INCOME Water Care

Improved Management of Contaminated Aquifers by Integration of Source Tracking, Monitoring Tools and Decision Strategies

Prompt program of activities for accidental pollution -

DSS for emergency water management (DSS-3)

Geological Survey of Slovenia

Ljubljana, 2012

CONTENTS

1 Introduction 3
2 DSS for emergency water management 4
3 Conclusions 7

FIGURES

Figure 1: Structure of DSS. 4
Figure 2: Main screen (left), and location screen (right). 5
Figure 3: Transport simulation. 5
Figure 4: Extracted concentrations from the results of simulation. 6
Figure 5: Scheme of decision model. 6
Figure 6: DSS (decision model) user interfaces. 7

APPENDICES

Appendix 1: Overview over the state of the emergency response plans, related to Groundwater resources

Appendix 2: Osnovne značilnosti onesnaževal, metode odstranjevanja onesnaževal, cena in učinkovitost metode - (Basic characteristic of pollutant, remediation techniques, the price and efficient of the method)

Appendix 2: CD - DSS-3 application with instructions for use

1 Introduction

Program of activities for accidental events is in the form of decision support system – DSS-3 which is part of results of the action A.5.1. Establishment of programme of activities based on Decision Support System (DSS), performed by Geological Survey of Slovenia within the project INCOME (LIFE07 ENV/SLO/000725). The main objective of the project is long-term effective management of aquifers and preservation of the quality of these water resources for future generations. The project is co-financed by European Commission, Municipality of Ljubljana and Ministry of the Environment and Spatial Planning of Republic of Slovenia.

The problems in water management are complex (interdisciplinary) and often solutions must be given under time constrains. The tools that can help decision makers and make program of activities more effective are decision support systems (DSS). In general they are defined as computer-based support systems that help decision makers utilize data and models to solve unstructured problems.

The basis for the development of DSS for emergency water management was the study of documented accidents in Slovenia, lessons learned from these events, and the current state in the field of emergency response plans, related to accidents involving hazardous substances. The biggest accidents with hazardous substances for the last few years were collected from the available sources. Additionally German experiences on improved management practices, elaborated in action A.5.3. and results of the INCOME workshop "Nenadna onesnaženja podzemne vode in stara bremena – smo pripravljeni na učinkovite rešitve?" were used for defining the proposals for improvement of programme of activities in case of accident with hazardous substance. A detailed description of aforementioned can be found in Appendix 1.

The developed DSS was customized to the project requirements by programming which was provided by Logon d.o.o.

2 DSS for emergency water management

The DSS for emergency water management is an integrated, interactive computer system that utilizes data, models, and (expert and stakeholder) knowledge. It consists of three main parts (Figure 1).

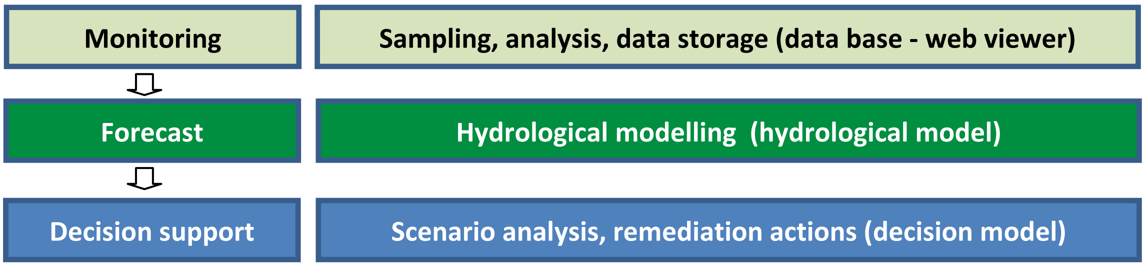

Figure 1: Structure of DSS.

The basis for DSS is **monitoring** system. The monitoring network was within the project INCOME optimized with new observation wells and provides good coverage of sampling points for detection of pollutants in the groundwater in the study area. Results of chemical analysis are stored in a common data base that contains results from three monitoring systems (MOL, VO-KA and ARSO). Data for all monitoring points are assessable through INCOME web viewer (http://akvamarin.geo-zs.si/incomepregledovalnik/).

In case that measured concentrations indicate pollution, module for the **forecast** of the traveling of the pollution in the groundwater can be initiated. It is based on the hydrological model, constructed in the action A.3.2. The user interacts with the DSS through user friendly interface which does not require any expert knowledge.

From the drop down menu in the main screen (Figure 2) the user can select the monitoring well, where high concentrations of pollutant were sampled.

In the next step in the location screen (Figure 2) time series of measured concentrations of specified pollutant are entered.

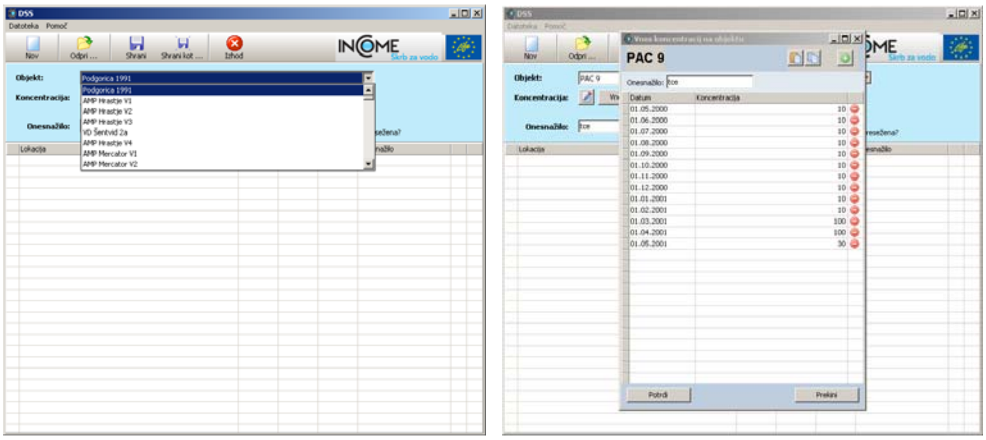

Figure 2: Main screen (left), and location screen (right).

After that transport simulation can be initiated - entered data are automatically transformed into a MIKE SHE input format, model set-up file is created and simulation is started (Figure 3). The status of simulation and other procedures which run in the background is shown on the status screen.

