UNIVERSITY OF NOVA GORICA
GRADUATE SCHOOL

THE THREAT TO LOCAL WATER RESOURCES FOR DRINKING WATER IN THE MUNICIPALITY OF LJUBLJANA

Polona LESJAK

MASTER'S THESIS

Mentor: doc. dr. Barbara Čenčur Curk

Nova Gorica, 2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND SYMBOLS

MOL	Municipality of Ljubljana
ZZV – LJ	Institute for Public Health of Ljubljana
IVZ	Institute of Public Health Republic of Slovenia
J.P. VO – KA	Public water supply company Vodovod – Kanalizacija d.o.o
DRINKING WATER SUPPLY SYSTEM	Provides an average of 10 m^3 or more water per day or serves 50 and more inhabitants
SUPPLY ZONE (OO)	Supply zone is a geographically defined zone which is supplied from one or more water sources and where values of tested parameters in the drinking water are about the same.
SMALL SERVICE AREA	Supply area serving 50 to 1.000 inhabitants
DOMESTIC DISTRIBUTION SYSTEM	Includes a pipeline, equipment and appliances that are built between the connector on the drinking water supply system and places of drinking water use

NARROWEST WATER PROTECTION ZONE (Zone I.) consists of intermediate vicinity of the buildings for supply with drinking water, where there is a possibility of direct impact on the quantity and quality of the drinking water. It is subject to the most stringent security regime.

NARROWER WATER PROTECTION ZONE (Zone II.) is the area from which are collected and where surface and ground waters pass towards the capture and where there is a possibility of indirect or direct impact on the quantity and quality of drinking water. It is subject to a stringent security regime.

WIDER WATER PROTECTION ZONE (Zone III. A and III. B) is the area from which surface and underground waters are discharged towards the capture and there is still a potential impact on the quality of water in captures. It is subject to hygienic – technical security regime.

WATER SOURCE is a source of water from which water is collected for the supply of inhabitants or for technological process and cooling in companies.

1 INTRODUCTION

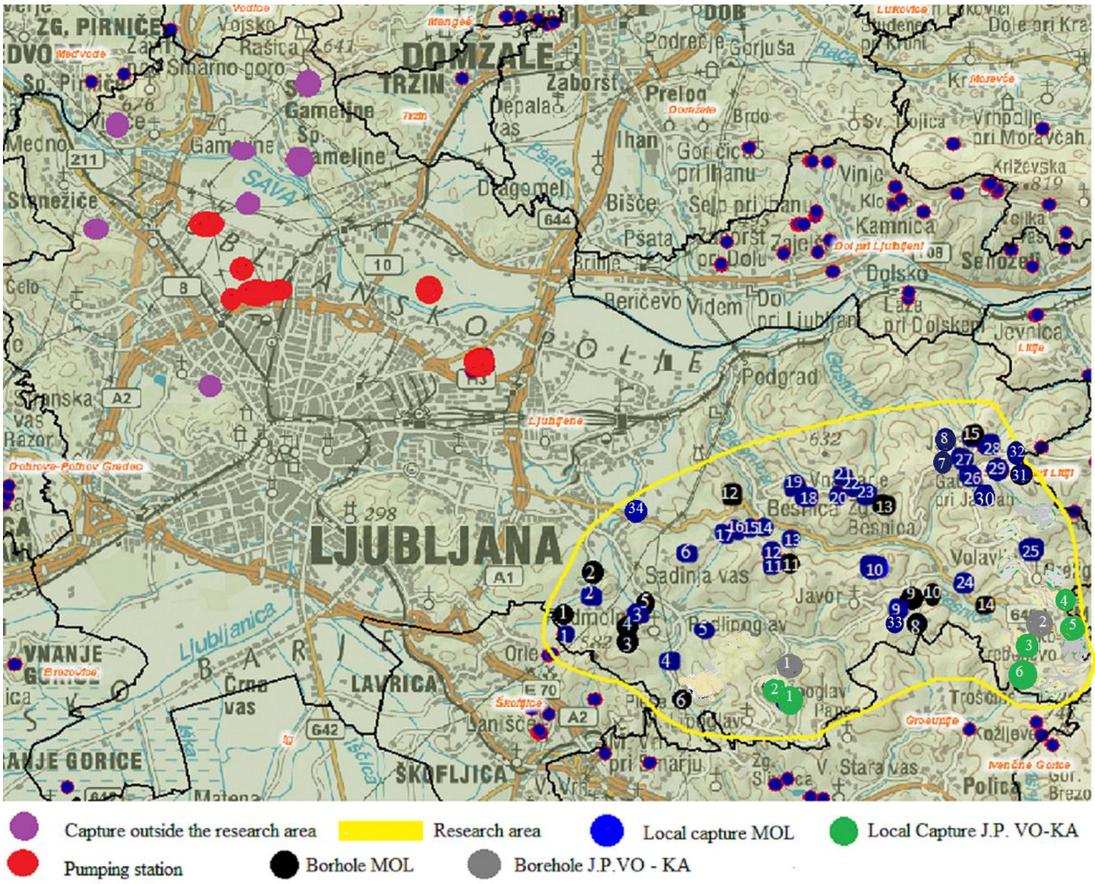
Provision of safe drinking water is one of the global challenges of the 21 st century *[1]*.

Yet, for several decades, about a billion people in developing countries do not have a safe and sustainable water supply.

It has been estimated that a minimum of 7,5 liters of water per person per day is required at home for drinking, preparing food and personal hygiene, the most basic requirements for water; at last 50 liters per person per day is needed to ensure all personal hygiene, food hygiene, domestic cleaning, and laundry needs *[2]*. The large majority of people in the European community have their water supplied by water utilities, some 10% receive their water from small or very small supplies that are often owned by the consumers themselves. Protecting water sources using good management strategies can help communities reduce the threat of drinking water contamination *[3]*. Water source protection in a watershed context poses significant challenges for local communities, especially smaller ones *[4]*. Small and very small water systems are common in Europe. For example, in Germany up to 20% (about 16 million people) have drinking water distributed by small scale water utilities and private wells *[5]*. In the capital city of Slovenia – Ljubljana, the management of local waterworks is divided among the Public water supply company Vodovod - kanalizacija d.o.o. (hereinafter “J.P. VO - KA”) and the Municipality of Ljubljana (hereinafter MOL) and the villagers themselves.

Supply areas are continuously replenished with drinking water from one water source, but may also be supplied from two or more; depending on the current water system pressure parameters.

There are 40 local captures (no boreholes) in the hilly south eastern part of MOL *[Figure 1]*. 6 (six) local captures are managed by Vodovod - kanalizacija d.o.o. and 34 local captures are operated by MOL. Other captures are abandoned or already connected to the water supply of other communities.



Note: data on boreholes and captures are taken from the ARSO map from the database of Atlas okolje http://meteo.arso.gov.si/met/sl/app/webmet.

***Figure 1**: Map of water sources in municipality of Ljubljana (Research area is in the hilly south eastern part)*

The local source of drinking water and facilities that provide drinking water (source capture, pumping wells - hereinafter capture) in Ljubljana are secured by three water protection areas: (I) Narrowest water protection area with the strictest protection regime; (II) Narrower protection area with a strict protection regime; and (III) Wider water protection area with a moderate protection regime *[6, 7, 8]*. Drinking water captures are protected with a Decree on determining the drinking water protection area for the Ljubljana moor (Slovene - Ljubljansko barje) and surroundings of Ljubljana *[8]*.

The amount of water consumed per person in Ljubljana in the areas under consideration varies widely and ranges from 150 to 250 l per person per day *[9]*.

Since drinking water is considered as food and is one of the most investigated foodstuffs, the internal control and compliance of the quality of drinking water is conducted continuously parallel to an external control performed by the Ministry of Health - Health inspection. The internal control is carried out in compliance with the HACCP system *[10,11]* which allows the assessment of risks and control of the entire supply system. From the perspective of local communities there is a need for the protection of local water sources, which are not yet protected by local law.

The study and the inventory of all excess microbiological and physic - chemical parameters from annual reports on drinking water compliance *[12]* and sampling in the field (Institute of Health Protection of Ljubljana) show that limit values have been exceeded in physic - chemical parameters (pH and taste) and in particular microbiological parameters (E. coli, Coliform b., Clostridium per., Iron,…). Since other parameters have not exceeded the limit values in the period 2005 – 2010, the survey focuses only on exceeded limit values in question in terms of excessive amount of data (over 15.000 documents reviewed - reports on testing drinking water, on 150 parameters).

1.1 Aim and Purpose of the study

The purpose of my study is to examine and investigate the quality of local water captures in hilly south eastern part of Municipality of Ljubljana and identify the main causes of pollution (climate causes or external pollutants) and find a comparison between the quality of local captures in the management of MOL and J.P. VO - KA.

1.2 Working hypothesis

H1 The working hypothesis presumes that the local water distribution system with captures in the eastern part of Ljubljana, which are managed by the Municipality of Ljubljana (MOL) are more endangered in terms of achieving quality and volume in comparison with other capture in Ljubljana which are managed by the public sewerage company (J. P. VO - KA).

Variablity in the quality of captures under the management of J.P. VO - KA compared with captures under the management of MOL is the small number of captures and consequently facilitating the control of external pollutants.

2 THEORETICAL SECTION

2.1 Legislation

Key legislation dealing directly or indirectly with local water distribution systems and their captures in the area of the Municipality of Ljubljana:

- Ordinance to protect local drinking water sources (Official Gazette of the RS no. 78/00) *[7]*
- Decree on determining the drinking water protection area for the Ljubljansko barje and outskirts of Ljubljana (Official Gazette of the RS no. *115/2007) [8]*
- Water Act (98/ 83/ ES) 2005 - 2011 *[13]*
- Rules on drinking water supply *(Official Gazette of the RS no. 35/06) [14]*
- Rules on drinking water (Official Gazette of the RS no. 19/04, 35/04, 26/06, 92/06, 25/09) *[15]*
- Rules on criteria for the designation of a water protection *zone [16]*
- Act Regulating the Sanitary Suitability of Foodstuff, Products and Materials Coming into Contact with Foodstuffs ZZUZIS *(Official Gazette of the RS no. 52/00) [17]*
- The Drinking Water Directive (98/ 83/ ES) 2005 – 2011 *[18]*

Drinking water is water from public systems for drinking water supply, water for packaging and pre - packaged drinking water intended for public consumption *(4th indent of article 2) [17]*

Compliance of drinking water is defined by Rules on drinking water *[15]*. A compliant sample of drinking water means that in respect of tested parameters the sample complies with provisions of the Rules *[14,15]* and an incompliant means that the sample does not comply with the said Rules.

Rules for drinking water are in conformity with the European Union Directive *[18]*.Quality must be under constant surveillance. According to our legislation this surveillance is dual: state monitoring carried out by the operator and control over it is conducted by the state through inspection.

INTERNAL CONTROL *of systems* for drinking water supply is carried out according to the Rules of drinking water *[15],* which in article 10 provides that the operator must implement internal control.

Internal control should be established on the basis of the HACCP system *[10,11]*, which allows identification of microbiological, chemical and physical agents that may pose a potential threat to human health, implementation of necessary measures and establishment of permanent control on those places (critical control points) in drinking water supply, where the risks may arise.

HACCP plan must also include a sampling point, type of testing and the minimum sampling frequency. Internal control is carried out in accordance with the regulations governing health compliance of foodstuffs *[11]*

EXTERNAL CONTROL - monitoring or control of the drinking source quality is carried out by the state (holder of water permit) according to a pre - established annual program *[19 - 24]* confirmed by the Ministry of Health.

Monitoring of local water source quality focuses on monitoring microbiological, chemical and physical parameters. For the most common acute effects of microbiological contamination the greatest attention is devoted to microbiological parameters.

Chemical substances are usually present in lower concentrations and are mainly associated with strong chronic effects.

In each detection in addition to direct risks that may be caused by an individual exceeded value of parameter, we must also consider the indicating meaning of the emergence and of course the dynamics, whether it is a one - time emergence, constant occurrence, increasing etc. Deviations always bring health risks. And health risks are better understood if the water source is studied in more detail and when quality is subject to frequent control.

2.2 Monitoring of drinking water quality

The scope of regular testing provides basic information about drinking water such as organoleptic properties, electrical conductivity and consequently mineralization of water, turbidity, microbiological safety; as well as information on effectiveness of drinking water treatment where it is used *[Table 1]*. Periodic testing is intended for obtaining detailed information on the quality of drinking water for several parameters (heavy metals, organic substances).

