ISO 9001
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OHSAS 18001
Responsible Care

KFAR YONA

RISK EVALUATION

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CONTENTS

1. Specification of the subjected site

The site is situated in Ha'Atzmaut (highway 57) and Rabin blvd corner, at the entrance to Kfar Yona in height a. s. l. approximately 60 meters. The area of the site is approx. 14.6 dunams. The site is plain with a slope towards west. It is drained towards a main drainage facility belonging to Kfar Yona, west to the site.

1.1. Existing and planned use of the site

At the site there used to be a transit station with fueling during the British mandate. After Israel was founded the site turned into a military car workshop. The workshop worked for 55 years, until 2004. The site is located app. 1 km from the Beit Lid army base and was used mainly for treating its vehicles. The IDF used this area as a car workshop until 2004. It contained areas for treating cars, offices, kitchen and residences (Fig. 2)

Today the area is deserted and surrounded by a fence and there is little construction waste on the terrain (old buildings remains, concrete infrastructure and greenery). There was no gasoline station – no use of fuels (the British gasoline station is a hear-say, the exact location and use are unclear). No evidence for volatiles was found. The purpose of the new plan is to remediate the site and change it into a residential and commerce area. The residence is planned as continuation to the neighborhood from south to the site and the commerce area is planned to be near highway 57.

1.2. Description of areas with soil pollution potential

All the buildings on site were shacks made of tin and asbestos, except for the commander's office and the office at the southern part of the site. The position of described objects is shown in Fig. 2.

<u>Armory</u>

Building purpose: storage and weapons maintenance.
Condition today: concrete infrastructure.

<u>Workshops A and B</u>
Buildings purpose: a concrete surfaces on which tin sheds are assembled and were used for treating cars.
Condition today: concrete surface.

Fig. 1: The area of interest - situation in a aerial map.

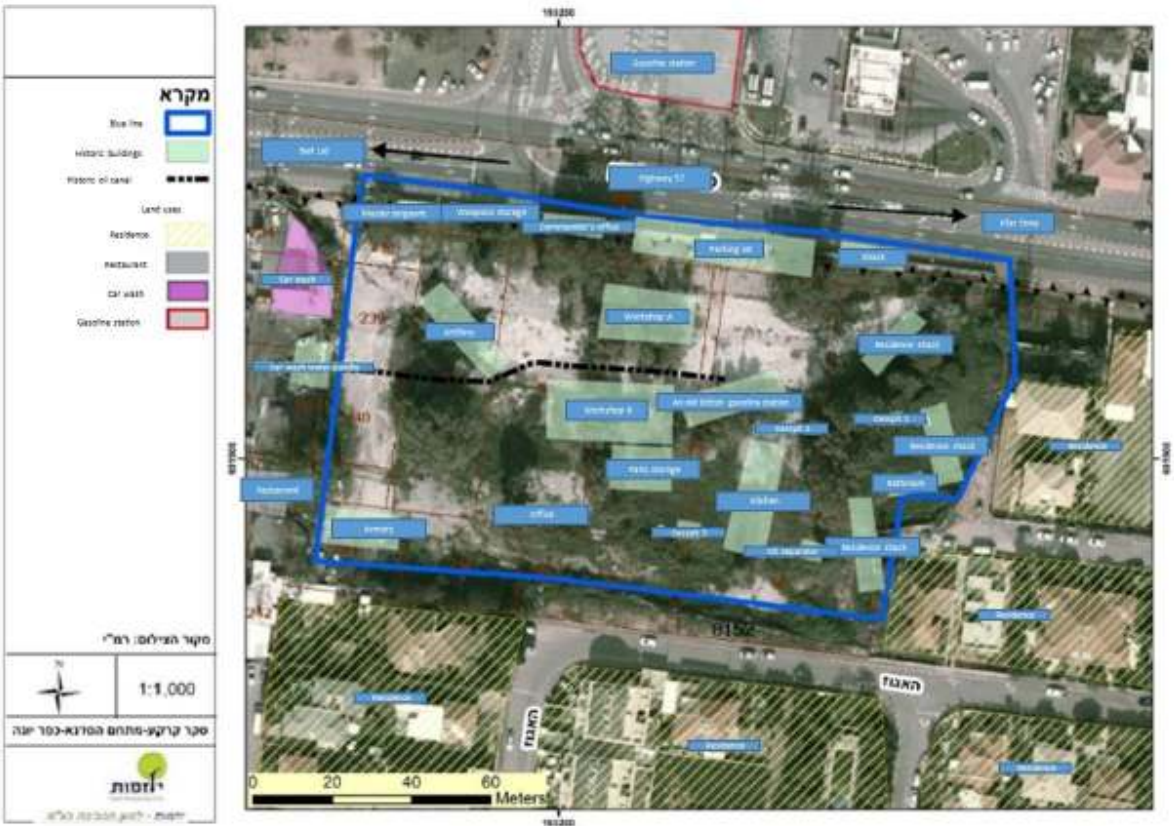

Fig. 2: Site description map.

Kitchen + oil separator

Building purpose: an army kitchen and an oil separator near it.
Condition today: not existing.

Treatment pit and flat tiers pit
Building purpose: small treatments for cars.
Condition today: not existing.