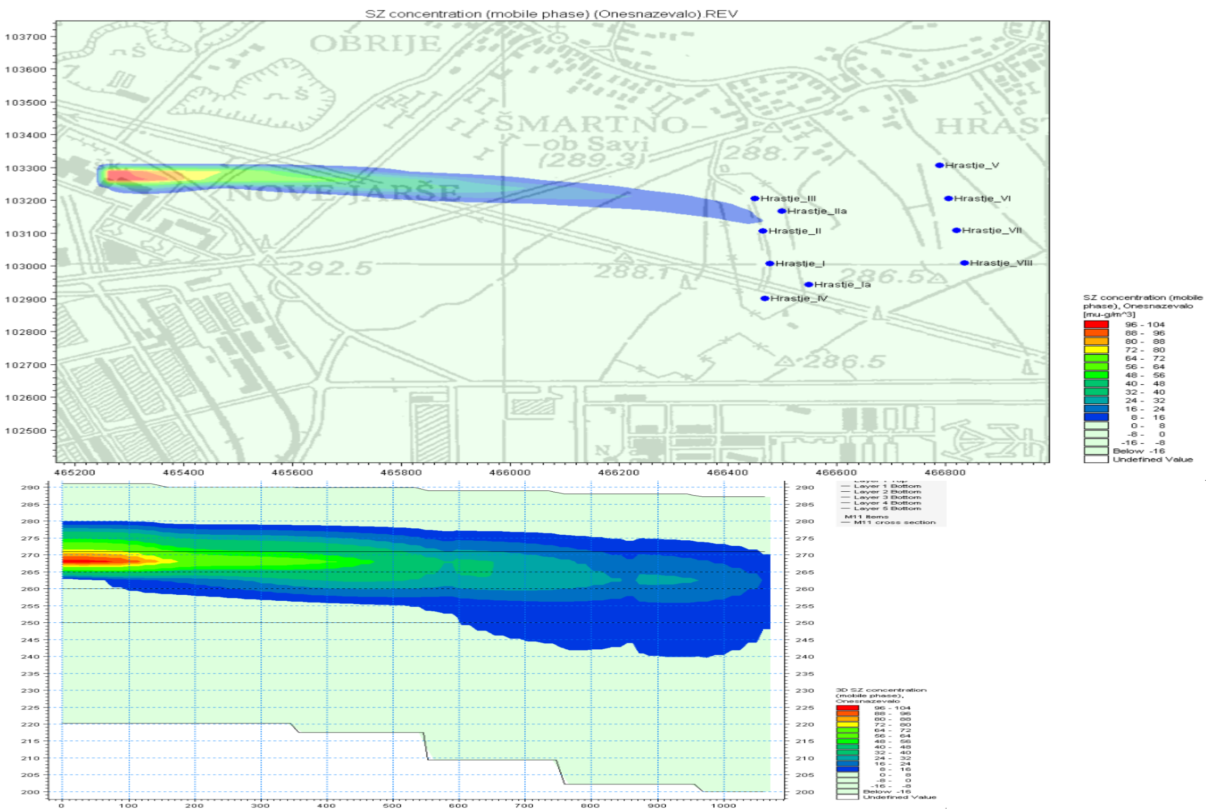

Figure 3: Transport simulation.

At the end of the simulation forecasted concentrations of pollutant in the abstraction wells of the drinking water supply system are extracted (Figure 4).

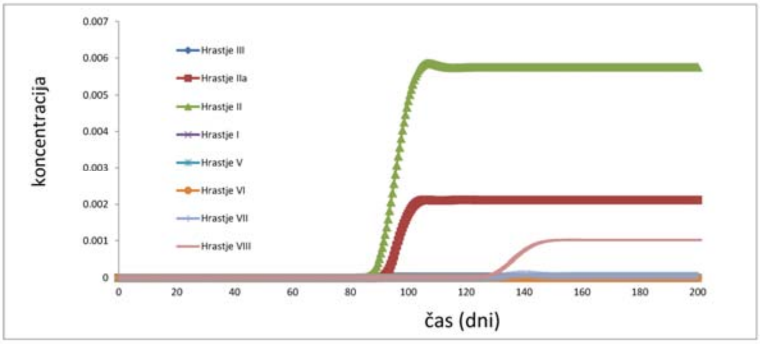

Figure 4: Extracted concentrations from the results of simulation.

The extracted (forecasted) maximum concentration is an input into a **decision model** (Figure 5). Based on defined rules which represent expert knowledge, DSS guides the user through the actions which are in a given situation, according to the experiences and expert knowledge, most suitable (Figure 6). The decision model is constructed in a way that enables adaptation and upgrade with additional actions.

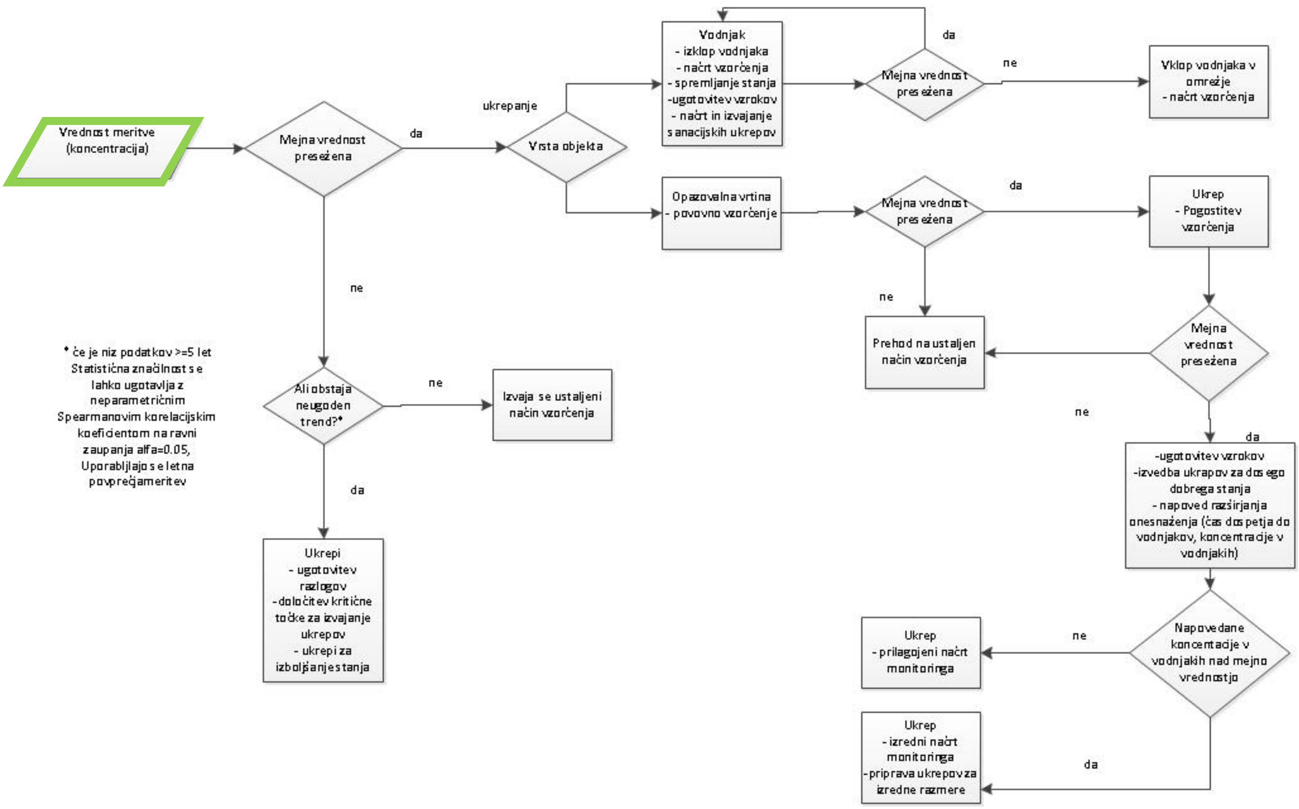

Figure 5: Scheme of decision model.