Table 1: *Parameters of regular and periodic analyses of drinking water*

The group parameters	**Regular testing**	**Periodic testing**
Field measurements	Electrical conductivity Air and waters temperature at the time covering the sample. * The concentration of hydrogen ions (pH) The concentration of free residual chlorine (Cl)	Electrical conductivity Temperature The concentration of hydrogen ions * (pH value) * The concentration of free residual chlorine (Cl)
Chemical parameters	Sensory parameters: odor, color, turbidity, taste. * Compounds of nitrogen: ammonium (NH4).	Sensory parameters: odor, color, turbidity, taste. Heavy metal and other chemical elements: aluminium) (Al), antimony (Sb), arsenic (As), boron (B), cadmium (Cd), chromium - total (Cr), * manganese (Mn), sodium (Na), nickel (Ni), selenium (Se), lead (Pb), Iron1) * (Fe), mercury (Hg). Compounds of carbon and total organic carbon (TOC). Compounds of nitrogen: ammonium (NH4), nitrite (NO2), nitrate (NO3). Anions: chloride (Cl), sulfate (SO4), bromate (BrO3), cyanide (CN), fluoride (F). Group of polycyclic aromatic hydrocarbons (PAHs): benzo (a). Volatile aromatic hydrocarbons: benzene Volatile halogenated hydrocarbons (solvents): 1,2-dichloroethane, trichloroethane (1,1,2-trichlorethylene, tetrachloroethane (1,1,2,2-tetrachloroethylene) Trihalomethanes: trichloromethane, tribromometan, Bromine dichloromethane, tetrachloromethane, dibromine chloromethane, dichloromethane. Pesticides
Microbiological parameters	Escherichia coli (E. coli) * Clostridium perfringens 6) * (including spores) Coliform bacteria * Colony count 22 ° C * Colony count at 37° C *	Escherichia coli (E. coli) Enterococci Clostridium perfringens (including spores) Coliform The number of colonies at 22 ° C The number of colonies at 37 ° C
Radiological analize		Tritium (3H) The total dose taken

*Note: * parameters, where outliers have been identified and are shown in graphs in the below paragraphs*

2.2.1 Sampling procedures

Basic documents on sampling of drinking water are ISO standard ISO 5667 – 5, 2006 »Water quality – Sampling, Part 5: "Guidance on sampling of drinking water from the treatment works and pipes distribution systems" as well as standards that set specific requirements of individual sampling methods. *[15]*.

Sampling means taking a sample of drinking water for the purposes of physical – chemical, microbiological and radiological testing. Radiological sampling is not conducted for the subject captures. Sampling also includes measurement implementation. The same also applies for periodic measurement of physical parameters of water in the field (pH, electrical conductivities, content of active chlorine and other parameters, for which relevant standards provide for an *in situ* implementation).

Sampling also includes implementation of sensory testing - colors, odor, turbidity and taste. Result of sampling is an extracted sample of water, conducted field measurement and sensory testing.

Sampling can only be performed by a qualified person - sampler, of appropriate education who has evidence of training in accordance with the provisions of SIST EN ISO/IEC 17025.

Qualification means proper conduct of field measurements, implementation of sensory testing and taking of samples, their preparation in the field (conservation and filtering), transport and delivery of samples. The sampler must be familiar with the criteria of determining sampling points and criteria of determining replacement points of sampling. In the area of regions which are within the program of monitoring covered by individual institutions the sampling process is conducted by the sampler from the same institution. Sampling for periodic and regular testing is ensured by the selected testing performer (i.e. Institute of Public Health of Ljubljana). Proper and coordinated work in sampling is the responsibility of a selected monitoring performer who is authorized by the operator.

2.2.2 Sampling method

The program includes testing of drinking water on pipes and other places, on which water is used as drinking water within the service area. Sampling site (building) is provided in the program of monitoring. Sampling is performed on particular week day from Monday to Friday in the morning. The day is chosen by the sampler themself. Sampling is not performed during certain periods.

Irrespective of the type of testing the sampler makes sure that the inner surface of a cooling bag, refrigerator, refrigerated vehicle and the like are clean for the transportation of samples and dry before transportation. During the time of sampling drinking waters for the needs of monitoring, no other samples, i.e., of foodstuffs, waste waters and the like, should be stored in them. After every use the inside of the cooling bag, refrigerator, refrigerated vehicle *[Figure 2]* etc. should be cleaned and disinfected in order to prevent contamination of the surfaces of the packaging and the date of the sampler.

Figure 2: *Packaging for taking of samples*

There should be no contamination, damage or spilling of samples during transport
Samples must be protected from light, during transport.
Samples must be clearly marked with identification number of the field sample data sheet and handed to the laboratory. The laboratory confirms reception on the field

sample data sheet for archiving from the sampler.

2.2.3 Physico - chemical parameters

The set of parameters *[Table 2]* for regular and periodic testing was determined in accordance with the Annex of Rules on drinking water, taking into account the provisions of the Rules on drinking water *[15]* and results of Monitoring of drinking water *[19 - 24]*, for the previous periods. Table 3 illustrates the physico – chemical parameters for regular and periodic testing and their limit values for drinking water.

Table 2: *Chemical parameters*

CHEMICAL PARAMETERS	Treshold value parameters / specification	Units
Electrical conductivity	2500	µS cm^{-1} pri 20°C
Temperature		°C
Hydrogen ion concentration	6,5 - 9,5	pH
The concentracion of free residual chlorine	-	mg/l*
Aluminium	200	µg/l
Ammonium	0,50	mg/l
Colour	0,50	m^{-1}
Total organic carbon (TOC)	4	mg/l
Chloride	250	mg/l
Manganese	50	µg/l
Turbidity*	5;1	NTU
Sodium	200	mg/l
Taste**	1	
Sulfate	250	mg/l
The smell ***	1;7	
Iron	200	µg/l
Antimony	5,0	µg/l
Arsenic	10	µg/l
Copper	2,0	mg/l
Benzene	1,0	µg/l
Benzo(a) pyrene	0,01	µg/l
Boron	1,0	mg/l
Bromate	25	µg/I
Cyanid	50	µg/l
1,2-dichloroethane	3,0	µg/l
Fluoride	1,5	mg/l
Cadmium	5,0	µg/I
Chromium	50	µg/l
Nickel	20	µg/l

CHEMICAL PARAMETERS	Treshold value parameters / specification	Units
Nitrate	50	mg/l
Nitrite	0,50	mg/l
[nitrate] mg/l /50 + [nitrite] mg/l /3	≤ 1	mg/l
Pesticides	0,10	μg/l
Pesticides – total	0,50	μg/l
Polycyclic aromatic hydrocarbons	0,10	μg/l
Selenium	10	μg/l
Lead	25	μg/l
Tetrakloroetenin Trikloroeten	10	μg/l
Trihalomethanes – total	100	μg/l
Mercury	1,0	μg/l
Desethyl atrazine	0,10	μg/l

Note:
** Concentration of the remaining free chlorine is determined by the DPD method.*
** limit value 1: in case of water treatment and/or if it is surface water or if it is affected by the surface water*
***codes: 1 - tasteless, 2 - with taste*
****codes: 1 - odourless, 2 - aromatic, 3 – earthy smell, 4 - stuffy,*
5 - smell of faeces, H2S, ammonia, 6 - chemical odour, 7 - smell of chlorine,
8 - smell of mineral oils and other petroleum products, 9 - smell of phenols

2.2.3.1 Hydrogen ion concentration (pH)

The pH value of water is used to express the acidity or alkalinity level of water. A pH of 7 indicates that the water is neutral, acid lies below this level and alkaline above this level. In most natural waters the pH level is related to the level of carbon dioxide, hydrogen carbonate and carbonate and thus, also with water hardness (soft water has a lower pH value, and hard water a higher value).

Normal pH in groundwater is between 6 and 8,5. Extreme levels in drinking water can result from accidents, errors in water treatment or release from materials in contact with water, e.g. cement, copper or lead pipes.

Lead pipes are still a problem in households in many parts of North America and Europe.A causal link between pH and lead pipes was also clearly described in a survey conducted for London *[25]*

Influence of hydrogen ion concentration (pH value) on human health can be either direct or indirect. Direct exposure to extremely high or low pH causes eye irritation, mucous membranes, skin, and tissue damage. Extreme values that would lead to such injuries (i.e. under 4 or above 11) are not permitted in systems for drinking water supply. Indirect impacts include increased corrosion of materials in contact with low pH value; corrosion may also cause water contamination, change of taste and appearance as well as damage to the material.

The appropriate pH value in water treatment process in order to ensure effective coagulations and for disinfection, is of particular importance. In order for water disinfection with chlorine to be effective the pH must be less than 8.

According to the Rules for drinking water *[15]* the parameter hydrogen ion concentration (pH value) is ranked among indicator parameters. The limit value for drinking water is set between 6,5 and 9,5. Monitoring the pH value of parameter in drinking water allows for quick and simple detection of changes in water characteristics in the field. Operation of drinking water supply system requires continuous monitoring and correction of pH values of water in the water treatment process and before entry of water into the distribution system.

In case of deviations from the specified values the operator is required to immediately identify the reasons for an improper pH value and to check the system's status by reviewing the entire drinking water supply system and to act in accordance with the findings. When consumer's pH reaches less than 4 or more than 11 it is necessary to interrupt the supply of drinking water to inhabitants.

2.2.3.2 Microbiological parameters found in drinking water

Table 3 provides microbiological parameters for regular and periodic testing and their limit values for drinking water. The survey shows that all parameters in the period 2005 - 2010 have already been exceeded for the subject water distribution systems and their captures.

Table 3: *Microbiological parameters*

MICROBIOLOGICAL PARAMETERS	LIMITS	UNIT
Escherichia coli (E. coli)	0	No./100ml
Enterococci	0	No./100ml
Clostridium perfringens (including spores)	0	No./100ml
Coliform bacterias	0	No./100ml
Colony count at 22° C	100	No./ ml
Colony count at 37 °C	100	No./ ml

Bacteria

Bacteria in drinking water systems can grow in bulk water and as biofilms attached to pipe walls, both causing regrowth problems in the distribution system *[26]*

Due to possible acute effects the management of micro - organisms in drinking water takes priority in importance for health. Microbiological parameters show the extent and degree of faecal or other contamination of drinking water by micro - organisms. Drinking water is subject to routine determination of faecal bacteria (Escherichia coli, enterococci) that have origins in human and /or animal excrement and indicator bacteria (Clostridium perfringens with spores, Coliform bacteria, number of colonies at 22 °C and number of colonies at 37 °C) and in packaged drinking water also the following bacteria Pseudomonas aeruginosa. In Slovenia, the results are estimated in connection with values of other parameters. Since the presence of bacteria can cause acute health effects water sometimes needs boiling until remedying the situation.

It was found that the impact of microbiological parameters in connection to copper plumbing pipes is different for rural and urban houses. In the research that was conducted as an example in Chile *[26]* the water in rural houses has lower pH and at the same time more soluble copper than in urban areas.

Escherichia Coli

These are bacteria that are always present in human and animal stools (faeces) in large numbers and, consequently in sewage and waters contaminated with faeces (human, domestic and wild animals, use in agriculture). Presence of E. coli in drinking water reliably proves that water was contaminated with faeces. The optimum pH for preservation of E. coli culture was around 8.2 or more. According to the Rules on drinking water *[15]* bacteria Escherichia coli rank among microbiological parameters. Limit value for E. coli in drinking water is: 0 /100 *ml [Table 3]*

Coliform bacteria

This is a group of bacteria that can be found not only in faeces but also in the environment. In case we failed to confirm the presence of E.coli and / or Enterococcus in the drinking water sample, we cannot use them as faecal contamination indicators.

Nowadays foreign countries also use a simple and inexpensive membrane - filter technique for detecting coliform bacteria in drinking water *[27]*.

The test is used to assess contamination with larger quantities of organic and inorganic substances from the environment, adequacy of water treatment, contamination after water treatment, damage or faults in the network etc. According to the Rules on drinking water coliform bacteria rank among indicator parameters. Limit value for Coliform bacteria is: 0/100 ml. *[Table 3]*

Enterococci

These are bacteria that are present in the intestines and in human and animal faeces. They are considered as more reliable faecal indicators than E. coli. They are retained longer in the water than E. coli, therefore their presence in the drinking water, in which other bacteria were not found, is assessed as older faecal contamination *[28]*. According to the Rules on drinking water *[15]* enterococci are classified as microbiological parameters. Limit value for Enterococci in drinking water is: 0 /100 ml.