Parts storage
Building purpose: storage of car parts and oils.
Condition today: not existing.

Septic tanks
Building purpose: 3 manholes 8 meters deep and 3 meters in diameter for sewage.
Condition today: existing.

Car wash puddle (outside the site)
Building purpose: collection of drained water.
Condition today: existing.

Burnt oil cesspit
Building purpose: collecting burnt oil – cesspit is 4 meters deep and 3 meters in diameter.
Condition today: not existing.

2. Natural relations in the site of interest

2.1. Topographic conditions at the site and its surroundings

The site has a small slope towards north-west. The height of the site in the south-eastern part is app. 56 meters above sea level and in the north-western part it is app. 53 meters. The groundwater level is estimated to be app. 10 meters above sea level.

2.2. Geology and hydrogeology

The site is located app. 7,5 km from the sea shore. According to geological cross sections prepared by the water authority, the soil in the area and the stratigraphic cross section (Fig. 4) is made of red loam and sand in the upper layer and beneath it clay sand. The site is located in an area where there is risk for harming groundwater. According to the water authority there are no water production wells in a radius of 1 km around the site.

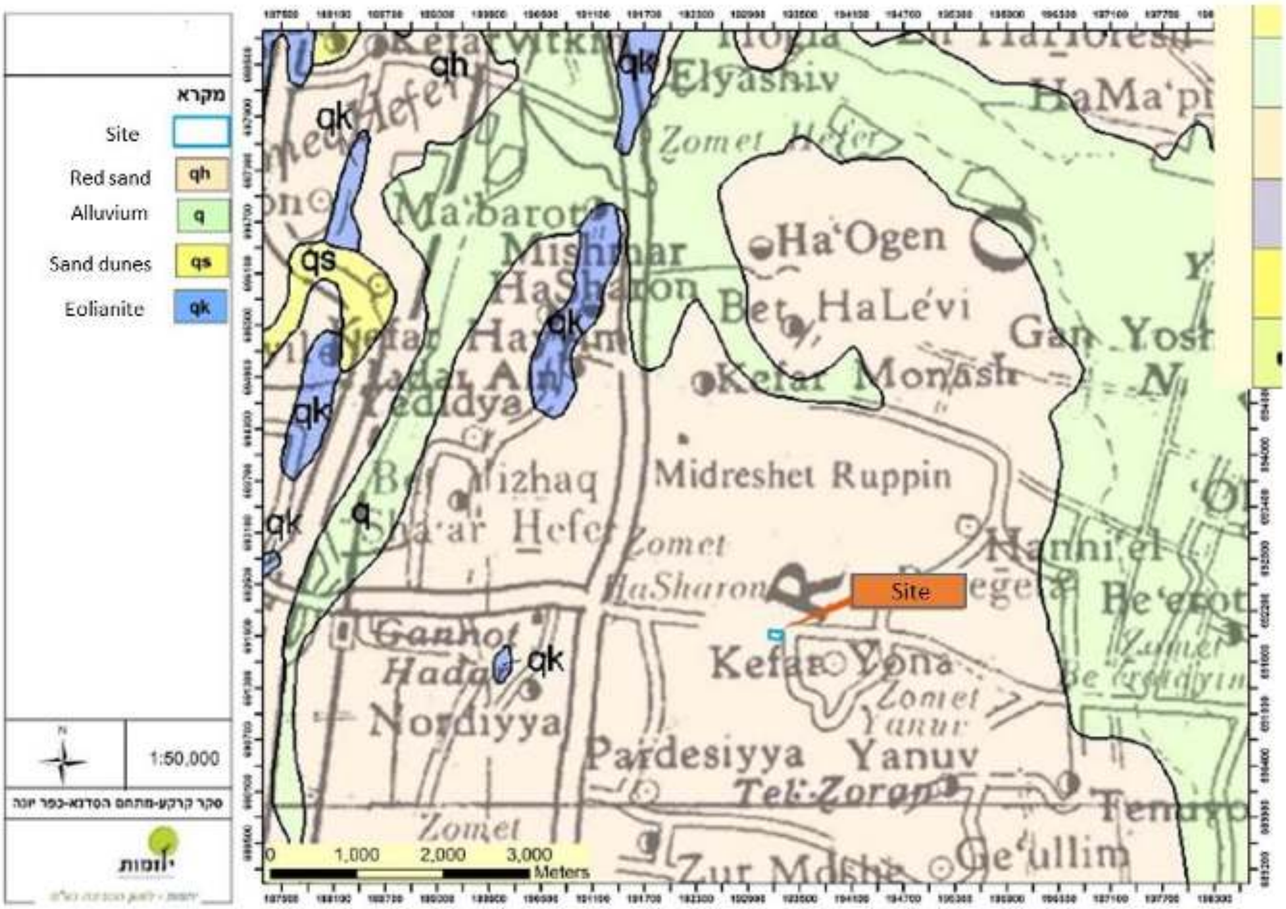

Fig. 3: Geological map of the subjected area.