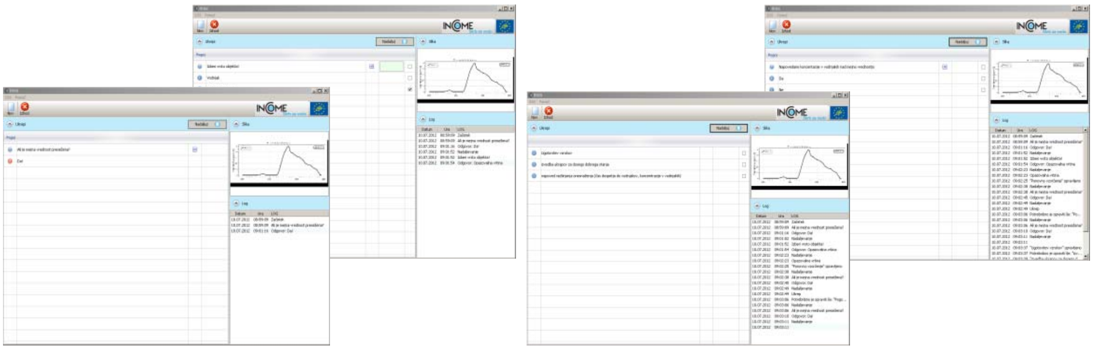

Figure 6: DSS (decision model) user interfaces.

Based on the register of active and potential sources of pollution (A.2.1.) and estimated groundwater chemical status (A.2.2.) following pollutants were recognized as most relevant threat to the good chemical status of the groundwater or pollutants which could be most probably released in an accident in the study area:

- Pesticides,
- Chromium 6+,
- Nitrates,
- Trichloroethylene.

For mentioned pollutants practical examples of activities in case of spilling of pollutants were studied.

Remediation techniques were searched and collected which represents supplementary part of the DSS. Based on the review of the literature a short list with basic characteristic of pollutant, its use and main remediation methods was made. For each method the price and remediation efficiency are given (Appendix 2).

3 Conclusions

The result of the described activities is a program of activities for accidental events in the form of decision support system (DSS). It will provide decision makers, in case of detection of pollutant in the aquifer, prompt information about direction of the pollution spreading, possible sources of pollution, traveling time to pumping wells, emergency contacts, details about chemicals and how they react in groundwater, and recommended remediation actions.

This way response time from detection of the pollution to the implemented action is significantly reduced which is in the study area, where groundwater flow velocities are very high, of crucial importance.

Improved Management of Contaminated Aquifers by Integration of Source Tracking, Monitoring Tools and Decision Strategies

Appendix 1

Overview over the state of the emergency response plans, related to groundwater resources

CONTENTS

1 Oil spill near Ortnek 3
2 Emergency response plans in Slovenia 3
3 Proposals for improvement of programme of activities in case accidents with hazardous substance 6
4 References.. 10

FIGURES

Figure 1: Notification tree structure for Ortnek spill (adapted after Malešič et al., 2003)........................3
Figure 2: Notification scheme from the Emergency Response Plan for the City Municipality of Ljubljana (Kus, 2006). 5
Figure 3: Proposed change in the scheme of notification for City Municipality of Ljubljana. 7
Figure 4: Groundwater source protection zones for Ljubljansko polje...7
Figure 5: Groundwater source protection zones for Ljubljansko barje. 8

TABLE

Table 1: Relevance of the accident, depending on place of occurrence, amount and type of hazardous substance made by Jamnik (2012). 9

1 Oil spill near Ortnek

Based on the gathered information, a scheme of notification – tree structure for one of the biggest accidents - oil spill near Ortnek was made (Figure 1). In the accident more than 1000 l of oil was spilled into a local stream, hence at least 8000 local inhabitants were provided with potable water from the water tanks for about one month. Dimensions of the accident drove different authors (Malešič et al., 2003; Kogovšek and Petrič, 2002; Ministry of Defence, 2012) to study the reasons, intervention, rehabilitation of accident and connections between different organizations in details. Collected data for Ortnek spill showed the network of notification on regional and state organization. It has also showed the gaps in communication between different organizations. At least three factors contributed to such consequences of the accident. First and probably most important was that no one of employees from oil warehouse did not immediately inform authorities about the spill. Second, polluted local stream is flowing on a karst region which is very vulnerable to pollution, due to the fast transport from the surface to groundwater. Third, the pollution affected two municipalities and the problem occurred at the administration level and financing.

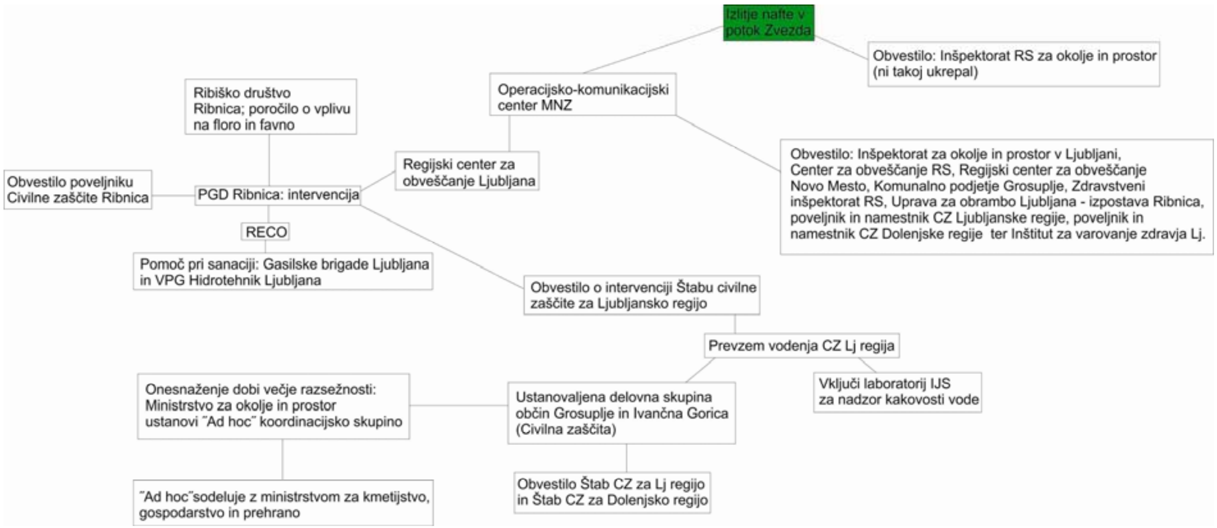

Figure 1: Notification tree structure for Ortnek spill (adapted after Malešič et al., 2003).

From the scheme of notification Ortnek and the others accidents, connections which should be improved were pointed out.

2 Emergency response plans in Slovenia

There are three levels of emergency response plans in case of accidents involving hazardous substances, proposed by Ministry of Defence, Republic of Slovenia:

- Company's level,
- Local level,
- Regional level.

For the City Municipality of Ljubljana emergency response plans on company's and local levels are prepared. On company's levels all companies, institutions and other organizations which are dealing with hazardous substance are obliged to prepare and update emergency response plans in case of accidents, involving hazardous substances. These companies are:

- Public company Snaga,
- DARS, Motorway Company in the Republic of Slovenia,
- Belinka Perkemija,
- Butan plin,
- Petrol,
- Te-Tol,
- SCT.

