JADROVÁ A VYRAĎOVACIA SPOLOČNOSŤ, a.s.
Tomášikova 22
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HEALTH IMPACT ASSESSMENT

for

"Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies
JAVYS, a.s.
at Jaslovské Bohunice."

Worked out by:

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I. INTRODUCTION

The subject of the submitted report is Health Impact Assessment (HIA) for "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice" proposed by Jadrová vyraďovacia spoločnosť, a.s. (hereinafter JAVYS, a.s.) at Jaslovské Bohunice. All the proposed technologies will be used for treatment and conditioning of low level and very low level RAW produced during decommissioning of A1 and V1 Nuclear Power Plants, RAW produced during operation of nuclear installation, operation of nuclear power plants in the Slovak Republic, institutional RAW from research activities, medical diagnostic and therapeutic activities, as well as RAW produced outside nuclear power plant operations, and radioactive material of unknown origin, and for RAW management within nuclear services provided to external foreign producers of radioactive waste.

In 2012 to 2014, the process of environmental impact assessment pursuant to Act No. 24/2006 Coll. was carried out for purposes of joint assessment of impacts of the then operated technologies for RAW treatment and conditioning and changes under preparation on the premises of JAVYS, a.s. Jaslovské Bohunice. The execution of assessed activities was recommended by Final Opinion of the Ministry of Environment of the Slovak Republic No. 2276/2014-3.4/hp dated 14 November 2014.

Nowadays, JAVYS, a.s. prepares optimisation of RAW treatment and conditioning capacities at the workplaces of RAW incineration, RAW supercompaction, RAW remelting, relocation of the existing fragmentation and decontamination facilities and supplementation of RAW storage capacities within the existing civil structures of the NI RAW TCT with the existing auxiliary, storage and transport systems or within annex buildings, workplace of V1 NPP electric cables management, and workplace for releasing materials from institutional control to the existing unused civil structures at the site within the structure system of the RAW TCT. The plan has been worked out in two variant solutions V0 (current state) and V1 (state after the execution of the plan).

The request for HIA was submitted within assessment No. 1101/2019-1.7/zg and HIA will form part of the assessment report for "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice".

HIA was worked out in compliance with Act of the National Council of the Slovak Republic No. 355/2007 Coll. on public health protection, support and development and on the amendment to certain acts as amended and in compliance with Decree of the MH SR No. 233/2014 Coll. on details of health impact assessment. The submitted assessment was prepared based on the data obtained from the HIA customer and other background documents listed in Chapters No. XVII and XVIII. The objective of HIA was to assess the influence on health of the affected inhabitants of the new RAW incineration plant and expansion of RAW remelting capacities at JAVYS, a.s. as the most relevant proposed changes. The impacts on employee health during working activity in the proposed operation is not part of HIA; it must be solved by work risk assessments in compliance with the applicable legislation.

During the first step of HIA (screening) all the available information from the customer was assessed and based on it, a screening questionnaire for the plan with questions about health determinants, population groups and gravity of the proposal's impact on the population was filled in. In compliance with Article 3 (2) of Decree of the MH SR No. 233/2014 Coll., the evaluation of screening questions resulted in the recommendation that maximum HIA should be worked out for the assessed activity. The proposed activity will affect the inhabitants from the municipalities Jaslovské Bohunice, Radošovce, Pečeňady, Malženice, Veľké Kostoľany, Dolné Dubové, Nižná, Ratkovce, and Žlkovce.

The evaluation of selected chemical pollutants is based on the data of the dispersion study worked out by Ing. Viliam Carach, PhD. (May 2019).

The evaluation of radioactive radiation is based on the data of the study "Discharges of radioactive substances from the NI JAVYS, a.s. Jaslovské Bohunice and the impact of the NI JAVYS, a.s. on the surroundings, 2018".

Considering the distance from the closest residential area, noise levels caused by the technological equipment of JAVYS, a.s. were not assessed.

Health risk assessment was focused on:

- quantitative assessment of chemical factors,
- quantitative assessment of radioactive radiation,
- qualitative assessment of socio-economic or psychological factors.

II. BASIC DATA ON THE PROPOSAL UNDER ASSESSMENT

1. Proposer

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2. Address

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3. Proposer's authorised representative

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4. Contact person

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5. Territory

Trnava Region
Trnava District
Municipality: Jaslovské Bohunice
Cadastral territory: Bohunice

6. Affected municipalities

Jaslovské Bohunice, Radošovce, Malženice, Dolné Dubové (Trnava District), Veľké Kostoľany, Nižná, Pečeňady (Piešťany District), Ratkovce, Žlkovce (Hlohovec District)

7. Date of beginning and completion of construction and operation of the proposed activity

Expected date of construction commencement: 12/2019
Expected date of construction completion: 12/2021
Expected date of operation commencement: 2022
Expected date of operation end: 2050

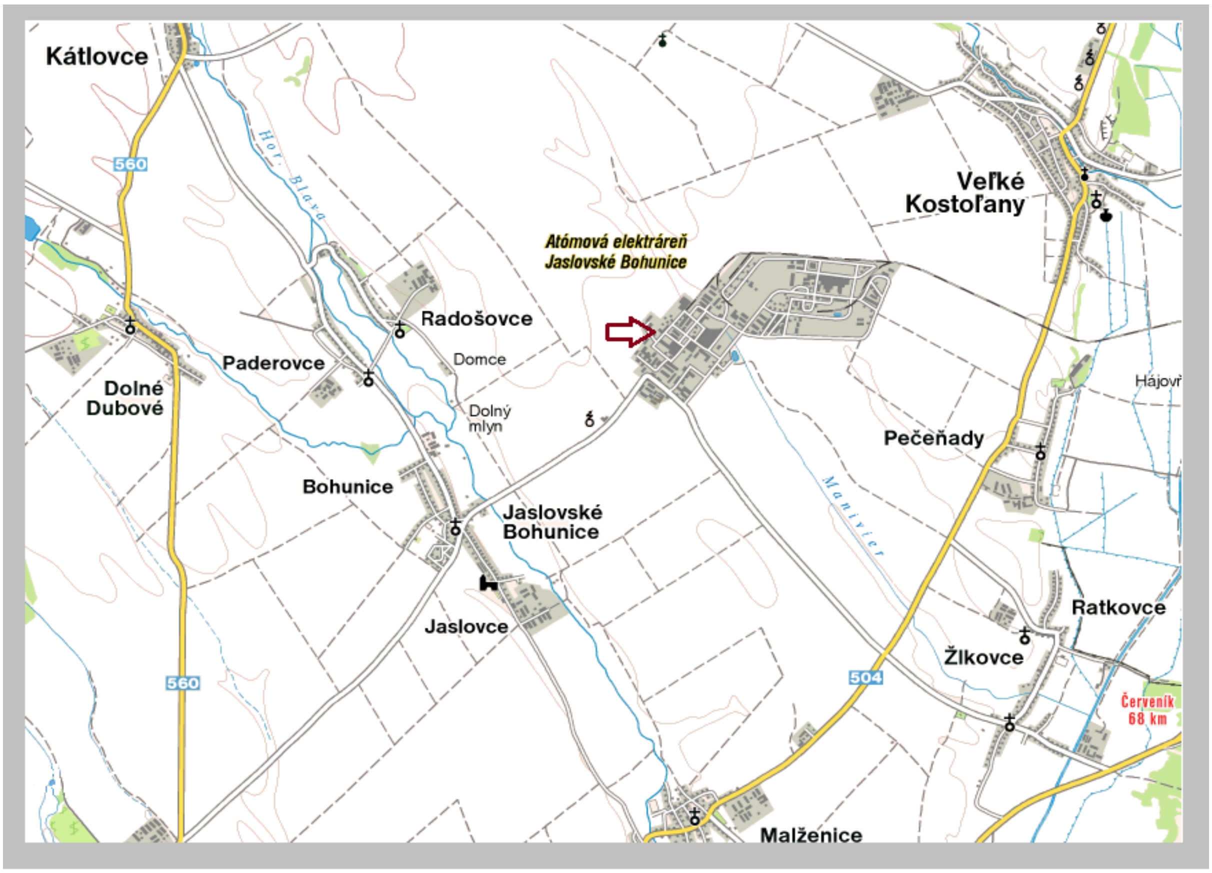
8. Expected investment costs

€21,000,000

III. DESCRIPTION OF THE ASSESSED SITE

The operation of the set of technologies for radioactive waste treatment and conditioning is situated in the south-eastern part of the premises with nuclear installations of JAVYS, a.s. in the cadastral territory Jaslovské Bohunice, Trnava District. All parcels of the premises are outside the built-up area of the municipality.

Fig. No. 1: Specification of the affected territory



Legenda: ⇨ **orientačné označenie umiestnenia činnosti**

Legend: approximate position of the site of activity

Source: Plan "Optimisation of RAW TCT treatment capacities JAVYS, a.s. at Jaslovské Bohunice" January 2018.

Table No.1 contains the affected municipalities and their distances from the proposed activity.

Table No.1: Distance of municipalities from the RAW TCT

Municipality	distance from the RAW TCT in m
Jaslovské Bohunice	2,200
Radošovce	2,200
Pečeňady	3,200
Malženice	3,800
Veľké Kostoľany	3,800
Ratkovce	4,100
Dolné Dubové	4,200
Nižná	4,200
Žlkovce	4,500

IV. PROPOSAL CHARACTERISTICS

The subject of the activity under assessment is a set of radioactive waste treatment and conditioning technologies of JAVYS, a.s. at Jaslovské Bohunice. The plan was worked out in two variant solutions.

Variant 0 (current state):
RAW treatment, conditioning and storage in the structures of NI RAW TCT technological facilities in the scope of environmental impacts assessed so far pursuant to Act No. 24/2006 Coll. as amended.

Variant 1 (state after the completion of the plan):
Optimisation of capacities of RAW incineration, RAW supercompaction, RAW remelting, relocation of the existing fragmentation and decontamination facilities and supplementation of RAW storage capacities within the existing civil structures of the NI RAW TCT with the existing auxiliary, storage and transport systems or in annex buildings, workplace of V1 NPP electric cables management, and workplace for releasing materials from institutional control to the existing unused civil structures at the site within the structure system of the RAW TCT.

1. Basic data on the proposal

Currently, JAVYS, a.s. operates the following nuclear installations at Jaslovské Bohunice:

- A1 NPP and V1 NPP, where decommissioning operations take place,
- RAW TCT, which represents a set of radioactive waste treatment and conditioning technologies
- ISFS - interim spent fuel storage
- IRAWS – integral RAW storage facility.

Among the proposed changes, in particular optimisation of RAW incineration capacities by constructing a new RAW incineration plant, and optimisation of metallic RAW remelting capacities have potentially relevant public health impacts. The other changes of the existing technologies or their proposed supplementations do not represent relevant sources of radioactive discharges or emissions of chemical substances.

The new incineration facility is intended for direct oxidation two-degree continual incineration of solid, pasty and liquid waste in vacuum regime.

Degree 1 – includes a rotary kiln furnace with adjustable inclination and speed of rotation; the expected waste hold time at this degree will be about 20 to 40 minutes and the adjustable range of incineration temperature will be up to 1400°C. It will be possible to add oxygen to the rotary kiln furnace, and an automatic controllable gas torch will be installed to ignite and stabilise burning.

Degree 2 – includes a thermoreactor for after-burning of waste gases at a temperature of 900 up to 1200°C, with an automatic controllable gas torch installed. The thermoreactor will have a sufficient flue gas hold time (min. 2 sec) that will be ensured by tangential direction and guiding of the flow of flue gases into spiral movement in the divided part of the thermoreactor chamber. The change of flue gas speed will also cause partial separation of ash and fly ash.

Pre-dedusted flue gases will be cooled down in the heat exchanger to a temperature necessary for input into the flue gas purification system. The dry system of flue gas purification will have four degrees:

a) chemisorption and adsorption to dry sorbent at three thermal levels depending on the sorbent used ($NaHCO_3$, $Ca(OH)_2$, ground activated carbon),

b) separation of PM and particles of reacted and non-reacted sorbents on the sleeve cloth filter with PTFE membrane for the reduction of PCDD/DF,
c) dioxin filter (granulated activated carbon),
d) separation of PM on the sleeve cloth filter.

The considered total annual capacity of the new incineration facility is 240 t of RAW/year.

Optimisation of the capacity of RAW remelting will be executed by installing another remelting line with a medium-frequency induction melting furnace with a capacity of 2 t/batch, it should be operated in three-shift operation. The service area of the workplace (e.g. after-cooling of moulds, preparation of material), and the exhaust opening of the lid of the induction furnace will be exhausted into a regenerative filter and then to the HEPA filter. The facility will serve to re-melt sorted decontaminated and fragmented metallic RAW, which consists mostly of stainless steel, to a smaller extent of copper and aluminium. The proposed optimisation will include the change of single-shift operation for the remelting line under construction to three-shift operation. The total annual treatment capacity of remelting technologies will increase from 1,000 t/year to max. 4,500 t/year of metallic RAW.

2. Stationary air pollution sources

Considering their belonging to the NI, the solved technologies of RAW treatment and conditioning, which represent sources of emissions of chemical substances, are not registered/categorised as air pollution sources in accordance with air protection legislation.

However, directly on the premises of JAVYS, a.s. at Jaslovské Bohunice, several air pollution sources are operated within the base of treatment technologies, most of them operate only as backup energy sources:

- medium-size sources:
    - start-up and standby boiler room (K3 boiler)
    - LOOS K4 boiler
    - Caterpillar Olympian diesel generator,
    - Martin Power MP 1700 diesel generator,
    - Martin Power MP 400 diesel generator (2 pcs),
- small sources:
    - Caterpillar 3306 diesel generator (ISFS),
    - production of fibre-concrete mixture.

Thus, on the premises of the NI complex Jaslovské Bohunice, emissions of the following common pollutants (PM, SO_2, NO_X, CO, C_{org}) are discharged; the BRWTC incineration plant also releases emissions of pollutants such as HCl, HF, Hg, Cd, Tl, As, Ni, Cr, Co, Sb, V, Pb, Cu, Mn and PCDD/DF.

3. Sources of ionising radiation in the operation of RAW treatment and conditioning technologies

The operation produces gaseous fluid contaminated by radioactive isotopes of strontium (^{90}Sr), radionuclides emitting beta and gamma radiation (isotopes of Mn, Co, Zn, Nb, Ag, Sb, Cs, Ce), and radionuclides emitting alpha radiation (Pu, Am).

The operation is also a source of liquid discharges of RAS into the river Váh, which can contaminate fish, sediments, and food irrigated by contaminated water.

The decontaminated waste carried away fulfils the limits of residual radiation and in practice does not affect the environment in the surroundings of the assessed activity.
A decision of the Public Health Authority of the SR permitted release of RAS from administrative control by discharging into the air, into waters and by carrying away wastes. Conditions were set for the above activity, including permanent evaluation of activity of released substances. Annual limits of emissions for the above discharges and groups of radionuclides were set.

4. Discharges of radioactive substances

JAVYS, a.s. monitors the discharges of radioactive substances from the A1, V1 Nuclear Power Plants under decommissioning, interim spent fuels storage facility and from individual structures of treatment technologies of radioactive wastes into the atmosphere and hydrosphere of the surroundings of NI premises.

The data from radioactive substances monitoring serve as input data for the model calculation of population dose rate in the surroundings of NI premises, which is calculated by the ESTE AI programme.

5. Radioactive waste types and management

Various types of wastes are produced during operation and decommissioning of nuclear installations – from common municipal waste to very low, low and intermediate level radioactive wastes in solid, liquid, and gaseous forms.

Very low and low-level liquid and solid radioactive wastes are conditioned by suitable technologies into forms meeting requirements for final disposal. Gaseous wastes are purified at special filters and after a certain time released in the form of gaseous discharges. Intermediate high-level wastes are stored in the long term until their final disposal in a deep repository.

JAVYS, a.s. provides activities of radioactive waste management. All radioactive wastes are collected, registered, and monitored and controlled for the entire period of work with them. Radioactive wastes are also produced in hospitals, research institutes, laboratories, in the machine, construction, and food industries, etc., they are also managed by JAVYS a. s.

The concept of storage of low-level radioactive wastes fixed in cement or bitumen, placed in fibre-concrete containers with long-term integrity in the National RAW Repository at Mochovce is executed in the Slovak Republic.

At the present time, radioactive waste is treated in the technological facilities of JAVYS, a. s. by incinerating, compacting, concentrating, cementing, bituminisation, vitrification, and other auxiliary technologies.

6. Radioactive waste storage

The conditioned waste is transported to the National RAW Repository at Mochovce, which is intended for final disposal of solid and solidified low and very low-level radioactive wastes. Only a part of waste with higher activity, which does not meet the conditions for disposal in the NRWR, is placed in the rooms intended for RAW storage on the NI premises (e.g. the Integral RAW Storage Facility), where it will be stored until the completion of a deep repository. To provide sufficient RAW storage capacities, certified storage facilities of solid and fixed RAW are built at Jaslovské Bohunice in the NI RAW TCT.

7. Radioactive waste transport

Operating road transport is carried out on the road III/504012 in two directions: through Jaslovské Bohunice in the direction of Trnava, and through Žlkovce to the road I/61 or R1, in the directions of Bratislava, Trenčín or Nitra. Transportation follows the operating regulation 8-PVD-006 "Traffic rules for RAS road transportation". Railway transport uses a siding 8.1 km long, which ends in the railway station Veľké Kostoľany. Railway transportation follows the operating regulation 8-PVD-007 "Traffic rules for RAS transportation on the railway siding of JAVYS, a.s.".

8. Drinking and surface water

The operation is connected to internal distribution systems. Drinking water is supplied by Trnavská vodárenská spoločnosť, a.s., cooling water is pumped from the Sĺňava reservoir through SE, a.s., EBO V2 Plant. Hot water and steam are supplied from the V2 NPP operation. Management of individual types of polluted waters uses sewerage collectors of the premises, contaminated water treatment plants and removal of treated waters into the river Dudváh and Váh.

9. Noise

Considering the distance from the closest residential area, noise levels caused by stationary sources of operation (technological equipment) were not assessed.

V. CHARACTERISTICS OF THE CURRENT CONDITION OF THE ENVIRONMENT

1. Air quality

In terms of air pollution within the territory of the SR, the site of the nuclear installations and their surroundings belong to territories with lower load, i.e. "moderate pollution". Thanks to favourite orographic and climatic conditions, the territory is well ventilated, which ensures sufficient dispersion of emitted pollutants. Air quality is affected in particular by emissions from large industrial sources situated in the evaluated territory. An increased concentration of pollutants can be observed in particular in the surroundings of Trnava and Hlohovec. The line air pollution source - D1 highway also affects the evaluated territory.

Air quality is evaluated based on measurements of pollutant concentrations carried out by the Slovak Hydrometeorological Institute at the stations of the National Air Quality Monitoring Network (NMSKO). There are three NMSKO stations in the Trnava region, which do not indicate any exceeding of legislative limits for human health protection pursuant to Decree No. 244/2016 Coll. on air quality as amended.

The sources of gaseous discharges of radioisotopes in the air in the affected territory are as follows:

- V2 NPP belonging to Slovenské elektrárne, a.s., (EBO Plant),
- Nuclear installations of Jadrová a vyraďovacia spoločnosť, a.s.:
    - V1 NPP - Stage II of decommissioning,
    - A1 NPP - Stage III of decommissioning,
    - RAW TCT (Radioactive waste treatment and conditioning technologies),
    - IRAWS (Integral radioactive waste storage facility)
    - ISFS (Interim spent fuel storage facility at Jaslovské Bohunice).

Gaseous emissions are monitored and the outputs are published at www.seas.sk and www.javys.sk. The general evaluation along with other monitored indicators prove only a minimum impact of the SE, a.s. EBO plant and JAVYS, a.s. premises on the environment.

2. Surface and ground water quality

Surface waters

Surface water pollution at all monitored places is monitored in compliance with Government Order No. 269/2010 Coll. as amended. The affected territory belongs to the partial basin of Váh. Water quality in the basin of the river Váh is affected in particular by point sources of pollution (industrial and municipal waste waters). The influence of regulation of the main flow containing a system of hydroelectric power stations and channels is also important.

Ground waters

Ground water at the site of the NI Jaslovské Bohunice is medium-mineralised, with moderately alkaline reaction. Cations of calcium and magnesium, and among anions the bicarbonates have dominant representation. The groundwater streaming direction is from NW to SE. The infiltration of the atmospheric precipitation water, with regard to the thickness and permeability of the loesses, is minimal.

Ground water quality assessment is based on comparison with the limit or maximum concentrations defined in Decree of the Ministry of Health SR No. 247/2017 Coll. laying down details on drinking water quality, drinking water quality control, programme of monitoring and risk management for drinking water supplies.

The issue of drinking waters in the affected territory and its surroundings is the unsuitability of ground water for drinking purposes due to the contents of nitrous substances, which come from the agricultural production.

Waters of the affected territory are loaded also by liquid radioactive discharges from operations of SE, a. s. EBO Plant and JAVYS, a.s. Quality of discharged waste waters from JAVYS, a.s. to the water body Váh is continuously monitored and the evaluation is published in environmental reports and radiation protection reports. Discharged activities in waste waters are controlled by measuring the volume activity of tritium, volume activity of corrosion and fission products, and quantity of waters in collecting tanks for the NI RAW TCT and NI V1 NPP. The results show that the limit for tritium activity in discharged waters was not exceeded and discharges of other corrosion and fission products in waste waters were well below the set authorised limits, which is proved by only minimum influence of SE, a.s. EBO Plant and JAVYS, a.s. on the surroundings.

Pollution of ground waters in the area of JAVYS, a.s. by tritium is solved by remediation pumping of ground waters (borehole N-3), whose objective is to limit the spread of ground water contamination out of the source area.

3. Soil pollution

The affected territory does not show anomalous contents of contaminating substances in soil (sampling density - about 1 sample per 3 km^2).

To the east from the affected territory, in the soils of alluvial bottom land of Váh, there is areal abundance of nickel (Ni), which increase A-limits at many places. Barium content is also increased at some points, e.g. soil samples to the west from the premises of the Jaslovské Bohunice NPP exceed the B-limit (1,000 mg/kg), which, however, does not represent any greater environmental issue.

Within the framework of Jaslovské Bohunice NI radiation control, the soil activity in the surroundings is monitored, as well. Mass activity of natural radionuclides (^{226}Ra, ^{232}Th and isotope ^{40}K) and mass activity of ^{137}Cs or other artificial radionuclides is determined in soil samples.

The monitoring results have confirmed that the contents of natural and artificial radionuclides in the soil are close to the average contents for the whole region, without distinguishable anomalies caused by the Jaslovské Bohunice NI operation.

4. Noise and vibrations

Besides NI, there are no other significant stationary noise sources in the affected territory. Road and railway transport represent a significant source of noise and vibrations in the affected area.

VI. CURRENT STATE OF DEMOGRAPHIC INDICATORS OF THE AFFECTED POPULATION

Graphs No. 1 to 13 show basic demographic indicators of the affected population, such as data on population, on population change, on population age composition, on average age and ageing index, which are compared with the population of neighbouring districts or regions and with the population of the Slovak Republic. Demographic data were taken over from the Statistical Office of the Slovak Republic from the DATAcube database and reflect information as at 18 February 2019. The demographic data evaluated in this chapter are available for years 1996 to 2018 (23 years). JAVYS, a.s. activities affect inhabitants of nine municipalities belonging to three districts:

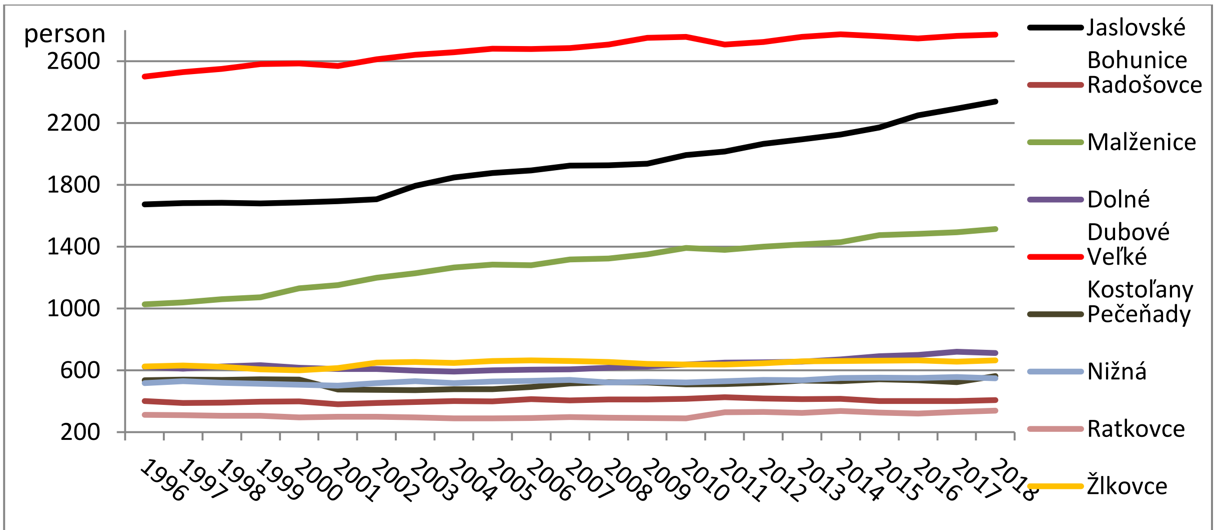
- Trnava District: Jaslovské Bohunice, Radošovce, Malženice, Dolné Dubové,
- Piešťany District: Veľké Kostoľany, Nižná, Pečeňady,
- Hlohovec District: Ratkovce, Žlkovce.