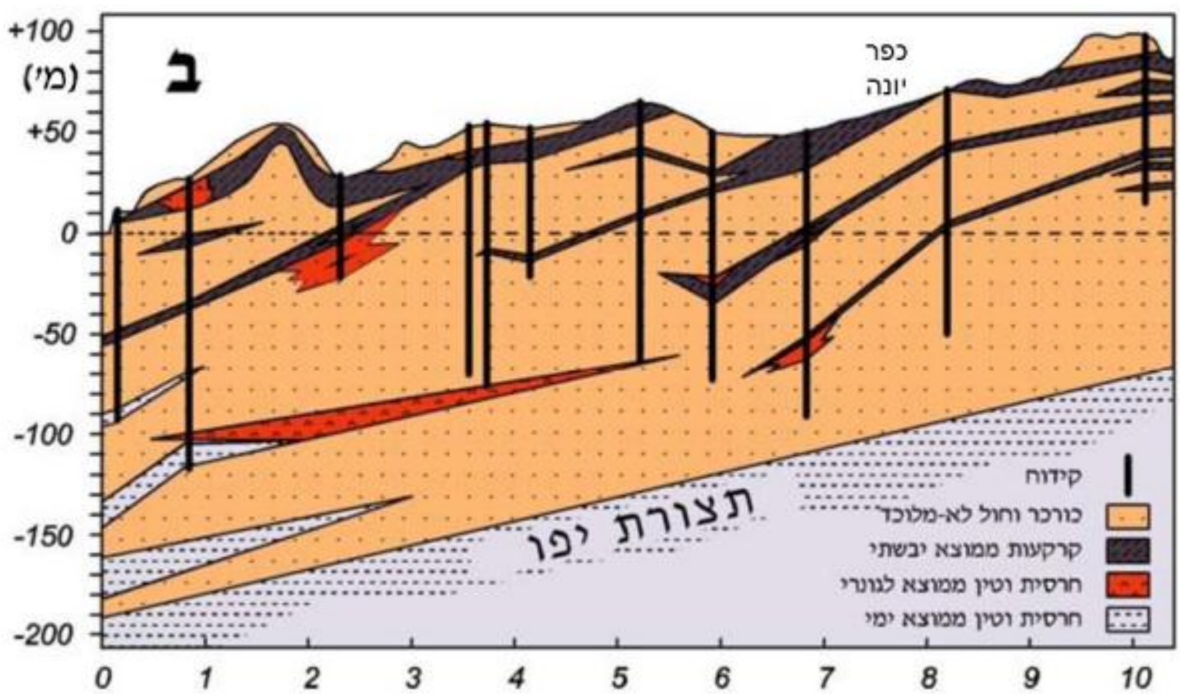

Fig. 4: Stratigraphic cross-section of the subjected area.

3. Soil and groundwater survey

During the previous survey the sampling points were divided to several locations (Fig. 2):

1. The car workshops;
2. The aromory;
3. The kitchen;
4. Used oil gathering pit;
5. Sewer;
6. Car wash – at the border of the site.

The soil survey included sampling from 30 boreholes spread-over the whole site area with depth ranging from 2 to 9 m (Fig. 5). In total 58 soil samples were taken from various depths ranging from 0.5 to 9 m b. t. Active soil gas sampling included collecting of gas samples from 7 boreholes where sampling was performed at a level of 10 m b. t. (and 7.5 m in case of borehole B-5). The complete laboratory results are summarized in Appendix 3.

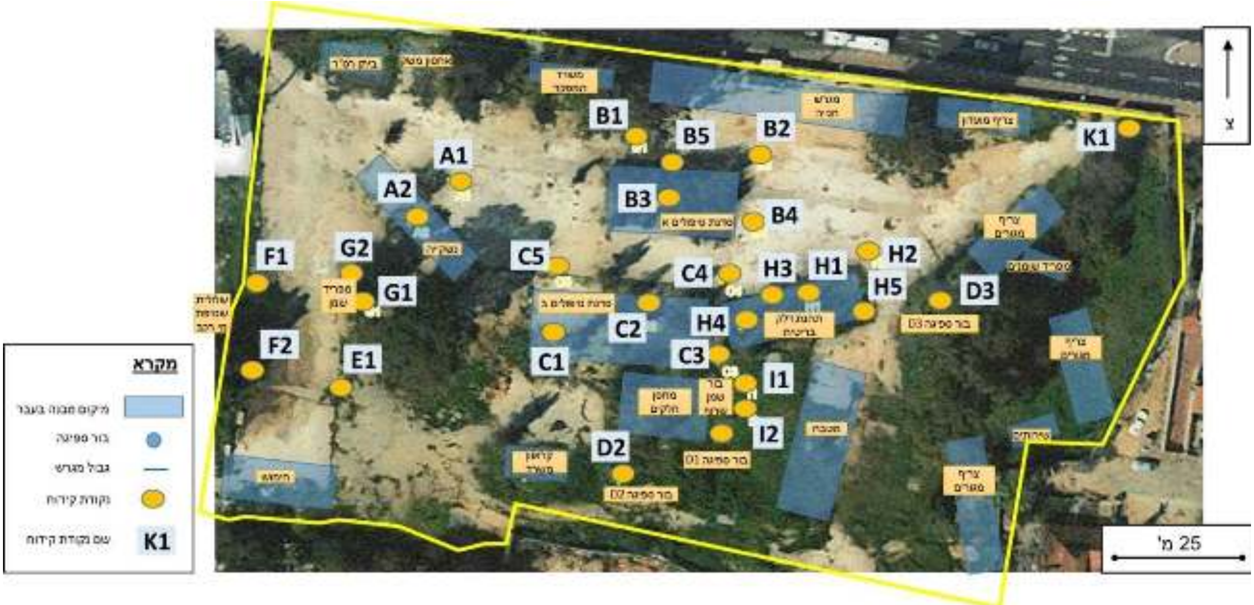

Fig. 5: The situation of soil survey boreholes.