The City Municipality of Ljubljana has prepared an emergency response plan on local level in year 2006, and updated it in year 2009 (Kus, 2006). In the plan all company's plans are included and logically connected. In the plan topics are defined as follows:

- The type of accident for which the plan was made,
- Scale of planning,
- Concept of protection, rescuing and help,
- Management and running,
- Safety measures and tasks of protection, rescuing in help,
- Personal and mutual protection,
- Explanation of concept and abbreviations,
- Forces and means needed and available sources,
- Organization and performance of observation, informing and alerting,
- Activation forces and sources.

In the local emergency response plan there is a tree structure of informing in case of accident with hazardous substance, where it is clearly defined who and when should be informed in case of accident (Figure 2).

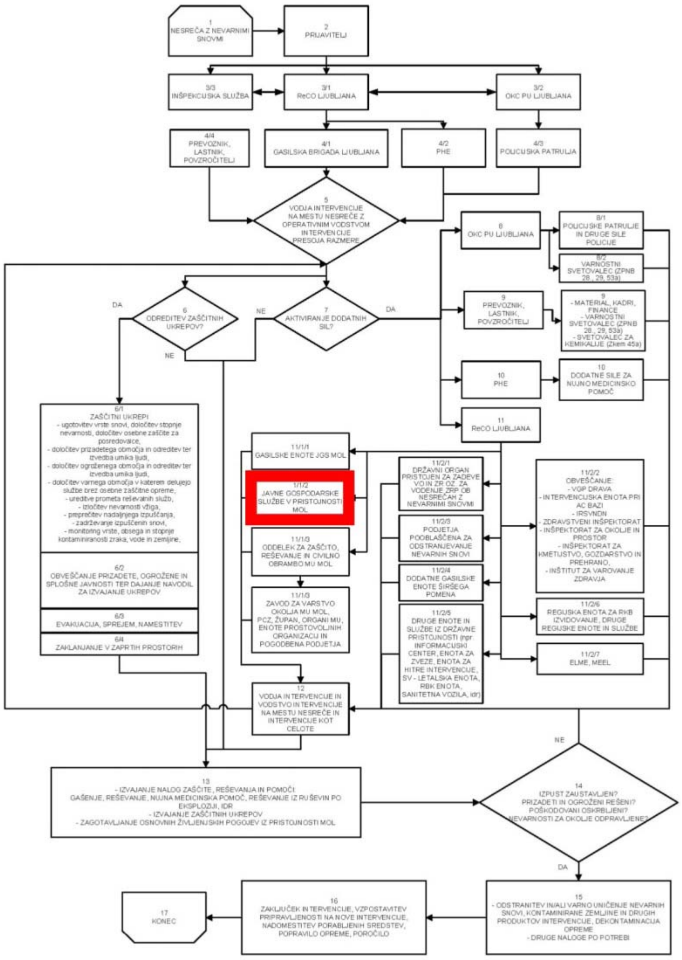

Figure 2: Notification scheme from the Emergency Response Plan for the City Municipality of Ljubljana (Kus, 2006).

In our opinion public company VO-KA is informed relatively late (red rectangle in Figure 2). After review of all public accessible Emergency plans it has turned out that public company Vodovod – Kanalizacija is informed too late in case of accident or is not informed at all. Clean and potable groundwater for inhabitants of Ljubljana is of vital importance. That´s why it is very important for public company Vodovod – Kanalizacija to be informed immediately when accident occurs at the areas where groundwater for abstraction can be affected.

3 Proposals for improvement of programme of activities in case accidents with hazardous substance

German partner in INCOME project Technische Universität Darmstadt has prepared the proposal for implementation of improved management practices from Federal Republic of Germany, such as Water and soil protection alarm directive Hesse, Water and Soil Protection Alarm Plan in Frankfurt/Main, Rhine alarm model. More details can be found in Action report A.5.3. (Technical University Darmstadt, 2012). The proposal was examined and the parts which could be adapted in Slovenian case were pointed out. These proposals were combined with the proposals from the INCOME workshop "Nenadna onesnaženja podzemne vode in stara bremena – smo pripravljeni na učinkovite rešitve?" and presented to lead employees of regional administration for civil protection and disaster relief, republic of Slovenia and professional fire fighters in Municipality of Ljubljana. On the meeting list of proposals which could be implemented in order to improve programme of activities in case of accidents with hazardous substances was created:

- VO-KA should be informed immediately after accident with hazardous substances occurs.
- Emergency response plans must be regularly exchanged between organizations.
- Similar to alarm plan for river Rheine, alarm plan for river Sava would be useful.
- Notification and report forms which contain all relevant information about the accident should be created.
- Monitoring data about chemical and quantitative status of the water resources should be public and freely accessible.

The most important accepted agreement between INCOME project partners and regional administration for civil protection and disaster relief, Republic of Slovenia (RECO) and professional fire fighters was the improvement of data base for informing VO-KA in case of accident with hazardous substances. As agreed VO-KA will be immediately informed about the accident in case that it occurs in catchment areas of the pumping wells and critical amount of hazardous substances is released (Figure 3).

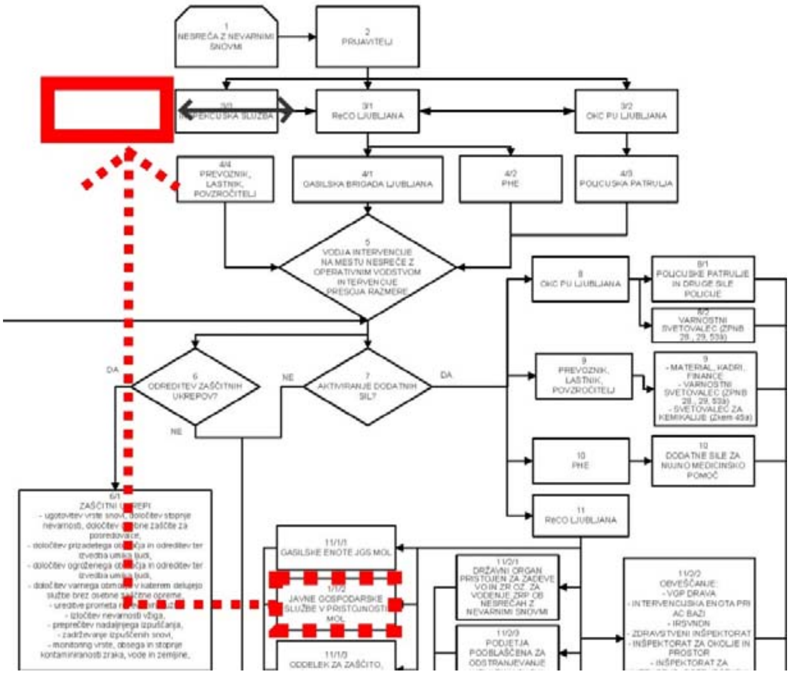

Figure 3: Proposed change in the scheme of notification for City Municipality of Ljubljana.

The catchment areas, defined by protection zones which were provided to the RECO in digital form (Figure 4 and Figure 5) together with the spreadsheet showing the relevance of the accident, depending on place of occurrence and amount and type of hazardous substance (Table 1).