Pseudomonas aeroginosa

These are bacteria that are generally present in the environment.They can form bio films in a humid environment and are very resistant to added disinfectants. Their determination is reasonable for the assessment of general hygiene status of water distribution system or chances of survival and reproduction of bacteria. We routinely seek them in water intended for packaging. According to Rules on drinking water *[15]* bacteria Pseudomonas aeruginosa ranks among microbiological parameters for water intended for packaging. Limit value for P. aeruginosa in water intended for packaging is: 0/250 ml.

Colony count at 22° C

This parameter is used to determine the number of bacteria that may be present in water as normal flora. Any sudden increase in the number of these bacteria may be an early indicator of disturbances anywhere in the entire system for drinking water supply. Temperature means the temperature, at which they were incubated in the laboratory or that these are mainly bacteria of non - faecal origin. According to the Rules on drinking water *[15]* the number of colonies at 22°C classifies among indicator parameters. Limit values for results from monitoring for the number of colonies at 22°C is agreed as follows: less than 100/ml.

Colony count at 37 ^{o}C

This parameter is used to determine the number of bacteria, which similarly as the number of colonies at 22° C, shows the effectiveness of the water treatment processes, reproduction in the network due to congestions or increased temperature, subsequent invasion of bacteria etc. The data means a starting point for the assessment of the entire system's status. Compared to the number of colonies at 22°C, the number of colonies at 37°C helps us assess whether bacteria of faecal origin is also present. According to Rules on drinking water *[15]* the number of colonies at 37°C ranks among indicator parameters. Limit value for number of colonies at 37°C is less than 100/ml.

Because of potentially acute effects the management of micro - organism in drinking water takes priority in terms of significance for health. Prevention of diseases caused by microbiological contamination of drinking water includes prevention of contamination at the source and during distribution and suitable water treatment, including disinfection; the most successful method is a system of multiple barriers.

Microbiological non-compliance is assessed in relation to the values of other parameters.

If we estimate that the identified bacteriological exceeded the limit value of non-compliance and is subject to faecal contamination of drinking water, then such water is damaging to human health. Without proper treatment such water is not suitable for use as drinking water. The operator must identify the reasons for the contamination of drinking water as soon as possible and take necessary steps for their elimination. When examining the entire system of a drinking water supply the operator needs to check its status and act according to the findings. Until the arrangement of suitable water treatment procedures or elimination of reasons of non compliance - water needs to be properly boiled when used for drinking, cooking or food preparation (measure of limitation). The operator should notify the users of such measure and provide them with instructions on boiling of drinking water.

If we estimate that the observed bacteriological exceeded limit value is not subject to faecal contamination of drinking water and that this is less likely, then, based on the result of an individual sample we cannot propose a measure of interruption or reduction in the use of drinking water. The operator must immediately identify the reasons of non-compliance of tested drinking water parameters and by reviewing the entire system for drinking water supply, check its status and act in accordance with the findings.

The operator must check the adequacy of implemented measures with a microbiological analysis of drinking water.

Viruses

The most important viruses that are transmitted by water are those reproduced in the human gastrointestinal tract and excreted with faeces (enteric viruses). Infection with viruses from the water is an important factor in the occurrence of gastroenteritis both in Slovenia and abroad. Despite the improved sanitary conditions, faecal contamination also occurs in developed countries *[29]*. The following viruses were found in contaminated water: adenoviruses, gastrointestinal viruses, caliciviruses, enteroviruses (polio, coxackie, echo, enteroviruses) hepatitis A, hepatitis E and rotaviruses. Their natural reservoir, with the exception of hepatitis E, are people. Viruses can be found in stools of those infected in symptomatic and asymptomatic infection. Although they cannot reproduce outside the cells of the host, some of them survive in the environment and remain infectious. They can survive for several months in fresh water. Presence of enteric viruses in drinking water is indubitable proof of faecal contamination.

Due to increasing resistance Enterococcus and Clostridium perfringes spores have been proposed as better indicators for the presence of viruses in drinking water.
Rules on drinking water *[15]* does not mention viruses, but they are covered in Article 3, where it is stated that drinking water is compliant in terms of health when it does not contain micro - organisms, parasites and their development forms in a number that may pose a risk to human health.

Today's laboratory methods do not justify routine monitoring of viruses in drinking water. Direct detection is justified in the case of epidemiological indication or for the assessment of performance during testing of equipment for water treatment. However, we must remember that negative results do not necessarily mean that there were no viruses in the water during sampling, or that they were not there at the time when the population was exposed. Virus isolation from the water by itself does not prove that disease was transferred via water, but indicates that such risk does exist.

Prevention of diseases caused by viruses through transfer via drinking water includes prevention of contamination on the distribution and during distribution as well as proper water treatment process, including disinfection. The system of multiple barriers is, therefore, the most successful way.

Possible presence of enteric viruses in drinking water in addition to other faecal indicators, is also determined by enterococcus and Clostridium perfringens spores as well as the epidemiologic situation. Since from the hygienic point of view, the presence of enteric viruses in drinking water presents an indubitable proof of faecal contamination; such water is not suitable for use as drinking water without proper treatment. As for the measures, the same requirements shall apply as in other cases of faecal contamination; that is until the arrangement of suitable water treatment processes or elimination of reasons drinking water needs to be boiled when it is used for drinking, cooking and food preparation (measure of limitation).

Parasites

Many parasites are transferred with water, i.e.: Giardia lamblia, Cryptosporidium spp. and Entamoeba histolytica. Most of them form cysts or oocysts, which are highly resistant to conventional forms of disinfection and some are difficult to remove even with filtration. Cysts or oocysts of parasites can survive in drinking water for a long time (oocysts cryptosporidium for example survive in fresh water for several months). Among parasites that transfer with water cryptosporidium is the one that is most persistent in the environment, most resistant to chemical disinfection and the smallest, so it is most difficult one for removal by filtration. It is therefore, chosen as a reference for intestinal parasites, which are transferred faecal orally with water. If we achieve the goals in relation to the quality of drinking water for cryptosporidium, we also achieve goals for other parasites in drinking water from the tap.

Cryptosporidium oocysts are excreted in the faeces of infected animals (especially cattle or sheep) or humans. An overarching mode of transferring cryptosporidium is from one human to another (feacal - orally), other methods are also: consuming contaminated food and water (also during recreation in water) and contact with infected animals. Persons at highest risk from exposure to cryptosporidium are: persons with an impaired immune system, small children and the elderly. The most common consequence of infection is diarrhea. Diarrhea can be acute or chronic. Extraction of parasites after a recovery from infection may be very time consuming. Experiments on human volunteers have shown that less than 10 oocysts suffice for infection, theoretical calculations show that consuming only one oocyst may cause infection *[30]*.

Rules on drinking water *[15]* mentions parasites in Article 3, where it is stated that drinking water complies in terms of health when it does not contain micro - organisms, parasites and when their development forms in a number that may pose a risk for healthy people. In drinking water, parasites are not routinely identified. Because of their greater resistance to disinfectants from E. coli, absence of E. coli does not present a reliable indicator of their absence.

A better indicator for the presence of parasites in water is Clostridium perfringens spores. Limit value *[Table 3]* of the parameter Clostridium perfringens with spores is: 0/100ml. In case of non - compliance the operator is obligated to perform additional testing and ensure that drinking water does not pose any potential risk to human health due to the presence of pathogenic micro-organisms, i.e. cryptosporidium.«

3 EXPERIMENTAL SECTION

3.1 Description of the study area

Study area is hilly eastern part of MOL *[Figure 1]*.

Three (3) local water distribution system, six (6) local captures are managed by J.P. VO - KA, 22 local water distribution system (34 local captures) are operated by the Municipality of Ljubljana.

For captures of MOL water committees (water distribution suppliers) are responsible for the on - going operation and maintenance, performance inspections and cooperate with water distribution managers. Water committees are consisted of local people, which take care for their operation and maintenance through water committees.

The service of drinking water supply provided by the public service in all settlement areas of Municipality of Ljubljana region is performed by JP Vodovod – Kanalizacija

Examination of each local capture in addition to obtaining the data on the number of persons receiving water service or consumers, also included a list of buildings' status, maintenance of these buildings and a description of the built water distribution network, including water connections. The inventory took place in the period 2010/ 2011.

In the recent years, the Municipality of Ljubljana has been systematically solving the complex problems of drinking water supplied from the local water distribution systems also by switching to new boreholes (Vnajnarje borehole Vn-1/08 - construction year 08/09, Borehole Dolina Besnice ZRB-1/05 - construction year 2015, Borehole RB1/03 - Ravno Brdo end of construction 2012). With the intention to finally solve the problem of drinking water supply the city began arranging the supply of local water distribution system with quality drinking water at greater pace in 2000.

Rehabilitation and renovation works on the local water distribution system that have no wholesome drinking water are implemented within the regular plan. Current renovation works are preventing serious physical - chemical water contamination in captures on the long run, and at some locations, their discharge has also increased.

Table 4 shows local water distribution systems, captures and boreholes of the local water distribution system. The survey subject of the present master’s thesis was only the captures in the area of the south - eastern sector of Ljubljana (yellow zone in *Figure 1*) Data on the displayed microbiological and physico - chemical results, which follow below, relate to the individual local water distribution systems to which also the captures and boreholes belong; hence the data are for transparency reasons classifield under water distribution systems and displayed on the graphs accordingly. The number of inhabitants served and distributed water is taken from the data in the year 2011 *[12]*. Sampling points are located for each water distribution system on pipes of surrounding houses, captures, water distribution systems and boreholes.

Table 4: *List of captures of local water distribution system in the reserach area*

Local water distribution sistem (Manager MOL)	**NO. IN FIG. 1**	**LOCAL CAPTURES OR BOREHOLE**	**No. of people supplied**	**The quantity of water distributed in the supply area (m^3 / year)**	**Protected areas under Regulation 115/2007 / official name /**
1.BAJDOVNA	**19** **18**	Local capture **Bajdovna-novo** Local capture **Andrejc zg.**	**85**	**2.571**	YES - Local capture ***Bajdovna*** - new YES - Local capture ***Andrejc zgornji***
2. BESNICA ŠOLA	**13**	Local capture **Besnica šola** (the dry season) Local capture **Besnica šola 2)**	**23**	**2.320**	YES -Local capture ***Besnica šola***
3.BESNICA VAS	**15** **14** **16**	Local capture **Jernačev Hrib** Local capture **Besnica-Jernačev hrib** Local capture **Tablarjev studenc**	**30**	**480**	YES - Local capture ***Jernačev hrib***
4.BREZJE PRI LIPOGLAVU	**33** **6**	Local capture **Brezje pri Lipoglavu** Borehole **B - 1/89**	**100**	**4.790**	YES - *Borehole* ***B*-1/89**

Local water distribution sistem (Manager MOL)	**NO. IN FIG. 1**	**LOCAL CAPTURES OR BOREHOLE**	**No. of people supplied**	**The quantity of water distributed in the supply area (m^3 / year)**	**Protected areas under Regulation 115/2007 / official name /**
5. ČEŠNJICE – ZAGRADIŠČE	**6** **17**	Local capture **Češnjice** Local capture **Zagradišče**	**205**	**4.620**	YES - Local capture **Češnjica** YES - Local capture ***Zagradišče***
6. DOLGO BRDO	**31**	Local capture **Pod Gašperjem**	**28**	**480**	NO
7. JANČE GABRJE / JANČE - PLANINSKI DOM	**27** **33** **34** **15**	Local capture **Janče - Močilo** Local capture **Lašče 1** Local capture **Lašče 2** Borehole **J - 1/02**	**100**	**4.020**	YES - Borehole ***J-1/02***
8. JAVOR - NOVI VAS	**9** **33** **9** **10**	Local capture **Javor Močila 1** **Local capture Javor Močila 2** Borehole - **3/89** Borehole **-J 4/02**	**110**	**3.500**	NO - Borehole **J- 4/02**
9. JAVOR - VRH	**10**	Local capture ***Pri Brezovarju***	**65**	**2.600**	YES - Local capture ***Pri Brezovarju***
10. JAVOR - ŽAGARSKI VRH	**11** **12** **11**	Local capture **Žagarjev izvir 1** Local capture **Žagarjev izvir 2** Borehole **ŽV- 1/01**	**55**	**2.670**	YES -Local capture **Žagarjev izvir 1** and **Žagarjev izvir 2** Borehole ŽV **-1/01**
11. PODLIPOGLAV	**5** **4**	Local capture **Pod Pugledom** Local capture **Pri Anžku**	**166**	**9.700**	YES - Local capture **Podlipoglav Pod Pugledom** YES - Local capture **Podlipoglav**

