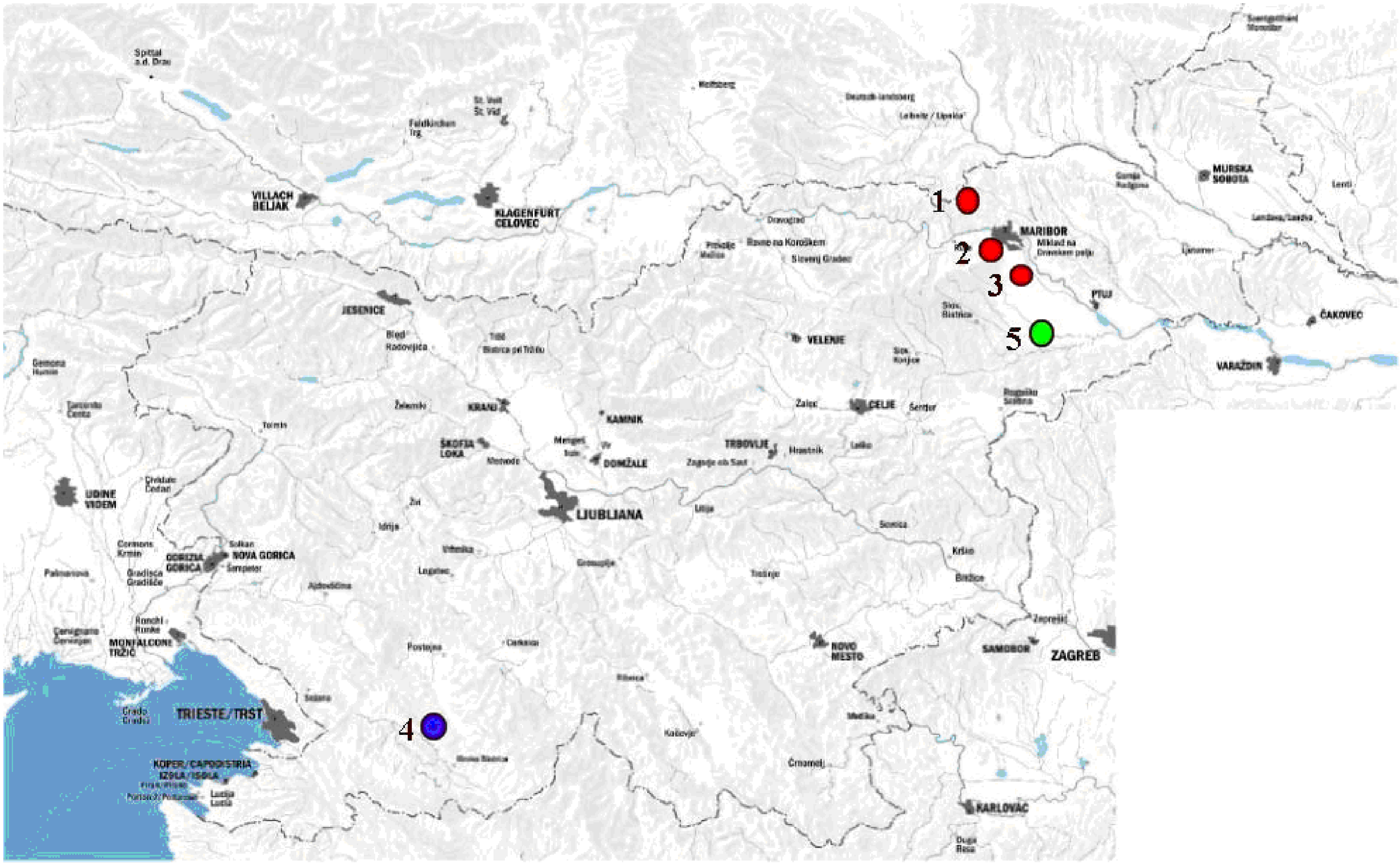
4. Omitted waste disposal sites

a. the disposal site of tar in Pesnica, Studenci and Bohova near Maribor (Figure 6, designation of disposal sites 1, 2, 3),

b. disposal site of waste materials arosen in the production of organic acids (tartaric acid, lactic acid, citric acid) in Globocnik near Ilirska Bistrica (Figure 6, designation of the disposal site is 4),

c. disposal site of red mud and ashes from the aluminium processing plant in Kidricevo (Figure 6, designation 5)

Figure 6



1
2
3
4
5
MARIBOR
MURSKA SOBOTA
VILLACH BELJAK
KLAGENFURT CELOVEC
JESENICE
VELENJE
PTUJ
ČAKOVEC
VARAŽDIN
CELJE
KRANJ
KAMNIK
TRBOVLJE
ŠKOFJA LOKA
DOMŽALE
LJUBLJANA
UDINE VIDEM
NOVA GORICA
GORIZIA GORICA
MONFALCONE TRŽIČ
TRIESTE/TRST
KOPER/CAPODISTRIA
IZOLA/ISOLA
NOVO MESTO
SAMOBOR
ZAGREB
KARLOVAC

5. Conclusions

- In the »Slovene National Program of Environmental Protection«, adopted by the National Assembly of the Republic of Slovenia in 1999 and in the Waste Management Strategy of the Republic of Slovenia there is also foreseen gradual eliomination of old burdens of the environment, i.e. remediation of the described contaminated disposal sites. In most of the described locations it was already started ten or even twenty years ago, and in some of them even earlier.

- This remediation has been running relatively satisfactorily above all on the disposal site of uranium mine at Zirovski vrh and also on other locations where radioactive wastes were deposited.
  Also the remediation of disposal sites on the area heavy metals mines, i.e. in Mezica (Pb, Zn)) and Idrija (Hg) has already been running for years, although it has been running slower as it was expected and as required by the inhabitants in the affected surroundings

- Faster than the above mentioned remediations has been running the remediation of the waste disposal site of the Jesenice ironworks
  Very badly or extremely slowly respectively has been running the remediation at the waste disposal site of the aluminium processing plant in Kidricevo. Also the remediation of the omitted old disposal sites, i.e. of:
  - - disposal site of old tar in Pesnica, Studenci and Bohova,
  - - disposal site of waste from the production of organic acids in Ilirska Bistrica, and
  - - disposal site of red mud in the area of the aluminium processing plant in Kidricevo

- as been running very, very slowly and on some locations it was even expected in the past that it would come to an ecological catastrophe – disposal site of tar in Pesnica.