Demographic data were evaluated either for each affected municipality separately or according to the type of indicator and availability of demographic data, they were evaluated for the whole affected population, i.e. sum of inhabitants of all nine municipalities.

1. Data on the number of affected inhabitants

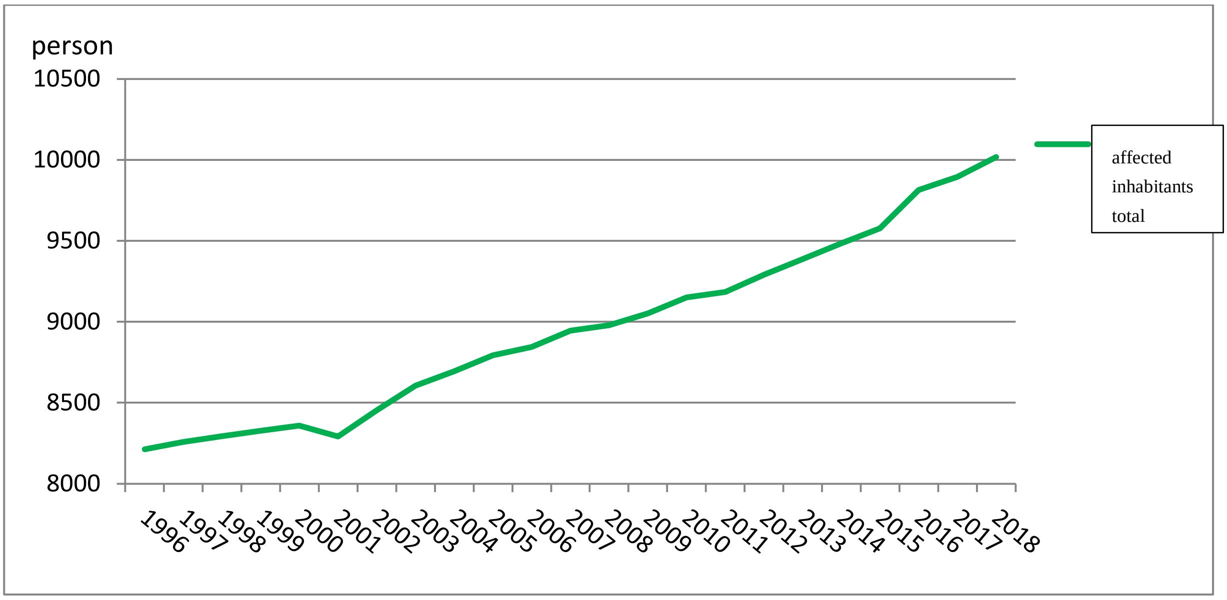
Graph No.1 contains data on the population development dynamics in the affected municipalities. The population has increased by 16.7% over the past 23 years, which represents 1,643 inhabitants. In 2018, the total population with permanent residence was 9,855. Population increase was highest in the municipalities Jaslovské Bohunice (by 665 inhabitants), Malženice (by 487 inhabitants), and Veľké Kostoľany (by 272 inhabitants). The population has increased by 7 to 88 inhabitants in smaller municipalities. The population has not decreased in any of the municipalities.

Graph No. 1: State of permanently living population in the affected municipalities

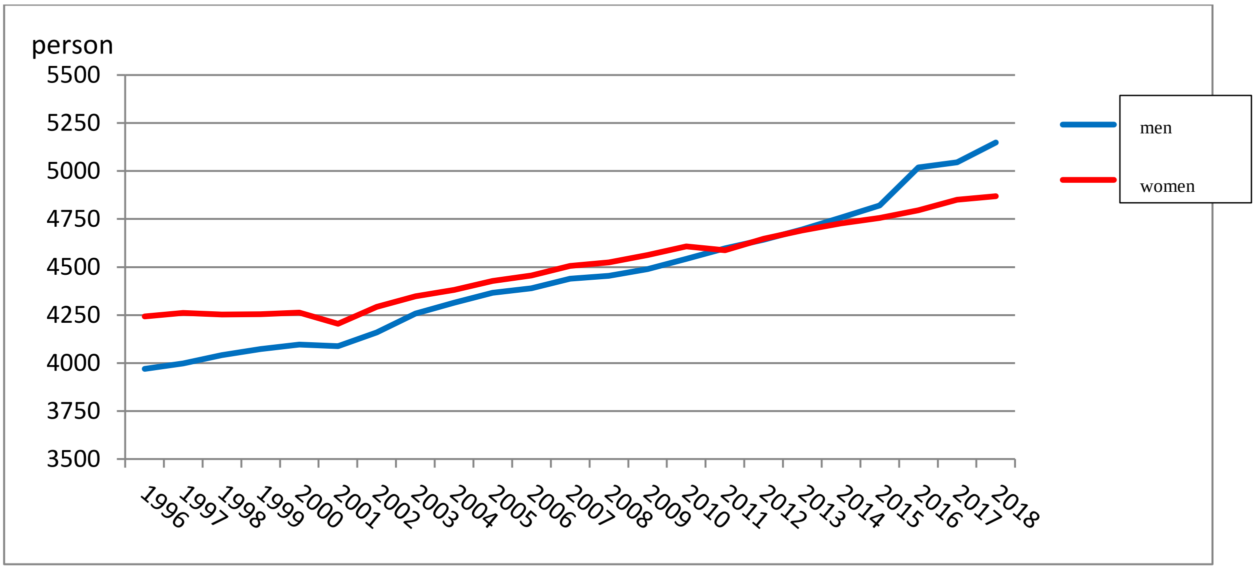


The total development of population over the past 23 years is shown in Graph No. 2; Graph No. 3 shows the number of men and women in the affected municipalities in the monitored period. In 2018, 5,149 men and 4,869 women lived in the affected municipalities, i.e. the number of women was lower by 2.8 % than the number of men. The ratio of men and women changed in 2011. Until then, more women lived in the affected municipalities.

Graph No. 2: Total population in the affected municipalities over the past 23 years.



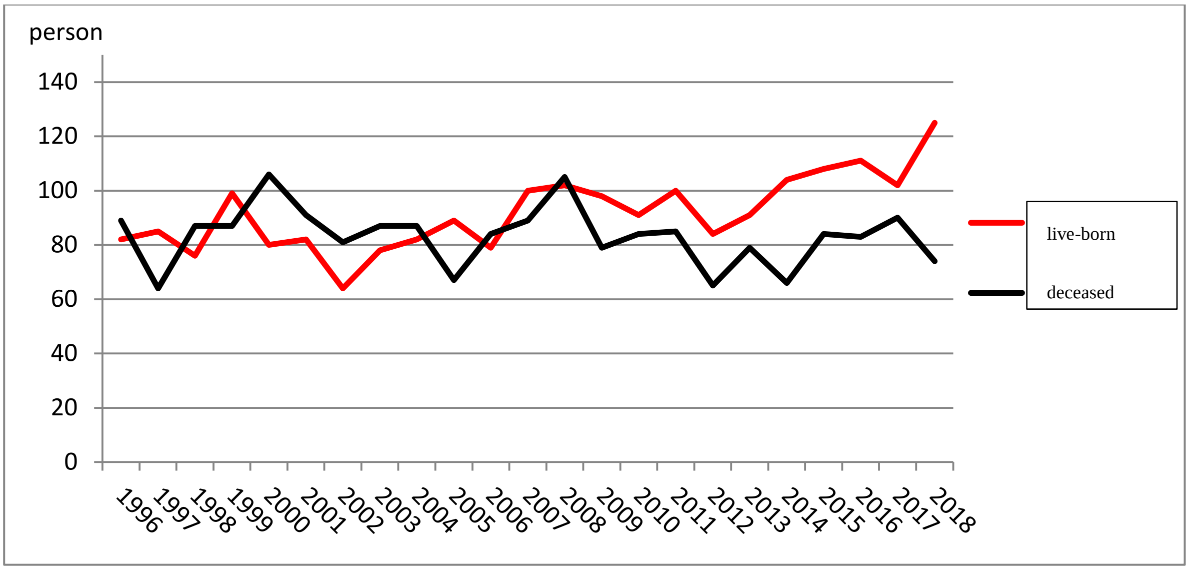
Graph No. 3: Number of men and women in the affected municipalities over the past 23 years.



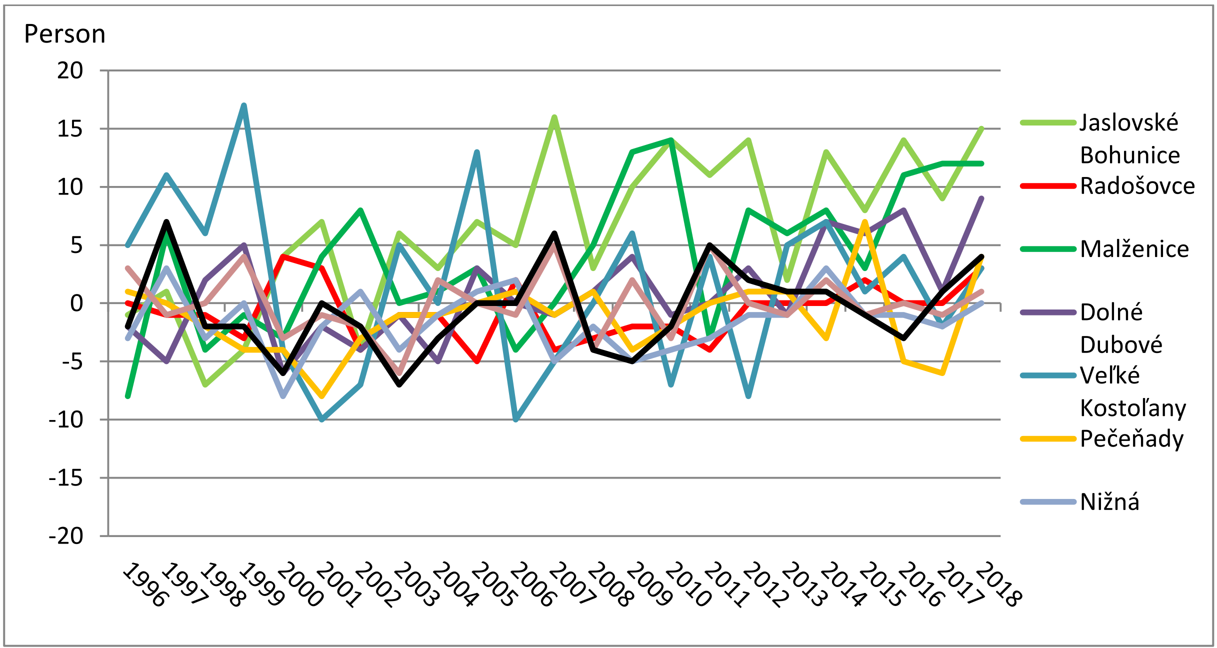
Graph No.4 contains data on live-born and deceased inhabitants in the affected municipalities over the past 23 years. The average number of live-born people in the affected municipalities is 92, and the annual average number of deceased people is 83. In 2018, the number of live-born people in the affected municipalities was 125, and the number of deceased people was 74. The number of live-born people in the assessed municipalities has been exceeding the number of deceased people in the long term.

Over the past 23 years, the natural increase has been fluctuating from minus 10 to plus 17. In 2018, the average natural increase in the affected municipalities was plus 6 people, (Graph No. 5).

Graph No. 4: Comparison of the number of live-born and deceased people in the affected municipalities over the past 23 years



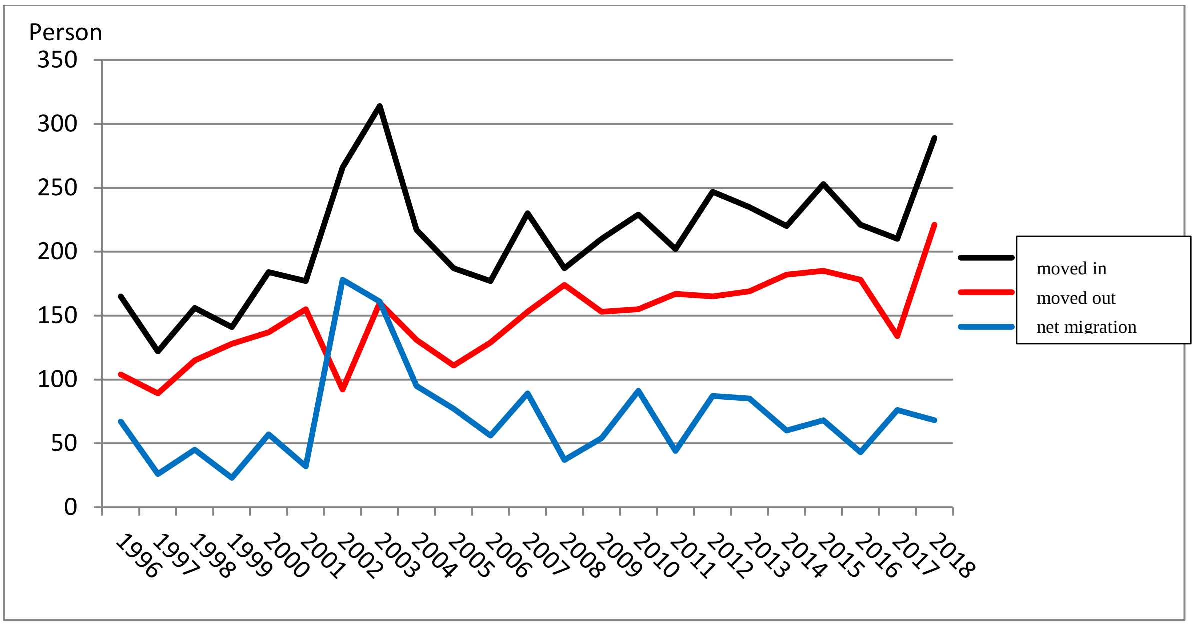
Graph No. 5: The natural increase in the affected municipalities over the past 23 years



Graph No.6 contains data on inhabitants moved in and moved out and on net migration in the affected municipalities over the past 23 years.

On average, 207 people have moved in the affected municipalities and 144 people have moved out over the past 23 years. In 2018, 289 people moved in the affected municipalities and 221 people moved out, i.e. net migration in 2018 amounted to plus 68 people. Over the past 23 years, net migration has been always positive, ranging from 23 to 178 people.

Graph No. 6: Inhabitants moved in and out, and net migration in the affected municipalities over the past 23 years



2. Age composition of the affected population

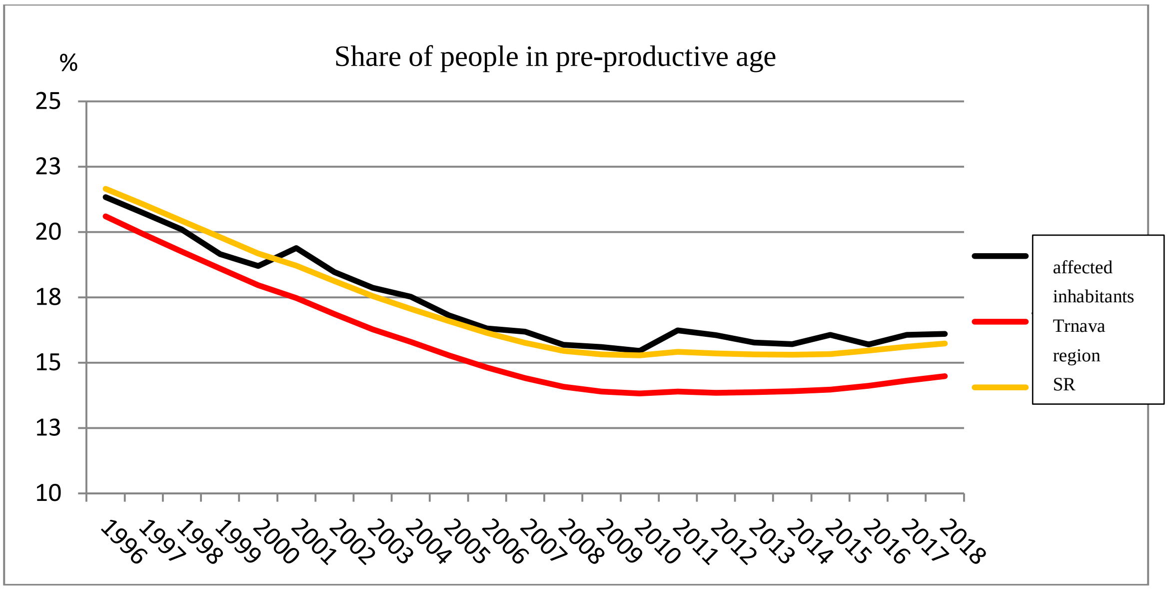
Graphs No.7 to 9 contain data on age composition of the affected population, compared with the Trnava region and population of the SR. Population structure represents the basic characteristics of population. Changes in the age structure of the population and in particular a decrease in the share of child population (from 0 to 14 years) warn of the process of demographic ageing of the population. From 1996 to 2018, the child population has decreased in the affected municipalities by 5.2 % and in the SR by 5.9%. The average value of child population share over the past 23 years was 17.3 % in the affected municipalities and 17.0 % in the SR.

Over the past 23 years, the productive age population has increased by 4.1 %, in the SR the increase amounted to 1 %. The share of productive age population (from 15 to 64 years) in the affected municipalities amounts to 69.6 %, the average for the SR is 70.4 %.

The post-productive age population (65 and more years) has also changed. In the affected municipalities, the share of people at post-productive age has increased by 1.1 %, in the SR, the share of inhabitants at post-productive age has increased by 5.0 %. In 2018, this age group represented a share of 14.8%, and in the SR 16.0 %.

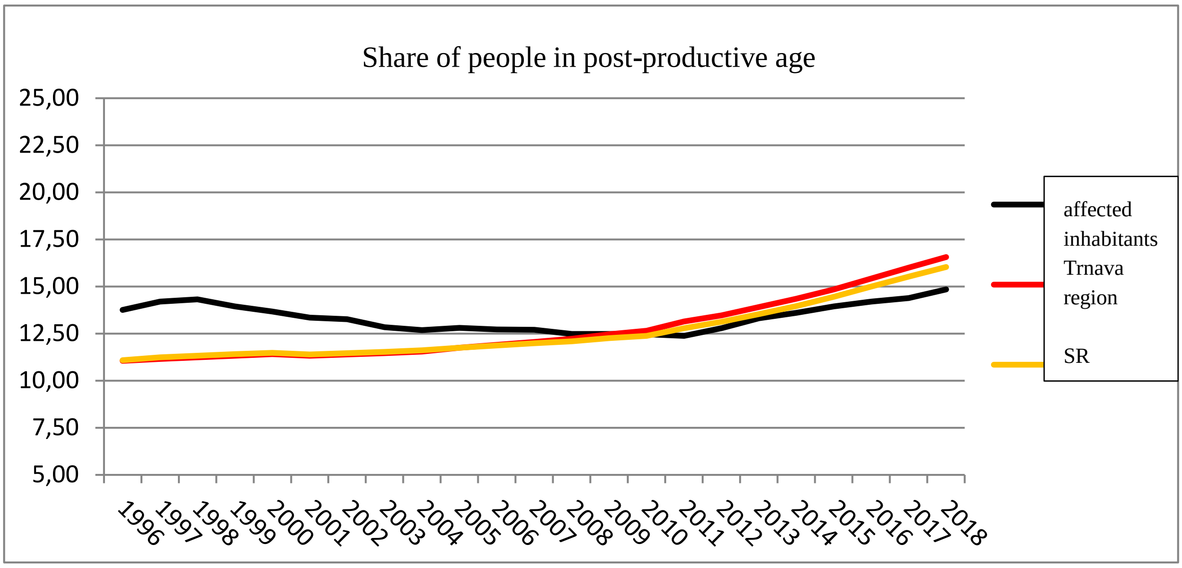
The demographic development of the population in the affected municipalities over the last 23 years suggests a reduced share of pre-productive age people and an increase in the number of people at productive and post-productive age. The development of demographic indicators in the affected municipalities is about the same as the development of indicators in the Trnava region and in the SR.

Graph No. 7: Share of pre-productive age people in the affected municipalities and in the higher territorial units



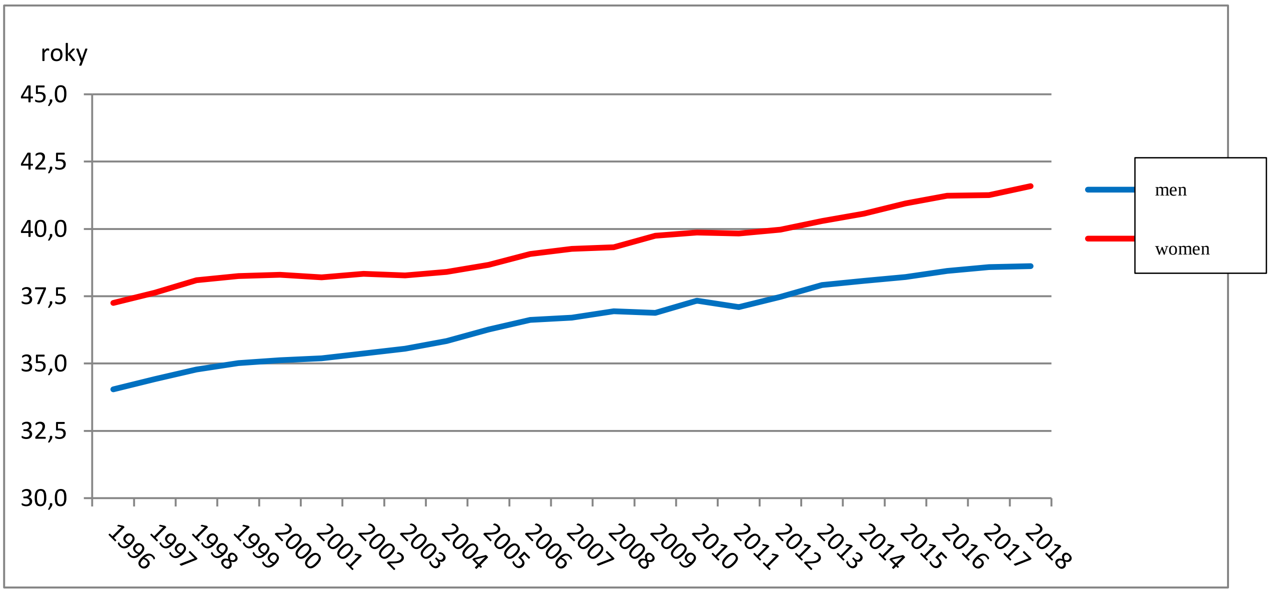
Graph No. 8: Share of productive age people in the affected municipalities and in the higher territorial units

Graph No. 9: Share of post-productive age people in the affected municipalities and in the higher territorial units

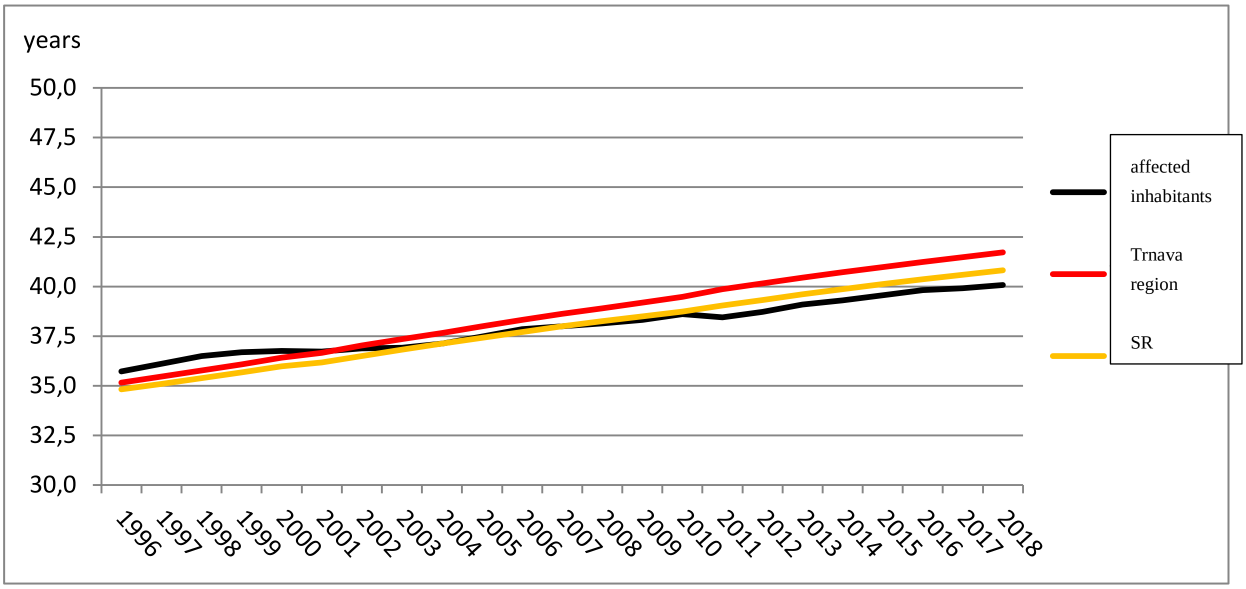


Population ageing in the Slovak Republic results mainly from the decreasing fertility and stabilised mortality rate in the past years, which are monitored through indicators, such as ageing index and mean age of inhabitants. From 1996 to 2018, a higher mean age of women has been persisting in the affected municipalities in comparison with men, by about 2.8 years (Graph No. 10). The mean age of population in the Slovak Republic keeps rising and in 2018 it reached a value of 40.8 years (men and women together). The mean age of population in the affected municipalities in 2018 was 40.1, which is higher by 4.4 years in comparison with 1996; in the Trnava region, the mean age has increased by 6.6 years and in the SR by 0.6 years over the same period. Till 2007, the mean age of inhabitants in the affected municipalities was higher by about 0.5 years than the mean age of inhabitants of the SR, and from 2007 to 2018 their mean age was lower by 0.5 years than the mean age of SR population (Graph No. 11).