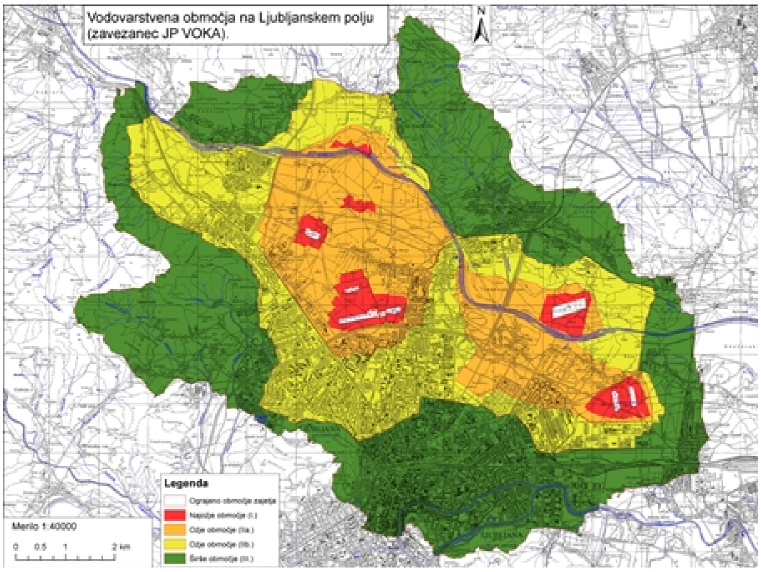

Figure 4: Groundwater source protection zones for Ljubljansko polje.

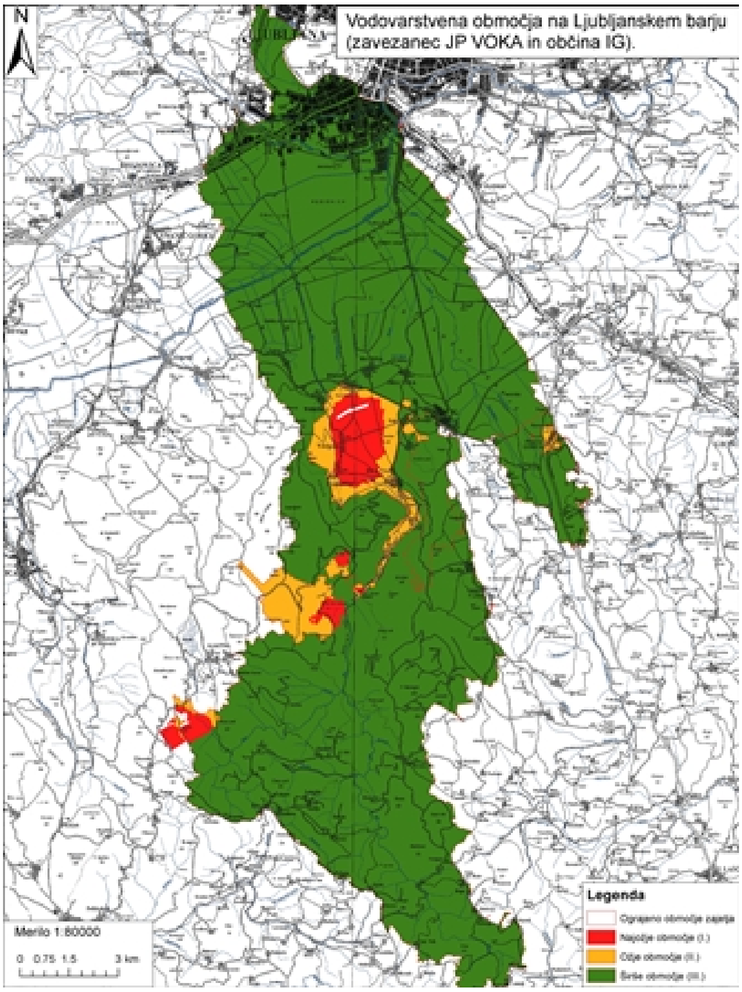

Figure 5: Groundwater source protection zones for Ljubljansko barje.

Table 1: Relevance of the accident, depending on place of occurrence, amount and type of hazardous substance made by Jamnik (2012).

Razredi nevarne snovi glede na ADR	**VVO I**			**VVI II A**			**VVO II B**			**VVO III**		
	do 100 kg	100-1000 kg	>1000 kg	do 100 kg	100-1000 kg	>1000 kg	do 100 kg	100-1000 kg	>1000 kg	do 100 kg	100-1000 kg	>1000 kg
Eksplozivne snovi	1	1	1	0	1	1	0	0	0	0	0	0
Plini	1	1	1	0	0	1	0	0	0	0	0	0
Vnetljive tekočine	1	1	1	0	1	1	0	1	1	0	0	1
Vnetljive trdne snovi	1	1	1	0	0	1	0	0	1	0	0	0
Oksidativne snovi	1	1	1	1	1	1	0	1	1	0	0	1
Strupi	1	1	1	1	1	1	1	1	1	0	1	1
Radioaktivne snovi	1	1	1	1	1	1	1	1	1	1	1	1
Jedke snovi	1	1	1	1	1	1	0	1	1	0	0	1
Druge nevarne snovi	1	1	1	0	1	1	0	1	1	0	1	1

4 References

Jamnik, B. 2012: Material for Proposals for improvement of programme of activities in case accidents with hazardous substance.

Kogovšek, J., Petrič, M. 2002: Podzemno raztekanje vode iz ponora Tržiščice (JV Slovenija). Ljubljana: Acta Carsologica 31/2, str. 75 -91.

Kus, R. 2006: Načrt mestne občine Ljubljana za zaščito in reševanje ob nesrečah z nevarnimi snovmni. Oddelek za zaščito, reševanje in civilno obrambo mestne uprave Mestne občine Ljubljana. 98 str.

Malešič, M., Polič, M., Prezelj, I., Prebilič, V., Svete, V., Kopač, E., Repovš, G., Krajnčec, R., Grošelj, K., Trifunović, J., Frankovič, M., Napotnik, D., Pipenbaher, B., Dolšćak, M., Jeraj, J., Kus, R., jeraj Dobnik, M., Risman, D. 2003: Upravljanje in vodenje v kriznih razmerah. Poročilo. Univerza v Ljubljani, Fakulteta za družbene vede. 377 str.

Ministry of defence, republic of Slovenia, administration for civil protection and disaster relief. 2012: Annual report of disaster in year 1998. Web: http://www.sos112.si/slo/clanek.php?catid=3

Technical University Darmstadt, 2012: Action A.5.3: Proposal for implementation of improved management practices - German view. INCOME action report.