Local water distribution sistem (Manager MOL)	**NO. IN FIG. 1**	**LOCAL CAPTURES OR BOREHOLE**	**No. of people supplied**	**The quantity of water distributed in the supply area (m^3 / year)**	**Protected areas under Regulation 115/2007 / official name /**
					Pri Anžku
12. PODMOLNIK	**1** **1** **2** **2**	Local capture ***Pri Dolinarju*** Borehole **D-1/05** Local capture ***Pod Marenčkom*** (abandoned) Borehole **PM 1/98**	**700**	**25.000**	YES - Local capture **Pri Dolinarju** YES - Borehole **1/05** YES - Borehole **PM- 1/98**
13. SADINJA VAS	**3** **5** 4	Local capture **Sadinja vas sp.** Borehole VSV-1/05 Borehole ***S-1/92***	**550**	**14.240**	YES - **Borehole S -1/92** YES - Local capture **Sadinja vas sp**
14. SOSTRO – BARAKE	**34**	Local capture **Sostro Barake**	**70**	**2.630**	NO
15. ŠENTPAVEL	**3**	Borehole **ŠP-1/98**	**100**	**4.300**	YES - Borehole **ŠP- 1/ 98**
16.TUJI GRM	**29** **32**	Local capture **Tuji Grm 1** Local Capture **Tuji Grm 2**	**65**	**1.260**	YES - Local capture **Tuji Grm 1,2**
17. VNAJNARJE - KORITO	**20**	Local capture **Korito**	**66**	**1.200**	YES - Local capture **Korito**
18.VNAJNARJE SMREČJE	**23**	Local capture **Pod Kostelcem**	**20**	**830**	YES - Local capture **Pod Kostelcem**
19.VNAJNARJE-ZABUKOVJE	**21** **22**	Local capture **Zabukovje** Local capture ***S Sodčkom***	**16**	**460**	YES - Local capture **Zabukovje** YES - Local capture **Sodček**
20. VOLAVLJE *	**26**	Local capture ***Farovški Studenec (lower)***	**120**	*****	YES - Local capture **Farovški studenec sp.**

Local water distribution sistem (Manager MOL)	**NO. IN FIG. 1**	**LOCAL CAPTURES OR BOREHOLE**	**No. of people supplied**	**The quantity of water distributed in the supply area (m^3 / year)**	**Protected areas under Regulation 115/2007 / official name /**
	30 **13**	Local capture ***Farovški studenec* *(top)*** Borehole VN-1/08			YES - **Farovški studenec zg.**
21. ZG. BESNICA	**24** **14**	Local capture **Matjaževa Draga** Borehole ZGB-1/05	**75**	**1.600**	YES - Local capture **Matjaževa Draga**

Local water distribution sistem (Manager J.P. VO - KA)	**NO. IN FIG. 1**	**CAPTURES / BOREHOLE**	**No. of people supplied**	**The quantity of water distributed in the supply area (m^3 / year)**	**Protected areas under Regulation 115/ 2007 / official name /**
1. LIPOGLAV	1 2 1	Local capture **VZ Lipoglav 1** Local capture **VZ Lipoglav 2** Borehole **VD Lipoglav**	**630**	**38. 825**	YES - **VZ Lipoglav 1, VZ** **Lipoglav 2** Borehole **VD Lipoglav 1**
2. PREŽGANJE	3 4 2 5	**Local capture V. Trebeljevo** **Local capture M. Trebeljevo** Borehole **TR-1/08)** Local capture **VZ Pečovje**	**650**	**34. 191**	YES – **VZ Pečovje**
3. M. VRH PRI PREŽGANJU	6	Local capture **VZ Brezovje**	**80**	**4.018**	YES - **VZ Brezovje**

* Transfer of management recently

The description in *[Table 5]* presents in more detail the captures of the local water distribution system. *Table 5* shows the inventory of all acquired technical data on individual captures and boreholes and where there is no such data the field is marked with an asterisk (*).

Technical data were partially obtained by interviewing *[Table 4]* suppliers, administrators of local captures and are in line with already acquired data from the reports *[37- 68]*. The description was also indicated for abandoned captures.

The supply area for most captures consists of Permian carboniferous sandstone and claystone slate. Most recharge areas consist of sandstone and claystone slate (46%) followed by 32 % Dolomite, 17% Carbon Permian and Limstone and other rocks.

Groundwater from these captures is periodically or continuously contaminated microbiologically and during the rains also physic - chemically contaminated.

Captures are mostly located in the eastern part of Ljubljana - high on the slopes (captures for water distribution systems Janče - Gabrje, Dolgo Brdo, Vnajnarje, Češnjica - Zagradišče, Žagarski vrh etc.), due to their high location catchment area is small, measuring just a few hectares, therefore the average discharge from these captures range from 0,05 up to 0,3 l/ sec. Maximum water flow rate was observed in the water supply system: Brezje in Lipoglav 5l/sec, Mali Lipoglav 11l/sec, Javor vas 5l/sec you, Podmolnik 5l/sec, Sostro barake 4l / sec.

During a prolonged drought most of them are left with no water, so it needs to be transported by tanks to the final users.

Samples are taken at the captures of the tank and water supply networks at users' locations (taking is performed by the IVZ RS), which is accredited by Rules on drinking water *[15]*.

__Table 5:__ Technical data on captures and boreholes

Local water distribution sistem	CAPTURE/ BOREHOLES	DEPTH OF BOREHOLES	EQUIPMENT BORE (Filter section)	GEODETIC FEEDER AREA PROPERTIES	PUMPING COLICKY	CAPTURE: MAXIMUM MEDIUM MINIMUM	GROUNDWATER LEVEL
BAJDOVNA	Local capture **Bajdovna – novo**	*	*	Sandstone rubble, silt, clay	*	0,05 l/sec 0.09 l/sec 0,18 l/sec	*
	Local capture **Andrejac zg.**	*	*	Permian carbon layer, slaty claystone and sandstone	*	0, 02 l/sec 0,05 l/sec 0,1 l/sec	*
BESNICA - šola	Local capture **Besnica šola / Besnica šola 2**	*	*	Permian carbon layer, slaty claystone	*	0,0 1 l/sec 0,2 l/sec 0,4 l/sec	*
BESNICA - vas	Local capture **Besnica - Jernačev hrib** Local capture **Jernacev hrib** Local capture **Tablarjev studenc**	*	*	Permian carbon, conglomerate and sandstone	*	0,15 l/sec 0,25 l/sec 0,35 l/sec	*
BREZJE PRI LIPOGLAVU	Local capture **Brezje pri Lipoglavu** Borehole **B -1/89**	70 m	0,0 m to 5,50 m	Clay, silt, dolomite	1 l/sek	above 5 l/sec	0,50m
ČEŠNJICA - ZAGRADIŠČE	Local Capture **Češnjice**	*	*	Sandstone, slaty claystone		0,1 l/sec 0,2 l/sec 0,5 l/sec	1,2 m
	Local capture **Za Zagradišče**	*	*	Sandstone and slaty claystone	*	0,02 l/sec 0,05 l/sec 0,2 l/sec	*
DOLGO BRDO	Local capture **Pod Gašperjem**	*	*	Sandstone, Sandy clay	*	0,05 l/sec 0,3 l/sec 0,2 l/sec	*
JAVOR ŽAGARSKI VRH	Local Capture **Žagarjev izvir 1** Local Capture **Žagarjev izvir 2** **Borehole ŽV-1/ 01**	* *	* *	Sandstone, clay Sandstone, Clay	* *	0,015 l/sec 0,1 l/sec 0,l5 l/sec 0,002 l/sec 0,07 l/sec 0,2 l/sec	* *
JAVOR - NOVI VAS	Local Capture **Javor- Močila1,2**	*	Filter tube diameter 114 mm;	Fractured dolomite	1 l/sek	1 l/sec	Static water level at a depth of 32m

Local water distribution sistem	CAPTURE/ BOREHOLES	DEPTH OF BOREHOLES	EQUIPMENT BORE (Filter section)	GEODETIC FEEDER AREA PROPERTIES	PUMPING COLICKY	CAPTURE: MAXIMUM MEDIUM MINIMUM	GROUNDWATER LEVEL
	Borehole **J- 3/89**		(40 m to 65 m)				
	Borehole **J-4/02**	98 m	Filter tube	Fractured dolomite	1,85 l/s	5 l/sec	32,80m
JAVOR -VRH	Local capture **Pri Brezovarju**	*	*	Permian carbon, sandstone, slaty claystone	*	0,02 l/sec 0,15 l/sec 0.3 l/sec	0,5 m below the surface
PODLIPOGLAV	Local capture **Podlipoglav - Pod Pugledom**	*	*	Crushed sandstone and slaty claystone	*	0,2 l/sec 0,3 l/sec 0,5 l/sec	On the surface of the capture
	Local capture **Podlipoglav Pri Anžku**	*	*	Sandstone and slaty claystone with limestone rubble	*	0,02 l/sec 0,1 l/sec 0,2 l/sec	Just below the surface
PODMOLNIK	Borehole **PM-1/ 98**	45 m	Steel tube of diameter 114 mm; (42 m to 45 m)	Gravel, silt, partially fractured dolomite	2,1 l/sek	Max 0,5 l/sec	2,80 m
	Local capture **Pri Dolinarju** Local capture **pod Marenčkom (abandoned)**	*	Drainage pipes with inspection chambers	Gravel, sand, silt	*	0,5 l/sec 2,5 l/sec 5 l/sec	1,5 meters below ground level
	Borehole **D -1/05**	50 m	Sloted pipes (filter tube) diameter 127 mm	Sand and rubble, covered by dolomite	1,5 l/s	5 l/sec	1,5 do 3 m below the mouth borehole
SADINJA VAS	Local capture **Sadinja vas Sp.** **Borehole SVS 1/05** **Borehole S-1/92**	*	*	Dolomite, milonite	*	0,05 l/sec 0,1 l/ sec 0,2 l/sec	Just below the surface
SOSTRO BARAKE	Local capture **Sostro Barake**	4m	Full of concrete pipes, diameter 100cm	Sandstone, clay	*	1,5 l/sec 2,5 l/sec 4 l/sec	2,5 m the mounth of the tube
ŠENTPAVEL	**(Borehole SP-1/98)**	138 m	Stell tubes, diameter 127mm	Partialliy fractured Dolomite	0.75 l/s	1 l/sec	110 m below the mouth borehole
TUJI GRM	Local capture **Tuji Grm 1, 2**	*	*	Permian carbon sandstone (C, P)	*	0,15 l/sec	*
VNAJNARJE (Vnajnarje - Korito,	Local capture **Korito**	*	*	Sandstone	*	0,15 l/sec 0,3 l/sec	*
	Local capture	*	*	*	*	0,2 l/sec	*

Local water distribution sistem	CAPTURE/ BOREHOLES	DEPTH OF BOREHOLES	EQUIPMENT BORE (Filter section)	GEODETIC FEEDER AREA PROPERTIES	PUMPING COLICKY	CAPTURE: MAXIMUM MEDIUM MINIMUM	GROUNDWATER LEVEL
Vnajnarje - Zabukovje, Vnajnarje - Smrečje)	**Zabukovje** Local capture **S sodčkom**						
	Local capture **Pod Kostevcem**	*	*	*	*	*0,1 l/sec	*
VOLAVLJE*	Local capture **Farovški studenec (zg. in sp.)** Borehole VN-1/08	*	*	Permian carbon sandstone, slaty claystone and weathered sandy clay	*	0,5 l/sec	*
ZG. BESNICA	Local capture **Matjaževa Draga** Borehole ZGB-1/05	*	*	*	*	0,2 l/sec 0,3 l/sec 0,5 l/sec	*
LIPOGLAV	Local capture VZ Lipoglav	*	*	*	*	*	*
PREŽGANJE	**V . Trebeljevo** **M. Trebeljevo** Borehole TR-1/08 Local capture **VZ Pečovje**	*	*	*	*	3,5l/s 4,5l/s 6l/s	*
MALI VRH PRI PREŽGANJU	Local capture **Mali vrh pri Prežganju (VZ Brezovje)**	*	*	Dolomite, slaty claystone, limestone, marl	*	0,7 l/sec	*

*Transfer of management recently

3.2 Methods

3.2.1 Analysis of water quality data

Internal control over compliance of drinking water in local water systems is carried out in accordance with the Rules on Drinking Water *[15]*. It has to follow established procedures based on the HACCP plan *[10,11]* which contains sampling sites, type of trials and a minimum frequency of sampling. In the period from 2005 to 2010 there were on average 352 microbiological samples and 144 samples for chemical testing conducted. Samples of captures managed by the Municipality of Ljubljana were collected and analysed in the laboratory of the Institute of Public Health, Ljubljana. Some analyses were conducted in the laboratory of the Institute of Public Health Maribor and Celje. Samples from captures managed by J.P. VO - KA were analysed by their own laboratory. Collection of samples for capture were carried out by representatives of the Institute of Public Health.