Graph No. 10: Mean age of men and women in the affected municipalities

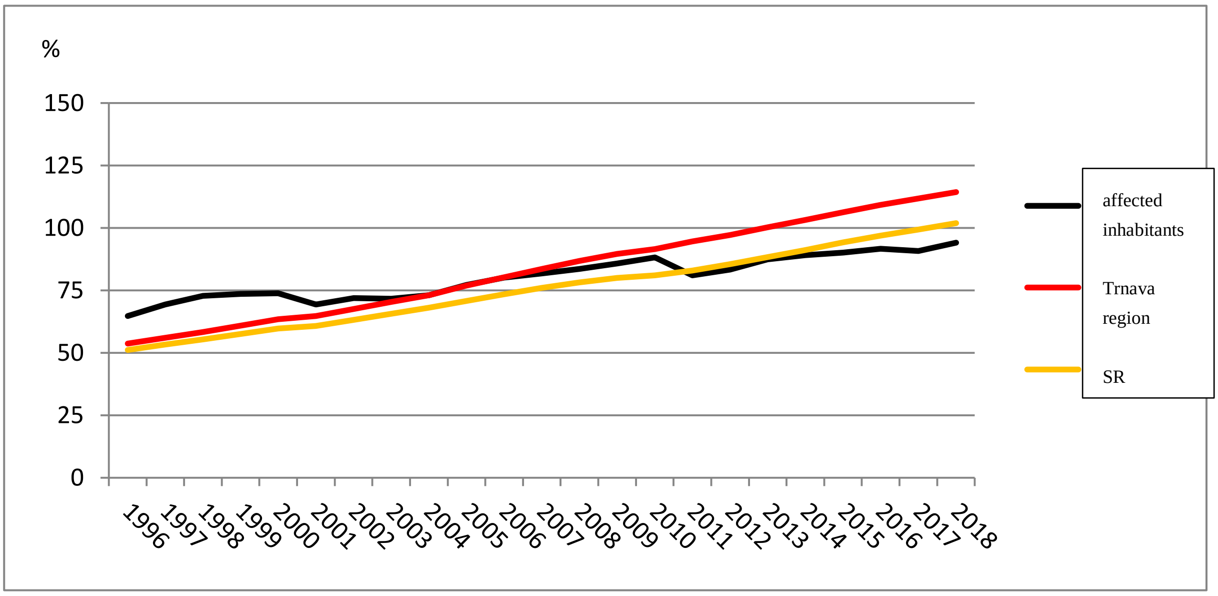


Graph No. 11: Comparison of mean age of inhabitants in the affected municipalities and higher territorial units



Graph No. 12 contains the comparison of ageing index of the affected inhabitants with higher territorial units and SR population. In 2018, the ageing index of the inhabitants in the affected municipalities was 94 %, i.e. there were 94 inhabitants at the age of 65 and more year per 100 children at the age of 0 to 14 years. In the Trnava region, the ageing index was 114 %, and in the SR 102 %. Over the past 23 years, the ageing index in the Trnava region has increased by 61 %, in the by 51 %, and in the affected municipalities only by 29 %.

Graph No. 12: Ageing index



the obtained demographic data show only small differences between the affected population, Trnava region and SR population. The population in all affected municipalities slightly increases, the number of live-born people also slightly increases, the number of deceased people has been approximately at the same level for 23 years, and the ageing index is lower than Slovakia's average. The share of pre-productive, productive and post-productive population as well as the mean age is comparable with the population of the SR.

VII. CURRENT STATE OF HEALTH CONDITION INDICATORS OF THE AFFECTED POPULATION

Environmental quality is among the significant factors affecting population health and mean age. Based on the statistics of the World Health Organisation, about 16 % of deaths in the Slovak Republic are caused by environmental risk factors (e.g. air, water, noise, climatic conditions, etc.).

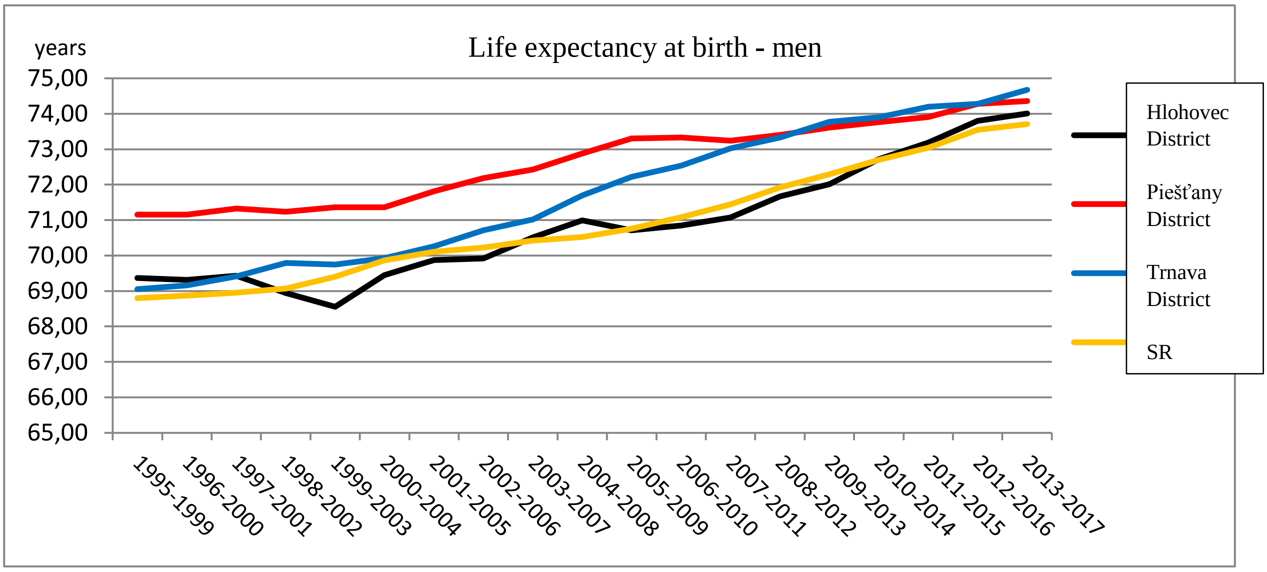
Health condition of the affected population was evaluated based on the data of the National Centre of Medical Information of the SR (Medical Year-Books, Incidence of Malignant Tumours in the Slovak Republic), and Research Demographic Centre. Some date on health condition were taken over from the Statistical Office of the SR (last update 13 March 2019). Health condition indicators for adults were evaluated based on the data on gross incidence of cancer and mortality of cardiovascular and respiratory diseases, and mortality of cancer diseases.

Life expectancy at birth, i.e. the number of years the new-born child can expect to live unless mortality conditions change, is an indicator of level of life conditions of inhabitants and mortality conditions. A decrease in total mortality, however, in particular in mortality of infants and new-born children, manifests itself as extension of life expectancy at birth, where life expectancy at birth has been higher for women than men in the long term.

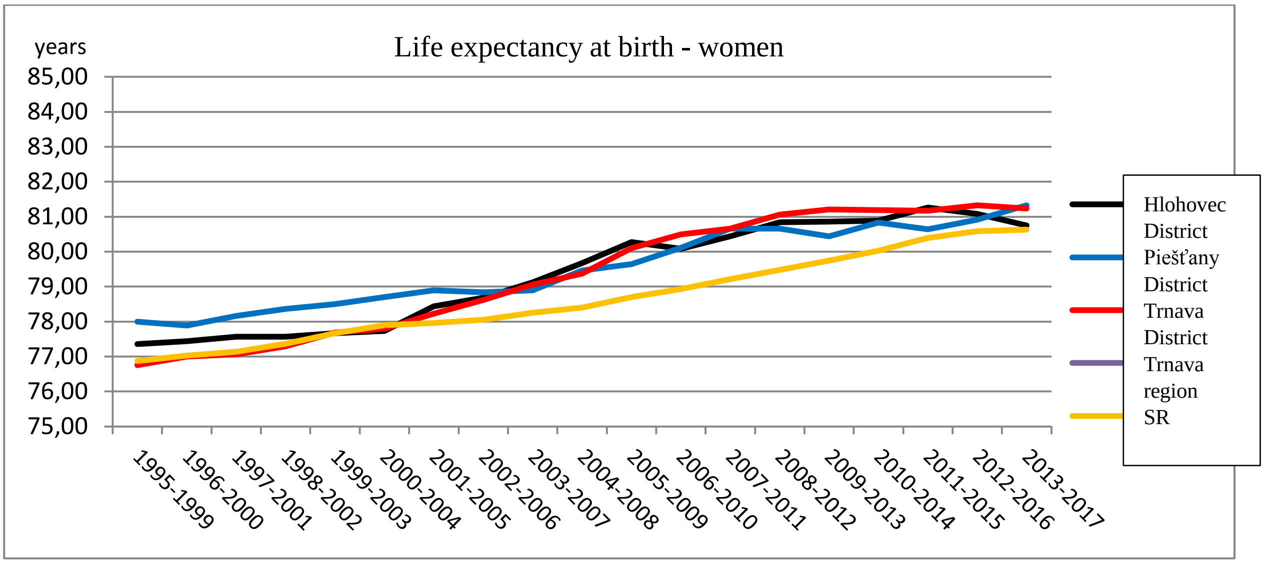
Graphs No. 13 and 14 contain information on life expectancy at birth for men and women in the districts Hlohovec, Piešťany, Trnava, and in the SR for 23 years (1995 to 2017), they were obtained from the Research Demographic Centre. In 2013 to 2017, life expectancy at birth for men from the districts Hlohovec, Piešťany and Trnava was slightly higher (74.0 to 74.7 years) than for men in the SR (73.7 years).

In 2013 to 2017, life expectancy at birth for women from the assessed districts was also slightly higher (80.8 to 81.3 years) then women in the SR (80.6 years). The highest increase in life expectancy at birth for 22 years can be seen for men from the Trnava District - by 5.6 years; in the Hlohovec District life expectancy at birth has increased by 4.6 years, and in the Piešťany District by 3.2 years. Life expectancy at birth for men in the SR has increased by 4.9 years in 22 years. For the same period, life expectancy at birth for women in the Trnava District has increased by 4.5 years, in the Hlohovec District by 3.4 years and in the Piešťany District, by 3.3 years. Life expectancy at birth for women in the SR has increased by 3.8 years in 22 years.

Graph No.13



Graph No.14



Graphs No. 15 and 17 show gross incidence rates of cancer for men and women in 2003 to 2011. The latest publication "Incidence of Malignant Tumours in the Slovak Republic" was issued in 2018, and it contains data for 2011. There are no later data on gross incidence of malignant tumours in the SR. Gross incidence means the number of cancer diseases per 100,000 inhabitants of the respective territorial unit. Graphs show a gradual increase in the incidence of malignant tumours in the SR as well as in the assessed districts.

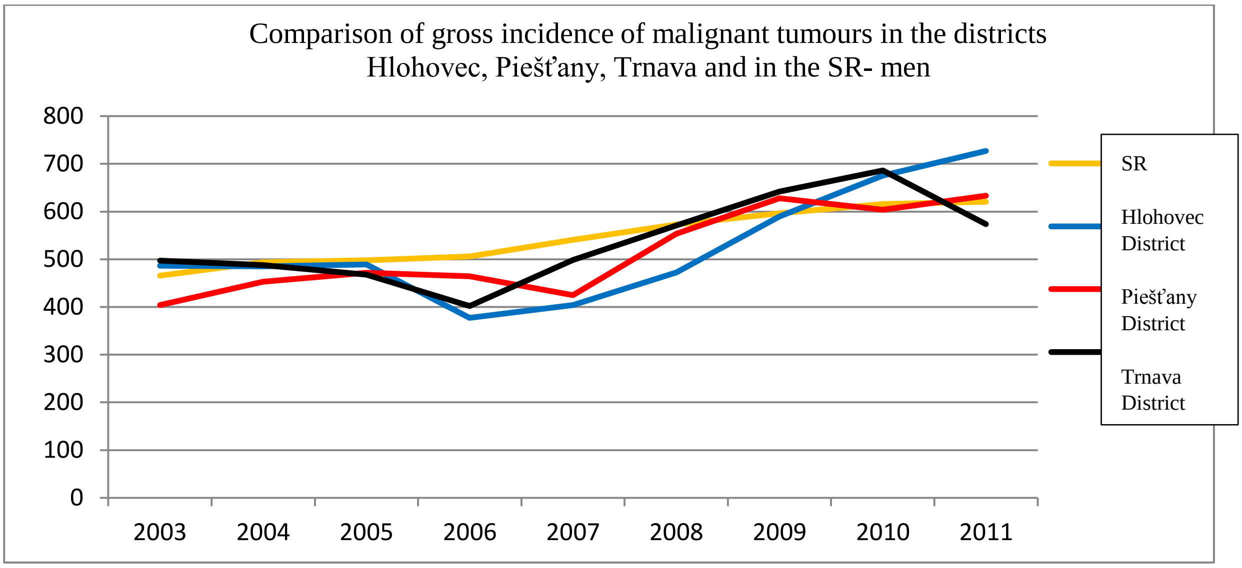
The highest average value of gross incidence of malignant tumours in men for the evaluated territorial units for the monitored period (2003 to 2011) was for the SR - 545 diseases per 100,000 inhabitants. For the same period, the average value of gross incidence of malignant tumours in men in the assessed districts was 515 to 536 diseases per 100,000 inhabitants. Consequently, average values of gross incidence of malignant tumours in men for the monitored period are slightly lower in the affected districts than in the SR. The values of gross incidence of malignant tumours in men only for 2011 are higher in the districts Piešťany (633 diseases per 100,000 inhabitants) and Hlohovec (727 diseases per 100,000 inhabitants) than for the SR (621 diseases per 100,000 inhabitants). On the contrary, only 573 diseases per 100,000 inhabitants were found in the Trnava Districts.

There is a similar situation for gross incidence of malignant tumours in women. The highest average value of gross incidence of malignant tumours in women for the evaluated territorial units for the monitored period (2003 to 2011) was for the SR - 503 diseases per 100,000 inhabitants. For the same period, the average value of gross incidence of malignant tumours in women in the assessed districts was 456 to 491 diseases per 100,000 inhabitants. Consequently, average values of gross incidence of malignant tumours in women for the monitored period are slightly lower in the affected districts than in the SR. The values of gross incidence of malignant tumours in women only for 2011 are higher in the districts Trnava (626 diseases per 100,000 inhabitants) and Hlohovec (629 diseases per 100,000 inhabitants) than for the SR (574 diseases per 100,000 inhabitants). On the contrary, only 518 diseases per 100,000 inhabitants were found in the Piešťany Districts.

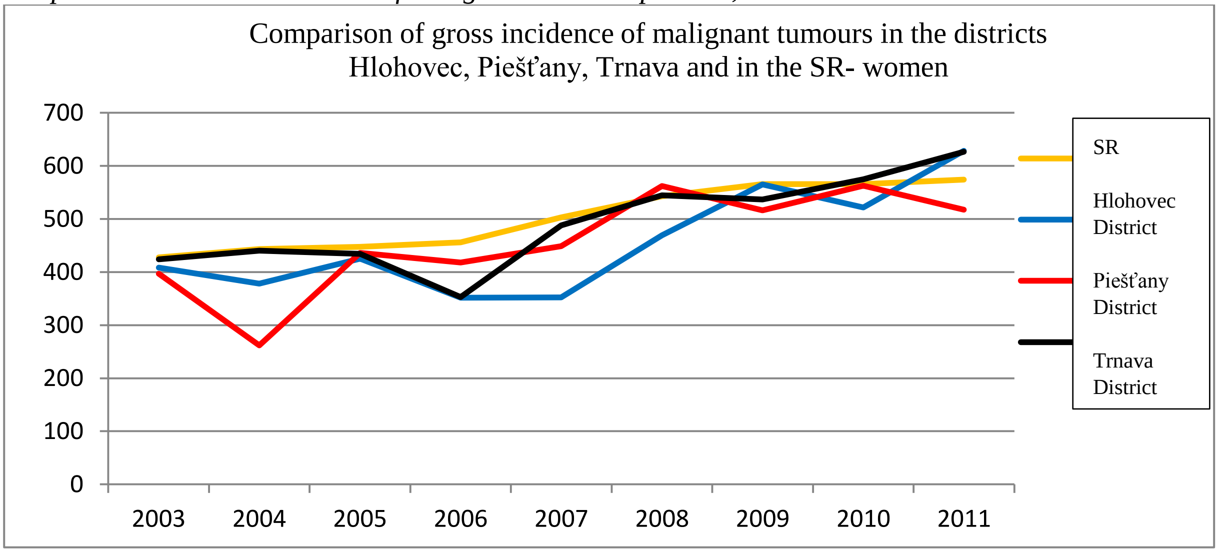
In the monitored period (2003 to 2011), the value of gross incidence of malignant tumours in the assessed districts was higher for men than women, ranging from 7 to 115 diseases per 100,000 inhabitants.

Consequently, differences in gross incidence of malignant tumours in men and women for the whole monitored period (2003 to 2011) are not very significant between the affected districts and Slovakia's average.

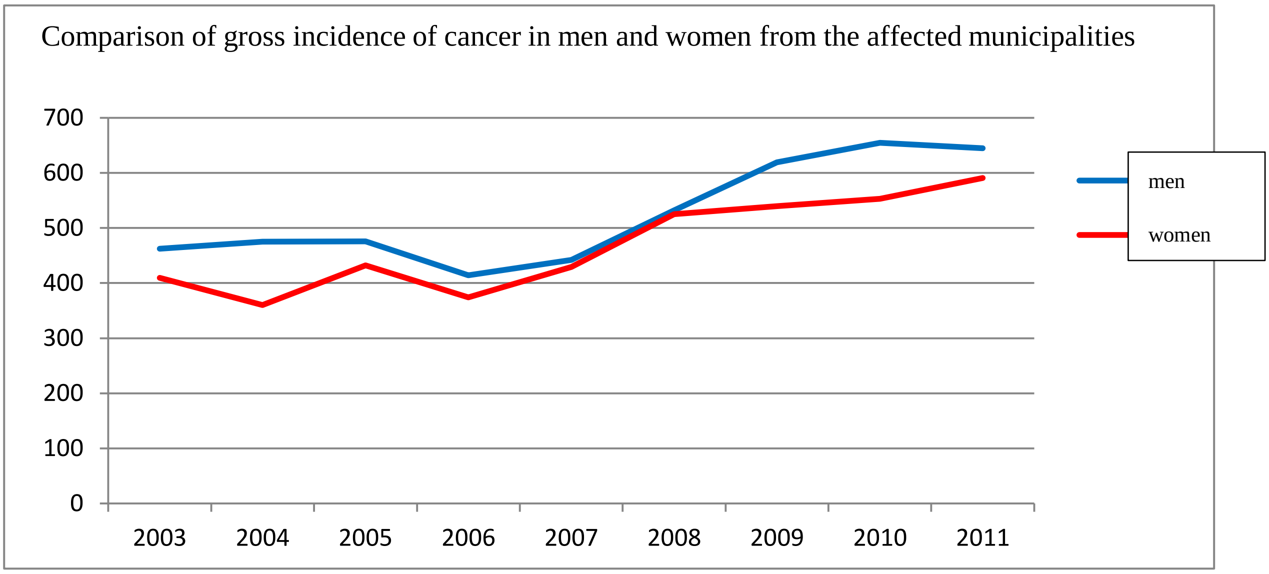
Graph No. 15: Gross incidence of malignant tumours per 100,000 inhabitants in 2003 to 2011



Graph No. 16: Gross incidence of malignant tumours per 100,000 inhabitants in 2003 to 2011



Graph No. 17: Gross incidence of malignant tumours in men and women in 2003 to 2011



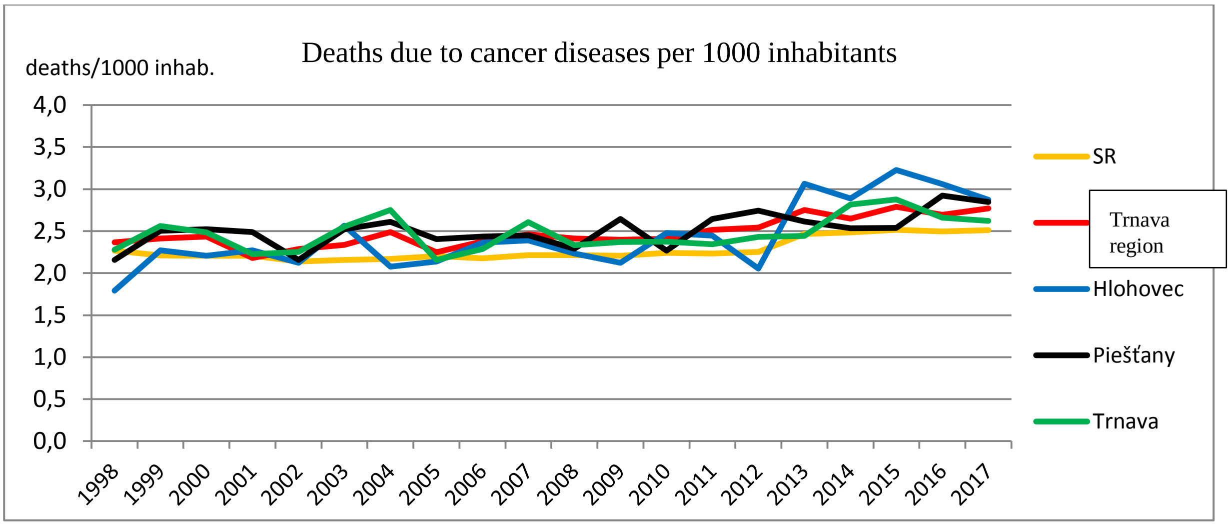
Graphs No. 18 to 20 contain data on deaths caused by individual diseases per 1,000 inhabitants; only those diseases were selected that can be connected with the set of technologies for radioactive waste treatment and conditioning.

Data on gross incidence are provided above, which represent the number of cancer diseases per 100,000 inhabitants. Moreover, mortality of cancer is monitored. Graph No. 18 contains data on deaths caused by cancer per 1,000 inhabitants in the districts Hlohovec, Piešťany, Trnava, in the Trnava region and in the SR for 20 years.

In the SR, over 20 years on average 2.3 people died of cancer, in the Hlohovec District 2.4 people and in the districts Piešťany, Trnava, and in the Trnava region 2.5 people per 1,000 inhabitants. In 2017, both in the assessed districts and in the Trnava region, 2.6 to 2.8 people died of cancer, and in the SR 2.5 people per 1,000 inhabitants.

It results from the above mentioned that the differences in the data on deaths caused by cancer per 1,000 inhabitants between the affected districts and Slovakia's average are not very significant.

Graph No. 18: Mortality of cancer



Graph No. 19 contains data on deaths caused by cardiovascular diseases per 1,000 inhabitants in the districts Hlohovec, Piešťany, Trnava, in the Trnava region and in the SR for 20 years.

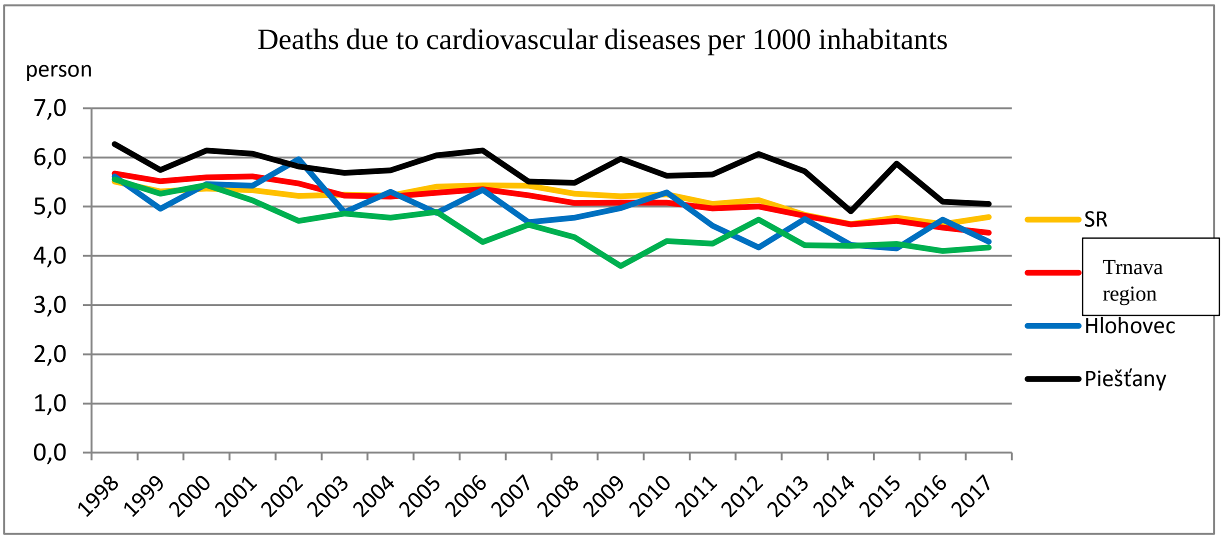
The average value of mortality of cardiovascular diseases over 20 years have been ranging in the assessed districts from 4.6 to 5.7 of diseased people per 1,000 inhabitants. In the SR, the average number of deaths caused by cardiovascular diseases over 20 years was 5.2 people, in the Trnava region, 5.1 people died per 1,000 inhabitants.