INCOME Water Care

Improved Management of Contaminated Aquifers by Integration of Source Tracking, Monitoring Tools and Decision Strategies

Appendix 2

Osnovne značilnosti onesnaževal, metode odstranjevanja onesnaževal, cena in učinkovitost metode

(Basic characteristic of pollutant, remediation techniques, the price and efficient of the method)

CONTENTS

KROM 6+ 3
NITRATI 5
Pesticidi 8
TCE - trikloroetilen 10

KROM 6+

FIZIKALNO – KEMIJSKI PARAMETRI

Formula: Cr^{6+}

Barva: svetlo rumen (Splet 2)

Topnost: dobra topnost

Strupenost: rakotvoren in zelo reaktiven (Splet 2)

UPORABA

V zemeljski skorji obstaja skoraj vedno kot Cr (III), Cr (VI) namreč hitro reducira v Cr (III). Krom se uporablja v številnih industrijskih panogah, npr. za strojenje usnja, v proizvodnji nerjavečega jekla, barv, fungicidov, eksplozivov, cementa, v keramični in steklarski industriji, pri kromiranju. Običajno so glavni vir Cr (VI) v naravnih vodah industrijske odplake oz. je posledica človekovega delovanja. V zemljini se močno veže. Kromove (VI) soli so bolj topne od kromovih (III) soli in je zato Cr (VI) bolj mobilen. Z oksidacijo z dezinficiensi (klor, klorov dioksid, ozon) se lahko Cr (III) oksidira v Cr (VI). Še posebej v klorirani in prezračevani vodi je krom v glavnem v obliki Cr (VI). V zraku je prisoten v aerosolih, s padavinami ali prahom se vrača na površino in od tu spira v zemljo in podzemno vodo. Glavni vnos za človeka je preko živil; če ga je v pitni vodi več kot 25 µg/l, postane tudi ta pomemben vir vnosa.

Cr (0) in Cr (III) sta relativno netoksična, dobro topen Cr (VI) je mnogo bolj toksičen, predvsem zaradi visokega oksidacijskega potenciala in dobre prehodnosti skozi biološke membrane. Cr (III) je esencialen mikroelement za človeka in se vključuje v telesno presnovo preko inzulina. Poleg vnosa skozi prebavni trakt (absorpcija je šibka, bolje se absorbira Cr (VI)), lahko pri poklicno izpostavljenih vstopa tudi preko dihal – poškodbe nosne sluznice ali pride v stik s kožo – draženje in alergije. Cr (VI) je dokazano karcinogen preko dihal in je po klasifikaciji IARC razvrščen v 1. skupino, kar pomeni dokazano karcinogena snov za človeka. Cr (0) in Cr (III) sta uvrščena v skupino 3, kar pomeni, da ni dokazov, da sta karcinogena za človeka. V nekaterih študijah je imel Cr (VI) genotoksičen učinek. Na otroke naj bi deloval podobno kot na odrasle (Splet 1).

MEJNA VREDNOST V PITNI VODI

V Pravilniku o pitni vodi je krom uvrščen v Prilogo I, del B, kjer je določena mejna vrednost v pitni vodi, 50 µg/l za celotni krom. V Avstraliji je določena koncentracija 50 µg/l za Cr (VI), in če je presežen celotni krom, določajo posebej še Cr (VI). Svetovna zdravstvena organizacija (SZO) je določila za celotni krom v pitni vodi (začasno) mejno vrednost 50 µg/l; kot začasna je opredeljena zato, ker je pri toksikoloških podatkih še vrsta nejasnosti, zaradi karcinogenosti šestvalentnega kroma preko dihal in njegove genotoksičnosti. NOAEL vrednost tako ni določena. Ameriška agencija za okolje (EPA) ima določeno mejo 100 µg/l. Po mnenju nemškega zveznega inštituta za ocenjevanje tveganj (BfR), je ustrezen vnos za Cr (III) 30-100 µg/dan.

Ob preseženih vrednostih kroma v pitni vodi je potrebno takojšnje ugotavljanje vzrokov in njihova odprava. Ukrepi morajo biti usmerjeni primarno v izbiro in preprečevanje onesnaževanja vodnega vira (onesnažen zrak, odplake, pronicanje razlitij v tla). V primeru, da so koncentracije Cr (VI) v pitni vodi nad 50 µg/l, predlagamo, da naj glede na rakotvornost in glede na navedene nejasnosti, ljudje uživajo za pitje in pripravo hrane embalirano vodo. Krom lahko iz vode v postopkih priprave odstranimo z uporabo koagulacije, filtracije, ionske izmenjave, reverzne osmoze (Splet 1).

METODE ODSTRANJEVANJA

REALNI (1) / TESTNI (2) PRIMERI	TIP VODONOSNIKA	GLOBINA DO PODZEMNE VODE	NAČIN ODSTRANJEVANJA	VELIKOST OBMOČJA	KONCENTRACIJA PRED/PO ODSTRANJEVANJU (µg/l)	ČAS	CENA	ČLANEK
1			Geokemična vezava		85mg/50µg	4 leta		9
1			Geokemična vezava		0.8mg/l/0.01mg/l	2 leti		9
1			aktivne bariere		100%	2 leti		9
2			aktivne bariere	2.3 km2	pod mejo zaznavanja	10 mesecev	130000$/km2	9
2			reakcijske cone		15mg/l/0.2mg/l	6 mesecev		9
1			reakcijske cone		1.95mg/l/0.01mg/l	3 leta		9
1			izpiranje zemljine		1923mg/L/207 mg/L	2.5 leti		9
2			elektrokinetika		500ppm/1ppm		200-325$/m3	9
2			elektrokinetika		75-95% odstranitve			9

VIRI:

EPA, 2000: In situ treatment of soil and groundwater contaminated with chromium. United States Environmental Protection Agency, Washington. (in table article 9)

Splet:

1. http://www.zzv-ce.si/uploads/2008/pdf/krom.doc (11.2.2012)
2. http://www.fera.org.uk/pdf/Feram%20seminar%202%20Feb%2006%20-%20Clive%20Pearce%20-%20Anochrome%20-%20ppt%202.pdf (11.2.2012)

NITRATI

FIZIKALNO – KEMIJSKI PARAMETRI

Opis:

Dušik stalno kroži med atmosfero in tlemi. Problematični so presežki dušika predvsem iz kmetijskih dejavnosti, ki v obliki nitrata prehajajo skozi talni profil v podzemno vodo in po tej poti onesnažujejo podzemne vodne vire. Izpiranje nitrata povečuje gnojenje ob nepravem času – pred padavinami in v zimskih mesecih – in prekomerna količina dodanih gnojil (Meden, 2010).

Nitrati prehajajo v tla in podzemno vodo po naravni poti ali kot posledica človeškega delovanja. Glavni viri dušika v površinski vodi so 30 % fekalne odplake, 31% industrijske odplake in 39 % komunalne čistilne naprave. Približno 80 % dušika priteka v obliki amonijevih spojin, ki se s pomočjo kisika pretvorijo v nitratni ion (Krajnc in Zupan, 1996).

Ljudje smo nitratom in nitritom izpostavljeni preko hrane in vode. Delež vnosa nitratov preko pitne vode v telo narašča z naraščanjem koncentracije nitratov v pitni vodi.

Nitrati se v telesu reducirajo v nitrite. Najbolj znan škodljiv učinek nitratov oz. nitritov na zdravje je pojav methemoglobinemije, kot posledica oksidacije hemoglobina. Oksidiran hemoglobin - methemoglobin ne more prenašati kisika po telesu. Dodatno lahko poslabša methemoglobinemijo prisotnost bakterij v pitni vodi in okužba prebavil. Zaradi posebnosti v razvoju so najbolj ogroženi dojenčki do 6 mesecev starosti, predvsem zalivančki. Ogrožene so lahko tudi nosečnice in ljudje s pomanjkanjem nekaterih encimov. Opozarjajo na možnost škodljivega delovanja na otroka zaradi prehajanje nitratov v materino mleko. Številne študije o pojavljanju drugih obolenj v povezavi z nitrati v pitni vodi niso dale enotnih rezultatov. Do sedaj zbrani podatki ne dopuščajo trdnih zaključkov o drugih vplivih na zdravje človeka. Ocena rakotvornosti nitratov, nitritov in endogenih nitrozaminov pri Svetovni zdravstveni organizaciji še poteka. Prav tako še ni trdnih zaključkov o vplivih mešanic nitratov z drugimi polutanti na zdravje (Splet 1).