Input data

More than 15,000 reports were examined (for microbiological and physico - chemical testing and other reports on the compliance of drinking water from local water supplies over the period of five years) *[12]*. This was done for 150 parameters for 25 water supply systems. Due to an excessive amount of data, this study focuses only on parameters which exceeded the limit levels in a five year period.

Sampling scheme

Drinking water monitoring analysis covers a period from 2005 - 2010. Table *6* combines annual data on the number of microbiological and physic - chemical samplings for the selected water distribution systems. Usually, there are several sampling locations available for each water distribution system. The bottom samples were taken several times a year at captures, tanks and water distribution networks at users' locations.

Data for the annual reports of the Institute of Public Health thus include sampling from all these locations, and the final results are presented under the heading local water supply system. Final annual reports thus do not indicate whether the data refers only to the capture or the near building, where the taking took place. In reviewing the entire documentation of reports for the period of five years we reasonably included only the data that stood out in terms of exceeding the limit values because of the excessive number of data (we reviewed 150 parameters for 20 water distribution systems in the period of 5 years, an average of 3 taken samples per year for individual water distribution system on approximately 3 locations).

Data on microbiological and physical - chemical parameters in the final reports thus include the total sum from all off take points. Due to lack of data for an individual sample point it was also irrational to separate the data in terms of graphical presentation.

The survey covered 81.8% of all captures, which are managed by the Municipality of Ljubljana. The captures, which are managed by the public sewerage company J.P. VO-KA have not been problematic in terms of water quality *[31]*.

Table 6: *Sampling of individual water supply system by the MOL operator*

Local water distribution sistem No. of people to 500	**No. of samples with excess limits for individual water supply sistem**		**No. of samples (regular and occasional) for MB testing (By year)**						**No. of samples (regular and occasional) for CHEM testing (By year)**						**No. of sampling points**	**Frequency of sampling**
	MB 2005-2010	KEM 2005-2010	05	06	07	08	09	10	05	06	07	08	09	10		
BAJDOVNA	54	0	15	12	16	21	15	18	4	4	9	7	5	6	3	At 5-7 mounth
BESNICA – ŠOLA	61	0	10	12	15	17	20	14	4	4	7	7	8	4	3	At 5-7 mounth
BESNICA – VAS	49	0	10	11	11	13	10	12	3	4	3	4	4	5	3	At 5-7 mounth
BREZJE PRI LIPOGLAVU	12	0	11	12	14	18	23	16	3	5	6	6	9	8	3	At 5-7 mounth
ČEŠNJICE – ZAGRADIŠE	15	1	12	17	21	21	21	27	5	5	6	6	9	6	3	At 5-7 mounth
DOLGO BRDO	66	22	9	15	13	12	14	9	0	0	4	6	6	4	3	At 5-7 mounth
JANČE-GABERJE	43	6	12	13	16	19	20	19	2	4	6	8	9	21	3	At 5-7 mounth
JANČE - PLANINSKI DOM	45	5	8	4	9	15	10	19	10	0	5	8	18	21	3	At 5-7 mounth
JAVOR - NOVI VAS	34	0	12	15	17	19	20	21	3	6	5	7	8	7	3	At 5-7 mounth
JAVOR – VRH	47	3	9	12	10	14	14	18	3	4	6	2	4	5	3	At 5-7 mounth
JAVOR - ŽAGARSKI VRH	65	5	9	12	16	17	17	14	3	5	6	6	7	5	3	At 5-7 mounth
MALI – VRH	23	31	2	2	3	3	4	5	6	2	6	2	5	4	3	At 5-7 mounth
PODLIPOGLAV	32	1	10	20	19	18	18	27	2	5	3	7	6	11	3	Na 5-7

Local water distribution sistem No. of people to 500	No. of samples with excess limits for individual water supply sistem		No. of samples (regular and occasional) for MB testing (By year)						No. of samples (regular and occasional) for CHEM testing (By year)						No. of sampling points	Frequency of sampling
	MB 2005-2010	KEM 2005-2010	05	06	07	08	09	10	05	06	07	08	09	10		
																mesecev
PODMOLNIK	60	0	16	29	30	21	18	44	14	5	13	-	14	19	3	At 5-7 mounth
SADINJA VAS	15	0	22	16	16	19	18	17	4	6	6	7	11	9	3	At 5-7 mounth
SOSTRO – BARAKE	56	0	10	11	14	16	16	13	3	4	4	4	6	4	3	At 5-7 mounth
ŠENTPAVEL	57	0	10	16	16	26	22	19	5	4	6	8	9	6	3	At 5-7 mounth
TUJI GRM	67	0	14	16	18	21	22	15	5	4	5	8	10	8	3	At 5-7 mounth
VNAJNARJE-KORITO	62	1	10	7	10	10	14	13	3	2	4	3	5	3	3	At 5-7 mounth
VNAJNARJE SMREČJE	27	5	10	8	10	12	12	7	1	4	2	2	5	4	3	At 5-7 mounth
VNAJNARJE-ZABUKOVJE	4	7	9	8	10	11	11	6	1	2	3	4	4	3	3	At 5-7 mounth
VOLAVLJE	47	1	12	15	18	18	8	-	3	6	-	4	4	-	3	At 5-7 mounth
ZG. BESNICA	58	1	11	10	16	17	17	21	3	4	4	7	5	5	3	At 5-7 mounth

For the period 2005 - 2010 there were on average two samples per month taken annually for individual capture for regular microbiological testing and more than six months one sample for periodic microbiological testing.

With regard to physical - chemical testing, there was an average of one sample taken every six months for regular testing as well as for periodic ones. Sampling dates were at the discretion of the sampler. There was also a term determined during the week, namely, from Monday to Friday in the morning. The day was selected by the sampler themself. Sampling was not performed in the periods, which were predetermined in the monitoring program. Sampling at the addressed captures was performed by the Institute of Public Health, Ljubljana.

Microbiological parameters include the origin of faecal bacteria - (Escherichia coli, Enterococci) Clostridium perfringens (including spores) and indicator bacteria (Coliform bacteria counts at 22 ° C, the number of Colonies at 37 ° C) The maximum value for E. coli, Enterococci, Clostridium perfingens coliform is 0 (unit /100 ml). The limits of colonies at 22 ° and number of colonies at 37 ° are less than 100 / ml.

The basis for the internal control system, HACCAP, was a period of five years (2005 – 2010) during which period the laboratory of the Institute of Public Health, took on average 352 samples per year for microbiological testing.

According to Slovenian legislation, drinking water is treated as food, therefore, since 2000 all public water supply systems in Slovenia must operate in accordance with HACCP principles (pursuant to Act regulating the Sanitary Suitability of Foodstuff, Products and Materials coming into Contact with Foodstuffs (zzuzis) Official Gaz. 52/2000).

Final annual reports from ZZV LJ show only the total number of inferior quality samples and the total number of faecal bacterial origin i.e the total recorded data for E. Coli and Enterococci.

Data and results from its calculation

From all results from microbiological and physic - chemical analyses, a set of data was prepaired, containing all results with the exceeded limit levels for a five - year period. With this we obtain data only for captures and parameters with exceeded limit values. We calculated the results for the proportion of samples in percentages with exceeded pH limit for five years *[Figure 4]*
(Calculations of the averages for all samples with the excess limit for a ten - year period have been provided for all included captures as well as for particular, more critical capture *[Table 7]*.

We calculated the results of proportion of samples in percentages with excess pH limit for five years *[Figure 4]*.
We also calculated the proportions of samples (in percentages) which contain one or more faecal bacteria for a period of five years for all selected captures *[Figure 6]*.
Exceeded levels of bacteria in a percentage of samples were correlated with monthly and daily rainfall data for the three most critical captures for the five - year period. Figure 7 shows as example the proportion of faecal bacteria for Spring 2012 for all captures.
According to results from the chemical and microbiological analyses the three most exposed captures for the period of five years were selected *[Figure 5]*.
The most exposed local water distribution systems (Besnica, Dolgo Brdo, V. Korito)

for Spring 2007 in correlations with monthly rainfall are presented. *[Figure 10]*.

Statistical analysis

The data set with exceeding values was statistically analyzed *[12]*.

Minimum, maximum and average values and trends were determined for each parameter and local water supply *[Table 8]*.

The numeric data of the most exposed captures were also presented in the form of graphs, from which the data is visible through the trend curves. The greatest values in the form of graphs (sum, average) have been processed in Excel Pivot Tables.

3.2.2 Interviewing - a field survey

The field survey section included interviewing local capture suppliers - their responsible individuals or members of water committees who are allowed to access water supply facilities and come in direct contact with drinking water when managing and maintaining water distribution systems. These persons must have certain acquired knowledge, attend workshops in literature and participate with the technical service of the Institute of Health Protection.

A field survey (opinion poll) included suppliers who are responsible for the maintenance of each individual capture.

The subject of our field study was to interview drinking water suppliers in order to determine the state of captures and to list all the factors that represent a potential risk of pollution (environment and interior of captures,..). The field survey *[Table 4]* helped us to obtain several additional parameters, such as contaminants in the water protection zones, state of captures (age, maintenance, supplies, construction), risk factors, cost control, analysis of land use etc.
There are 40 captures (no wells) located on the addressed area *[Table 1]*.
In collaboration with local committees for water distribution systems we successfully interviewed 85% of captures. Three (3) local water distribution sistem are operated

by the J. P VO - KA and 22 are operated by Municipality of Ljubljana *[Figure 1] [Table 4]*.

In collaboration with the 22 managers (individual managers has managed one local distribution sistems), 40 captures were successfully examined useful information was obtained. For other captures there was no useful information, because there was insufficient data to process or already connected to the water supply of other communities.

Data processing and evaluation was conducted with the help of the inventory data regarding the technical conditions of the captures and proposed measures in order to improve the situation of the local water supplies. The results from interviewing suppliers are presented in the form of pie charts *[Figures 17 - 24]*

We have selected a field »*face to face* survey« *[36]*, which includes answers from suppliers of water committees. Using this method has advantages over other methods, as this type of interview helped us reach data that would otherwise be inaccessible to us (opinions, subjective views, plans)**.** The negative side of this type of survey is that it is very time consuming and expensive.

Survey sheet *[Table 7]* includes: ranking closed type questions (ranking by importance), categorical questions (selecting one of the options) and the most basic type of question – yes / no / no data available). Open type questions were those which were answered by the administrators in their own words.

Part of the questions were used for presentation in form of charts; another part of the data was used for additions and entering into tables indicating the current status (according to already known reports). Open type questions were utilized in the preparatory phase of the research process as it helped us in identifying the problem of research, setting up the hypothesis and in the construction of closed type questions. Conversely, closed type questions were more appropriate for testing the hypothesis.

Table 7: *Survey sheet*

CONTENTS QUESTIONNAIRE
1. Local capture: *(to complete a form - author of the research)* 2. In management: MOL / J. P. VO-KA 3. Photo: 4. Administrator: 5. Location: -- 6. Factors in the strict protection zone: (List the contaminants)* *(to complete a form - respondents and author of the research)* * These *data are used to describe the contaminants* Factors in the wider protection zone: (List the contaminants)* -- 8. Status of the facility : (age, maintenance, material, construction) *(to complete a form - respondents)* Age: (year) Material: sand, stones, plastic,…. 9. Proposals for refurbishment or replacement: 10. Reasonableness of conecction to the central sistem 1….2…3…4…..5 (circle) *1......does not make sense* *5……very meaningful* 11. Cost control : 1…2…3…4…5 (circle) *1…… not at all economical* *5…….very economical* 12. The possibility of preventive : 13. Threats of water source : 1…2…3…4…5…6…7…8…9…10 (circle) *1 - very low risk* *10 – very high risk* 14. The presence of municipal waste in the vicinity of capture yes / no / no data (circle) 15. The presence of illegal construction in the vicinty of capture yes / no / no data (circle) 16. Plans for the area: (for example: change for spatial plan, construction of roads.) 17. The reasons, that this capture is under a single management:
18. Analysis of land use (quality, population density, forest, vegetation, animals) * **This data are used in the descriptive part of the task* *(to complete a form - respondents)*
19. Year of renovation single capture (tanks, pipelines *(to complete a form - respondents)* 20. Collection of samples : (year / month): 21. Risk factor : 22. Opininon on the sense of the connection to the central system 1…2…3…4….5 (circle) *1...... does not make sense* *5.…. very meaningful* 23. Proposal for renewal of capture: 24. The economics of control: (cultivated, environment, barriers to access) 25. Opininon about the quality of the local capture of the measurement results: 26. Suggestions: 27. Impacts of current land - use plans: 28. Long - term proposals to protect the catchment: 29. The use of materials in the manufacture of capture: (concrete, rocks, bricks, plastic) 30. Soil composition:

3.2.3 DPSIR approach

Analysis of land use with specification of potential contaminants and construction of impact and effect matrix

Groundwater is a very important drinking water resource, therefore, it needs to be protected The very first groundwater legislation (Directive 80 / 68 / EEC) had a limited scope and focused on controlling emissions of substances from industrial and urban sources. *[32]*.