In 2017, the highest number of deaths caused by cardiovascular diseases was in the Piešťany District (5.1 people per 1,000 inhabitants). In the districts Trnava and Hlohovec, about 4.3 people died, in the Trnava region 4.5 people, and in the SR 4.8 people per 1,000 inhabitants.

The number of deaths caused by cardiovascular diseases in the assessed districts has decreased over 20 years by 1.3 people, in the Trnava region by 1.2 people, and in the SR by 0.7 people per 1,000 inhabitants.

It results from the above mentioned that the differences in the data on deaths caused by cardiovascular diseases per 1,000 inhabitants between the affected districts and Slovakia's average are not very big.

Graph No. 19: Mortality of cardiovascular diseases

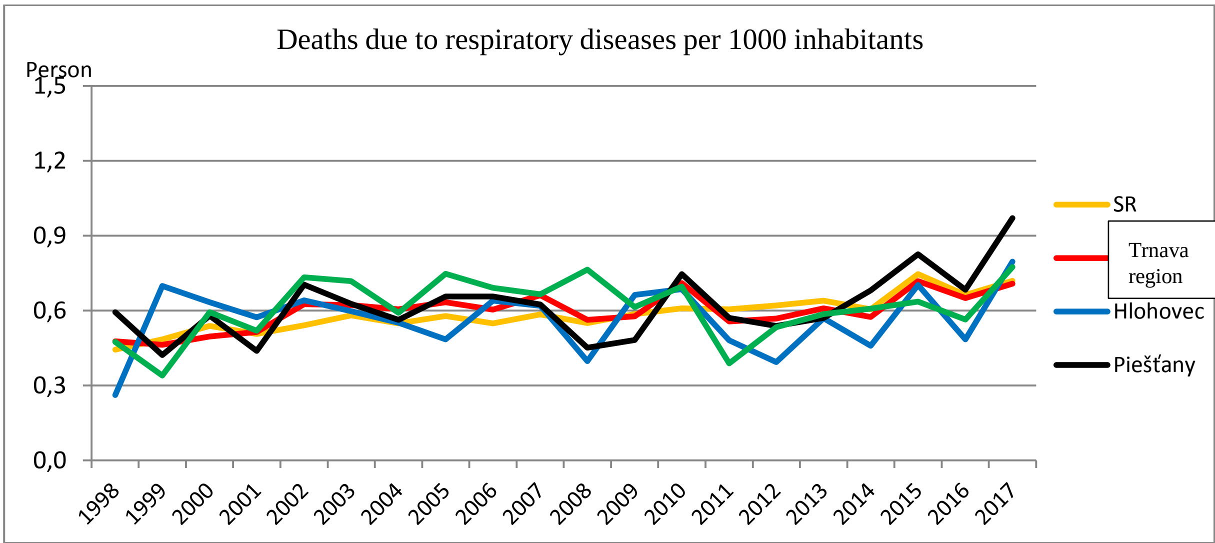


Graph No. 20 contains data on deaths caused by respiratory diseases per 1,000 inhabitants in the districts Hlohovec, Piešťany, Trnava, Trnava region and in the SR for 20 years.

In 2017, the number of deceased people due to respiratory diseases in the districts Trnava and Hlohovec was 0.8 people per 1,000 inhabitants, in the Piešťany District it was one person and in the Trnava region and in the SR 0.7 people per 1,000 inhabitants. The average number of deaths caused by respiratory diseases per 1,000 inhabitants over the whole monitored period in all assessed territorial units was identical (0.6 people per 1,000 inhabitants).

It results from the above mentioned that the differences in the data on deaths caused by respiratory diseases per 1,000 inhabitants between the affected districts, Trnava region and Slovakia's average are not very big.

Graph No. 20: Mortality of respiratory diseases



In Slovakia, just like in most developed countries, the number of deaths caused by cancer have been gradually increasing. In the evaluated districts and in the Trnava region, on average 2.5 people per 1,000 inhabitants and in the SR 2.3 people per 1,000 inhabitants died of cancer diseases. In particular in the last decades, there has been in increase in malignant tumours of lungs, colon, rectum, skin, prostate, and stomach in men, and breast, colon, rectum, reproductive system, lungs, and stomach in women. This gradual increase in cancer occurrence, however, cannot be attributed only to air pollution because serious causes of cancer disease occurrence and development also include other factors, such as smoking, alcohol, nutrition factors, professional exposure to carcinogenic substances, etc.

In the long term, most death have been recorded as caused by cardiovascular diseases, the average number in the SR is 5.2 deaths/1,000 inhabitants. In the evaluated districts, the average number of deaths caused by cardiovascular diseases ranged from 4.6 to 5.7 people (Piešťany District).

The lowest number of deaths was caused by respiratory diseases, about 0.6 persons/1,000 inhabitants in all evaluated districts, in the Trnava region and in the SR.

Availability of data on health condition of inhabitants is limited in the Slovak Republic. Some data are available at the level of municipalities, however, most data are available only at the level of districts or regions. Based on the obtained data, no significant differences have been found for health condition of inhabitants of the territorial units under comparison.

VIII. HEALTH RISK ASSESSMENT FOR CHEMICAL SUBSTANCES

Health risk assessment represents the process of quantitative or qualitative evaluation of probability and gravity of harmful effects of hazardous factors on humans as a consequence of exposure under defined conditions and from defined sources. Risk assessment is a tool for objective selection of the most suitable alternative of a corrective measure, whose objective is to reduce risk to a certain rate.

The submitted assessment is based on US EPA methodology: Risk Assessment Guidance for Superfund. Human Health Evaluation Manual.

Evaluation was carried out in four steps:

- ***determination of hazard,***
- ***determination of relation between the dose and effect,***
- ***exposure evaluation,***
- ***risk characteristics.***

1. Determination of hazard of chemical substances

Determination of hazard consisted of identification of effects of the chemical substances present in the air in the surroundings of the respective technologies of JAVYS, a.s. and of the assessment, whether these substances are able to be harmful to human organism. The determination of hazardous properties of the assessed chemical substances was carried out based on the results of epidemiological studies carried out in people or the results of laboratory examinations in animals. The results of the studies were obtained from TOXNET, ATSDR databases and from professional publications of WHO, US EPA, IARC and other materials listed in Chapter XVIII. Quality and gravity of evidence is important in preparing the risk analysis; thus, only trustworthy sources of information were used.

Determination of hazard of the evaluated chemical substances is included in Subhead 2.1.

2. Determination of relation between the dose and effect of chemical substances

Determination of relation between the dose and effect of a chemical substance describes quantitative relations between the dose and the scope of adverse effects caused by it, such as damage to health, disease occurrence and in extreme cases death or perishing of individuals.

To quantify the relation dose - effect, two basic approaches were used: evaluation of doses ***with threshold effect*** (non-carcinogenic substances) and/or ***thresholdless effect*** (carcinogenic substances). Substances with threshold effect have a certain level of exposure, the so-called threshold dose, below which no effect is expected. For the substances with thresholdless effect it is expected that even the lowest possible concentration may cause a cancer disease.

2.1 Evaluated chemical substances

This chapter describes hazardous features of the assessed chemical substances and determination of the relation dose - effect for the substances.

Based on the results of the dispersion study worked out by Ing. V. Carach, PhD., health risk assessment was carried out for the chemical substances produced during the activity of RAW treatment and conditioning technologies, including their operating background, which affect air quality in the affected area. To assess the impact on the residential area, 12 reference points were selected at the level of the place of municipality closest to the assessed source.

Health risk assessment was carried out for the following chemical substances:

Basic pollutants:

- PM - particulate matter was evaluated the sum of PM_{10} and $PM_{2.5}$,
- SO_2 - sulphur dioxide,
- NO_2 - nitrogen dioxide,
- CO - carbon monoxide,
- TOC – total organic carbon was evaluated as volatile organic compounds (VOC) and health risk was calculated for benzene.

Other than basic pollutants:

- HCl - hydrogen chloride,
- HF – hydrogen fluoride,
- Hg – mercury,
- Cd+Tl – cadmium + thallium,
- Cu – copper,
- Sum of heavy metals – arsenic, lead, chrome, cobalt, manganese, nickel, antimony, vanadium,
- PCDD/DF - dioxins, furans.

Immission modelling of air pollution was carried out for short-term maximum concentrations at adverse dispersion conditions, when the impact of the source on air pollution is highest, and for average annual concentrations. Brief description of hazardous features of the assessed chemical substances and determination of relation between the dose and effect for the substances are provided below.

2.1.1 Particulate matter

Determination of hazard of PM

Particulate matter (PM) means the sum of particles of various sizes freely dispersed in the air in liquid or solid form. According to origin, PM can be primary or secondary. Primary PM is released into the air from natural and industrial sources of pollution without proper separation technology. PM is released mainly during combustion of solid substances and is contained in exhaust fumes of motor vehicles. Secondary PM gets into the air by whirling of particles settled on the ground.

PM can be divided into two groups according to size: large PM_{10} (with a size of 2.5 to 10 μm), which gets into the air from industrial sources (e.g. power plants, heat plants, boiler rooms) and smaller particles $PM_{2.5}$ (with a size of 2.5 μm) created by condensed vapours of organic compounds and metals.

Relation between the dose and effect of PM

The only exposure pathway for dust particles to get into human body is inhalation. health significance depends on the size of particles. Larger particles (over 10 μm) can cause only irritation of upper respiratory tract with cough, sneezing and irritation of conjunctiva, whereas smaller particles (2.5 to 10 μm) get to the lower respiratory tract. Particles with a dimension smaller than 2.5 μm may enter lung alveoli and accumulate in lungs or penetrate into blood circulation. Increased air dustiness in general irritates air passages. Vulnerable groups of population include asthmatics, people with respiratory and cardiovascular diseases, little children and old people.

Epidemiological studies have shown that a long-term exposure to PM_{10} particles may lead to the reduction of life expectancy by about 1 to 2 years. Other studies suggest that prevalence of bronchial syndromes in children and reduction of lung function in children and adults is also connected with exposure to PM_{10} particles.

PM affects mortality, where an increase in PM concentration by 10 μg/m^3 causes an increase in mortality by 1 %. PM also affects the increase in the number of people hospitalised due to respiratory and cardiovascular diseases, which is observed at the level of PM of 100 μg/m^3. The EU has a 24-hour average concentration of PM_{10} at a level of 50 μg/m^3. However, this level is currently exceeded in larger towns of the SR, as well as in most European countries.

2.1.2 Sulphur dioxide

Sulphur dioxide (SO_2) CAS 7446-09-5

Determination of hazard of SO2

Physical and chemical properties

Molar mass: 64.1 g/mol
Boiling point: 10.0 °C
Melting point: -75.5 °C
Water solubility at 25 °C: 8.5 ml/100 ml
Relative density of vapours (air = 1): 2.25

Conversion factor: 1 ppm (20 °C, 1013 hPa) = 2.860 mg/m^3
1 mg/m^3 = 0.35 ppm

Sulphur dioxide is a colourless gas with strong suffocating and pungent odour. It is soluble in water and is volatile. It acts both as oxidiser and reducer. It is non-flammable. It explodes only after compression. It reacts with water or steam producing toxic and corrosive vapours.

Odour threshold – upper limit: 12.5 mg/m^3
lower limit: 1.175 mg/m^3
irritating concentration: 5.0 mg/m^3

Relation between the dose and effect of SO2

SO_2 poisoning causes damage to lung epithelium and massive invasion of bacteria. High concentrations result in the vocal cord closure reflex, in asthmatics it causes a asthmatic attack, which lasts several days after the exposure. Exposure to SO_2 is accompanied by vasodilatation, pain in chest, burning sensation in the oesophagus and pharynx, nausea and vomiting. Long-term exposure to high concentrations results in damage to the nervous system.

Workers in cold stores exposed to SO_2 at a level of 20 to 32 ppm suffered from a significantly higher incidence of respiratory diseases. Workers of paper-mills exposed to 2 to 36 ppm of SO_2 suffered from considerably higher incidence of cough, sliminess and impaired respiration indicators.

In the studies including people with obstructive lung disease, healthy non-smokers and smokers, exposure to SO_2 at a level of 0; 0.3; 1 and 3 ppm was used. Lung functions were impaired at the concentration 1 ppm. Repeated exposure during two years to concentrations of about 30 ppm with intermittent peaks up to 100 ppm causes changes in tastes perception, high acidity of urine, and increased general fatigue. Chronic effect of SO_2 was reviewed in Britain in 10,000 workers at a concentration of about 0.35 ppm. No effects appeared.

Acute exposure to 5 ppm of SO_2 manifests itself as a feeling of dry nose and throat, at 6 to 8 ppm respiration is reduced, at 10 ppm runny nose appears along with cough and irritated eyes, at 20 ppm bronchospasm, at 50 ppm extreme discomfort, and at 1,000 ppm death within 10 minutes. Exposure to SO_2 for a period shorter than one hour, to concentrations over 10 ppm, caused irritation of nose and throat, sometimes feelings of suffocation occur followed by runny nose, cough and increased mucous secretion. An ecological study in the USA was focused on monitoring the dependence between SO_2 concentration in free air and incidence of asthmatic attacks in the area of New York. Concentrations achieved 0.1 ppm; 0.3 ppm and 0.5 ppm. No relation was proved.

2.1.3 Nitrogen dioxide

Nitrogen dioxide (NO_2) CAS 10102-44-0

Determination of hazard of NO2

<u>Physical and chemical properties</u>

Molar mass: 46.006 g/mol
Boiling point: 21.15 ºC
Melting point: - 9.3 ºC
Relative density of vapours (air = 1): 1.58
Vapour pressure, kPa at 20 °C: 96

Conversion factor: 1 ppm = 1.88 mg/m^3
1 mg/m^3 = 0.532 ppm

NO_2 is a red-brown gas, when liquefied, it is a yellow liquid with acrid odour. It supports burning, burning produces pungent, corrosive and toxic vapours. Dermal contact may induce burn or frost-bite. Liquefied gas is a strong oxidiser, which reacts violently and creates explosive mixtures. Heating results in toxic vapours. It creates nitric acid with water.

Odour threshold – upper limit: 10.0 mg/m^3
lower limit: 2.0 mg/m^3
irritating concentration: 20.0 mg/m^3

NO_2 is an irritating gas. Up to 50 % of NO_2 come from automobile transport. Natural gas combustion and industrial production also represent significant sources. In the air, it is among the gases causing acid rains and smog.

Relation between the dose and effect of NO2

NO_2 irritates air passages, causes their narrowing and reduces their ability to defend against infections. In particular asthmatics and persons with an already existing respiratory disease react to higher concentrations of NO2 in the air. Mainly little children and old people are more vulnerable. NO_2 causes mild to moderate bronchitis or pneumonia and increased occurrence of acute respiratory diseases. No data on NO_2 carcinogenicity are available.

Epidemiological studies with healthy people have proved that high concentrations of NO2 are necessary to induce lung function changes during acute exposure to NO_2. Studies carried out with people suffering from lung diseases have confirmed that even exposure to low concentrations of NO2 can affect lung functions in these people. The lowest observed level affecting lung functions was a 30-minute exposure to NO_2 at a concentration of 560 $\mu g/m^3$. NO_2 concentrations of about 5 ppm (10.25 mg/m^3) are recognisable by the sense of smell, and concentrations at a level of 10 to 20 ppm (20.5 to 41 mg/m^3) are considerably pungent.

2.1.4 Carbon monoxide

Carbon monoxide (CO) CAS 630-08-0

Determination of hazard of CO

Physical and chemical properties

Molar mass: 28.0 g/mol
Boiling point: -191.5 ºC
Melting point: -199.0 ºC
Water solubility: low solubility
Relative density of vapours (air = 1): 1.58
Vapour pressure, kPa at 20 °C: 96

Conversion factor: 1 ppm = 1.145 mg/m^3
1 mg/l = 873 ppm

Carbon monoxide is a colourless and odourless gas. CO is flammable, lighter than air, creating explosive mixtures with the air. CO is produced during imperfect combustion of fossil fuels, in metallurgy, in coke-oven plants, energy generation, and is part of exhaust fumes from motor vehicles.

Relation between the dose and effect of CO

CO is absorbed by lungs and penetrating into blood, where it binds to haemoglobin producing carboxyhaemoglobin, which causes failure of oxygen transfer to tissues. Human organism is able to tolerate relatively high concentrations of CO without damage to health. However, it can affect reproduction or damage foetus in mother's body. Pregnant women, little children, people with cardiovascular diseases, and old people are most CO sensitive. The rate of CO absorption depends on its concentration in the air, intensity of physical effort during exposure, state of lungs, and atmospheric pressure. No data on CO carcinogenicity are available according to IARC.

The results of epidemiological studies show that carboxyhaemoglobin concentration in blood at a level of 2.4 % has been identified as the lowest-observed-adverse-effect level (LOAEL), which had adverse effects on the cardiovascular system. The carboxyhaemoglobin concentration in blood at a level of 2.4 % was converted to exposure concentration of CO at a level of about 14 ppm (17.5 mg/m^3).

The no-observed-adverse-effect level (NOAEL) has not been identified for CO. Although a level of exposure to CO, which can be tolerated with a minimum risk of undesirable effects, may exist, toxicological epidemiological studies have not confirmed concentrations with a minimum level of risk. With the use of suitable uncertainty factors (extrapolation from LOAEL to NOAEL, extrapolation to vulnerable population groups), the found LOAEL levels (lowest-observed-adverse-effect level) within the range of 10 to 14 ppm can be converted to the level without any effect observed (0.1 to 0.5 ppm).

2.1.5 Volatile organic compounds - VOC

Determination of hazard of VOC

VOC are various liquid or solid organic chemical substances, some of which can have short-term and long-term adverse health effects. VOC evaporate easily at common temperatures and pressures. Volatile organic compounds are released during combustion of fuel, such as petrol, wood, coal or natural gas. Many VOC are commonly released from a wide scale of products, such as thinning agents, varnishes, cleaning agents, protective agents for wood, aerosol sprays, degreasers, automobile industry products, etc. Important representatives of VOC include, for example, benzene, formaldehyde, toluene, tetrachloroethene, tetrachloroethylene, acetylene, etc.

Health effects of VOC

VOC get into organism mostly by inhaling and only some of them can be absorbed by skin. VOC health effects are both acute and chronic. Acute toxicity of VOC at concentration of 0.16 mg/m^3 can manifest itself as dry mucous membranes, dry skin, rashes, headaches, nausea, throat irritation, hoarseness and cough. Chronic toxicity may manifest itself after a long-term exposure to VOC vapours, which can even lead to cancer occurrence or damage to central nervous system, liver and kidneys. Certain VOC are damaging to health after inhaling them and may cause cancer in animals and people. Identically with other pollutants, the scope and nature of effects on human health depends on many factors, including the level of exposure and time of exposure.

VOC is a summary indicator of several volatile organic compounds and no immission limit for outdoor air has been set for it. Health risk was assessed for benzene.

Benzene (C6H6) CAS 71-43-2

Determination of hazard of benzene

Physical and chemical properties

Molar mass: 78.11 g/mol
Boiling point: 80 °C
Density at 20 °C: 0.88 g/cm^3
Water solubility at 20 °C: 0.7 g/l
Vapour pressure at 20 °C: 100 hPa

Benzene is a colourless aromatic liquid, which is not hazardous in terms of explosiveness, however, it can create hazardous explosive vapours/mixtures with the air.

Health effects of benzene

Benzene may get into organism by inhalation, dermal and oral routes - consuming contaminated drinking water or food. Acute toxicity of benzene is manifested by headache, nausea, vomiting, drowsiness, incomprehensible speech, and unconsciousness.

Chronic toxicity is manifested by effects on bone marrow, skin irritation and irritation of central nervous system, which includes moodiness, failure of short-term memory and impaired concentration. According to the International Agency for Research on Cancer (IARC), benzene is classified as a Group I carcinogen, i.e. proved carcinogen for people (causing leukaemia). US EPA also classifies benzene as an A Group carcinogen (proved carcinogen for people).

2.1.6 Hydrogen chloride

Hydrogen chloride (HCl) CAS 7647-01-0

Determination of hazard of HCl

Physical and chemical properties

Physical and chemical properties

Molar mass: 36.46 g/mol
Boiling point: -84.9 ºC
Melting point: -114.8 ºC
Water solubility: soluble in water, producing hydrochloric acid

Conversion factor of HCl: 1 ppm = 1.47 mg/m^3
1 mg/m^3 = 679 ppm

HCl is a non-flammable, colourless gas with acrid odour, heavier than air. It is highly irritating and erosive to mucous membranes.

Relation between the dose and effect of HCl

HCl causes strong irritation of eyes and air passages, swell of larynx and lungs. Chronic exposure to HCl causes long-term and repeated irritation of respiratory system, frequent nose bleeding and development of chronic bronchitis. Contact with water solution causes severe erosion of eyes and skin. When ingested, it causes erosion to the alimentary tract or even stomach perforation. HCl is not included among carcinogens.

A concentration of 5 ppm of HCl lightly irritates, a concentration of 10 ppm causes strong irritation of air passages and concentrations of 50 to 100 ppm can be borne for about one hour; if exposure is repeated, tolerance can be developed (even several hundred ppm). Already a short exposure to concentrations higher than 1000 ppm is life-threatening due to possible pulmonary oedema.

No subjective symptoms or changes of lung functions appeared in volunteers with asthma exposed to 0.8 ppm and 1.8 ppm of HCl for a period of 45 minutes.

An inhalation study with mice exposed for 90 days to HCl at a level of 10, 20 and 50 ppm for 6 hours a day during 5 days in week found a statistically significant reduction of weight and mild to moderate degree of runny nose.

2.1.7 Hydrogen fluoride

Hydrogen fluoride (HF) CAS 7664-39-3

Determination of hazard of HF

Physical and chemical properties

Molar mass: 20.006 g/mol
Boiling point: 19.4 ºC
Melting point: -83.36 ºC
Water solubility: soluble in water, producing hydrofluoric acid

Conversion factor of HF: 1 ppm = 0.818 mg/m^3
1 mg/m^3 = 1223 ppm

Odour threshold: 0.5 – 3 ppm

HF is a non-flammable, colourless gas with acrid odour, lighter than air. It is strongly reactive and strongly irritating.

Relation between the dose and effect of HF

Inhalation of low concentrations of HF causes nasal mucosa inflammation, spasmodic cough, suffocation feeling, and inflammation of nasopharynx. Inhalation of higher concentrations of HF may lead quickly to pulmonary oedema and death. After chronic exposure to lower concentrations of HF, inflammation of nasal and mouth mucosa, inflammation of pharynx, larynx, trachea and bronchi with severe course appear. Other symptoms of chronic poisoning include blood pressure drop, slower heart rate, haematopoiesis disorders, damage to teeth and skin inflammation.

A concentration of 30 ppm of HF during several minutes causes irritation of conjunctiva, air passages, concentrations of 50 to 250 ppm of HF are dangerous after several minutes, one minute at a concentration of 60 ppm irritates conjunctiva, air passages, and one minute at a concentration of 122 ppm also irritates skin. A concentration of 1200 ppm is fatal. Contact of water-free hydrogen fluoride with skin causes burn.

2.1.8 Mercury

Mercury (Hg) CAS 7439-97-6

Determination of hazard of Hg

Physical and chemical properties

Relative atomic mass: 200.59
Melting point: 38.9 °C
Boiling point: 356 °C (sublimates)
Density at 20 °C: 13,546 g/cm^3
Water solubility: none

In elementary form, mercury exists as shrilly silver thick liquid or vapour. It evaporates already at room temperature, heating increases production of toxic vapours. Mercury is emitted into the air from both natural and anthropogenic sources, such as coal combustion, production of metals, cement, waste combustion, and cremation.

Relation between the dose and effect of Hg

Mercury and its compounds are toxic substances, where methylmercury and dimethylmercury have the highest toxicity. Mercury enters organism by inhalation, ingestion and through the skin. The most important route of human organism exposure to methylmercury and dimethylmercury is ingestion, in particular consummation of fish. Dental amalgam fillings represent the most significant routes of exposure. Acute intoxication after the exposure to mercury vapours occurs at high concentrations (> 1,000 μg/m^3), which is manifested by irritation of air passages, pulmonary oedema and even lung failure. Damage to brain, nerves, kidneys, lungs may occur, and in extreme cases coma and death. During chronic exposure to mercury vapours (50-100 μg/m^3), adverse effects on central nervous system, kidneys, thyroid gland may occur. The impact on central nervous system is manifested by irritation, muscle weakness, depression, changes of personality, short-term amnesia, and skin rashes. WHO recommended as an average annual value of inorganic forms of mercury a concentration of 1μg/m^3. Mercury and its compounds are not classified as carcinogenic substances (IARC, US EPA).

2.1.9 Thallium

Thallium (Tl) CAS 7440-28-0

Determination of hazard of Tl

Physical and chemical properties

Relative atomic mass: 204.37
Melting point: 302.5 °C
Boiling point: 1,457 °C
Density at 20 °C: 11.85 g/cm^3
Water solubility: insoluble

Thallium is a relatively toxic, soft, white glossy metal. In nature. it exists only in compounds, in valences Tl^{+1} and Tl^{+3}. It is used in special alloys for electrical purposes, in production of special glass and fusible alloys. For its toxicity, it used to be added to preparations for eradication of rats, mice, and insects (in many States already prohibited).