Formula: NO^{3-}

Topnost: dobro topni v vodi

UPORABA

V naravi se nitrati in nitriti pojavljajo tudi kot posledica človekove dejavnosti: uporaba umetnih in naravnih gnojil, nahajajo se v komunalnih odplakah, uporabljajo se v industriji.

MEJNA VREDNOST V PITNI VODI

Pitna voda s koncentracijami nitratov nad vrednostjo 50 mg/l predstavlja zdravstveni problem za dojenčke, nosečnice in doječe matere. Uživanje take vode zanje ni primerno in je potrebna omejitev uporabe. Prekuhavanje vode nitratov ne uniči, zaradi izhlapevanja vode, se njihova koncentracija lahko celo poviša. Ukrepi za zmanjšanje izpostavljenosti nitritom in nitratom preko pitne vode so kratki in dolgoročni. Če koncentracija presega 50 mg/l, je potrebna nadomestna oskrba za ogrožene skupine: npr. s predpakirano (embalirano) pitno vodo. Možna rešitev so tudi hišne naprave za čiščenje pitne vode, vendar ta način za dojenčke odsvetujemo, ker lahko zaradi motenj delovanja naprave pride do nepričakovane izpostavljenosti nitratom in drugim tveganjem.

V Pravilniku o pitni vodi (Ur.l. RS št.:19/04 in 35/04) so nitrati in nitriti uvrščeni v Prilogo 1, del B med kemijske parametre. Mejna vrednost je 50 mg/l za nitrat (NO3) in 0,50 mg/l za nitrit (NO2). Pogoj za mejno vrednost je, da je [nitrat]/50 + [nitrit]/3 =< 1, pri čemer je mejna vrednost za nitrat (NO3) in za nitrit (NO2), v oglatih oklepajih, izražena v mg/l. Za nitrite mora biti dosežena mejna vrednost 0,10 mg/l v vodi pri izstopu iz naprave za pripravo vode (Splet 1).

METODE ODSTRANJEVANJA

REALNI (1) / TESTNI (2) PRIMERI	TIP VODONOSNIKA	GLOBINA DO PODZEMNE VODE	NAČIN ODSTRANJEVANJA	VELIKOST OBMOČJA	KONCENTRACIJA PRED/PO ODSTRANJEVANJU (mg/l)	ČAS	CENA	ČLANEK
1	peščenjak, peščenjak - meljevec	15 m	Odstranjevanje v bioreaktorju (rastline bakterije)	27 km2	50/0	3 tedne		5
1	peščenjak	20-30m	Heterotrofna dentrifikacija, avtotrofna dentrifikacija	profil v dolžini 90 m	130/0	6 mesecev		6
1	brakična voda (zaliv)	3m	NITREX™ bariere – dentrifikacija	3,3 km^2	1-14%			7
2		površinsko odstranjevanje	Odstranjevanje z ionsko izmenjavo		90/0		0,15$ /3,8 L	8

VIRI:

Krajnc M., Zupan M., 1996: Kako ohranjene so naše podtalnice. V: Dušik-naravovarstvena paradigma. Ljubljana, 28-29. marec. 1996, Ljubljana, Zavod za tehnično izobraževanje: 41-52.

Meden, N. 2010: Učinkovitost fertigacije pri gnojenju solatnic za zmanjšanje nevarnosti onesnaženja podtalnice z nitrati. Diplomsko delo. Univerza v Ljubljani, Biotehniška fakulteta. 39 str.

Splet:

1. www.zzv-ce.si/uploads/2008/nitrati%20in%20nitriti.doc (27.1.2012)

2. Krauter, P., Daily, Jr B., Dibley, V., Pinkart, H., Legler, T. 2007: Perchlorate and nitrate remediation efficiency and microbial diversity in a containerized wetland bioreactor. International Journal of Phytoremediation. Vol 7. DOI: 10.1080/16226510590950414 (in table article 5)
3. Eppinger, R. 1998: Mobility and removal of nitrate in heterogeneous Eocene aquifers. Groundwater Quality: Remediation and Protection (Proceedings of the GQ'98 Conference held atTubingen, Germany, September 1998) (in table article 6)
4. Bizzari, L. 2012: Nitrate Removal in NITREX Permeable Reactive Barriers: Investigating Denitrification Using a 15NO3 Tracer. http://ecosystems.mbl.edu/ses/2007%20projects/bizarri07.pdf (in table article 7)
5. Burge, S., Halden, R. 1999: Nitrate and Perchlorate Removal from Groundwater by Ion Exchange - Pilot Testing and Cost Analysis. University of Idaho Moscow, Environmental Protection Department. Idaho. (in table article 8)

Pesticidi

FIZIKALNO – KEMIJSKI PARAMETRI

Formula: različne spojine

Topnost:

UPORABA

Pesticidi so snovi, ki se v kmetijstvu uporabljajo za zatiranje škodljivcev, plevelov in rastlinskih bolezni. Uporabljajo jih tudi v gozdarstvu, lesarstvu, ladjedelništvu... Po svojem nastanku so lahko naravne snovi, izolirane iz rastlin, ali sintetično pridobljene s sintezo. Predvsem te pa lahko ob neustrezni uporabi ogrožajo tako človeka kot ekosfero (biosfero).

Pesticidi naj bi selektivno uničevali določeno vrsto škodljivcev, vendar se v praksi pogosto izkaže drugače. Po določenem času lahko namreč določena vrsta škodljivcev pridobi naravno odpornost in tako je treba na novo sintetizirati še bolj toksične pesticide. Stopnja toksičnosti različnih pesticidov je zaradi njihove kemične sestave različna. Negativni vpliv pesticidov na človeški organizem je odvisen predvsem od koncentracije pesticida, ki vstopa v okolje, načina uporabe, stopnje razgradljivosti, obstojnosti v okolju, sposobnosti bioakumulacije in biokoncentracije, vključevanja v prehranjevalne verige, mutagenosti, genotoksičnosti in še mnogih drugih dejavnikov. Pesticid, ki se uporablja za zatiranje škodljivcev, je v bistvu aktivna substanca, ki je v določeni koncentraciji primešana inertnemu mediju.

Najpogostejši sta dve razvrstitvi pesticidov in sicer glede na ciljno skupino organizmov, ki jih posamezna skupina pesticidov uničuje, in glede na kemično sestavo (Splet 1).