The Driver - Pressure - State - Impact - Response (DPSIR) framework was developed in the late 1990s and was proposed by the Organization of Economic Co - operation and Development (OECD, 2003) as a means of structuring and organizing indicators in a way that is meaningful to decision makers *[33]*.

DPSIR *[Figure 3]* is a causal approach for describing interaction between society and the environment and an approach that can determine the cause - effect relationships between interacting components of social, economic and environmental factors *[34]* :

(D) Driving forces - the driving force in the environment (i.e. industrial plant, agriculture, traffic etc.) **(P) Pressures** - environmental pressures (i.e. discharges of waste water into environment), **(S) State** - state of the environment (i.e. quality of captured underground water), **(I) Impacts** - impacts on population, economy, ecosystems (i.e. water unsuitable for drinking), **(R) Responses** - social responses (for example capture protection).

DPSIR is proposed as a well - known methodology and together with some new methodological approaches is used in assessing the significance of the relevant pressures identified in the Basque Country (as a case study). The use of the DPSIR analysis in the Basque Country case (together with the methodologies in identifying relevant pressures and impacts) has been demonstrated as a useful approach in assessing the risk of failing the WFD - Water Framework Directive objectives. *[34]*
Tschang et al. (2012) mention several studies that were mainly concerned with

criticism and drawbacks of the DPSIR framework. They analyzed 21 studies using the DPSIR framework with regard to their relevance for decision making. They conclude that the DPSIR framework offers the chance to link scientific findings with " real world" issues and therefore, may serve as means of bridging the gap between research and decision making. They found that the application of DPSIR may allow for policy relevant research because it supports the explanation and communication of research results in an accessible and presentation of stakeholder values and alternative decision options, rather than to rigid and predetermined solutions *[33]*.

Using this model has helped us easily cover all the obtained data collected in the field (interviewing, sampling, reports,..) and the DPSIR frame facilitated displaying the essence of the problem for individual capture.

Collected existing studies and the background of individual captures were used in the preparation of the analysis. For each water capture description of the location, hydrogeological characteristics of catchment area, aquifer type and other parameters were determined.

Data on existing land use were obtained from the European CORINE land cover map[1]. Planned land use was gained from the spatial master plan for the Municipality of Ljubljana. The investigation defined the existing state of the captures including the recharge area from a sanitary - technical aspect.

[1] CORINE (land cover CLC 2000) is an important dataset for the implementation of key priority areas of the EU's 6th environment action programme. CLC2000 can show, for instance, where fragmentation of the landscape by roads and other infrastructure is worsening and thus increasing the risk that ecosystems can no longer connect with each other, putting the survival of their flora and fauna in danger.

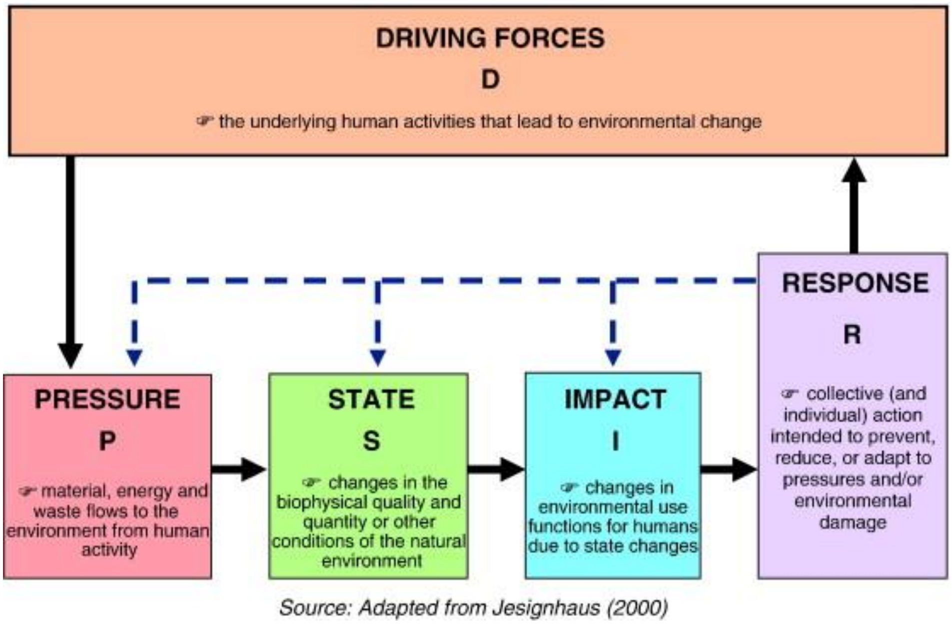


Figure 3: *DPSIR assessment framework of the European Environment Agency [35].*

Input data for the DPSIR model are:

- field inspections for determination of landuse
- CORINE data on landuse
- data on contaminants in selected protection areas,
- (%) of samples in which microbiological and physical - chemical values were exceeded in the period from 2005 to 2010 (data were calculated from data obtained from the archive of reports for the 10 - year period)

3.3 Analysis of results for the physical - chemical and microbiological parameters in local systems for drinking water supply

The following is an analysis of the results from physical and chemical water quality tests. Capture was not shown in the management J.P. VO - KA, because there were reports of a 5 -year period without adequate and excess levels.

3.3.1 The results of physical parameters (pH value of drinking water)

Basic regular physical analyses of drinking water include measurements of the following parameters: color, suspended material, odor, turbidity, pH and specific electric conductivity.

On the basis of the Rules on drinking water *[15]* an annual monitoring program for drinking water has been prepared *[19 - 24]*, which includes sampling frequency for regular physical testing, and once a year for an occasional one.

The maximum concentration of hydrogen ions (pH below) is in the range 6.5 to 9.5. Analysis of measurements for the period from 2005 to 2010 showed that the pH of excess threshold values samples (75 %) ranging from 5.6 to 6.4 while the remaining 25 % of excess threshold values samples in the alkaline from pH of 9.8 to 10.4.

Figure 4 shows the highest proportion of samples (%) with exceeded threshold values for pH for local water distribution systems (in the 2005 - 2010 period). There are three prominent local water distribution system: Dolgo Brdo, Vnajnarje Smrečje and Vnajnarje Zabukovje. The highest portion of inferior quality samples in 2008 were found in Dolgo Brdo, in 2007 in Vnajnarje Smrečje and in 2006 in Vnajnarje Zabukovje. The portion of inferior quality samples was taken from the entire analysis in which an individual water supply is covered by a water supply capture area and the corresponding well.

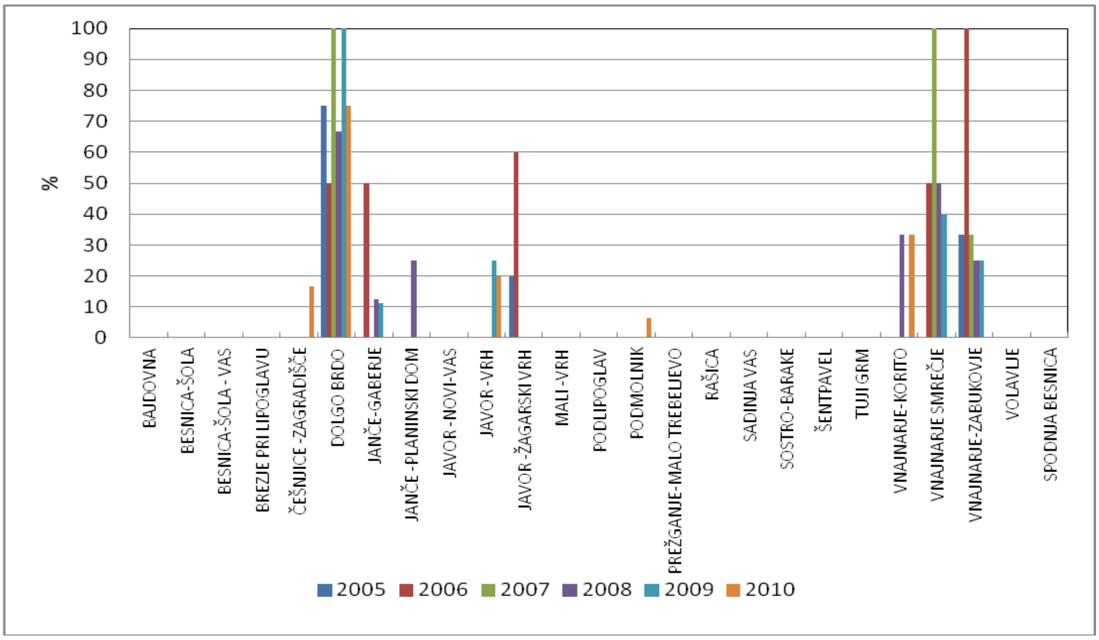


Figure 4: *Portion of samples (%) with exceeded threshold values for pH for the local water distribution system (in the 2005 - 2010 period).*

The largest shares of water samples with exceeding pH threshold values are in the following local water distribution systems: Dolgo Brdo, Janče Gaberje, Javor

Žagarski vrh Vnajnarje, and Vnajnarje - Zabukovje.100 % exceeding pH threshold values were found in the following local water distribution systems: Vnajnarje Smrečje in 2007, Vnajnarje - Zabukovje in 2005 and Dolgo Brdo in 2010. More than 50 % of proportion samples were found in the following local water distribution system: Dolgo Brdo (In 2005, 2006, 2007, 2008 and 2010. In 2009 there were no samples outside the limits). Vnajnarje - Smrečje (In 2005, 2007, 2008, 2009. In 2006 and 2010 there were no samples outside the limits.), Vnajnarje - Zabukovje (In 2005, 2007, 2008. In 2006 and 2010 there were no samples outside the limits).

The lower pH in the capture is due to pollution and the geological composition of the recharge area. Acidity, pH soil affect, soil fertility and susceptibility to pollution and due to various uses. Poor content of plant nutrients often coincides with increased acidity of the soil. Soil can be acidic due to non - hydrocarbon composition or due to leaching of nutrients.

Figure 5 shows the yearly average pH of water samples with exceeded threshold values for five years (2005 - 2010). The highest portion is in the following local water distribution systems: Dolgo Brdo, Janče Gaberje, Javor Žagarski vrh Vnajnarje, and Vnajnarje - Zabukovje. 100 % share of poor quality samples (of pH) were found in the following local water distribution systems: Vnajnarje Smrečje in 2007, Vnajnarje - Zabukovje in 2005 and Dolgo Brdo in 2010. More than 50 % proportion of inferior quality samples was found in the following local water distribution systems: Dolgo Brdo (In 2005, 2006, 2007, 2008 and 2010. In 2009 there were no samples outside the limits) and Vnajnarje - Smrečje (In 2005, 2007, 2008, 2009. In 2006 and 2010 there were no samples outside the limits.)