Relation between the dose and effect of Tl

Acute intoxication depends on the size of dose received. Large doses cause delirium, cramps, deep unconsciousness, even death. Smaller doses cause vomiting, diarrhoea or constipation within hours after ingestion. Poisoning symptoms escalate within days, with pains in chest and stomach, salivation, inflammation of oral mucosa. Chronic poisoning is not frequent and has symptoms similar to acute poisoning. It is manifested by inflammation of peripheral nerves, lack of appetite, weight loss, and hair loss.

2.1.10 Cadmium

Cadmium (Cd)　　　CAS　7440-43-9

Determination of hazard of Cd

Physical and chemical properties

Relative atomic mass: 112.411
Melting point: 321 °C
Boiling point: 765 °C (sublimates)
Density at 20 °C: 8,650 g/cm^3
Water solubility: insoluble

Cadmium is a soft metal with silver gloss, it is present in both inorganic and organic compounds. Cadmium is flammable in powder form, burning produces irritating and toxic vapours. Cadmium is emitted into the air from both natural and anthropogenic sources, such as combustion of fossil fuels, production of iron, steel, cement, waste incineration, production of non-ferrous metals.

For human health protection, WHO recommends an average annual concentration of cadmium in the air at a level of up to 5 ng/m^3.

Relation between the dose and effect of Cd

Cadmium enters organism by inhaling and ingesting. Dust contaminated by cadmium in the areas with contaminated soil may represent a potential source of inhalation exposure. Smoking represents a significant source of cadmium; one cigarette contains 1-2 μg of cadmium. Food is the most significant source of cadmium (> 90 % of total intake).

Acute poisoning is manifested as vomiting, diarrhoea, cramps in digestive system, headache, intense salivation. Fatal dose at oral exposure is 20-30 mg/kg of body weight. Threshold concentration for vomiting is 15 mg of cadmium/l of water. During chronic exposure, cadmium accumulates in kidneys, causes their diseases, damage to lungs, osteoporosis and liver damage. Main damaged organs are kidneys (in particular in smokers) and liver.

Cadmium and its compounds are classified by the IARC as carcinogenic substances of Group I. However, there is still no sufficient evidence that cadmium is a human carcinogen.

2.1.11 Copper

Copper (Cu)　　　CAS　7440-50-8

Determination of hazard of Cu

Physical and chemical properties

Relative atomic mass: 64
Melting point: 2595 °C
Boiling point: 1083 °C
Density: 8.960 g/cm^3

Water solubility: insoluble

Copper is a red, relatively resistant, drawing and noble metal. Pure copper is rare. In general, copper salts are considered more toxic that the relatively non-toxic copper dust and fumes. Copper is produced by processes of fossil fuel combustion, the metallurgical industry, ore melting. Copper is an essential element of many enzyme systems. It is an important catalyst for haematopoiesis, it is a component of enzymes of tissue respiration, and it is necessary for nervous system activity.

Relation between the dose and effect of Cu

On the one hand, copper is an irreplaceable component for humans, on the other hand, it is a potentially toxic element. Damage to cells and tissues is connected with effects of free copper, when the possibilities of binding capacity of ceruloplasmin and metallothionein are exceeded. Acute poisoning by copper salts after ingestion (in particular copper sulphate) results in intravascular haemolysis, failure of kidneys and even death. Acute inhalation of copper dust and fumes is manifested as irritation of mucous membranes of the respiratory system, sometimes of conjunctiva. Copper salts are irritating to skin, their effect can be seen as itching, erythema, skin inflammation. Chronic intoxication by copper in humans is rare and is primarily manifested as damage to liver. RfC values for inhalation of copper are not available in the available professional literature, and no carcinogenic, teratogenic or mutagenic properties of copper have been found.

2.1.12 Lead

Lead (Pb) CAS 7439-92-1

Determination of hazard of Pb

<u>Physical and chemical properties</u>

Relative atomic mass: 207.19
Melting point: 327.5 °C
Boiling point: 1740 °C
Water solubility: none
Density at 20 °C: 11,350 kg/m^3

It exists in solid state and is blue-white or grey-silver. Its dust and granulated forms create explosive mixtures with air. Heating releases toxic vapours. Lead gets into the air from iron and steel production, coal and waste combustion, combustion of fuels containing lead additives. Long-term average concentrations of lead in the vicinity of roads range from 0.5 to 3 μg/m^3 in most European towns.

Relation between the dose and effect of Pb

Lead gets into organism by ingesting and inhaling. Acute poisoning is manifested as pains in stomach, nausea and vomiting. Long-term exposure is manifested by adverse impacts on blood, bone marrow, central nervous system, peripheral nervous system, and kidneys. It results in anaemia, encephalopathy (e.g. cramps), diseases of peripheral nervous system, stomach cramps, damage to kidneys. Inhalation exposure to concentrations of 10 μg/m^3 causes gastritis and negative changes in liver function. Oral exposure to doses of 450 μg/kg/6 years affects peripheral nerves, perception and muscle weakness. Lead has toxic effects on reproduction and development. Mutagenic effect was observed at a Pb concentration of 50 μg/m^3. It affects the reproductive system. In animals, fetotoxicity, fertility effects and embryotoxicity were proved. EPA classifies lead as a probable carcinogen B2 (sufficient evidence of carcinogenicity in animals and insufficient evidence of carcinogenicity in humans), IARC.

2.1.13 Cobalt

Cobalt (Co) CAS 7440-48-4

Determination of hazard of Co

Physical and chemical properties

Relative atomic mass: 58.9
Melting point: 1,495 °C
Boiling point: 2,927 °C
Density at 20 °C: 8.9 g/cm^3
Water solubility: water stable

Cobalt is a metal with a grey colour shade, soluble in strong mineral acids. It is ferromagnetic, harder and stronger than steel. In trace amounts, cobalt is an essential element for living organisms including humans. It has a significant task in haematopoiesis, it is part of vitamin B12. Cobalt is used in the steel industry as a component of steel, for production of magnets, glass and ceramics dyeing.

Relation between the dose and effect of Co

Acute poisoning by cobalt is rather rare. After ingestion of soluble cobalt salts, irritation of digestive system appears as vomiting, diarrhoea, stomach pains. After the inhalation of dust containing cobalt compounds, respiratory system is irritated, fever and digesting problems occur. Inhalation during professional exposure results in a special form of pneumonia and asthmatic reactions. Chronic poisoning is manifested as vomiting, liver enlargement, inflammation of kidneys and dermatitis.

2.1.14 Vanadium

Vanadium (V) CAS 16065-83-1

Determination of hazard of V

Physical and chemical properties

Relative atomic mass: 50.9 g/mol
Melting point: 1,980 ± 10°C
Boiling point: 3,380°C
Density at 20°C: 6.0 g/cm^3
Water solubility: insoluble

Vanadium is a steel-grey metal. In compounds, it can have several degrees of oxidation (III, IV, V). Quinquivalent compounds are most frequent. Divanadium pentoxide (V_2O_5) is the most toxic chemical form of vanadium. Vanadium has high corrosion resistance and is highly flammable. It is stable in bases, sulphuric acid and hydrochloric acid.

Vanadium is present in many minerals. It is part of difficult-to-melt alloys, addition of 0.5 % of vanadium to an alloy guarantees double strength of steel. The largest anthropogenic sources of vanadium include emissions from the metallurgical industry, liquid fuel and coal combustion. Wood and municipal waste combustion does not represent a significant source of vanadium emissions. For vanadium content in free air, WHO recommends a value of 1μg/m^3/24 hours.

Relation between the dose and effect of V

Vanadium gets into organism by inhaling, ingesting, soluble vanadium compounds are also absorbed through skin. Vanadium is well absorbed in air passages (25 %), vanadium absorption after it has been ingested is lower (1 - 2 %). For people living in towns, daily intake of vanadium by ingesting in the amount of 20 μg is expected, and by inhalation for people living in rural areas at a level of 1.5 μg and 0.2 μg.

Acute poisoning by V_2O_5 is manifested by irritation of mucous membranes of the respiratory system, after several hours, irritating cough and damage to conjunctiva and skin (eczemas) may occur. After one to six days, significant breathing difficulties occur lasting several days, with pulmonary oedema. Chronic poisoning by vanadium is manifested by serious skin eczema and bronchial asthma. A higher incidence of chronic obstructive lung disease may occur as a later consequence.

2.1.15 Manganese

Manganese (Mn) CAS 7439-96-5

Determination of hazard of Mn

Physical and chemical properties

Atomic mass: 55 g/mol
Melting point: 1,260 °C
Boiling point: 2,061 °C
Density: 7.21 g/cm^3
Water solubility: it reacts with water, producing hydrogen

Manganese is a fragile grey metal present in particular in the terrestrial crust, sediments and biological material in the form of oxides. Steelworks, foundries and coal combustion are main sources of manganese. Waste combustion and waste sludge can also represent a source. Concentrations of up to 0.5 to 0.3 μg/m^3 are found in industrial areas with ferro-alloy production. WHO recommends the average annual concentration of Mn in free air at a level of 0.15 μg/m^3, which ensures protection of vulnerable population groups. Manganese is among trace biogenous elements for humans, fauna and flora.

Relation between the dose and effect of Mn

Manganese is an essential element; however, it is toxic at high exposure levels. It gets into organism by inhalation and oral pathway. As for health effects, manganese effects on the central nervous system and respiratory system are most important. Exposure of children to concentrations of about 7 μg/m^3 resulted in an increase in respiratory symptoms. In increase in the incidence of acute bronchitis was found in the population living in the area with a level of manganese of 1μg/m^3. Neurological changes have been described in connection with professional exposure at high concentrations of manganese oxides (10 mg/m^3).

2.1.16 Antimony

Antimony (Sb) CAS 7440-36-0

Determination of hazard of Sb

Physical and chemical properties

Relative atomic mass: 121.76
Melting point: 630.5 °C
Boiling point: 1,440 °C
Density at 20 °C: 6.6 – 6.7 g/cm^3
Water solubility: insoluble

Antimony is a fragile silver glossy metal, which can be spread into powder. Antimony is part of minerals, it is used from alloy production. Antimony concentrations of about 32 ng/m^3 were found in the air in industry. Antimony concentrations in the working environment of metallurgical production of antimony and its alloys range from 1 to 10 mg/m^3.

Relation between the dose and effect of Sb

The most important antimony exposure pathway is inhalation. Acute poisoning is manifested as irritation of the digestive tract, diarrhoea, vomiting, blood pressure drop, blood sugar drop, damage to liver, which can be very serious. After a long-term professional exposure to aerosols containing antimony, rashes in particular on uncovered parts of body, signs of irritation of the respiratory system without lung function disturbance have been reported. In people working with antimony, ECG was changed, the changes were reversible and after exposure had been interrupted, they returned to normal.

2.1.17 Chrome

Chrome (Cr) Cr^{III}: CAS 16065-83-1
Cr^{VI}: CAS 18540-89-9

Determination of hazard of Cr

Physical and chemical properties

Relative atomic mass (g/mol): 51.996
Melting point: 1,857°C
Boiling point: 2,672°C
Density at 20°C: 7.15 g/cm^3 (at 28°C)
Water solubility: insoluble

Chromium is a silver-white metal with a high melting point. It is the hardest metal of all metals. In nature, chrome exists in several forms. Bivalent chrome compounds quickly oxidise in the air to trivalent compounds, which are stable. Trivalent chrome is biologically significant, hexavalent chrome is mainly the product of industrial production. It gets into the air from both natural and anthropogenic sources, such as mining, alloy production, the metallurgical industry, leather industry. Combustion processes in the industry are the largest source of chrome emissions in the SR.

As a consequence of human activities, chrome is present in dust particles released from fossil fuel combustion, in exhaust fumes of cars with catalytic converters, in emissions from municipal waste incineration plants, waste sludge and cement plants. Other sources include waste waters from plants dealing with chrome plating and leather tanning. Smokers are exposed to increased doses of chrome.

Relation between the dose and effect of Cr

Toxicity of oxidation states of chrome varies. Compounds of Cr^{6+} are strongly toxic, Cr^{3+} medium toxic, Cr^{2+} and metallic chrome are of low toxicity. Chrome causes damage to kidneys, liver, digestive and cardiovascular system. Chrome is among contact allergens, Cr^{3+} compounds with low solubility are less efficient allergens than Cr^{6+}.

Compounds of hexavalent chrome are toxic and have carcinogenic properties, whereas trivalent chrome is a biogenous elements present in trace quantities of organisms of animals, humans and plants. Fish, meat, vegetables, unrefined sugar, and vegetable oils are the best sources of it. Trivalent chrome affects biochemical utilisation of glucose and its shortage manifests itself as insulin metabolic disorder. Recommended daily intake of trivalent chrome for adults amounts to 60-200 μg. Human organism receives chrome most frequently through air passages, to a lesser extent through the digestive system, mucous membranes and skin.

Trivalent chrome

EPA has assigned Cr^{3+} to D Category (insufficient evidence of carcinogenicity), and according to IARC, Cr^{3+} belongs to Group 3 - substances, which cannot be classified in terms of their carcinogenic effects yet.

Inhalation exposure to Cr^{3+} can have adverse effects on the respiratory system and may affect the immune system. In vulnerable individuals, inhalation of high doses (occupational exposure) may even cause an asthmatic attack.

The influence of chrome on foetus and fertility is not known, however, experiments with mice orally administered high doses of chrome reported reproductive disorders and young ones with development defects.

RBC value (risk-based concentrations) according to U.S. EPA for inhalation exposure to chrome in oxidation state Cr^{3+} is for non-carcinogenic effects - 5.5 $x10^3$ $\mu g/m^3$.

Hexavalent chrome

A short-term exposure to high doses of Cr^{6+} has adverse effects at the point of contact, e.g. after inhalation it causes irritation of nasal mucosa and perforation of the nasal septum, after contact with liquids and solid substances containing Cr^{6+} it is irritating and even causes burns, skin ulcers, in allergic individuals it can lead to erythema, itching, etc. It can also have adverse effects on liver and kidneys.

Chronic professional inhalation exposure may be manifested as irritation of air passages, asthma, eye irritation, conjunctivitis and damage to cornea. Cr^{6+} belongs to inhalation carcinogens, an increased incidence of lung carcinoma has been observed in workers with long-term occupational exposure. Hexavalent chrome is also considered a mutagen.

According to IARC, hexavalent chrome is assigned to Group 1 (i.e. substances carcinogenic for humans). According to U.S. EPA it is also classified as a proved human carcinogen (A).

In 1998, U.S. EPA set RfC for vapours and soluble aerosols of Cr^{6+} of $8x10^{-6}$ mg/ m^3 based on a chronic epidemiological study of professionally exposed workers (nasal septum atrophy was monitored) and RfC for solid particles of Cr^{6+} of $1x10^{-4}$ mg/m^3 from a subchronic study with rats (respiratory effects, lung tissue inflammation).

For carcinogenic effects of Cr^{6+}, WHO reports carcinogenic risk unit for a concentration of 1$\mu g/m^3$ UR (Unit Risk) within the range of 1.1 to 13 x 10^{-2} $[\mu g/m^3]^{-1}$. Carcinogenic effects of Cr^{6+} were monitored in professionally exposed persons, lungs were the target organ.

2.1.18 Arsenic

Arsenic (As) CAS 7440-38-2

Determination of hazard of As

Physical and chemical properties

Relative atomic mass: 74.9
Melting point: 817 °C
Boiling point: 613 °C
Water solubility: insoluble

Arsenic is a grey metal; it exists in several modifications. In common conditions, it is a grey metal, at normal pressure it sublimates and yellow vapours are produced. Arsenic in the form of sulphides is virtually non-toxic. However, sulphides are often polluted by arsenic trioxide, which has strong toxic effects. Inorganic As compounds are also toxic. It creates highly toxic colourless gaseous substances with hydrogen.

Relation between the dose and effect of As

As exists in two forms: toxic inorganic and non-toxic organic form. Organic forms are in some food (e.g. sea fish), the air contains in particular inorganic, toxic forms. Inorganic forms of As may have acute, subacute and chronic health effects.

Short-term exposure irritates eyes, skin, respiratory system and may have adverse impacts of the cardiovascular system, kidneys, gastrointestinal tract. It results in unconsciousness, loss of liquids, damage to kidneys, intensive bleeding, shock. Acute exposure to inorganic As with a dose of 600 μg/kg/day or higher causes death. Lower concentrations cause nausea, vomiting, headaches, fainting, shock, cyanosis, anaemia, leukopenia.

Chronic exposure with skin contact causes dermatitis and sensitisation. As affect mucous membranes, skin, kidneys and liver.

Inhalation exposure of human to As is connected with lung cancer occurrence. Ingestion of inorganic arsenic is related to an increased incidence of bladder and kidney cancer. According to the International Agency for Research on Cancer (IARC), arsenic is classified as Group I carcinogen. U.S. EPA classifies As as a proved human carcinogen – A Group.

2.1.19 Nickel

Nickel (Ni) CAS 7440-02-0

Determination of hazard of Ni

<u>Physical and chemical properties</u>

Relative atomic mass (g/mol): 58.693
Melting point: 1555 °C
Boiling point: 2837 °C
Density: 8.9 kg/m^3
Water solubility: insoluble

Nickel is a silver-white and glossy metal. It is represented in terrestrial crust in the amount of 58 to 75 g/t. Main anthropogenic sources of nickel emissions in the air include oil and coal combustion, metallurgy (production of nickel, stainless steel and alloys), ore mining and treatment, production and processing of NiCd accumulators, metal plating, and waste incineration. Nickel is often present in asbestos in significant concentrations, where it increases carcinogenicity. In compounds, nickel is mostly present in the oxidation state Ni^{2+}.

Relation between the dose and effect of Ni

Nickel compounds are characterised by low acute toxicity, except for $Ni(CO)_4$, which is acutely and chronically toxic.

Acute professional poisoning (exposure to high concentrations) is manifested by irritation of the digestive tract. Absorbed nickel salts damage blood vessels (in particular brain vessels), they are nephrotoxic and neurotoxic.

In case of chronic professional exposure to higher concentrations, nickel may irritate air passages and eyes, damage liver, kidneys, cardiac muscle, and it may cause various immunological responses. Irritating effect during dust inhalation and on skin is very frequent (dermatitis is usually caused by contact with nickel-plated objects, metal-plating baths). For chronic professional exposure to nickel, carcinogenic effects were also described – the risk of carcinoma of lungs, nasal cavities and probably also larynx. Recently, possible teratogenicity and mutagenicity of nickel is pointed out. According to IARC, nickel is assigned to Group 1 (i.e. substances carcinogenic for humans). According to U.S. EPA it is also classified as a proved human carcinogen (A Group). For carcinogenic effects of nickel, WHO reports carcinogenic risk unit for a concentration of 1 $\mu g/m^3$ UR (Unit Risk) = 3.8 x 10^{-4} $(\mu g/m^3)^{-1}$. Carcinogenic effects of nickel have been observed in professionally exposed people, lungs were the target organ. In 1997, ATSDR set the MRL (Minimal Risk Level) for chronic inhalation exposure for non-carcinogenic effects of nickel at a level of 0.0002 mg/m^3.

2.1.20 Dioxins and furans

Polychlorinated dibenzo-dioxins (PCDD) and dibenzofurans (PCDF)

Determination of hazard of PCDD/DF

Physical and chemical properties

Dioxins mean two groups of tricyclic aromatic compounds with similar physical and chemical properties. They are generally wide-spread in the environment, highly persistent, they are bioaccumulable, they accumulate in particular in adipose tissues of living organisms.

Polychlorinated dibenzo-dioxins and dibenzofurans cannot be found naturally in the environment, in trace quantities they are created as admixtures during production of other chemicals. The biggest primary sources include PVC processing and production, processing and production of ferrous and non-ferrous metals, and they can also be found in wastes from production of cellulose and paper, fly ash and gaseous emissions of waste incineration plants. They also can come into existence in pesticide production.

Relation between the dose and effect of PCDD/DF

Dioxins are highly toxic substances. A minimum quantity gets into organism through inhalation (1 to 5 %), up to 90% get into organism with food (milk, meat, fish). Dermal exposure applies to people in the production of herbicides. Acute poisoning (e.g. during accidents) is manifested as irritation of eyes, air passages, skin, headache, nausea. After two weeks, acne, muscle pains, pains in limbs and chest, nervousness, agitation, dyspnoea, liver damage symptoms, neuritis appear. Chronic poisoning is manifested as skin changes (acne and dark colour of skin). Other symptoms include fatigue, weight loss, muscle pains, insomnia, agitation. Objectively, reduced sensitivity of lower limbs, mental disorders, liver enlargement, more frequent cardiovascular diseases, sight disorders, diabetes were diagnosed.

IARC assigns the most toxic PCDD (2, 3, 7, 8 – TCDD) to Group 1 - proved human carcinogen. It causes various types of cancer (sarcoma of soft tissues, lung cancers, leukaemia, lymphoma and cancer of the digestive tract). EPA assigned TCDD to B2 Group (there is sufficient evidence of carcinogenicity for animals and insufficient evidence of carcinogenicity for humans). Laboratory experiments with animals have recorded their adverse hepatotoxic, reproductive, immunotoxic and dermal effects, as well as occurrence of tumours of liver and nasal cavities. In order to exclude health risks, WHO requests for TCDD the admissible daily intake at a level of 1 to 4 pg/kg/day.

2.2 Determination of concentration of chemical substances without harmful effect

Limit values for individual pollutants are set in order to protect population health and are based on the assumption that even a lifetime exposure to the respective pollutants in recommended concentration will not represent a health risk for the most vulnerable population groups. The method of determination of concentrations of selected pollutants without harmful effect is described below.

Threshold (non-carcinogenic) effects were calculated for CO, NO_2, PM (evaluated as PM_{10} + $PM_{2.5}$), SO_2, HCl, HF, Cu, Cd/Tl (evaluated as Cd), Hg, Σ HM (evaluated as As), TOC (evaluated as benzene), and PCDD/DF (evaluated as TCDD).

Thresholdless (carcinogenic) effects were calculated for proved human carcinogens according to IARC (Group 1) – benzene, arsenic, cadmium, nickel, $chrome^{VI}$, TCDD.

Based on the results of quantitative health risk assessment for chemical substances, impact on health of the affected inhabitants was estimated.

2.2.1 Threshold effects of chemical substances

Calculation of health risk for ***threshold (non-carcinogenic) effects*** of selected chemical substances was carried out according to the US EPA methodology (2009), which sets chronic or subchronic exposure, the so-called ***reference concentration (RfC).***

RfC values for the evaluated pollutants were found in professional literature or calculated according to the equation:

$$\mathbf{RfC = NOAEL\ or\ LOAEL / UF \times MF} \qquad [1]$$

where:

RfC - estimated concentration of the respective substance in the air, which during inhalation exposure probably represents no risk of adverse effects. It is expressed in mg of the respective substance per m^3 of air, which is converted according to relation [2] to $RfD_{inhal.}$

NOAEL - the highest level of exposure, at which there is no statistically significant adverse response in comparison with the control group.

LOAEL - the lowest level of exposure, at which there is still statistically significant adverse response in comparison with the control group.

UF - uncertainty factor (multiples of 10), which is used to cover individual differences, to protect vulnerable population groups, to balance uncertainties when extrapolating from animals to humans, to balance uncertainties when using NOAEL derived from subchronic instead of chronic study, and to balance uncertainties caused by using LOAEL instead of NOAEL.

MF – modifying factor (> 0 – 10), which is used to balance other uncertainties.

Using the RfC value, reference doses (RfD) for inhalation pathway of exposure were calculated according to the equation:

$$\mathbf{RfD_{inhal.} = RfC\ (mg/m^3) \times 20m^3 / 70kg} \qquad [2]$$

where: 20 m^3 is the volume of air inhaled per day and 70 kg is the average body weight of an adult; for a child 16 m^3 and 20 kg . $RfD_{inhal.}$ is expressed in mg/kg/day.

According to US EPA, RfD means "safe" values of daily intake for threshold effects of chemical substances. RfD is an estimate of everyday exposure of human population including especially vulnerable population groups, which probably represents no risk of adverse effects. It is expressed as the weight of of the respective substance absorbed by a unit of body weight per a unit of time (mg/kg/day). For exposed people, RfD values are compared with the values of real daily intake averaged for the whole time of exposure (ADD – average daily dose). If the average daily dose is sufficiently higher that the reference dose, symptoms of system toxicity will appear in several individuals and the severity of the symptoms will increase.

Table No. 2 contains values of RfD_{inhal} calculated from RfC or obtained from the TOXNET database, toxicological profiles of ATSDR and professional literature of WHO and US EPA (Chapter XVIII.).

Table No.2: RfDinhal values used in calculations

No.	Evaluated chemical substances	$RfD_{inhal.}$ ADULTS (mg/kg/day)	$RfD_{inhal.}$ CHILDREN (mg/kg/day)
1	CO	1.6×10^{-1}	4.6×10^{-1}
2	NO_2	1.6×10^{-2}	4.5×10^{-2}
3	$PM_{10} + PM_{2.5}$	1.4×10^{-2}	4.0×10^{-2}
4	SO_2	5.1×10^{-1}	1.4
5	HCl	5.7×10^{-3}	1.6×10^{-2}
6	HF	5.7×10^{-4}	1.6×10^{-3}
7	Cu	2.9×10^{-2}	8.0×10^{-2}
8	Cd/Tl as Cd	5.7×10^{-3}	1.6×10^{-2}
9	Hg	8.6×10^{-3}	2.4×10^{-2}
10	∑ HM as As	4.3×10^{-3}	1.2×10^{-2}
11	TOC as benzene	8.6×10^{-3}	2.4×10^{-2}
12	PCDD/DF as TCDD*	1.1×10^{-8}	3.2×10^{-8}

*Explanatory notes: * - 2,3,7,8 - tetrachlorodibenzo-dioxin*

2.2.2 Thresholdless effects of chemical substances

Slope Factor (SF) expressing the relation dose – response in the area of low doses, is a parameter characterising ***thresholdless (carcinogenic) effects***. The result is the Cancer Slope Factor (CSF), i.e. cancer occurrence unit. For inhalation route of exposure, IUR (Inhalation Unit Risk) is determined.