SKUPINE PESTICIDOV GLEDE NA ORGANIZME, KI JIH UNIČUJE

ciljna skupina organizmov	skupina pesticidov	nekatere aktivne snovi	nevarnost za zdravje
glivice, bakterije	fungicidi	kaptan, benomil, triadimefon, folpet, mankozeb	Fungicide velikokrat posipljejo ali poškropijo po užitnem delu rastline. Sledove fungicidov lahko najdemo na sadju, zelenjavi, zato se nabirajo v telesu; ne vemo še kakšne posledice nas čakajo.
žuželke	insekticidi	DDT, metidation, metomil, lindan, heptaklor	Veliko insekticidov je zelo obstojnih. Počasi razpadajo s hrano in lahko pridejo v telo ter povzročijo razna obolenja (npr. jeter).
pleveli	herbicidi	atrazin, alaklor, simazin, 2,4-D	Nekateri herbicidi so smrtno nevarni, če bi jih pomotoma použili. Drugi lahko, zaužiti s hrano, povzročijo manj težka obolenja.

pršice	akaricidi	dikofol, propargit, klorfentazin	
glodalci	rodenticidi	endrin, varfarin, cinkfosfid	
polži	limacidi	metaldehid, metiokarb	

MEJNA VREDNOST V PITNI VODI

Za pesticide in njihove relevantne metabolne,razgradne in reakcijske produkte, razen za aldrin, dieldrin, heptaklor in heptaklor epoksid, velja pri nas in v državah Evropske Unije (EU) predpisana mejna vrednost 0,10 μg/l. Pri mejni vrednosti 0,10 μg/l želimo doseči ničelno vrednost teh snovi v pitni vodi (splet 2).

METODE ODSTRANJEVANJA

REALNI (1) / TESTNI (2) PRIMERI	MEDIJ	PESTICID	NAČIN ODSTRANJEVANJA	VELIKOST OBMOČJA	KONCENTRACIJA PRED/PO ODSTRANJEVANJU (mg/l)	ČAS	CENA	ČLANEK
1	zemljina	dinoseb (dinitrofenol)	bioreaktor	3750m3	99.80%	23 dni	97$/0.75m3 /brez izkopavanja	10
1	zemljina	dinoseb (dinitrofenol)	bioreaktor	200m3	600ppm/pod mejo detekcije	35 dni		10
1	zemljina	atrazin in metolaklor	kompost	200 ton	17mg/kg/pod mejo detekcije (atrazin)	18 mesecev	120$/tono	10
1	zemljina	več pesticidev	bioremediacija	914 m3	do 98% učinkovitost		192$/m3	10
2	zemljina	več pesticidev	rastlinsko odstranjevanje	7.5 arov	uspešno	1 leto		10
1	zemljina	hlapne organske komponente	termična desorbcija	38$/m3				11

VIRI:

Splet:

http://www.pesticidi.net/opesticidih/kaj_so_pesticidi.asp (12.6.2012)

http://www.szd.si/user_files/vsebina/Zdravniski_Vestnik/vestnik/st6-9/537-548.pdf (22.3.2012)

1. Frazar, C. 2000: The bioremediation and phytoremediation of pesticide-contaminated sites. United States Environmental Protection Agency, Washington. (in table article 10)
2. Castelo-Grande, T., Augosto, A., Monteiro, P., Estevez, A., Barbosa, D. 2010: Remediation of soils contaminated with pesticides: a review. Intern. J. Environ. Anal. Chem.Vol. 90, DOI: 10.1080/03067310903374152. (in table article 11)

TCE - trikloroetilen

Druga imena: trikloroeten, 1,1-2-trikloroetilen, 1,1-dikloro-2-cloroetilen, acetil triklorid in etilni triklorid

FIZIKALNO – KEMIJSKI PARAMETRI (Splet 1)

Opis: brezbarvna tekočina, ima sladek, kloroformu ($CHCL_3$) podobnega vonj.

Formula: C_2HCl_3

Gostota: 1,47 g/cm^3 pri 20°C

Vrelišče: 87,2°C

Topnost: topen v alkoholu, etrih, naftnih derivatih in drugih halogenih topilih.

UPORABA

V preteklosti so izvlečke TCE-ja v živilski industriji uporabljali kot anestetik in analgetik v medecinske namene. Danes se uporablja kot topilo maščob v kovinski industriji. Z drugimi topili se uporablja v industriji lepil (adhesive paint) ter proizvodnji polivinilnega klorida (PVC). TCE se prav tako uporablja v tekstilni industriji, kot topilo za lepila in lubrikante. Uporablja se tudi pri proizvodnji pesticidov (Splet 1)

Trikloroetilen se uporablja za kemično čiščenje oblačil, kot odlično topilo za voske, masti, gumo, barve. Po IARC je uvrščen v skupino 3 (Splet 2).

MEJNA VREDNOST V PITNI VODI

Pravilniku o zdravstveni ustreznosti pitne vode je določena v vsoti skupaj s tetrakloroetenom in je 10 µg/l (Splet 2).

METODE ODSTRANJEVANJA

REALNI (1) / TESTNI (2) PRIMERI	TIP VODONOSNIKA	GLOBINA DO PODZEMNE VODE	NAČIN ODSTRANJEVANJA	VELIKOST OBMOČJA	KONCENTRACIJA PRED/PO ODSTRANJEVANJU (µg/l)	ČAS	CENA	ČLANEK
1	sedimentne kamnine (drobno zrnati peščenjak *meljevci, glinavci*).	7m	segrevanje zemljine/vodonosnika (Steam Enhanced Extraction – SEE)		cca. 120000/200	1 - 12 mesecev		1
1	preperina amfibolitnega gnajsa, amfibolitni gnajs	10m v preperini, neznano v matični podlagi	odstranjevanje z vodikom	300 m^2	preperina: 21000/1500; amfibolitni gnajs 17000/79	2-12 mesecev	190$/ m2	2
1		površinsko odstranjevanje	zračenje		6000-10000/1,5	12 mesecev		3
1		površinsko odstranjevanje	Kombinacija z zračenjem in ogljikovo absorbcijo			15 mesecev		3
2	pesek (0,1-0,5 mm)		prezračevanje	200cm * 60cm * 68cm	1000-50000/cca 0-30000	200h		4
2			Prezračevanje v vrtini		70% odstranitev TCE			3
2	peščenjak ledeniškega izvora		Prezračevanje zemljine (Soil venting)		5000000-7000000/do 20% manj	3.5 mesecev		3
2	plitek, zaprt vodonosnik, debelo zrnat pesek		biološko odstranjevanje (in situ-bioremediation)	cca. 50 m^2	100000000/ do 30% manj			3

VIRI:

1. http://oehha.ca.gov/air/chronic_rels/pdf/79016.pdf (12.3.2012)
2. http://www.sdzv-drustvo.si/si/VD-05_Referati/Bregar.pdf (12.3.2012)
3. Dusilek P., Kvapil P., Udell K. S, 2012: Remediation of a partially fractured aquifer system containing a TCE source using Steam Enhanced Extraction. http://www.containment.fsu.edu/cd/content/pdf/117.pdf (in table article 1)
4. Regenesis, 2012: TCE Remediation in Saprolite and Bedrock Aquifers. http://regenesis.com/images/csfiles/17_hrc_oconee_county_sc_case_study%5B1%5D.pdf (in table article 2)
5. Russell H., H., Matthews, J.E., Sewell, G.W. 1992: TCE removal from contaminated soil and ground water. http://www.epa.gov/tio/tsp/download/tce.pdf (in table article 3)
6. Hun-Mi Kim, Yunjang H., Kang-Kun L. 2007: Remediation of TCE-contaminated groundwater in a Sandy Aquifer using pulsed air Sparging: Laboratory and numerical studies. Journal of environmental engineering. DOI: 10.1061/_ASCE_0733-9372_2007_133:4_380 (in table article 4)