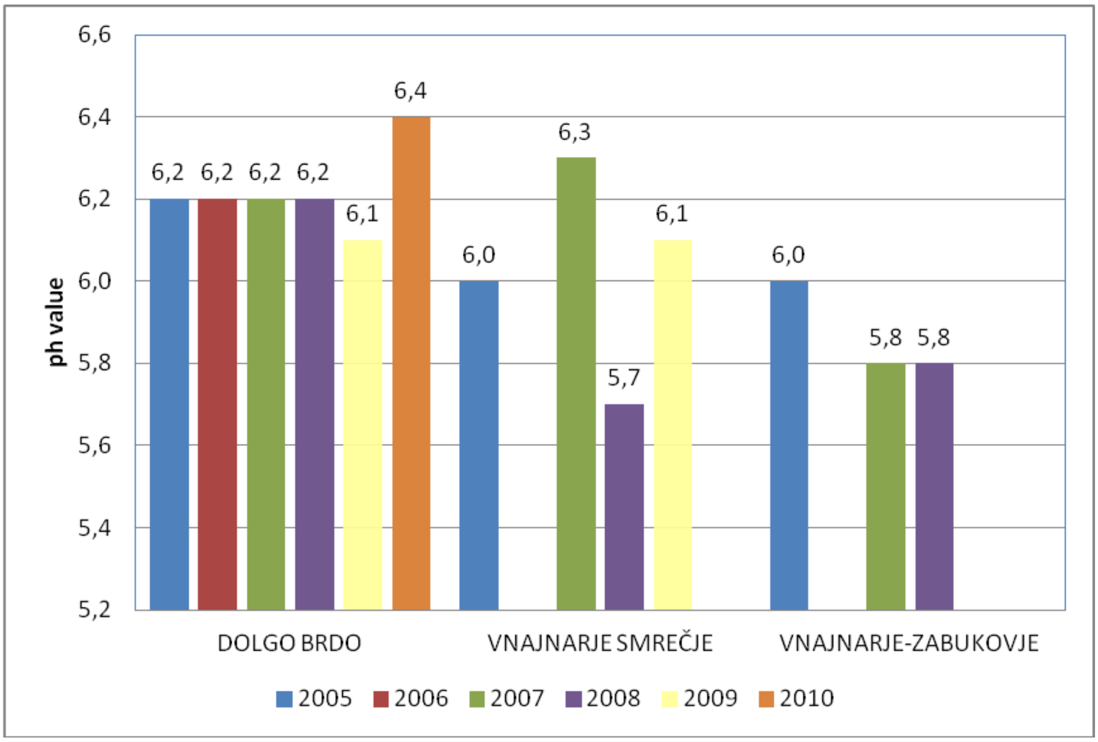


Figure 5: *pH values for individual local water distribution systems (based on all samples with exceeded value included in the 2005 – 2010 period).*

3.3.2 The resultes of chemical parameters

Basic regular chemical analyses of drinking water include the following parameters: TOC, ammonium, nitrite and occasional investigations nitrate. Detailed chemical analyses include general physical parameters and chemical parameters (smell, taste, colour, conductivity, pH, nitrate, etc...), metals and non - metals (aluminium, boron, manganese, iron, mercury, etc.), pesticides and metabolites (atrazine, desethylatrazine, etc...), polycyclic aromatic hydrocarbons (benzo (b) fluoranthene, etc...), trihalomethanes (trichloromethane, etc...), volatile halogenated aliphatic hydrocarbons (1, 1, 2-trichloroethene, etc...) and volatile aromatic hydrocarbons (benzene, etc.).

Under guidelines for public water supplies set by the Environmental Protection Agency (EPA), iron and mangenese are considered secondary contaminants. *[69]*

Iron and manganese may be present in the water supply or caused by corroding pipes (iron or steel). Iron from pipe corrosion indicates low pH that may need to be corrected. *[70]*

Soluble metals such as iron (Fe) and manganese (Mn) often reach problematic levels in water - captures during summer stratification following the onset of hypolimnetic hypoxia *[71]*

Threshold values for the parameters in this study are: Manganese 50 μg/L, Iron 200 μg/L, Desethyl atrazine 0,10 μg/L.

Other parameters in this study were recorded in the five year period. Only the exceeded values of the following parameters in local water distribution system are shown:

- The taste was unacceptable: twice in Janče Gabrje, Janče planinski dom, Dolgo brdo in 2008.
- MAX. exceeded threshold values for Desethylatrazine: Podmolnik (0,12 μg/L in 2005).
- MAX. exceeded threshold values for Manganese: captures Janče planinski dom, 15.4. 2008 (3375 μg/l)

For the five year period only those parameters and samples, which had exceeded values, while all the rest of the data is not included in the analysis.

3.3.3 The resultes of microbiological analysis

3.3.3.1 Analysis of the statistical results for selected parameters

Table 8 shows statistical results for the local water distribution system; depending on the outstanding excess values the following paragraphs indicate peak maximum, minimum and average values as well as trends of all examined samples with excess limit value. The calculation arises for the period of five years (2005 - 2010).

MAX. excess limit value for ***Enterococcus*** is (100/100 ml), found in the local water distribution system Volavlje. The highest TREND for ***Enterococcuses*** is (4,2) in the local water distribution system Bajdovna. The highest AVERAGE VALUE for ***Enterococcuses*** (4,7/100 ml) was found in the local water distribution system Volavlje.

MAX. excess limit value for ***E. coli*** is (100 /100 ml), found in the local water distribution system Dolgo Brdo, Besnica Šola,Vnajnarje Korito, Janče Gabrje, Besnica vas, Bajdovna, Besnica Šola, Javor Žagarski Vrh. The highest TREND for ***E. coli*** is (20,9), found in the local water distribution system Dolgo Brdo. The highest AVERAGE VALUE for ***E. coli*** is (35,6/100 ml) found in the local water distribution system Prežganje M. in V. Trebeljevo.

MAX. excess limit value for ***Colif. Bacteria*** is (200,5 /100 ml) and was found in the local water distribution sytem Tuji Grm, the highest TREND for ***Colif. Bacteria*** (61,3) was found in the local water distribution system Vnajnarje Korito. The highest AVERAGE VALUE for ***Colif. bacteria*** is (66,6/100 ml), and was found in the local water distribution system Prežganje M. in V. Trebeljevo.

MAX excess limit value for ***Colonies at 36°*** is (300/100ml), found in the local water distribution system Sostro barake, Podmolnik, Rašica, Prežganje M. and V. Trebeljevo, Javor Žagarski vrh, Javor Vrh, Dolgo Brdo, Dolgo Brdo, Volavlje. The highest TREND for ***Colonies at 37°*** is (116,17) and was found in the local water distribution system in Volavlje, the highest AVERAGE VALUE for ***Colonies at 36°*** is (173,3/100ml) found in the local water distribution system Prežganje Malo and Veliko Trebeljevo.

MAX excess **pH** value is (10,4 / 100 ml) found in the local water distribution system Janče Planinski dom. The highest **pH** TREND: (7,6) is found in the local water distribution system Janče planinski dom. The highest AVERAGE VALUE of **pH** (3,6 /100ml) is found in the local water distribution system Janče Planinski dom.

Table 8: *The statistics covered for microbiological parameters in* the period *from* 2005 to 2010

Local water distribution sistem	Statistics	Enterococci	E. coli	Colifom. bacterias	Colonies at 22C°	Colonies at 36C°
BAJDOVNA	Min	0,0	0,0	0,0	0,0	0,0
	max	32,0	35,0	100,0	0,0	120,0
	trend	3,4	7,0	54,8	0,0	10,9
	Average	3,1	3,8	33,8	0,0	3,8
BESNICA ŠOLA	Min	0,0	5,0	5,0	0,0	16,6
	Max	39,0	100,0	100,0	0,0	180,0

Local water distribution sistem	Statistics	Enterococci	E. coli	Colifom. bacterias	Colonies at 22C°	Colonies at 36C°
	Trend	-0,7	1,4	15,6	0,0	11,5
	Average	1,2	12,3	31,1	0,0	8,8
BESNICA VAS	Min	0,0	0,0	1,0	0,0	0,0
	Max	1,0	100,0	100,0	0,0	101,0
	Trend	0,0	4,1	37,4	0,0	0,1
	average	0,0	11,8	30,5	0,0	2,7
BREZJE PRI LIPOGLAVU	Min	0,0	0,0	0,0	0,0	0,0
	Max	0,0	1,0	7,0	0,0	200,0
	Trend	0,0	-0,2	4,3	0,0	-16,7
	average	0,0	0,1	2,0	0,0	25,0
ČEŠNJICE ZAGRADIŠČE	Min	0,0	1,0	0,1	0,0	0,0
	Max	0,0	50,4	82,0	0,0	300,0
	Trend	0,0	4,8	10,6	0,0	11,5
	average	0,0	2,1	17,7	0,0	12,2
DOLGO BRDO	Min	5,0	0,1	0,1	0,0	120,0
	Max	58,0	100,0	100,0	0,0	300,0
	Trend	2,13	30,9	57,7	0,0	43
	average	1,0	15,6	32,2	0,0	23,8
JANČE GABERJE	Min	0,0	2,0	1,1	0,0	0,0
	Max	0,0	28,0	100,0	0,0	159,0
	Trend	0,0	1,9	25,7	0,0	4,4
	average	0,0	1,6	15,9	0,0	5,5
JANČE PLANINSKI DOM	Min	0,0	0,0	0,1	0,0	0,0
	Max	0,0	5,0	16,0	0,0	120,0
	Trend	0,0	-0,7	-2,2	0,0	27,4
	average	0,0	0,6	2,0	0,0	7,5
JAVOR - NOVI – VAS	Min	0,0	0.0	0,5	0,0	0,0
	Max	1,0	0,0	30,0	0,0	0,0
	Trend	0,4	0,0	6,4	0,0	0,0
	average	0,0	0,0	4,6	0,0	0,0
JAVOR-VRH	Min	0,0	0,5	0,1	0,0	0,0
	Max	48,0	20,0	65,0	0,0	300,0
	Trend	4,1	-0,1	4,8	0,0	9,1
	average	1,1	1,1	13,0	0,0	30,2
JAVOR ŽAGARSKI VRH	Min	0,0	0,1	0,1	0,0	140,0
	Max	2,0	100,0	100,0	0,0	300,0
	Trend	0,0	5,3	44,1	0,0	7,5
	average	0,0	4,8	21,1	0,0	8,3
PODLIPOGLAV	Min	0,0	1,0	0,1	0,0	0,0
	Max	0,0	8,0	30,0	0.0	0,0
	Trend	0,0	0,8	6,3	0.0	0,0
	average	0,0	0,6	5,7	0,0	0,0
PODMOLNIK	Min	1,0	0,1	0,0	0,0	121,0

Local water distribution sistem	Statistics	Enterococci	E. coli	Colifom. bacterias	Colonies at 22C°	Colonies at 36C°
	max	26,0	49,0	100,0	0,0	300,0
	trend	0,5	0,5	23,7	0,0	49,0
	average	0,6	3,5	23,8	0,0	34,4
PREŽGANJE - MALO TREBELJEVO	Min	0,0	32,0	0,0	0,0	220,0
	max	0,0	75,0	100,0	0,0	300,0
	trend	0,0	51,0	16,7	0,0	28,3
	average	0,0	35,7	66,7	0,0	173,3
RAŠICA	Min	0,0	1,0	1,0	0,0	240,0
	max	0,0	22,0	80,0	0,0	300,0
	trend	0,0	1,0	16,6	0,0	84,5
	average	0,0	4,5	17,0	0,0	49,1
SADINJA VAS	Min	0,0	0,1	0,1	0,0	16,0
	max	0,0	1,0	3,0	0,0	103,0
	trend	0,0	0,1	1,1	0,0	-3,1
	average	0,0	0,1	1,5	0,0	9,2
SOSTRO BARAKE	Min	0,0	1,0	0,1	0,0	157,0
	max	0,0	12,0	100,0	0,0	300,0
	trend	0,0	0,4	9,2	0,0	18,5
	average	0,0	0,7	11,7	0,0	24,6
ŠENTPAVEL	Min	0,0	1,0	0,1	0,0	0,0
	max	0,0	37,0	100,0	0,0	0,0
	trend	0,0	5,3	21,8	0,0	0,0
	average	0,0	3,9	17,2	0,0	0,0
TOMAJEV STUDENEC	Min	0,0	0,0	2,2	0,0	0,0
	max	0,0	0,0	5,1	0,0	0,0
	trend	0,0	0,0	5,1	0,0	0,0
	average	0,0	0,0	3,7	0,0	0,0
TUJI GRM	Min	0,0	0,1	0,1	0,0	0,0
	max	7,0	28,0	200,5	0,0	300,0
	trend	0,2	1,9	14,3	0,0	42,9
	average	0,1	1,9	24,4	0,0	18,8
VELIKO TERBELJEVO	Min	0,0	0,0	5,1	0,0	0,0
	max	0,0	16,0	16,0	0,0	0,0
	trend	0,0	9,0	13,2	0,0	0,0
	average	0,0	11,3	15,2	0,0	0,0
VNAJNARJE KORITO	Min	2,0	0,1	1,0	0,0	112,0
	max	19,0	100,0	100,0	0,0	224,0
	trend	1,0	5,9	61,3	0,0	4,2
	average	0,5	11,9	41,9	0,0	7,9
VNAJNARJE SMREČJE	Min	0,0	2,2	0,1	0,0	160,0
	max	0,0	50,0	100,0	0,0	240,0
	trend	0,0	-3,2	-5,9	0,0	60,9
	average	0,0	4,5	11,3	0,0	29,7

Local water distribution sistem	Statistics	Enterococci	E. coli	Colifom. bacterias	Colonies at 22C°	Colonies at 36C°
VNAJNARJE ZABUKOVJE	Min	0,0	0,1	0,1	0,0	0,0
	Max	0,0	2,2	47,0	0,0	0,0
	Trend	0,0	0,1	28,9	0,0	0,0
	average	0,0	0,2	13,7	0,0	0,0
VOLAVLJE	Min	87,0	1,0	1,0	0,0	118,0
	Max	100,0	100,0	100,0	0,0	300,0
	Trend	7,1	14,2	37,9	0,0	116,2
	average	4,5	10,9	27,9	0,0	45,1
ZGORNJA BESNICA	Min	0,0	0,1	0,1	0,0	0,0
	Max	1,0	29,0	59,0	0,0	0,0
	Trend	0,0	-0,2	12,0	0,0	0,0
	average	0,2	1,3	11,7	0,0	0,0

**Note: there are no inconsistent data*

Microbiological parameters include the origin of faecal bacteria: Escherichia coli, Enterococci, Clostridium perfringens (including spores) and indicator bacteria (Coliform bacteria counts at 22 °C, the number of Colonies at 37 °C). The maximum value for E. coli, Enterococci, Clostridium perfingens coliform is 0 (unit /100 mL). The limits of colonies at 22 °C and number of colonies at 37 °C are less than 100 pro mL.