3.1. Soil survey results summary

The soil survey results can be summarized as follows:

<u>**Comparison with screening levels of the ministry of Environmental Protection**</u>

Soil:

- No heavy metals, pH and SVOCs did exceed the threshold values.
- **TPH** concentration exceeded threshold value (of 350 mg/kg) at two boreholes: samples G-2 (depth 1 m) and sample H-4 (depth 1 m).

Soil gas:

- In samples C-3 and D-2 there were **benzene** concentrations exceeding threshold value (of 16 µg/m^3) – Tab. 3-1.

Comparison with Tier 1 Risk-Based Target Levels - Residential Land Use (IRBCA)

Soil:

- **TPH** concentration exceeded threshold value (here of 450 mg/kg) at two boreholes: samples G-2 (depth 1 m) and sample H-4 (depth 1 m).

Soil gas:

- Only in a single case, in borehole D-2 the **benzene** concentration exceeded Tier 1 RBTL (of 40,4 µg/m^3) – see Tab. 3-1.

Table No. 3-1: The active soil gas survey results with marking out a single exceeding value for benzene.

Borehole ID	**Tier 1 Risk-Based Target Level - Residential Land Use (IRBCA)[1] (µg/m3)**	**K-1**	**G-1**	**D-2**	**D-1**	**C-3**	**C-2**	**B-5**	
Depth (m)		10	10	10	10	6	6	**7,5	7,5
1,2,4-Trimethylbenzene	9,46E+02			244,7	9,54	13,92		8,11	7,23
1,3,5-Trimethylbenzene	NA	ND	ND	121,5			ND		
1-Ethyl-4-methylbenzene	NA			102,8	ND	ND			
1,1,1-Trichloroethane	6,76E+05		12,49	ND			18,7	ND	ND
2-Butanone	NA	6,37	4,55	9,36	6,85	15,99	8,61		
Hexane	9,46E+04	ND	ND	113,5	ND	57,1	4,86		
Freon-11	NA		15,04	ND		ND	ND		
Isopropyl alcohol	NA	<24,58	42,71	<24,58	<24,58	<24,58	<24,58	158,4	92,79
Methylene chloride	NA	5,84	10,29	79,04	32,9	ND	5,68	12,82	11,46
Propene	NA	ND	4,39	908,7	11,93	605	63,51	ND	ND
Tetrachloroethylene	1,21E+03	37,51	13,22	15,62	142,7	33,94	50,42	28,42	30,05
Toluene	6,76E+05	ND		53,64		39,24		7,69	6,86
Acetone	NA	25,11		85,56	ND	84,87			
Benzene	4,04E+01			**45,33**		25,72			
Carbon disulfide	NA			83,52	20,19	9,71			
Ethylbenzene	1,26E+02			31,9		9,9			
Heptane	NA		ND	50,83	ND	27,31	ND	ND	ND
Methyl tert-butyl ether	1,21E+03	ND		49,69		8,97			
Xylenes	1,35E+04			178,1	6,52	25,92			
Trichloroethylene	7,69E+01			ND	4,07				
Chloromethane	NA			23,77	ND	ND			
Ethanol	NA			21,48					

[1])SOILVAPOR - Indoor Inhalation of Vapor Emissions (α = 0.01)
ND – not detected

3.2. Groundwater survey results

During the survey groundwater samples were taken from 2 cesspits (the third cesspit was dry). Results are attached in Appendix 3. The results showed a slightly high concentrations of beryllium (threshold value: 0.004 mg/l), chromium (threshold value: 0.05 mg/l), lead (threshold value: 0.01 mg/L) and nickel (threshold value: 0.02 mg/L) in sample D2.

4. Risk assessment

Before the quantification of risks, it is necessary to specify scenarios for the exposure of possible threatened recipients. This information, which is the subject of the identification of risks, is derived from data about the character and scope of contamination.

4.1. The determination and the justification of risks of priority contaminants

As has been already described above the soil gas survey confirmed the exceeding of the Tier 1 RBTL for benzene in case of only single sample D-2 taken at the depth 10 m. Although the other boreholes for active gas sampling didn't capture exceeding values of benzene, in this study we will consider benzene the priority contaminant.

In a further step the intrusion of benzene through the soil profile and foundation construction layer and potential health risks resulting from contact with human organism is to be evaluated. As there are no technical information about the building's foundation design for the parameters of the foundational structure will be used the suggested values in IRBCA methodology.

4.2. Toxicological properties of priority contaminants

Benzene

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities. To the atmosphere is benzene as a major VAH (Volatile Aromatic Hydrocarbons) emitted during petroleum refinery operations or has been widely used as a solvent in industries such as printing and the manufacture of shoes.