Thresholdless effects were evaluated for proved human carcinogens according to IARC (Table No. 3), where the level of exposure was converted to entire life expectancy of an exposed person (70 years). Lifetime risk of cancer development is proportional to the lifetime dose averaged for one day ***(LADD - lifetime average daily dose***). The risk of cancer development was estimated by means of the cancer slope factor due to inhalation exposure (IUR).

Table No.3: IUR values used in calculations

No.	Evaluated chemical substances	IUR (mg/m^3)
1	benzene	7.8×10^{-9}
2	Cd	4.2×10^{-6}
3	Cr^{VI}	1.2×10^{-5}
4	Ni	2.4×10^{-7}
5	As	4.3×10^{-6}
6	TCDD	3.8×10^{-2}

3. Evaluation of exposure to chemical substances

The objective of evaluation of exposure to selected chemical substances was to estimate the exposure dose, the so-called average daily dose (ADD) and lifetime average daily dose (LADD), to which the affected inhabitants could be exposed. Exposure doses were estimated based on the data of the dispersion study worked out by Ing. Viliam Carach, PhD. (May 2019).

3.1 Exposure routes

After the potential ways of exposure of the affected inhabitants in the surroundings of the radioactive waste treatment technologies have been analysed, the inhalation route of exposure was evaluated. Considering the properties of the evaluated chemical substances and the source of exposure, the dermal and oral exposure route was not considered. In evaluating the exposure, vulnerability of population groups was taken into account, therefore, health risk was estimated for both adults and children. Children inhale a larger volume of air per unit of body weight, spent more time outdoors, have more physical activity, consequently, they have increased lung ventilation and higher intake of potential harmful substances from the air per kg of body weight, which was taken into account in the calculations.

3.2 Immission values at the site concerned

Chapters IV and V describe air pollution sources and pollutants, to which the inhabitants living at the assessed site may be potentially exposed. The current state and variant 1 were assessed.

Tables No. 4 and 5 contain concentrations of pollutants in the air, which were calculated by the dispersion study by means of the mathematical model MODIM; Table No. 4 contains background concentrations (full-area evaluation) along with the contribution of the evaluated air pollution source, and Table No. 5 contains only the contribution of the evaluated source for the current and new states. To estimate the exposure dose for the closest residential zone, ***maximum short-term*** as well as ***average annual concentrations*** were used, where TOC was assessed as VOC (benzene), PM was assessed as the sum of PM_{10} and $PM_{2.5}$, Cd/Tl as Cd, and the sum of heavy metals was assessed as As.

Table No.4: ***Full-area evaluation (background concentrations****) of the current state (V0) and new state (V1).*

No.	Evaluated chemical substances	Highest values of pollutants from 12 reference points			
		maximum short-term concentrations in µg/m^3		**average annual concentrations in µg/m^3**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	600.000	600.088	450.000	450.002
2	NO_2	35.000	35.160	12.000	12.003
3	PM_{10}	20.000	20.069	18.000	18.001
4	$PM_{2.5}$	18.000	18.046	16.000	16.001
5	SO_2	14.000	14.280	8.000	8.004
6	HCl	0.500	0.586	0.100	0.101
7	HF	0.500	0.506	0.100	0.10007
8	Cu	0.010	0.025	0.005	0.0052
9	Cd/Tl	0.010	0.0101	0.005	0.005001
10	Hg	0.010	0.0101	0.005	0.005001
11	∑ HM	0.100	0.101	0.050	0.05001
12	TOC	5.000	5.028	1.000	1.0004
13	PCDD/DF	1.00×10^{-7}	1.001×10^{-7}	5.00×10^{-8}	5.0002×10^{-8}

Table No.5: Contribution of the evaluated source of the current state (V0) and new state (V1).

No.	Evaluated chemical substances	Highest values of pollutants from 12 reference points			
		maximum short-term concentrations in μg/m³		**average annual concentrations in μg/m³**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	2.222	2.310	0.04213	0.04398
2	NO_2	2.341	2.495	0.03363	0.03624
3	PM_{10}	0.2188	0.2874	0.002554	0.003428
4	$PM_{2.5}$	0.1465	0.1923	0.00171	0.002293
5	SO_2	2.653	2.933	0.03004	0.03349
6	HCl	0.1814	0.2678	0.00210	0.003128
7	HF	0.00831	0.01413	0.000100	0.000165
8	Cu	*	0.015050	*	0.000180
9	Cd/Tl	0.00059	0.000657	0.000007	0.000008
10	Hg	0.00059	0.000657	0.000007	0.000657
11	∑ HM	0.02138	0.02208	0.000247	0.000255
12	TOC	0.1155	0.1438	0.00133	0.001678
13	PCDD/DF	3.56×10^{-10}	5.92×10^{-10}	4.12×10^{-12}	5.92×10^{-12}

*Explanatory notes: * - for Variant 0, the contribution of the assessed source was not calculated as no special source of the pollutant has been identified.*

3.3 Quantitative expression of exposure to chemical substances

Quantitative expression of exposure to chemical substances was executed by determining the quantity of substance, which will really cross the boundary of organism and which is expressed as the concentration absorbed per unit of body weight per unit of time (mg/kg/day).

3.3.1 Calculation of average daily dose of chemical substances

For threshold effects (non-carcinogenic risk), chronic daily intake was calculated as the ***average daily dose*** (***ADD***). For thresholdless effects (carcinogenic risk), the level of exposure was converted to the entire lifetime, i.e. ***lifetime average dose (LADD).***

For the evaluated chemical substances, the ADD and LADD values were calculated according to the equation:

$$\text{ADD or LADD (mg/kg/day)} = CA \,.\, IR \,.\, ET \,.\, EF \,.\, ED / BW \,.\, AT \qquad [3]$$

CA - concentration of the substance in the air (mg/ m^3)
IR – inhalation rate (m^3/h), according to EPA - adult 20 m^3/ day, child - 16 m^3/ day,
ET – exposure time (h/day), permanent resident 16 hours on average,
EF - exposure frequency (day/year), actual number of days, in which exposure exists in the territory, according to EPA - 350 days/year,
ED - exposure duration in years (used: 6 years for a child and lifetime exposure of an adult - 70 years),
BW - average body weight (kg), according to EPA – adults 70 kg and child up to 6 years 20 kg,
AT - averaging time, a time, for which the exposure concentration is considered constant (day).

ADD values were calculated separately for adults and children (Tables No. 6 to 9). Calculation of concentrations of pollutants was made in the dispersion study for 12 reference points, which were specified at the level of the surrounding municipalities at the place closest to the evaluated source.

Tables No. 6 and 7 contain the ***full-area evaluation*** (background concentrations) along with the contribution of the evaluated air pollution source.

*Table No.6: ADD values - full area evaluation along with the contribution of the evaluated source - **adults***

No.	Evaluated chemical substances	**ADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	1.09×10^{-1}	1.09×10^{-1}	8.19×10^{-2}	8.19×10^{-2}
2	NO_2	6.37×10^{-3}	6.40×10^{-3}	2.18×10^{-3}	2.18×10^{-3}
3	$PM_{10} + PM_{2.5}$	6.91×10^{-3}	6.93×10^{-3}	6.19×10^{-3}	6.19×10^{-3}
4	SO_2	2.55×10^{-3}	2.60×10^{-3}	1.46×10^{-3}	1.46×10^{-3}
5	HCl	9.10×10^{-5}	1.07×10^{-4}	1.82×10^{-5}	1.84×10^{-5}
6	HF	9.10×10^{-5}	9.21×10^{-5}	1.82×10^{-5}	1.82×10^{-5}
7	Cu	1.82×10^{-6}	4.55×10^{-6}	9.10×10^{-7}	9.46×10^{-7}
8	Cd/Tl as Cd	1.82×10^{-6}	1.84×10^{-6}	9.10×10^{-7}	9.10×10^{-7}
9	Hg	1.82×10^{-6}	1.84×10^{-6}	9.10×10^{-7}	9.10×10^{-7}
10	∑ HM as As	2.27×10^{-6}	2.30×10^{-6}	1.14×10^{-6}	1.14×10^{-6}
11	TOC as benzene	9.10×10^{-6}	9.15×10^{-6}	1.82×10^{-6}	1.82×10^{-6}
12	TCDD	1.82×10^{-11}	1.82×10^{-11}	9.10×10^{-12}	9.10×10^{-12}

*Table No.7: ADD values - full area evaluation along with the contribution of the evaluated source - **children***

No.	Evaluated chemical substances	**ADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	3.08×10^{-1}	3.08×10^{-1}	2.31×10^{-1}	2.31×10^{-1}
2	NO_2	1.80×10^{-2}	1.81×10^{-2}	6.17×10^{-3}	6.17×10^{-3}
3	$PM_{10} + PM_{2.5}$	1.95×10^{-2}	1.96×10^{-2}	1.75×10^{-2}	1.75×10^{-2}
4	SO_2	7.20×10^{-3}	7.34×10^{-3}	4.11×10^{-3}	4.11×10^{-3}
5	HCl	2.57×10^{-4}	3.01×10^{-4}	5.14×10^{-5}	5.19×10^{-5}
6	HF	2.57×10^{-4}	2.60×10^{-4}	5.14×10^{-5}	5.14×10^{-5}
7	Cu	5.14×10^{-6}	1.28×10^{-5}	2.57×10^{-6}	2.67×10^{-6}
8	Cd/Tl as Cd	5.14×10^{-6}	5.19×10^{-6}	2.57×10^{-6}	2.57×10^{-6}
9	Hg	5.14×10^{-6}	5.19×10^{-6}	2.57×10^{-6}	2.57×10^{-6}
10	∑ HM as As	6.42×10^{-6}	6.49×10^{-6}	3.21×10^{-6}	3.21×10^{-6}
11	TOC as benzene	2.57×10^{-5}	2.58×10^{-5}	5.14×10^{-6}	5.14×10^{-6}
12	TCDD	5.14×10^{-11}	5.14×10^{-11}	2.57×10^{-11}	2.57×10^{-11}

Tables No. 8 and 9 show ***the contribution of the evaluated air pollution source.***

*Table No.8: ADD values - contribution of the evaluated source - **adults***

No.	Evaluated chemical substances	**ADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	4.04×10^{-4}	4.20×10^{-4}	7.66×10^{-6}	8.00×10^{-6}
2	NO_2	4.26×10^{-4}	4.54×10^{-4}	6.12×10^{-6}	6.59×10^{-6}
3	$PM_{10} + PM_{2.5}$	6.65×10^{-5}	8.73×10^{-5}	7.76×10^{-7}	1.04×10^{-6}
4	SO_2	4.83×10^{-4}	5.34×10^{-4}	5.46×10^{-6}	6.09×10^{-6}
5	HCl	3.30×10^{-5}	4.87×10^{-5}	3.82×10^{-7}	5.69×10^{-7}
6	HF	1.51×10^{-6}	2.57×10^{-6}	1.82×10^{-8}	3.00×10^{-8}
7	Cu	*	2.74×10^{-6}	*	3.27×10^{-8}
8	Cd/Tl as Cd	1.07×10^{-7}	1.20×10^{-7}	1.27×10^{-9}	1.46×10^{-9}
9	Hg	1.07×10^{-7}	1.20×10^{-7}	1.27×10^{-9}	1.46×10^{-9}
10	∑ HM as As	4.86×10^{-7}	5.02×10^{-7}	5.62×10^{-9}	5.80×10^{-9}
11	TOC as benzene	2.10×10^{-7}	2.62×10^{-7}	2.42×10^{-9}	3.05×10^{-9}
12	TCDD	6.48×10^{-14}	9.22×10^{-14}	7.50×10^{-16}	1.08×10^{-15}

*Table No.9: ADD values - contribution of the evaluated source - **children***

No.	Evaluated chemical substances	**ADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	CO	1.14×10^{-3}	1.19×10^{-3}	2.17×10^{-5}	2.26×10^{-5}
2	NO_2	1.20×10^{-3}	1.28×10^{-3}	1.73×10^{-5}	1.86×10^{-5}
3	$PM_{10} + PM_{2.5}$	1.88×10^{-4}	2.47×10^{-4}	2.19×10^{-6}	2.94×10^{-6}
4	SO_2	1.36×10^{-3}	1.51×10^{-3}	1.54×10^{-5}	1.72×10^{-5}
5	HCl	9.32×10^{-5}	1.38×10^{-4}	1.08×10^{-6}	1.61×10^{-6}
6	HF	4.27×10^{-6}	7.26×10^{-6}	5.14×10^{-8}	8.48×10^{-8}
7	Cu	*	7.74×10^{-6}	*	9.25×10^{-8}
8	Cd/Tl as Cd	3.03×10^{-7}	3.38×10^{-7}	3.60×10^{-9}	4.11×10^{-9}
9	Hg	3.03×10^{-7}	3.38×10^{-7}	3.60×10^{-9}	4.11×10^{-9}
10	∑ HM as As	1.37×10^{-6}	1.42×10^{-6}	1.59×10^{-8}	1.64×10^{-8}
11	TOC as benzene	5.94×10^{-7}	7.39×10^{-7}	6.84×10^{-9}	8.62×10^{-9}
12	TCDD	1.83×10^{-13}	2.61×10^{-13}	2.12×10^{-15}	3.04×10^{-15}

*Explanatory notes: * - for Variant 0, the contribution of the assessed source was not calculated as no special source of the pollutant has been identified.*

Tables No. 10 and 11 contain calculated values of lifetime average daily dose (LADD) for adults for carcinogenic substances of Group 1 according to IARC.

Table No.10: LADD values for carcinogenic substances - full area evaluation along with the contribution of the evaluated source - adults

No.	Evaluated chemical substances	**LADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	benzene	9.10×10^{-6}	9.15×10^{-6}	1.82×10^{-6}	1.82×10^{-6}
2	Cd	1.82×10^{-6}	1.84×10^{-6}	9.10×10^{-7}	9.10×10^{-7}
3	Cr^{VI}	2.27×10^{-6}	2.30×10^{-6}	1.14×10^{-6}	1.14×10^{-6}
4	Ni	2.27×10^{-6}	2.30×10^{-6}	1.14×10^{-6}	1.14×10^{-6}
5	As	2.27×10^{-6}	2.30×10^{-6}	1.14×10^{-6}	1.14×10^{-6}
6	TCDD	1.82×10^{-11}	1.82×10^{-11}	9.10×10^{-12}	9.10×10^{-12}

Table No.11: LADD values for carcinogenic substances - contribution of the evaluated source - adults

No.	Evaluated chemical substances	**LADD** in mg/kg/day			
		maximum short-term concentrations		**average annual concentrations**	
		Current state **V0**	State after the completion of the proposal – **V1**	Current state **V0**	State after the completion of the proposal – **V1**
1	benzene	2.10×10^{-7}	2.62×10^{-7}	5.62×10^{-9}	3.05×10^{-9}
2	Cd	1.07×10^{-7}	1.20×10^{-7}	1.27×10^{-9}	1.46×10^{-9}
3	Cr^{VI}	4.86×10^{-7}	5.02×10^{-7}	5.62×10^{-9}	5.80×10^{-9}
4	Ni	4.86×10^{-7}	5.02×10^{-7}	5.62×10^{-9}	5.80×10^{-9}
5	As	4.86×10^{-7}	5.02×10^{-7}	5.62×10^{-9}	5.80×10^{-9}
6	TCDD	6.48×10^{-14}	9.22×10^{-14}	7.50×10^{-16}	1.08×10^{-15}

4. Characteristics of the risk of chemical substances

Based on RfD_{inhal}. values and calculated ADD, the quantitative rate of potential health risk due to selected chemical substances was set, i.e. ***hazard quotient (HQ).***

4.1 Estimated risk for threshold effects of chemical substances

HQ values for the threshold risk of pollutants emitted into the air were calculated according to the equation:

HQ = intake of substance for the inhalation exposure pathway (ADD)/ $RfD_{inhal.}$ [4]

The result is the dimensionless hazard quotient, which allows the assessment of impact of the evaluated chemical substances with threshold health effects.

Tables No. 12 to 15 contain hazard quotients for the evaluated pollutants calculated from the full-area pollution along with the contribution of the evaluated source and separately from the contribution of the evaluated air pollution source. The current state (V0) and state after the completion of the proposal (V1) were evaluated and the calculation used maximum short-term and average annual concentrations for adults and children.

Maximum short-term concentrations

*Table No.12: HQ values – **adults***

No.	Evaluated chemical substances	HAZARD QUOTIENTS			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	solely the contribution of the evaluated source	overall air pollution including background	solely the contribution of the evaluated source
1	CO	0.66730	0.00247	0.66739	0.00257
2	NO_2	0.39795	0.02662	0.39976	0.02837
3	PM_{10} + $PM_{2.5}$	0.48390	0.00465	0.48537	0.00611
4	SO_2	0.00495	0.00094	0.00505	0.00104
5	HCl	0.01592	0.00577	0.01866	0.00853
6	HF	0.15918	0.00265	0.16109	0.00450
7	Cu	0.00006	*	0.00016	0.00010
8	Cd/Tl as Cd	0.31836	0.01878	0.32154	0.02092
9	Hg	0.02122	0.00125	0.02144	0.00139
10	∑ HM as As	0.53059	0.11344	0.53590	0.11716
11	TOC as benzene	0.01061	0.00025	0.01067	0.00031
12	TCDD	1.59×10^{-3}	5.67×10^{-6}	1.59×10^{-3}	8.07×10^{-6}

*Table No.12: HQ values – **children***

No.	Evaluated chemical substances	HAZARD QUOTIENTS			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	solely the contribution of the evaluated source	overall air pollution including background	solely the contribution of the evaluated source
1	CO	0.67333	0.00249	0.67343	0.00259
2	NO_2	0.40154	0.02686	0.40338	0.02862
3	PM_{10} + $PM_{2.5}$	0.48827	0.00469	0.48975	0.00616
4	SO_2	0.00500	0.00095	0.00510	0.00105
5	HCl	0.01606	0.00583	0.01882	0.00860
6	HF	0.16062	0.00267	0.16254	0.00454
7	Cu	0.00006	*	0.00016	0.00010
8	Cd/Tl as Cd	0.32123	0.01895	0.32445	0.02111
9	Hg	0.02142	0.00126	0.02163	0.00141
10	∑ HM as As	0.53539	0.11447	0.54074	0.11821
11	TOC as benzene	0.01071	0.00025	0.01077	0.00031
12	TCDD	1.61×10^{-3}	5.72×10^{-6}	1.61×10^{-3}	8.14×10^{-6}

*Explanatory notes: * - for Variant 0, the contribution of the assessed source was not calculated as no special source of the pollutant has been identified.*

Average annual concentrations

*Table No.14: HQ values – **adults***

No.	Evaluated chemical substances	HAZARD QUOTIENTS			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	solely the contribution of the evaluated source	overall air pollution including background	solely the contribution of the evaluated source
1	CO	0.50047	4.69×10^{-5}	0.50047	4.89×10^{-5}
2	NO_2	0.13644	3.82×10^{-4}	0.13647	4.12×10^{-4}
3	$PM_{10} + PM_{2.5}$	0.43296	5.43×10^{-5}	0.43299	7.29×10^{-5}
4	SO_2	0.00283	1.06×10^{-5}	0.00283	1.18×10^{-5}
5	HCl	0.00318	6.69×10^{-5}	0.00322	9.96×10^{-5}
6	HF	0.03184	3.18×10^{-5}	0.03186	5.25×10^{-5}
7	Cu	0.00003	*	0.00003	1.15×10^{-6}
8	Cd/Tl as Cd	0.15918	2.23×10^{-4}	0.15921	2.55×10^{-4}
9	Hg	0.01061	1.49×10^{-5}	0.01061	1.70×10^{-5}
10	∑ HM as As	0.26530	1.31×10^{-3}	0.26535	1.35×10^{-3}
11	TOC as benzene	0.00212	2.82×10^{-6}	0.00212	3.56×10^{-6}
12	TCDD	7.96×10^{-4}	6.56×10^{-8}	7.96×10^{-4}	9.42×10^{-8}

*Table No.15: HQ values – **children***

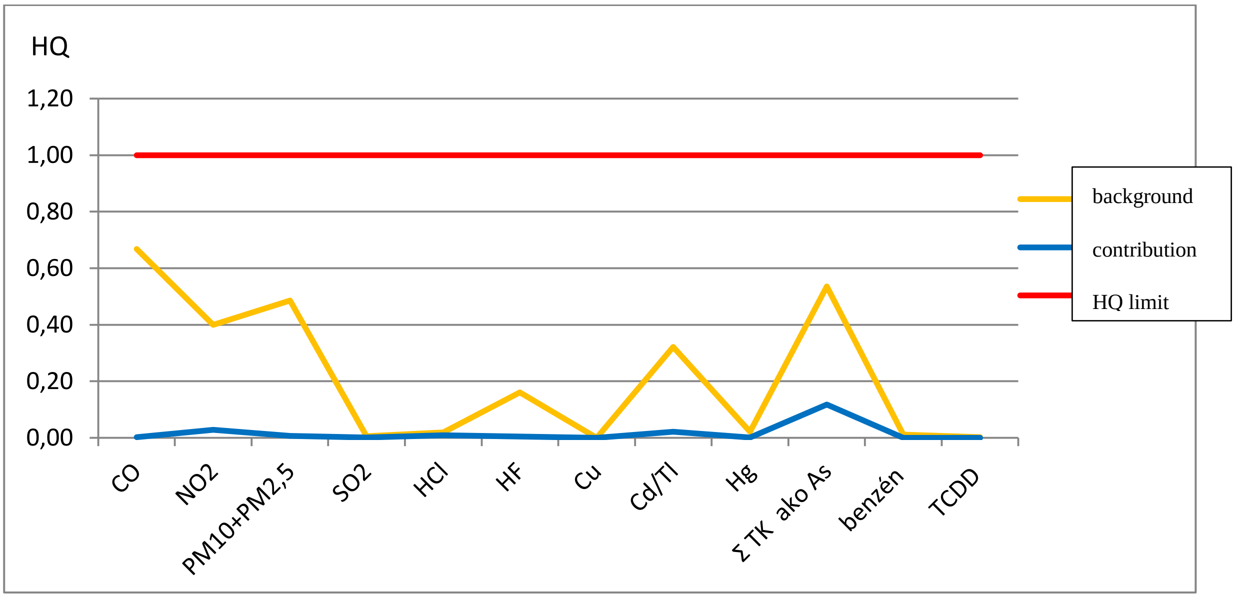
No.	Evaluated chemical substances	HAZARD QUOTIENTS			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	solely the contribution of the evaluated source	overall air pollution including background	solely the contribution of the evaluated source
1	CO	0.50499	4.73×10^{-5}	0.50500	4.94×10^{-5}
2	NO_2	0.13767	3.86×10^{-4}	0.13771	4.16×10^{-4}
3	$PM_{10} + PM_{2.5}$	0.43688	5.48×10^{-5}	0.43690	7.35×10^{-5}
4	SO_2	0.00286	1.07×10^{-5}	0.00286	1.20×10^{-5}
5	HCl	0.00321	6.75×10^{-5}	0.00324	1.00×10^{-4}
6	HF	0.03212	3.21×10^{-5}	0.03215	5.30×10^{-5}
7	Cu	0.00003	*	0.00003	1.16×10^{-6}
8	Cd/Tl as Cd	0.16062	2.25×10^{-4}	0.16065	2.57×10^{-4}
9	Hg	0.01071	1.50×10^{-5}	0.01071	1.71×10^{-5}
10	∑ HM as As	0.26769	1.32×10^{-3}	0.26775	1.37×10^{-3}
11	TOC as benzene	0.00214	2.85×10^{-6}	0.00214	3.59×10^{-6}
12	TCDD	8.03×10^{-4}	6.62×10^{-8}	8.03×10^{-4}	9.51×10^{-8}

*Explanatory notes: * - for Variant 0, the contribution of the assessed source was not calculated as no special source of the pollutant has been identified.*