The inhalation pathway represents the major route of human exposure to benzene. Inhaled benzene taken up by diffusion through the alveoli with the highest extraction occurring at the onset of inhalation exposure with declining extraction coefficient with time due to the declining concentration gradient between the concentration in the alveoli and concentration in blood. Benzene is distributed throughout the body following absorption into blood. Benzene is lipophilic and lipid-rich tissues have been found to contain the highest levels. It also has been shown to cross the human placenta and has been found in the cord blood in amounts equal to or greater than those in maternal blood.

It is a confirmed human carcinogen and epidemiological studies have shown it causes the occurrence of acute and chronic leukemia, even at low concentrations. Acute exposure to high benzene concentrations can also affect the central nervous system and cause dizziness, headaches and nausea, while chronic exposure can give rise to more serious adverse health effects such as blood disease, haematotoxicity, genotoxicity, increased levels of persistent chromosome aberrations, reproductive effects and mortality.

Where possible, the use of benzene in manufacturing processes has been reduced by replacement with less hazardous compounds. Hence, benzene is now generally regarded as almost exclusively a product of petroleum refining. Workers in petroleum refineries, including those involved in loading and transportation of petroleum products, may have some level of exposure to benzene.

Table No. 4-1: Values of toxicological parameters of priority contaminants used in this assessment.

Substance	Carcinogenicity by IARC[2]	Carcinogenicity by U.S.EPA[1]	IUR* (Inhalation Unit Risk) $[\mu g.m^{-3}]^{-1}$
Benzene	1	CH	7,8E-06

*source: database www.epa.gov, http://www.iarc.fr/

[1]) EPA WOE (2005 Guidelines) = weight of evidence for carcinogenicity under 2005 EPA cancer guidelines: CH - carcinogenic to humans;

[2]) 1 – carcinogenic to humans,
2A – probably carcinogenic to humans,
2B – possibly carcinogenic to humans,
3 – can not yet be assessed in terms of carcinogenicity,
4 - probably not carcinogenic to humans.

Inhalation unit risk (IUR) is an estimate of the increased cancer risk from inhalation exposure to a concentration of 1 $\mu g/m^3$ for a lifetime. The IUR can be multiplied by an estimate of lifetime exposure (in $\mu g/m^3$) to estimate the lifetime cancer risk.

Table No. 4-2: List of usable reference doses for calculations of health risks.

Effects	Noncancerous	Carcinogenic
Exposure	$RfC_{inhalation}$	$SF_{inhalation}$
	$[mg.kg^{-1}.day^{-1}]^{-1}$	$[mg.kg^{-1}.day^{-1}]^{-1}$
Benzene	3,0E-02	3,73E-02

* source: epa.gov.cz – composite sl table -05/2016

Note: $SF_{inhalation}$ was derived from equation: $SF_{inhalation}$ =(IUR*1000*70)/15

Reference concentration for inhalation ($RfC_{inhalation}$) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

4.3. Summary of transport methods and real exposure scenarios

The selected group of potential human health risks recipients for the site, studied exposure scenario and the pollutants pathway are r**esidents (adults and children),** who will live inside the planned buildings and who might face risks from inhalation of gases intruding through the foundation constructions.

As a group of potential recipients of exposition to benzene soil gas contamination only the **residents (adults and children)** were chosen to be assessed using quantitative analyses. These are inhabitants who will live inside the planned buildings and who might face risks from inhalation of gases intruding through the foundation constructions.

Because there is no information about the depth of planned excavations works at the site and further information about the building placement and design, risks for construction workers whose stay at the site will be only temporary, will be not quantitatively evaluated.
Also, generally the risks for the construction workers are not evaluated as these workers have to use personal protective equipment during the construction works at the site that mitigate all the potential health risks.

4.4. Assessed exposure scenario and its parameters

The considered exposure scenario which will be quantitatively assessed is only one – **Residents (adults and children)** living in the buildings. The parameters of exposure used in our calculations are summarized in the following tables together with the exposure parameters identified in the exposure scenario. The values of these parameters were estimated on the basis of expectations about the movements of inhabitants.

The two representative age groups of residents were selected with respect to various values of exposure parameters. With calculations of exposure doses and health risks, they are combined with the maximum concentration of contaminants discovered which served for modelling of indoor concentration (see next chapter).

In the estimate of health risks, following exposition parameters values were chosen: exposure of adults with the average length of life of 70 years with the body weight of 72 kg during maximum 25 years with the frequency of exposure of 350 days in one year for exposure by inhalation which includes only the indoor air exposure of 18 hours per day. In the case of the child population, children up to 6 years old with the body weight of 19 kg are considered, the time of exposure is considered as a maximum of 6 years. Within the scenario, **the acceptable value of risk at the level of 1.10^{-6} for the group of up to 10 - 100** threatened people is considered as that which corresponds to the probability of the origination of cancer for 1 person in 1 million.

Table No. 4-3: Exposure scenario Residents - list of exposure methods and risk recipients.

Environmental element	Exposure method	Recipient of risks
Soil gas intruded into the basement levels of the buildings	**Inhalation**	**Residents (children 1-6 years, adults 18 – 70 years);**

Table No. 4-4: Exposition scenario Residents - list of exposure parameters used.