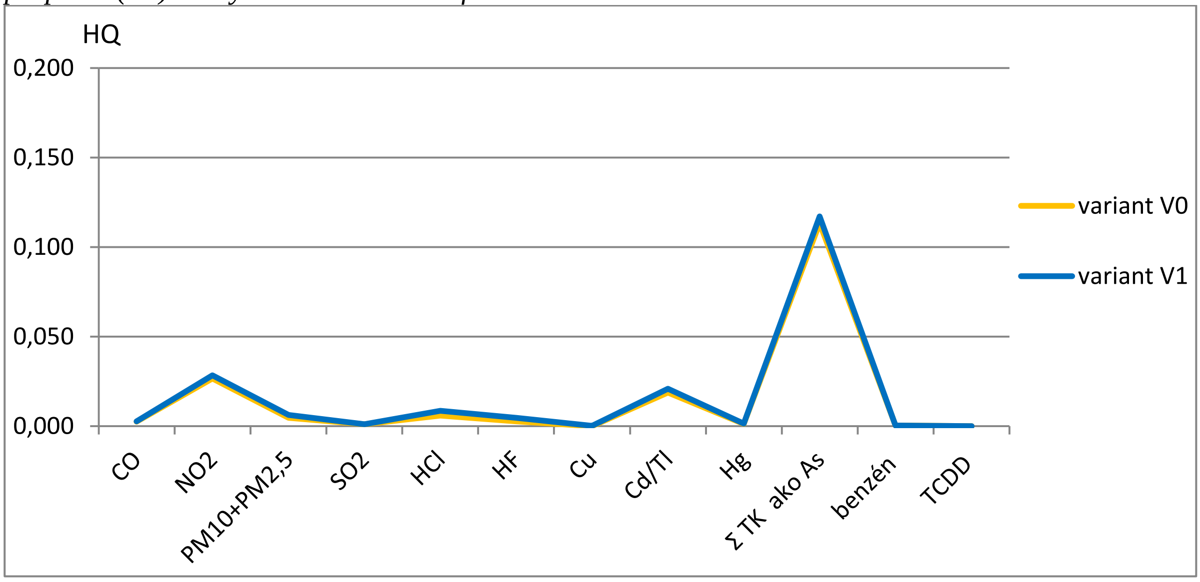
GRAPHIC PRESENTATION OF HQ

Maximum short-term concentrations - adults

Graph No. 22: HQ comparison for the state after the completion of the proposal (V1) – background and contribution of the source



Graph No. 23: HQ comparison for the current state (V0) and the state after the completion of the proposal (V1) - only the contribution of the evaluated source



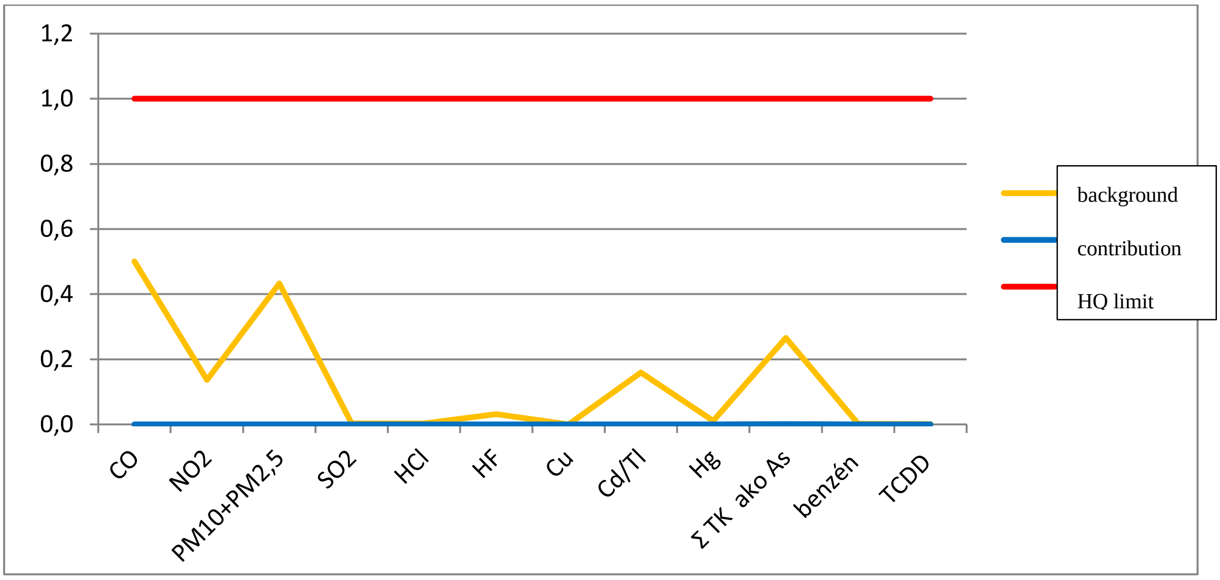
It is obvious from Graph No. 22 that all HQs calculated from maximum short-term concentrations of pollutants are lower than 1 at the site concerned. This applies both to overall air pollution including background and to the contribution of the respective source. It can also be stated that the contribution of the new RAW incineration plant and expansion of RAW remelting capacities of JAVYS, a.s. is negligible in comparison with the full-area pollution. Graph No. 23 shows the comparison of contribution of the respective air pollution source for the current and new state, which was calculated from maximum short-term concentrations of evaluated chemical substances. There are minimum differences between V0 and V1.

It results from the above mentioned that even maximum short-term concentrations of pollutants occurring during adverse dispersion conditions with highest impacts of the source on air pollution are insignificant in terms of health impacts (HQ < 1). This applies to both variant solutions.

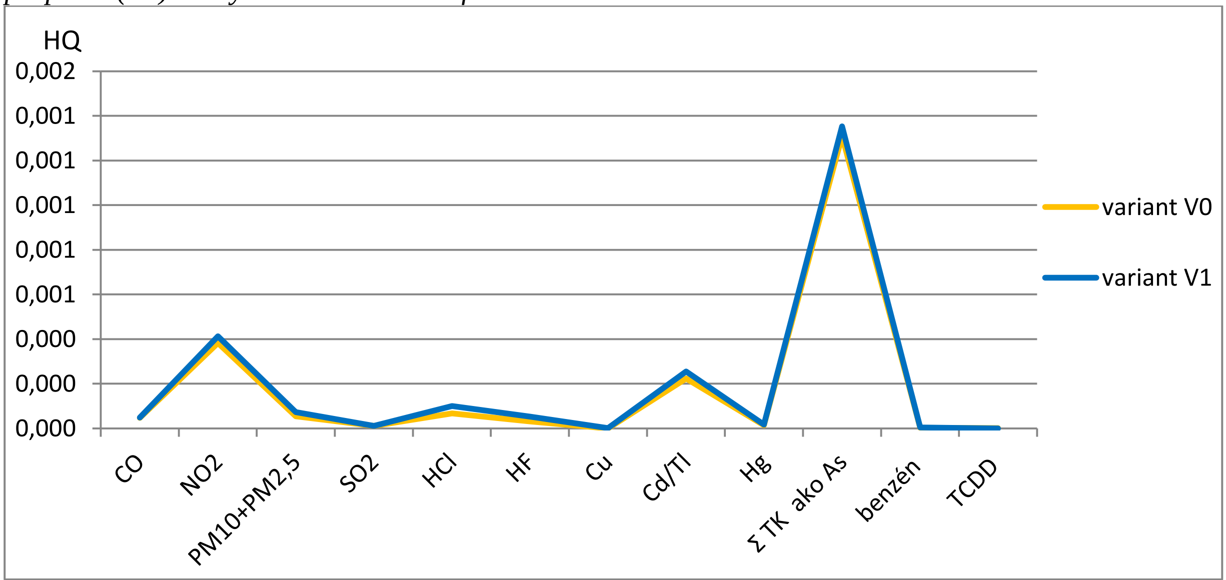
GRAPHIC PRESENTATION OF HQ

Average annual concentrations - adults

Graph No. 24: HQ comparison for the state after the completion of the proposal (V1) – background and contribution of the source



Graph No. 25: HQ comparison for the current state (V0) and the state after the completion of the proposal (V1) - only the contribution of the evaluated source



It is obvious from Graph No. 24 that all HQs calculated from average annual concentrations of pollutants are lower than 1 at the site concerned. This applies both to overall air pollution including background and to the contribution of the proposed source. It can also be stated that the contribution of the new RAW incineration plant and expansion of RAW remelting capacities of JAVYS, a.s. is negligible in comparison with the full-area pollution. Graph No. 25 shows the comparison of contribution of the respective air pollution source for the current and new state, which was calculated from average annual concentrations of evaluated chemical substances. There are minimum differences between V0 and V1.

It results from the above mentioned that the evaluated average annual concentrations of pollutants of both variant solutions are insignificant in terms of health impacts (HQ < 1).

This statements apply both to adults and children, the differences between them are minimal.

The calculated hazard quotients are evaluated as follows:

HQ < 1, no significant risk of non-carcinogenic effects is expected,

HQ 1 to 10, there is a potential risk, it is suitable to commence corrective measures

HQ > 10, emergency situation, remediation needs to be started as soon as possible.

The results show that from the maximum short-term as well as average annual concentrations, HQ > 1 was calculated for none of the evaluated chemical substances both for the current and the new states, which means that pollutants produced by the proposed activity of JAVYS, a.s. will not represent ***any significant risk of non-carcinogenic effects on health of adults or children***.

4.2 Estimated risk for thresholdless effects of chemical substances

The quantitative expression of the risk of carcinogenic effects of pollutants was calculated as the lifetime increase of probability of cancer diseases above the general average for the population (APCR).

The lifetime cancer risk for the population was calculated:

$$APCR = ILCR \times \text{size of population} \qquad [6]$$

where: ILCR – lifetime increase in the probability of the number of cancer diseases above the general average in the population for an individual,
size of population – number of inhabitants of the affected municipalities: 8,953 (average for 23 years).

The lifetime cancer risk was calculated for adults from maximum values of short-term and average annual concentrations of carcinogenic substances for the current state, as well as for variant V1. As regards the assessment of risk acceptability, probability of cancer disease occurrence at a level of 10^{-6} is considered "health safe" for the population. The value APCR for the affected inhabitants for the evaluated carcinogenic substances for overall air pollution including background was calculated at a level of 10^{-8} to 10^{-11} , and for the proposed operation at a level of 10^{-8} to 10^{-14} (Tab. No. 16 and 17).

Maximum short-term concentrations

Table No.16: APCR values for carcinogenic substances - adults

No.	Evaluated chemical substances	APCR			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	**solely the contribution of the evaluated source**	**overall air pollution including background**	**solely the contribution of the evaluated source**
1	benzene	1.81×10^{-10}	4.19×10^{-12}	1.83×10^{-10}	5.22×10^{-12}
2	Cd	1.95×10^{-8}	1.15×10^{-9}	1.97×10^{-8}	1.28×10^{-9}
3	Cr^{VI}	6.98×10^{-8}	1.49×10^{-8}	7.05×10^{-8}	1.54×10^{-8}
4	Ni	1.40×10^{-9}	2.98×10^{-10}	1.41×10^{-9}	3.08×10^{-10}
5	As	2.50×10^{-8}	5.35×10^{-9}	2.53×10^{-8}	5.52×10^{-9}
6	TCDD	1.77×10^{-9}	6.30×10^{-12}	1.77×10^{-9}	8.97×10^{-12}

Average annual concentrations

Table No.17: APCR values for carcinogenic substances - adults

No.	Evaluated chemical substances	APCR			
		Current state **V0**		State after the completion of the proposal **V1**	
		overall air pollution including background	**solely the contribution of the evaluated source**	**overall air pollution including background**	**solely the contribution of the evaluated source**
1	benzene	3.63×10^{-11}	1.12×10^{-13}	3.63×10^{-11}	6.09×10^{-14}
2	Cd	9.77×10^{-9}	1.37×10^{-11}	9.77×10^{-9}	1.56×10^{-11}
3	Cr^{VI}	3.49×10^{-8}	1.72×10^{-10}	3.49×10^{-8}	1.78×10^{-10}
4	Ni	6.98×10^{-10}	3.45×10^{-12}	6.98×10^{-10}	3.56×10^{-12}
5	As	1.25×10^{-8}	6.18×10^{-11}	1.25×10^{-8}	6.38×10^{-11}

6	TCDD	8.84×10^{-10}	7.29×10^{-14}	8.84×10^{-10}	1.05×10^{-13}

For the affected population in the surroundings of the set of radioactive waste treatment and conditioning technologies of JAVYS, a.s., for the evaluated carcinogenic substances, the value APCR<10^{-6} was determined, which means that ***the socially acceptable lifetime rate of cancer occurrence will not be exceeded.***

4.3. Summary assessment of chemical substances

The results of health risk assessment show that:

- the contribution of the respective source is minimal in comparison with the overall pollution including background,
- neither for adults nor for children, the risk of damage to health due to exposure to CO, NO_2, SO_2, PM, HCl, HF, Cu, Cd/Tl, Hg, Σ HM, TOC and PCDD/DF (HQ < 1) for either variant solution has been proved,
- as regards the contribution of the proposed source, heavy metals are the most significant pollutants at the evaluated site in terms of health effects; the HQ value calculated for heavy metals in the residential zone is, however, lower than 1 (HQ = 0.1172 for maximum short-term concentrations for V1 and HQ = 0.0014 for average annual concentrations for V1),
- as regards evaluation of the overall pollution including background, CO is the most significant pollutant at the evaluated site in terms of health effects; the HQ value calculated for CO in the residential zone is, however, lower than 1 (HQ = 0.6734 for maximum short-term concentrations for V1 and HQ = 0.5005 for average annual concentrations for V1),
- the evaluation of carcinogenic effects of benzene, cadmium, chrome ^{VI}, nickel, arsenic, and TCDD shows that the lifetime risk of cancer occurrence will not exceed the admissible risk value for the population - 10^{-6},
- the highest APCR value was calculated from chrome^{VI} (APCR = 1.54×10^{-8} for maximum short-term concentrations for V1 and APCR = 1.78×10^{-10} for average annual concentrations for V1).

4.4 Uncertainties in estimating health risk of chemical substances

The uncertainty in determining the hazard quotients may relate to, for example, quality of the data used to determine no-effect concentrations. In order to minimise this uncertainty, only data from trustworthy sources (US EPA, WHO, ATSDR, IRIS, IARC, etc.) were used in calculations.

The uncertainty in estimating the health risk of chemical substances polluting the air in the closest residential zone is that the concentrations of substances were calculated by means of the mathematical calculation, although the concentrations of pollutants were calculated according to an approved and fully acceptable methodology. However, due to the conservative approach, the calculated concentrations may be rather overestimated.

The indicators of population health condition are based on the databases of the National Centre of Medical Information of the SR and the Statistical Office of the SR. However, some data are only available for individual districts and regions, and it is not possible do deduce from them the exact impact of local pollution sources on health of the inhabitants of a particular municipality. On the other hand, statistical data for municipalities could be affected by the small number error, i.e. several accidental diseases or deaths could distort the resulting value of the indicator.

Because of the unavailability of the chronic RfC for inhalation pathway of exposure, threshold effects of Cu were calculated from the acute RfC, therefore, the calculated HQ may be slightly overestimated.

The hazard quotient for the sum of heavy metals was calculated for one of the most toxic heavy metals (As), which could also overestimate the HQ results. This situation is also caused by the fact that the applicable reference concentrations are not available for less toxic heavy metals.

In general, average annual concentrations are used for HQ calculation because chronic effects (70 years) of pollutants on health of the affected inhabitants are monitored. In the interest of maximum caution, HQ were also calculated for maximum short-term concentrations, which, however, represent an extremely improbable condition because the inhabitants will not be exposed to these short-term concentrations continuously during the whole life.

5. Conclusion of health risk assessment for chemical substances

The conclusion of health risk assessment regarding exposure to CO, NO_2, PM, SO_2, HCl, HF, Hg, Cu, Cd/Tl, sum of heavy metals, TOC and PCDD/DF, which come from the set of technologies for radioactive waste treatment and conditioning of JAVYS, a.s. for the current state (V0) and variant V1 is as follows:

"Optimisation of RAW incineration capacities JAVYS, a.s. at Jaslovské Bohunice"

does not represent an increased risk for the inhabitants of the affected municipalities

IX. HEALTH RISK ASSESSMENT FOR RADIOACTIVE RADIATION

1. Determination of hazard or radioactive radiation

Radioactive radiation causes atomic nucleus conversion and is divided into:

1) alpha radiation, which emits alpha-particles from the nucleus of atom, which reduces the number of protons and neutrons in nucleus, it has strong ionising effects and a low penetrating power (several cm),
2) beta radiation, which emits beta-particles (electrons or positrons) from the nucleus of atom, with the change of the proton number, it has a penetrating power 100-times higher than alpha radiation,
3) gamma radiation is electromagnetic radiation (photon flux), the nucleus of atom does not change, it has the lowest ionising effects but highest penetrating power.

The effects of radioactive radiation are assessed according to the following quantities:

- ***radioactivity*** - it is indicated in Bq (becquerel) units, 1 Bq = one decay per second,
- ***absorbed dose*** – it represents the rate of effects of radioactive radiation on human organism, it is given by the amount of energy absorbed per body weight and its unit is Gy (gray), 1 Gy = 1 J/kg,
- ***effective dose*** - it represents the product of absorbed dose and dimensionless weighting factor set for the type of radiation. The unit of effective dose is Sv (sievert), 1 Sv = 1 J/kg.

2. Relation between the dose and effect

Irradiation of humans may cause certain pathological changes, which can be expected within days and weeks, but also within years or decades. While passing through living substance, radiation ionises molecules of biologically significant substances in cells. In terms of health protection against radiation, biological effects of ionising radiation are divided into deterministic (causal) and stochastic (accidental).

2.1 Deterministic effects

Deterministic effects of radiation have a threshold dose, i.e. a dose without health effect. It is caused by reparation abilities of tissues. The rate of damage increase with the irradiation dose. Occurrence of clinical symptoms visible to the naked eye is expected with deterministic effects. Small cell losses are "tolerated" by the organism and the function remains undisturbed. The number of affected cells increases with the increasing dose of ionising radiation and after reaching a certain threshold, damage occurs. The seriousness of damage increases with the size of threshold exceeding. Damage to the most sensitive tissues is caused by a dose amounting to about tenths of Gy. Very sensitive tissues include testicles, crystalline lens, bone marrow, and ovaries. Tissue reactions are either early (i.e. after days or weeks of irradiations) or late (after months or years of irradiation). Effects range from inflammation reactions to tissue damage due to necrosis of a part of cells and the resulting malfunctions of organs.

2.1.1 Acute local damage

Acute skin damage is the most frequent type of local damage, it can have three grades:

1) ***Grade 1 radiation dermatitis (skin inflammation, skin changes)***
   Early erythema (skin redness) appears already during the first hours after irradiation (no later than within 2 – 3 days) by a dose of 3 to 4 Gy, and it lasts about 24 hours. However, late erythema (skin thickening) is the real radiation effect, which appears in the 2nd to 4th week after irradiation. Approximately in the 3rd week after single irradiation, epilation (loss of

vellus hair) occurs. After a dose of more than 3 Gy, epilation is temporary, after of dose of 6 Gy it is permanent.

2) ***Grade 2 radiation dermatitis***
After irradiation by doses from 12 to 20 Gy, a blister appears in the area of irradiated skin and no later than within two days, early, indistinctive erythema appears, which lasts about 24 hours. After a period of 2- to 3-week latency, an inflamed blister appears and skin is recovered after additional 2 or 3 weeks.

3) ***Grade 3 radiation dermatitis***
Grade 3 dermatitis occurs as a consequence of damage to deeper skin layers or subcutaneous layers. In general, it is the consequence of vessel changes and complicating infections, when the respective part of tissue is necrotic and an ulcer is created. Often, after one or two years, a secondary ulcer appears, which requires surgery.

2.1.2 Fertility disorders

Fertility disorders due to irradiation by a higher dose belong to damages caused by local irradiation. As regards sterility caused by ionising radiation, men are more radiosensitive than women, however, even with fractioned doses from 0.5 to 2.0 Gy, recovery occurs in men within one to three years. Women's sensitivity to irradiation depends on age. The number of ovarian follicles decreases with age, which increases sensitivity to irradiation. No reparation processes exist in women.

2.1.3 Effects on embryo and foetus development

Cells of foetal tissues are more radiosensitive than cell systems of an adult organism. The degree and scope of damage to foetal tissues or foetus depends on the dose size and in particular on the stage of development. The second and third stages of foetus development are critical. Within the time interval from the 4th to 8th week, irradiation may cause damage to foetal tissues and even the death of embryo or reduction of its weight, or it can cause malformations. Irradiation between the 8th to 15th week after insemination may affect the development of the central nervous system, which can manifest itself as retarded mental development of children born. Irradiation of foetus by a dose of 1Sv means IQ reduction from 100 to 70. In the period from the 16th to 25th week, the risk of damage to CNS decreases in comparison with the previous period to one quarter.
Threshold doses causing damage were monitored in small rodents; a distinct effect occurs within the range of doses from 0.25 to 4 Gy.

2.1.4 Late manifestations of deterministic damage

This category includes the following types of effects:

Chronic radiation dermatitis (skin inflammation, skin changes) - premature ageing. This type may include skin atrophy, which leads to skin cracks and secondary ulcers. Pigmentation disorders and nail brittleness also appear. With the ahypertrophic type, focal hyperkeratosis occur, which can develop into carcinoma.

Cataract (clouding of the lens in the eye)
Eye lens is very sensitive to irradiation. The threshold dose for damage occurrence at single irradiation by weakly ionising radiation (X-ray) is at a level of 1.5 to 2.0 Gy. At single irradiation by neutrons or gamma radiation, the threshold dose is lower than 1 Gy. The latency period until cataract occurrence is at least 6 months and a serious degree develops within several years. If the dose is distributed for a longer period, the value of threshold dose is from 4 to 6 Gy and the latency period is at least two years.

2.2 Stochastic effects

The most significant long-term effects of ionising radiation are carcinogenesis and mutagenesis, whose nature is stochastic. Carcinogenic effects can be observed in irradiated individuals and mutagenic effects are detectable in the offspring of the irradiated population.

Stochastic effects are thresholdless and with an increasing dose, the probability of damage and late forms of damage increases. The damage is caused by changes in the genetic information of cell. Organism copes with low doses of ionising radiation by means of reparation mechanisms. However, even with small doses, there is a probability that some damage cannot be repaired and late permanent consequences of genetic or tumour character will occur. Stochastic effects have probabilistic character, they are accidental, individual and unpredictable. With stochastic effects, the severity of handicap and the course of disease do not depend on the size of the absorbed dose. Only the probability of tumour or genetic damage depends on the size of the absorbed dose.

The evaluation of severity of effects of the ionising radiation is based on the background of occurrence of such phenomena. Professional literature uses the term "admissible (tolerable) risk", i.e. the number of cases considered acceptable in connection with the evaluated load. According to US EPA, the admissible (tolerable) risk of dying of cancer, i.e. the number of cases considered acceptable in connection with the evaluated load is one case per million people exposed (1×10^{-6}). In the European countries, the admissible value of tolerable risk of death is 1 to 5 cases per one hundred thousand of exposed people (1 to 5×10^{-5}).

2.2.1 Malignant tumours

Malignant tumours are among the most serious stochastic effects of ionising radiation. They result from mutations, which end as loss of control over cell division. However, exposure to ionising radiation does not cause a special type of cancer, it increases the incidence of commonly occurring cancer types. Causality of relation between carcinogenesis and exposure to ionising radiation is accepted for stomach, lungs, skin (carcinoma), mammary gland in women, thyroid gland, and haematopoietic organs. All carcinomas induced by radiation have a relatively long period of latency. Based on epidemiological studies, a period of eight years was determined as latency period for leukaemia occurrence after single irradiation. The shortest period of latency (about two years) was recorded for bone sarcoma caused by ^{224}Ra. For many tumours, the period of latency is from 15 to 20 years.

2.2.2 Genetic damage

Genetic damage occurs as a consequence of ionising radiation effects on the exposed individual, which manifest themselves clinically only in their offspring. The risk coefficient for the estimate of genetic consequences in humans is set based on the extrapolation of results of experiments with rodents. Genetic mutations affect the offspring; however, they do not endanger the generation of parents.

3. Limit values of radioactive radiation and risk coefficients

Radioactivity is divided into natural and artificial. Natural radioactivity results from spontaneous decay of atomic nucleus. People are permanently exposed to natural radioactive radiation from various sources. The load from natural sources significantly increases, for example, after the long stay in higher elevations above sea level or in depths (mines, caves). Another increase in load is caused by medical examination and treatment methods. The average dose from the use of radioactive radiation in healthcare is 1.5 mSv/year. People are also irradiated by using radiation sources in the working environment, by irradiating during experiments with nuclear weapons, and from nuclear power plant activities.

Artificial radioactivity can create elements, which do not exist in nature, or elements with atomic number higher than 92 (medical purposes, research). Elements obtain artificial radioactivity as a consequence of chain reaction or by the action of accelerated particles.

The legislation of the SR contains limit values for radioactive radiation. Article 15 of Act of the National Council of the Slovak Republic No. 87/2018 on radiation protection and on the amendment to certain acts sets, inter alia, limits of population irradiation, and everybody performing the activities leading to irradiation are obliged to limit the irradiation of workers and inhabitants from all performed activities so that irradiation limits are not exceeded.

Limits of irradiation of an inhabitant in a calendar year are as follows:

- effective dose 1 mSv,
- equivalent dose in the crystalline lens 15 mSv,
- equivalent dose in skin 50 mSv, it applies to an average dose on an area of any 1 cm^2 regardless of the size of the irradiated skin area.

The doses from all pathways of irradiation of an individual from the population, from all sources of ionising radiation and all registered and permitted activities with the sources of ionising radiation worth considering, shall be included in the irradiation of an inhabitant. Irradiation limits do not apply to medical irradiation, irradiation of a person from natural sources of ionising radiation, irradiation of a person in emergency situation.

To optimise radiation protection, marginal doses of irradiation of an inhabitant can be determined; they are set as a value of individual effective dose or equivalent dose that can be received by an individual from the population from the planned operation of a certain source of ionising radiation. The marginal dose for individual planned activities must be set so that the sum of doses that could be received by an individual from the population from all the planned activities with sources of radiation does not exceed the limits of irradiation of an inhabitant.

The International Commission on Radiological Protection has set a coefficient for the occurrence of cancer diseases or congenital disorders at a level of $5.7x10^{-2}$/ Sv, i.e. if 100 people are irradiated by one Sv, health consequences, or consequences in the next generation will develop in 5 to 6 persons.