Exposure parameter	Symbol	Adults	Children
Duration of exposure [year]	ED	25	6
Averaging period [day] - for non-carcinogenic : ED (year) x 365 days.year-1	AT	9125	2190
Averaging period [day] - for carcinogenic : 70 years x 365 days.year^{-1}	AT kar.	25550	
Average weight of the individual [kg]	BW	72	19
Inhalation rate (medium activity) [m3.hour-1]	InhR	0,625	0,35
Frequency of exposure [hour.year-1]	EF	6300	6300

4.5. The methodology of quantitative assessment and soil gas intrusion modelling

For the evaluation of exposure by contaminated soil gas of indoor air a software tool Risk 5.0 was used. In the SW the Johnson-Ettinger model is integrated which enables modelling of the vapor intrusion pathway into buildings trough the soil and foundational structure based on pre-adjusted settings/parameters of soil, building structures and the contaminant. For intrusion modelling as an input the maximum concentration of contaminant in the soil gas was used. All input parameters that were used in the model are summarized in following tables.

Table No. 4-5: Unsaturated zone properties beneath building used in the Johnson-Ettinger model.

Parameter	Unit	Value
Total porosity	cm3/cm3	4,0E-01
Water content	cm3/cm3	1,0E-01
Air content	cm3/cm3	3,0E-01
Distance from source to building	m	1,0E-03
Bioattenuation factor	-	1,0E+00

Table No. 4-6: Building parameters used in the Johnson-Ettinger model.

Parameter	Unit	Value
Foundation thickness	cm	1,5E+01
Fraction of cracks	-	2,0E-03
Porosity in cracks	cm3/cm3	4,0E-01
Water content in cracks	cm3/cm3	1,0E-01
Enclosed space floor length	m	1,0E+01
Enclosed space floor width	m	1,0E+01
Enclosed space height	m	2,0E+00
Number of air changes per hour	1/hr	5,0E-01

Table No. 4-7: Soil gas source concentration for vapor model.

Chemical	Units	Concentration
Benzene	mg/m3	4,5E-02

Table No. 4-8: Chemical properties of contaminant soil gases used in the Johnson-Ettinger model.

Chemical Properties	Units	Benzene
Diffusion coefficient in air	cm2/s	8,8E-02
Diffusion coefficient in water	cm2/s	9,8E-06
Solubility	mg/l	1,8E+03
Kd (total soil partition coefficient)	L/kg	ND
KOC (organiChem carbon partition coefficient	L/kg	5,9E+01
Henry's Law coefficient	(m3-H2O)/(m3-air)	2,3E-01
Molecular weight	g/mol	7,8E+01

4.6. Evaluation of health risks

During the evaluation of health risks, it is necessary to distinguish between the evaluation of substances with carcinogenic (stochastic) effects and non-carcinogenic (systematic) effects. Mechanisms of the affection of these two types of contaminants are different. In the case of substances with a carcinogenic effect event, a small number of changes at the molecular level may cause uncontrolled cell proliferation, or the development of malignancies. It is derived from the existing idea about the origination of malignancies, when the initiating moment may be any contact with carcinogenic substances. Because theoretically there is no safe level of exposure to such substances, the mechanism of the action is described as a non-threshold. In the case of systemic toxicity, the toxic effect of pollutants must overcome at first some (threshold) physiological detoxification capacity, compensation and the defense mechanisms of the body. So, it is possible to identify the rate of exposure which is safe for the human body and does not cause any negative effects under normal circumstances. For the evaluation of the chronic influence of contaminants from the environment on the human body, the fact is characteristic that as a rule it concerns the affection of very low concentrations whose toxic effect must be extrapolated from areas of high concentrations.

For the evaluation of the systematic toxic substances with non-cancer effects, US EPA introduces the so-called reference doses of RfD [$mg.kg^{-1}.day^{-1}$], whereas The world health organization WHO uses a system of acceptable daily doses (ADI). The value of RfD represents the level of the everyday exposure dose of the contaminant which the population (including sensitive groups) may face during the whole length of life without the reflection of any unfavorable effects. Doses varying under the level of RfD cannot be considered with the highest probability as risky. Values of RfD are, as a rule, obtained from toxicological tests on animals, from the so-called NOAEL values (the highest levels of exposure and no negative influence was observed), which are reduced by one or more orders of factors of uncertainty expressing uncertainty resulting from semi-kind extrapolation and extrapolation from the area of high into the area of low doses.

At present, there are more organizations stating RfD values, which are regularly published and updated. For the calculation of the risks in this work, the values of RfD will be used from updated databases US EPA and IRIS, and also from the database RAIS, which summarizes the knowledge from the database US EPA (United States Environmental Protection Agency), IRIS (Integrated Risk Information System), PPRTVs (EPA Provisional Peer Reviewed Toxicity Values) and others.