The coefficient of risk of dying of cancer is $5x10^{-2}$/ Sv, i.e. if 100 people are irradiated by one Sv, five people will die of consequences of cancer disease caused by irradiation besides the background.

4. Evaluation of exposure to radioactive substances

4.1 Limit values of discharges from JAVYS, a .s.

Guide values of discharges from the NI of JAVYS, a.s. provide for that the annual limit of irradiation for a representative person from the population will not be exceeded as a consequence of radioactive discharges into the atmosphere and hydrosphere due to decommissioning operations at the A1 NPP, V1 NPP, and operation of RAW treatment technologies and ISFS under normal operating conditions.

The annual limit of irradiation of 20 μSv/year for a representative person from the population from V1 NPP discharges was set by decision of the state supervision - Public Health Authority of the Slovak Republic No. OOZPŽ/3760/2011. Decision No. OOZPŽ/7119/2011 set the limit of irradiation of 12 μSv/year for a representative person from the population due to the discharges from the NI RAW TCT, A1 NPP, and ISFS. The joint annual limit of irradiation for a representative person from the population due to the discharges of radioactive substances from the nuclear installations of JAVYS, a.s. amounts to 0.32 x 10^{-4} Sv.

Guide limits of discharges of radioactive substances are set for the discharges of radioactive substances from ventilation stacks (discharges into the atmosphere) as well as for liquid discharges into the water bodies Váh and Dudváh (discharges into the hydrosphere).

4.2 Discharges of radioactive substances from JAVYS, a. s. to the atmosphere

Monitoring of individual discharges of radioactive substances from JAVYS, a.s. into the atmosphere is carried out by continual measurement by instruments or by continual sampling in ventilation stacks of the V1 NPP, A1 NPP, RAW TCT and ISFS.

The results of monitoring of discharges into the atmosphere from individual ventilation stacks in 2018 showed that the emitted radioactive aerosols, strontium, transuranium elements, tritium ^{3}H and carbon ^{14}C were at low levels and without emergency events. In 2018, discharges from JAVYS, a. s. into the atmosphere were well below the authorised guide limits set by the Public Health Authority of the SR.

The values of discharges of radioactive substances are provided in the report "Discharges of radioactive substances from the NI JAVYS, a.s. Jaslovské Bohunice and the impact of the NI JAVYS, a.s. on the surroundings, 2018".

4.3 Discharges of radioactive substances from JAVYS, a. s. to the hydrosphere

Waste waters from JAVYS, a.s. – A1 NPP, RAW TCT (waters from structures 41, 809 and 28, water from pumped boreholes) and V1 NPP were discharged in 2018 through the piping collector SOCOMAN and Drahovský channel to the water body Váh. No waste waters were discharged to the water body Dudváh in 2018.

Since 1999, JAVYS, a.s. – A1 NPP in cooperation with EKOSUR has been executing remediation pumping of ground waters from the borehole N-3, covered by a permit issued by the Regional Office Trnava.

Radioisotope composition of discharges of corrosion and fission products in the discharged waste waters, and the content of strontium and transuranium elements are set in JAVYS, a.s. for balancing purposes. In 2018, during the remediation pumping of ground waters from the borehole N-3, 186,000 m^3 of ground waters were pumped with an activity of tritium of 54 GBq and with an activity of corrosion products of 1.6 MBq (^{60}Co).

The results show that the tritium activity limit in discharged waters was not exceeded and the discharges of other corrosion and fission products in waste waters were well below the set authorised limits.

4.4 Estimated discharges of radioactive substances for the proposed state

The contribution of discharges of radioactive substances from the proposed activity into the atmosphere will come in particular from the new RAW incineration plant and new line of metallic RAW remelting. With respect to their character, the other supplemented technologies of RAW treatment and the proposed RAW storage do not represent a relevant source of discharges of radionuclides. Relocation of certain fragmentation and decontamination facilities of the V1 NPP representing a relevant source of discharges of radionuclides will not affect their belonging to the V1 NPP or the share in the dose from the V1 NPP. No contribution to discharges of radioactive substances into the hydrosphere in connection with the proposed changes is considered. Changes of guide values (limits) for individual discharges of individual NIs are not considered, either.

4.4.1 New RAW incineration plant with a capacity of 240 t/year

The new incineration plant will discharge into the ventilation stack 46/B. The existing incineration plant discharges into the ventilation stack No. 808. Maximum permitted activity for RAW entering the incineration plant is currently 6 x 10^6 Bq/kg, i.e. with the considered capacity of the new incineration plant (240 t/year), total activity of input RAW will be maximum 1.44 x 10^{12} Bq/year, and appertaining activity in the discharge will be maximum 3.60 x 10^6 Bq/year.

The limit for both ventilation stacks connected to RAW incineration plants is identical - 1.41 x 10^8 Bq/year (a mixture of radionuclides with long half life ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{94}Nb, ^{110m}Ag, ^{125}Sb, ^{134}Cs, ^{137}Cs, ^{144}Ce) , where the discharged activity of radionuclides will respect it with a reserve even after the proposed optimisation of RAW incineration capacities. The appertaining individual effective dose for the new RAW incineration plant will be maximum 9.70 x 10^{-10} Sv /year.

4.4.2 Metallic RAW remelting

Currently, the first remelting line with a capacity of 1000 t/flow (variant 0) is under construction. The assessment covers another remelting line (variant V1), which will ensure the joint total capacity of remelting - 4500 t/year. Both remelting lines will be connected to the ventilation stack (VS) 46A.

Table No.18: Expected annual discharges of radionuclides into the atmosphere and individual dose

Radionuclide	Discharge at a capacity of 1,000 t/year (Bq/year)	VS limit used	Discharge at a capacity of 4,500 t/year (Bq/year)	VS limit used
60Co	3.0 x 10^5	0.05	1.35 x 10^6	0.225
94Nb	6.0 x 10^5	0.09	2.7 x 10^6	0.405
125Sb	3.0 x 10^5	0.05	1.35 x 10^6	0.225
137Cs	1.2 x 10^7	1.82	5.4 x 10^7	8.19
90Sr	6.0 x 10^5	3.10	2.7 x 10^6	13.95
239Pu, 241Am	4.06 x 10^3	0.07	1.83 x 10^4	0.315
Expected individual effective dose	2.24 x 10^{-9} Sv/year	-	1.01 x 10^{-8} Sv/year	-

Estimated contribution to the existing individual effective dose from the new RAW incineration plant and new metallic RAW remelting line was calculated by the ESTE AI programme for the residential zone - sector 76 (Ratkovce), as the most loaded residential area.

5. Characteristics of the risk of radioactive substances

Based on the monitoring of discharges of radioactive substances from JAVYS, a.s., in 2018, the highest value of individual effective dose of a representative person in the residential zone 76 (Ratkovce) for the group 6 to 15 years was calculated at a level of 8.72 x 10^{-9} Sv (0.03 % of total annual limit).

Table No.19 Maximum individual effective doses in Sv/year

Site	Current state **V0**	State after the completion of the proposal **V1**	
Ratkovce	JAVYS, a.s. 2018	contribution of the new RAW incineration plant	contribution of metallic RAW remelting

	$8.72x10^{-9}$*	9.70×10^{-10}	$1.01x10^{-8}$**

Explanatory notes:
** individual effective dose from the monitoring of discharges of radioactive substances from operation of all JAVYS, a.s. facilities in 2018,*
*** the contribution of metallic RAW remelting also includes the share of remelting currently under construction, thus, it has not manifested itself in the individual effective dose of 2018. This is also connected with the calculation of death risk in Table No. 20 for the contribution of the proposed activity, which also includes the share of metallic RAW remelting under construction.*

The calculation of irradiation risk was carried out for the inhabitants living all life (70 years) in the residential zone with the highest radiation. The risk posed by irradiation was calculated by means of the coefficient of risk of death caused by malignancy from irradiation, i.e. 5×10^{-2}/ Sv, and by means of cancer occurrence coefficient. The resulting values of the risk posed by irradiation for the current state and state after the completion of the proposal are listed in Table No. 20.

Table No.20 Calculated risk for the most critical group of inhabitants (6 to 15 years) of the municipality Ratkovce

	variant	annual dose in Sv	lifetime dose in Sv	mortality risk
JAVYS, a.s.	**V0**	$8.72x10^{-9}$	$6.10 x10^{-7}$	$3.1 x10^{-8}$
contribution of the proposed activity	**V1**	$1.11x10^{-8}$	$7.75x10^{-7}$	$3.9 x10^{-8}$
Total V0 + V1	**-**	$1.98 x10^{-8}$	$1.39 x10^{-6}$	$7.0 x10^{-8}$

The resulting risk of death due to cancer diseases caused by irradiation by ionising radiation coming from the current operations of JAVYS, a.s. is $3.1 x10^{-8}$, i.e. three cases of death in excess of the background per 100 million. The risk of irradiation coming from the proposed activity is $3.9 x10^{-8}$ and represents four deaths in excess of the background per 100 million. At present, 2.5×10^{-3} inhabitants or 250,000 per 100 million inhabitants die of cancer in the SR (Graph No.18, page 24). Taking into account the above facts, the risk of irradiation calculated for both the current and proposed operations of JAVYS, a.s. is negligible.

The quantities of radioactive substances discharged into the atmosphere and hydrosphere from JAVYS, a.s. discharges in 2018 did not exceed the authorised annual limits for the discharges of radioactive substances approved by supervisory authorities. The obtained results of control of JAVYS, a.s. surroundings document that the operation of the NI JAVYS, a.s. had negligible radiological influence on the surroundings in 2018. This was also confirmed by the calculation of negligible risk coming from JAVYS, a.s. operation, as well as from the proposed set of technologies for radioactive waste treatment and conditioning.

6. Conclusion of health risk assessment for radioactive substances

Conclusion of health risk assessment concerning exposure to radioactive substances coming from the set of technologies for radioactive waste treatment and conditioning in JAVYS, a.s. is as follows for the current state (V0) and variant V1:

"Optimisation of RAW incineration capacities JAVYS, a.s. at Jaslovské Bohunice"

does not represent an increased risk for the inhabitants of the affected municipalities

XI. EVALUATION OF SOCIO-ECONOMIC AND PSYCHOLOGICAL FACTORS

During the evaluation of the proposed activity, the anxiety of inhabitants in the nearby municipalities about the impairment of their life conditions due to construction of a new radioactive waste incineration plant and expansion of radioactive waste remelting capacities in JAVYS, a.s. were also taken into account. The anxiety about the impairment of life quality and health threats may for some people living in the close surroundings represent stress. The feeling of subjective discomfort and dissatisfaction about life can also affect life quality. To eliminate the anxiety, it is suitable to communicate with the affected inhabitants and inform them on the proposed measures to reduce emissions of pollutants and radioactivity in the environment.

The affected municipalities (Jaslovské Bohunice, Pečeňady, Veľké Kostoľany, Ratkovce, Žlkovce, Malženice, Radošovce and Dolné Dubové) submitted a joint opinion on the plan "Optimisation of RAW TCT treatment capacities JAVYS, a.s. at Jaslovské Bohunice", which is identical with the opinion of the Association of Towns and Municipalities, Jaslovské Bohunice NPP region. In the opinions, the municipalities expressed mainly their concerns about radiation load and emissions of pollutants from RAW incineration in the proposed activity. The affected municipalities accept Variant 0, which does not include an increased quantity of treated RAW. The Nižná municipality had no comments on the submitted plan.

To explain the purpose of optimisation, meetings took place with JAVYS, a.s. representatives (Chief Executive Officer, Division Directors, Section Heads) and Mayors of the affected municipalities. The Chief Executive Officer and Section Heads took part in the meeting of the council at the municipality Jaslovské Bohunice on 11 March 2019, where questions about foreign RAW treatment by incinerating technology were explained.

On 24 March to 29 March 2019, a meeting of Mayors of the affected municipalities took place at the places of foreign partners (Sogin, Nucleco); they could familiarise themselves with Caorso NPP decommissioning, look at the premises for the storage of RAW intended for treatment at JAVYS, a.s. They were presented the procedures of Caorso NPP decommissioning, and communication strategy of Sogin with the public was discussed.

Further, the magazine "JAVYS u nás" No. 2/2018 published the article "Optimisation of RAW treatment capacities for more efficient utilisation".

As the acceptability for the affected municipalities has been proved, it was stated that the population of the affected municipalities is not and will not be affected by an increased radiation load and emissions of pollutants.

On the other hand, the execution of the proposal "Optimisation of RAW incineration capacities JAVYS, a.s. at Jaslovské Bohunice" will increase the number of employees, which can positively affect population's health and increase the living standard of inhabitants.

XII. EXPECTED IMPACTS ON HEALTH OF THE AFFECTED POPULATION

Optimisation of RAW incineration capacities and expansion of RAW remelting capacities at JAVYS, a.s. will not increase radiation load and emissions of pollutants from waste incineration above the rate set by decisions of competent authorities. The benefit of optimisation of capacities of RAW treatment and conditioning technologies will be that it will ensure faster treatment of RAW into a stable form preventing leakage of radioactive substances into the surroundings.

RAW import from external (foreign) RAW producers within the EU is subject to the fulfilment of legislative requirements resulting from Act No. 541/2004 Coll. on peaceful use of nuclear energy

(Atomic Act) and on the amendment to certain acts, i.e. RAW import to the territory of the SR for purpose of treatment or conditioning in the territory of the Slovak Republic is possible only if export of material with aliquot activity is contracted and permitted by the authority.

Impacts of operation of nuclear installations are monitored through gaseous and liquid discharges, for which annual guide values (limits) have been determined. Summary discharges of radioactive substances into the atmosphere and hydrosphere from all sources at the site under normal and specific operating conditions must not exceed the annual limit of irradiation of 0.25 mSv for an individual from the critical group of population, out of it only 32μSv fall on JAVYS, a.s.; this irradiation limit will not change after the proposed change. It results from the above mentioned that the proposed set of radioactive waste treatment and conditioning technologies at JAVYS, a.s. will not exceed the limit of irradiation of the inhabitants in the affected municipalities due to an increase in the discharges of radioactive substances into the atmosphere and hydrosphere.

The evaluation of selected chemical substances polluting the air shows that the proposed construction of the new RAW incineration plant and expansion of RAW remelting capacities of JAVYS, a.s. will not represent an increased health risk to the affected inhabitants.

There is no assumption, either, that the operation of the set of radioactive waste treatment and conditioning technologies would adversely affect health of the inhabitants concerned due to the use of groundwater for drinking purposes as in the surroundings of the premises, there is no protective zone of a water source for drinking water supplies to inhabitants, groundwater is monitored on a regular basis and drinking water quality is in compliance with the respective legislative regulations. The situation with surface waters in the surroundings of the premises of the NI Jaslovské Bohunice is similar. Further information on contamination of ground and surface waters can be found in Chap. V.

The unfavourable radiation status of the area groundwater is solved by implementation of remediation pumping, which removes contaminated groundwaters from the geological environment and inhibits movement of residual contamination outside the premises. The radiation situation of groundwaters on the premises of the NI is significantly affected by A1 NPP decommissioning. Volume activity of the main contaminant - tritium - in the geological environment beneath the premises of the A1 NPP reaches a maximum value of 10^5 $Bq.dm^{-3}$.

Nor it is expected that the execution of the proposal will cause any significant changes of the determining noise values in comparison with the current state. Considering the distance from the closest residential area, noise levels caused by technological equipment of JAVYS, a.s. will not represent any increased health risk for the affected inhabitants.

The proposed changes in JAVYS, a.s. could have indirect health impacts on some inhabitants resulting from stress because they fear of impairment of the quality of environment in the surroundings. The proposed changes were explained to mayors of the affected municipalities and to the public in various ways (participation in the meeting of the council, Caorso NPP excursion, article in a magazine).

XIII. RECOMMENDATIONS FOR MITIGATION OF ADVERSE HEALTH IMPACTS

To prevent any adverse health impacts, it is necessary:

- to perform regular service and maintenance of installed equipment, observe the required emission and immission limits, guide values for discharges and dose rate limits,
- if necessary, to inform suitably again the affected inhabitants on the technical support in JAVYS, a.s., which prevents adverse environmental impacts and consequently, negative impacts on human health,

- to observe the valid technical, organisational, safety and hygienic regulations related to operation activities.

Additional particular measures to prevent leakage of air pollutant emissions and leakage of discharges of radioactive substances into the atmosphere and hydrosphere are described in the assessment report for "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice".

XIV. MONITORING

Within the activity in JAVYS, a.s. it is necessary to perform measurements of pollutant emissions and activities of radioactive substances both in the atmosphere and hydrosphere in compliance with the valid legislation and decisions of the NRA SR.

Radioactivity of surface, drinking and ground waters is monitored within radiation control of the surroundings of the NI Jaslovské Bohunice in the following intervals: drinking waters once per quarter, surface waters once per month, ground waters in boreholes twice a year (in spring and in autumn).

The soils are sampled once a year. Sampling is divided into two groups; for grassy lands, they are performed in spring, and for arable lands, they are performed in autumn.

Dose rates in the surroundings of the Jaslovské Bohunice NI premises are measured continuously on 24 stations of the teledosimetric system.

It results from the above mentioned that emissions into the atmosphere and hydrosphere are monitored on a regular basis. Outputs of monitoring of individual indicators are published at www.javys.sk.

XV. FINAL SUMMARY

Based on the performed health impact assessment and provided that during operation of the RAW treatment and conditioning technologies the approved technological procedures and all recommendations, as well as limits stipulated by applicable legal regulations or authorised guide values set by the Public Health Authority of the Slovak Republic are consistently observed, I evaluate

the current condition (V0) as well as variant V1 for

"Optimisation of RAW incineration capacities JAVYS, a.s. at Jaslovské Bohunice"

as without any significant impact on health of the affected inhabitants and recommend its execution.

XVI. CONFIRMATION OF DATA CORRECTNESS

BY SIGNING IT, I CONFIRM THE DATA CORRECTNESS:

....

RNDr. Iveta Drastichová
Milana Marečka 3
Bratislava 841 08

Bratislava, 31 May 2019

Professional competence document No.: OOD/7760/2010 - Certificate of Professional Competence for Health Impact Assessment (Annex)

XVII. BACKGROUND DOCUMENTS USED FOR HEALTH IMPACT ASSESSMENT

Plan "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice" in accordance with Act of the National Council of the SR No. 24/2006 Coll. as amended. JAVYS, a.s., January 2018.

Decision of the Ministry of Environment of the Slovak Republic, Environmental Impact Assessment Department, issued during the screening process for "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice", Bratislava 22 February 2019.

Discharges of radioactive substances from the NI JAVYS, a.s. Jaslovské Bohunice and the impact of the NI JAVYS, a.s. on the surroundings,
2018.

Expert opinion on health risk and impact assessment for the operation of the Radioactive Waste Treatment and Conditioning Technology JAVYS, a.s. at Jaslovské Bohunice, Trnava District, MUDr. Jindra Holíková, July 2013.

Dispersion study for the proposed activity: "Optimisation of treatment capacities of radioactive waste treatment and conditioning technologies JAVYS, a.s. at Jaslovské Bohunice", Ing. Viliam Carach, May 2019.

Information obtained from e-mail communication with EKOS PLUS, s.r.o.

XVIII. INFORMATION SOURCES USED

Agents Classified by the IARC Monographs, Volumes 1–123, available at:
https://monographs.iarc.fr/wp-content/uploads/2019/02/List_of_Classifications.pdf

Air Quality Guidelines - Second Edition, WHO Regional Office for Europe, 2000, available at:
http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

European Union Risk Assessment Report Cumene, European Chemicals Bureau, 2001, ISBN 92-894-0500-7.

Glossary of Key Terms, US EPA, available at:
http://www.epa.gov/airtoxics/natamain/gloss1.html

Health Impact Assessment. Explanatory dictionary, Drastichová I., WHO Office in slovakia, Bratislava 2011, ISBN 978-80-7159-209-9.

International Agency for Research on Cancer (IARC), WHO, available at:
http://www.iarc.fr/en/publications/list/index.php

Incidence of malignant tumours in the Slovak Republic, National Cancer Registry of the Slovak Republic, NCZI Publishing House, Bratislava, available at:
http://www.nczisk.sk/Search/results.aspx?k=Incidencia zhubných nádorov

International Agency for Research on Cancer (IARC), WHO, available at:
http://www.iarc.fr/en/publications/list/index.php

Ionising radiation and health risk, RNDr. Helena Cabáneková, PhD., Slovak Medical University in Bratislava.

Koppová, K. et al.: Health risk assessment, management, and communication, Slovak Medical University, Bratislava, 2007, p. 150, ISBN 978-80-969611-8-4.

The Risk Assessment Information System (RAIS), Chemical Toxicity Values, available at: https://rais.ornl.gov/cgi-bin/tools/TOX_search

Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Office of Superfund Remediation and Technology Innovation, US EPA, 2009, available at: http://www.epa.gov/oswer/riskassessment/ragsf/pdf/partf_200901_final.pdf

Statistical Office (Statistics of towns and municipalities), available at: http://app.statistics.sk/mosmis/sk/run.html

Toxicity Values for Inhalation Exposure, New Jersey Department of Environmental Protection Division of Air Quality, August 2018, available at: https://www.state.nj.us/dep/aqpp/downloads/risk/ToxAll2018.pdf

TOXNET Databases (IRIS, ITER, HSDB, TOXLINE), Toxicology Data Network, U.S. National Library of Medicine, available at: http://toxnet.nlm.nih.gov/

Decree of the MH SR No. 233/2014 Coll. on details of health impact assessment. Collection of Laws of the SR.

Decree of the Ministry of Environment of the Slovak Republic No. 410/2012 Coll. implementing certain provisions of the Act on Air as amended by Decree No. 270/2014 Coll. and as amended by Decree No. 252/2016 Coll. Collection of Laws of the SR.

Decree of the Ministry of Environment of the Slovak Republic No. 244/2016 Coll. on air quality as amended. Collection of Laws of the SR.

Act of the National Council of the Slovak Republic No. 355/2007 Coll. on public health protection, support and development and on the amendment to certain acts as amended. Collection of Laws of the SR.

Act of the National Council of the Slovak Republic No. 24/2006 Coll. on environmental impact assessment and on the amendment to certain acts as amended. Collection of Laws of the SR.

Act of the National Council of the Slovak Republic No. 87/2018 Coll. on radiation protection and on the amendment to certain acts. Collection of Laws of the SR.

XIX. EXPLANATION OF TERMS AND ABBREVIATIONS

Risk assessment means the process of evaluation of probability and gravity of a harmful effect on humans as a consequence of exposure to a hazardous factor under defined conditions and from defined sources.

Hazard means the capability of a risk factor to cause adverse impacts on human health.

Admissible (acceptable) risk represents a level of risk, which the society is willing to accept. It is a socially acceptable rate of health and ecological risk.

Risk means the probability of occurrence of a harmful effect on humans as a consequence of exposure to a hazardous factor.

ADD - Average Daily Dose;

ADI - Acceptable Daily Intake;

CNS - Central Nervous System;

BRWTC - Bohunice Radioactive Waste Treatment Centre;

EBO - Bohunice Power Plant;

HIA - Health Impact Assessment;

HQ - Hazard Quotient;

JAVYS, a.s. - Jadrová vyraďovacia spoločnosť, a.s.

NI - Nuclear Installation;

KÚ – Regional Office;

ISFS - Interim Spent Fuel Storage;

NOAEL - No Observed Adverse Effect Level;

RAS – Radioactive Substances;

RAW - Radioactive Waste;

RfD - Reference Dose;

TDI - Tolerable Daily Intake;

RAW TCT –Radioactive Waste Treatment and Conditioning Technologies

MH SR – Ministry of Health of the Slovak Republic,

NR - National Repository,

LE - Life Expectancy,

PM - Particulate Matter,

NRA SR – Nuclear Regulatory Authority of the Slovak Republic

VS - Ventilation Stack,

Pol - Pollutant;

TOXNET - Toxicology data network;

IARC - International Agency for Research on Cancer,

IRIS - Integrated Risk Information System;

ATSDR – Agency for Toxic Substances and Disease Registry;

US EPA - United States Environmental Protection Agency;

WHO - World Health Organization;

ANNEX CERTIFICATE OF PROFESSIONAL COMPETENCE

PUBLIC HEALTH AUTHORITY
OF THE SLOVAK REPUBLIC
Trnavská cesta 52
P.O.BOX 45
826 45 Bratislava

No.: OOD/7760/2010
Date: 18 November 2010

CERTIFICATE OF PROFESSIONAL COMPETENCE

issued pursuant to Article 15 and Article 16 of Act No.355/2007 Coll. on public health protection, support and development and on the amendment to certain acts as amended

Degree, name and surname: RNDr. Iveta Drastichová
Date and place of birth: 28 May 1960 Bratislava
Residing at: Milana Marečka 3 Bratislava 841 08

for health impact assessment or environmental health risk assessment.

Date and place of examination performance: 8 November 2010 before the examination commission of the Public Health Authority of the Slovak Republic, with its registered office in Bratislava, established on 5 December 2007 under No. ZHHSR/100096/2007 including amendments.

The above-mentioned person is capable of performing health impact assessment.
Certificate validity: for an indefinite period
Chairwoman of the examination commission: Ing. Katarína Halzlová, MPH

illegible signature
MUDr. Gabriel Šimko, MPH
Chief Hygienist of the Slovak Republic – per proxy *Official seal:* Public Health Authority of the Slovak Republic

Administrative fee paid on 8 November 2010
Receipt No. 1670/2010 *Official seal:* Public Health Authority of the Slovak Republic