The purpose **of the evaluation of exposure** is deriving / calculating the average daily intake or the lifelong intake of the monitored contaminant. As a rule, long-term, (chronic) exposure with low doses of the contaminant from the environment is considered. If the concentration of the contaminant in the monitored medium during the exposure is constant, the volume of the substance entering into the organism can be expressed as the average daily intake [$mg.kg^{-1}.day^{-1}$], which can be calculated by the following equation:

$$CADD = C \,.\, IR\ FI \,.\, EF \,.\, ED / BW \,.\, AT$$

CADD	Chronic Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
C	concentration of the contaminant in the monitored medium [$mg.kg^{-1}$, $mg.m^{-3}$, $mg.l^{-1}$]
IR	rate of contact with the contaminated medium [$kg.day^{-1}$, $l.day^{-1}$, $m^3.day^{-1}$] (inhalation of air per day)
FI	ratio of intake of the monitored medium from the contaminated source [0 – 1, dimensionless]
EF	frequency of exposure [$day.year^{-1}$]
ED	duration of the exposure [year]
BW	average body weight of the exposed individual [kg]
AT	time at which the exposure dose is averaged [day]

For substances with non-cancerous effects, the parameter AT corresponds to the time of the duration of the exposure, whereas with the cancer effect, there is the accumulation of exposure doses during the whole length of the life of the individual. The average daily intake of substances is related to the supposed length of human life LT (as a rule 70 years) and the exposure in this case is expressed as the life-long average daily intake of LCDI so that in the equation the parameter AT is replaced by LT.

The purpose **of the characterization of the risk** is to summarize all data and information and to quantitatively express the rate of the actual health risk from chronic exposure of the contaminant under the stated situation, which may serve as the source information for the decision about measures, i.e. risk management. The recommended index of the risky character of substances with a non-cancerous effect is the risk index “Hazard Quotient” (HQ), expressed as the ratio of daily intake and the respective reference dose (RfD).

When evaluating the risk character of the affection of substances with non-cancerous effects, it is valid that if the average daily intake (CDI) is lower than the reference dose (HI < 1), then the supposed exposure is so low that with the highest probability it does not bear any health risks. If HI > 1, it is necessary to obtain detailed data about the monitored substance and the manner of exposure or to start suitable corrective measures.

For the measurement of the risk of the cancerous effect for the exposed population, the lifetime increase of the probability of the origination of cancer disease ILCR is used (“Incremental Lifetime Cancer Risk”), i.e. the theoretical number of statistically supposed cases of the tumour disease and the number of people exposed. ELCR can be obtained as the multiple of the lifetime of the average daily dose of LADD and the value of the slope factor SF according to the equation valid for relatively low risks to the value 1×10^{-2}:

ILCR = LADD . SF

ILCR	Incremental Lifetime Cancer Risk (theoretical number of statistically expected cases of the tumor per number of exposed people)
LADD	Lifetime Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
SF	Slope Factor [$mg.kg^{-1}.day^{-1}$]$^{-1}$

The following values of ILCR (MŽP 2011) are considered to be acceptable rate of risk for carcinogens

- 1×10^{-6}(probability of the origination of cancer for 1 person in a million) when evaluating regional influences – usually above 100 people at risk
- 1×10^{-5}(probability of the origination of cancer for 1 person in 100,000) when evaluating regional influences – usually between 10 and 100 people at risk
- 1×10^{-4}(probability of the origination of cancer for 1 person in 10,000) when evaluating individuals up to 10 people

In the case of exposure by further contaminants, their individual contributions to non-carcinogenic risk are summed up (synergistic effect) and then it is necessary to consider the summary quotient of risk or ILCR:

- HItotal = HI1 + HI2 + HI3 + ... + HIn
- $ILCR_{total} = ILCR_1 + ILCR_2 + ILCR_3 + ... + ILCR_n$

The following equation states the manner of quantification of exposure by inhalation of indoor air:
where:

$$CADD = \frac{C_{max} \times InhR \times ET \times EF}{BW \times 365 \frac{d}{yr}}$$

$$LADD = \frac{C_{ave} \times InhR \times ET \times EF \times ED}{LT \times BW \times 365 \frac{d}{yr}}$$

CADD	Chronic Average Daily Dose [$mg.kg^{-1}.day^{-1}$]
LADD	lifetime average daily dose [mg/kg-day]
C_{max}	maximum 7-year concentration of chemical in indoor air [mg/m^3]
C_{ave}	Time-averaged concentration of chemical in outdoor air over the exposure duration [mg/m^3]
InhR	inhalation rate indoors [m3/hr]
EF	Frequency of exposure in the indoor environment [$hour.year^{-1}$]
ET	exposure time indoors [hr/day]
LT	lifetime = 70 years
ED	duration of exposure [year]
BW	average body weight [kg]

4.6.1. Evaluation of exposure

The evaluation of exposure was conducted for the priority contaminant benzene based on the estimated indoor concentration level modelled with the Johnson-Ettinger model and exposure parameters defined in chapter 4.4.

Values of calculated indexes of hazardous substances or carcinogenic effect, HI and ILCR are mentioned in the following tables.

Table No. 4-9: Results of evaluation of **non-carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**children**).

Substance	**C_{ind-g}**	**$CADD_{inhalation}$**	**$HI_{inhalation}$**	**HI_{total}**
	[mg/m^3]	**[$mg.kg^{-1}.d^{-1}$]**		
Benzene	4,5E-09	1,0E-06	7,7E-05	1,2E-07

where C_{ind-g} is for the modelled indoor gas contamination.

Table No. 4-10: Results of evaluation of **non-carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**adults**).

Substance	**C_{ind-g}**	**$CADD_{inhalation}$**	**$HI_{inhalation}$**	**HI_{total}**
	[mg/m^3]	**[$mg.kg^{-1}.d^{-1}$]**		
Benzene	4,5E-09	4,5E-07	7,3E-05	1,1E-07

Table No. 4-11: Results of evaluation of **carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**children**).

Substance	**C_{ind-g}**	**$LADD_{inhalation}$**	**$ILCR_{inhalation}$**	**$ILCR_{total}$**
	[mg/m^3]	**[$mg.kg^{-1}.d^{-1}$]**		
Benzene	4,5E-09	8,8E-08	1,6E-09	2,3E-12

Table No. 4-12: Results of evaluation of **carcinogenic** health risks resulting from contact with intruded contaminated soil gas for scenario Residents (**adults**).

Substance	$C_{ind\text{-}g}$	$LADD_{inhalation}$	$ILCR_{inhalation}$	$ILCR_{total}$
	[mg/m^3]	[mg.kg^{-1}.d^{-1}]		
Benzene	4,5E-09	1,6E-07	6,1E-09	9,2E-12

4.6.2. Estimation of health risks

In this chapter is the interpretation of the health risk related to the evaluation of the exposure scenario and individual methods of exposure.

The submitted results represent the estimated health risks that can be approximately expected in conditions specific for the stated site in presumed conditions but, what is important, while integrating many uncertain inputs (due to the lack of data about the construction design etc.). All model calculations of exposure doses and health risks are therefore loaded by certain restrictions and uncertainty. They are in detail specified in the separate chapter 4.7. Restrictions and uncertainty.

Scenario: Residents (adults and children)

Non-carcinogenic risks

The results of the calculation presented in the tables above show that when taking into consideration the maximum ascertained levels of contamination of the soil gas as monitored (and afterwards modelled for indoor conditions) the exposure method of inhalation **represent no health risks for children, as well as adults** living in the buildings ($HI_{total\ adult}$ = 1,1E-07; $HI_{total\ child}$ = 1,2E-07).

Carcinogenic risks:

The values of the lifelong increase of the probability of the origination of ILCR tumor diseases for residents (children and adults) living in the buildings do not exceed the acceptable level of risk of 1.10-6 for the evaluation of individuals up to 100 persons. Therefore **the probability of origination of tumor diseases caused by the exposition to contaminated intruded soil gas is very low**.

4.7. Restrictions and uncertainty

The evaluation of possible health risks always relates to a series of uncertainties that are derived, e.g. generally defined exposure parameters or the application of specific preconditions. Uncertainties to bring into the evaluation of risks are the method of quantitative evaluation of exposure, which includes certain simplifying preconditions, constants and empirical relations, which need not correspond to the relations of the site of interest and the actual behaviour of the risk recipients. The results of the evaluation of health risks are restricted by the existing level of knowledge of the methodology for the evaluation of the possible affection of monitored factors on human health.

Health risks are evaluated within the submitted RE and are related to the following restrictions and uncertainties:

- To ensure safety and protection and for more sensitive risk recipients then during the evaluation of risks from the viewpoint of safety, conservative preconditions are introduced. Exposure parameters are defined on the side of caution due to which some results may be overvalued in relation to the actual status. During the evaluation of the exposition it is supposed that the individual faces maximum concentrations during the whole period of this exposure and that this contamination is divided proportionally. The exposure may also differ depending on the type, age, sensitivity of the individual, etc.
- During selection of exposure parameters, in the case of uncertainty, higher values of parameters are taken into consideration that the risk analysis on the side of security (e.g. duration of exposure, volume of breathed air) is as objective as possible and, at the same time, prevents any devaluation of risks resulting from exposure by radio nuclides.
- The evaluated exposure scenario and transport routes are models and cannot be fully applied for each individual. The submitted analysis cannot involve individual transport routes in the rate source of contamination → individual recipient.
- The soil gas survey on which is this RE based might not capture the real maximum concentrations of soil gas occurring in the placement of future building construction.
- The Johnson-Ettinger model results are loaded with high uncertainty because of subjective estimation of many parameters which are not known at this moment (foundation structures composition, thickness, soil physical properties etc.)

The loading of the results of the risk evaluation by the above-mentioned types of uncertainties may not principally influence the ascertained conclusions.

5. Conclusions and recommendations

Health risk evaluation based on soil gas survey results for the Kfar Yona site was performed in this study.

Comparison of the soil samples laboratory analyses results with the Tier 1 RBTL showed that exceeding values were detected in two cases for TPH.

In case of active soil gas sampling the exceeding value compared to Tier 1 RBTL was detected only once for benzene. As the request was to provide only risk assessment of soil gas influence, only benzene exceeding concentration in soil gas was subjected to a health risk evaluation.

Based on Johnson-Ettinger model the rate of soil gas intrusion through the foundation constructions was simulated and indoor soil gas concentration was modelled. Obtained values were then used for the health risk evaluation resulting from indoor exposition of residents (children and adults) by inhalation of intruded contaminated soil gas. **For this scenario both the non-carcinogenic and carcinogenic risks potentially resulting from benzene contamination were not confirmed.** From this reason no further corrective measures are suggested.

According to the evaluation of all available data about the site, especially regarding the level of the soil and soil gas residual contamination it can be stated that no human health risks were identified/calculated for the studied exposure scenario (penetration of the soil gas into the underground constructions - basements of new buildings at the site).

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