On the basis of an internal control system HACCAP *[10,11]* in the period of five years (2005 - 2010) on average 352 samples per year were taken for microbiological testing by the laboratory of the Institute of Public Health of Ljubljana (ZZV Ljubljana). Annual reports only include the total number of samples with exceeding parameters and the total number of the faecal bacteria origin.

The maximum exceeded threshold values in the period from 2005 to 2010 for the local water distribution system parameters:

Clostridium perfingens: Dolgo Brdo (3/100 mL), Prežganje and Trebeljevo (11/100 mL), Sadinja Vas (1/100 mL), Vnajnarje (3/100 mL), Volavlje (34/100 mL).

The taste was unacceptable: (Janče Gabrje year 2008, Janče planinski dom, year 2008)

Desethyl - atrazine: Podmolnik (0,12 μg/l, year 2005)

Manganese: Vrtina pri Jančah (500 - 1100 µg/l, year 2007), Janče planinski dom (375 - 1525 µg/l, year 2008),

Figure 6 shows the portion (in %) of water samples with the presence of faecal bacteria for a local water distribution system in the period from 2005 to 2010. Water supplies Volavlje, Dolgo Brdo and Vnajnarje Korito have the higest percentage of bacteria. In 2008 in Dolgo brdo all samples contained faecal bacteria. The latter were present in 60 % of samples in 2006 in Volavlje and in 70 % or more samples in 2007 and 2009 in Vnajnarje Korito.

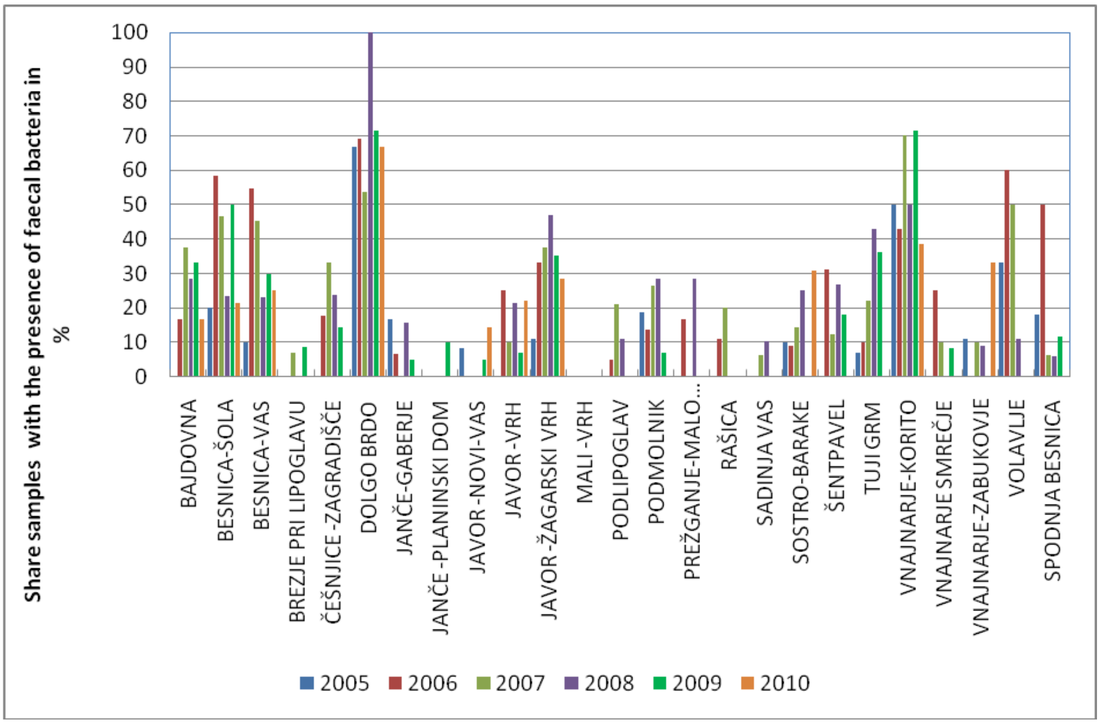


Figure 6: *The portion (in %) of water samples with the presence of faecal bacteria for the local water distribution system in the period from 2005 to - 2010.*

The obtained results show the relationship between the content of bacteria and amount of rainfall for the most critical local water distribution systems: Besnica vas, Dolgo Brdo and Vnajnarje Korito.Data presented. In ***Figure 6*** data were taken and calculated from monthly and annual reports of the Institute of Public health. The data indicate the period on which the samples contained minimal faecal bacteria. Figure 6 contains monthly data on precipitation over the 10 year period covered in the reports from rainfall figures compiled in the nearest meterological station at Dobrunje *[73]*

3.3.3.2 Comparison of precipitation and the presence of bacteria for three critical local captures

In the following paragraphs there are presented three local water distribution systems (Vnajnarje Korito, Besnica Vas, Dolgo Brdo), which proved to be the most outstanding according to data analysis on the maximum excess levels of faecal bacteria. The reason for the increased number of faecal bacteria in samples is attributed to the position of individual captures, age of buildings and external factors (rain, the road above the capture, permeable septic tanks nearby and agricultural activity).

Figure 7 shows the comparison between the amount of bacteria (E. coli and Coliform bacteria) depending on rainfall. The largest increase in Coliform bacteria for the local water distribution system Vnajnarje Korito is evident for the periods May - October 2007 as well as in February, June and September 2008. An increase in E. coli in this waterworks can be seen in May 2007. The highest amount of rainfall was observed in the region in July 2005, August 2006 and December 2008. The graph below shows that it is not possible to find a correlation between the occurrence of the number of bacteria and the increased rainfall, because of the half yearly data and because bacteria usually occurs only in heavy rain (short term).

In this case, it is necessary to look for the reason for the increase in faecal bacteria mainly in the spillage of septic tanks or manure from nearby farms.

On the basis of an examination of the terrain, the survey and examination of reports it was established that there are other prevailing factors present (poor construction of the captures, fertilizing meadows, seepage from septic tanks, slope of the terrain).

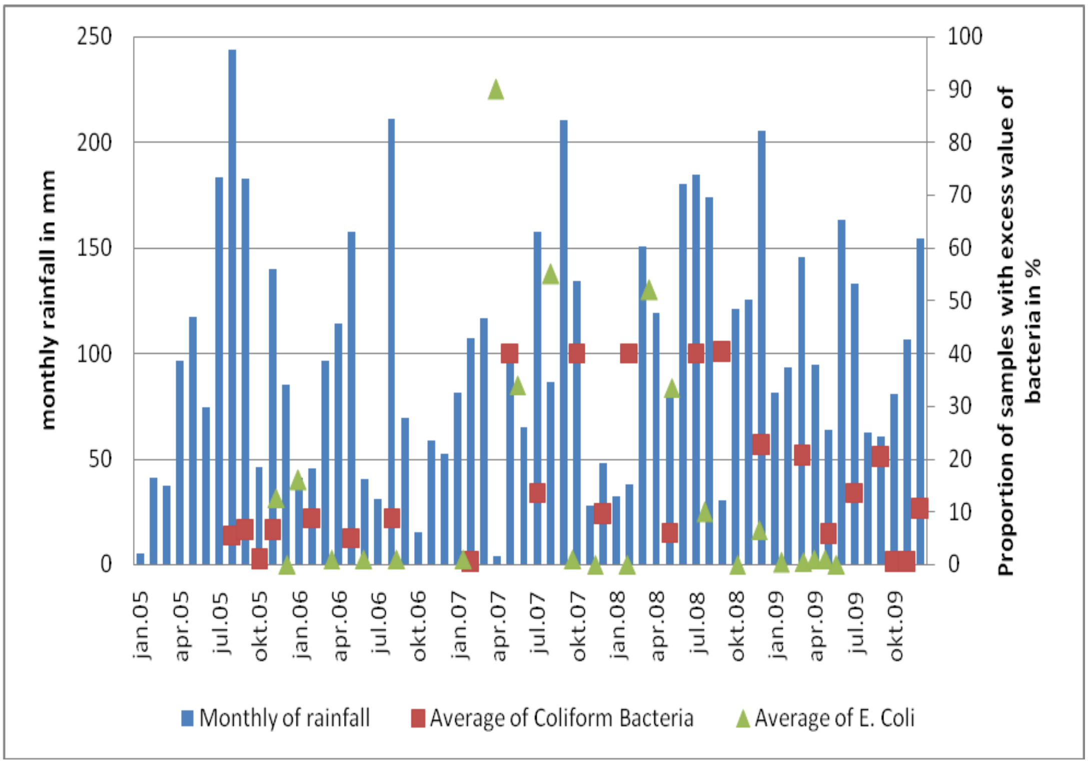


Figure 7: *Share of samples with excess value of bacteria in % and monthly amount of rainfall for the local water distribution system Vnajnarje Korito*

Based on the above data the year 2007 is exposed and **Figure 8** demonstrates the trends of faecal bacterial in relation to daily rainfall in 2007. The reason for the occurrence of faecal bacteria should be found to the geological situation (soil composition: Carboniferous - Permian (C,P) sandstone with rare layers of slate clay stone), contaminates with percolation rainfall, septic tanks and agricultural activity.

Immediate hinterland of captures covers the forest; there are meadows, an orchard and fields in the hinterland, which pose a great threat to underground water flowing towards the capture due to fertilization and pesticides.

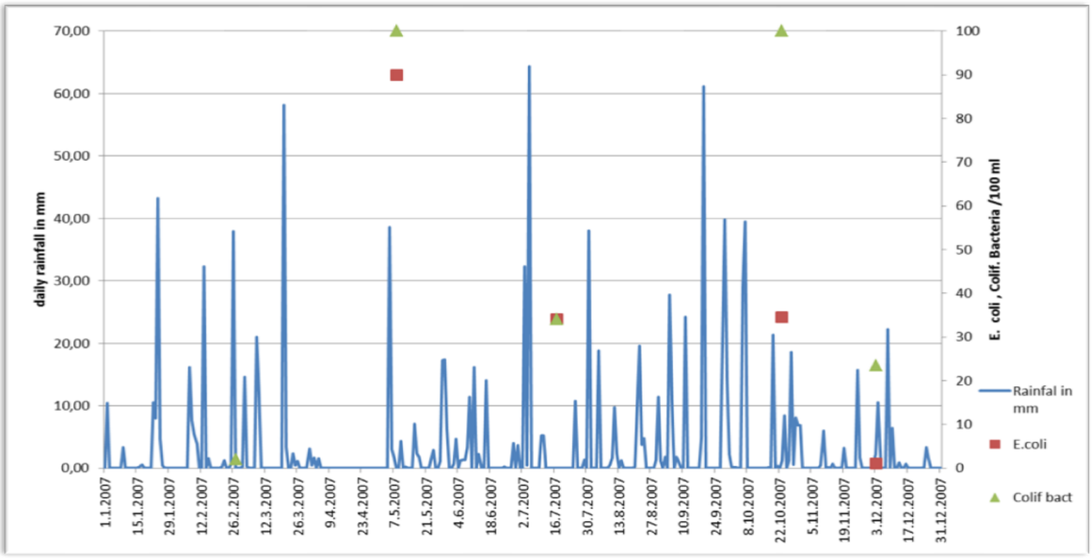


Figure 8: *Faecal bacteria according to the daily occurrence of rainfall 2007 in Vnajnarje Korito capture.*

Highest concentration of water samples with excess value of bacteria in the local water distribution system Besnica vas ***[Figure 9]*** in August - September 2006 (100 %) and October 2007 (66 % and 100 %). E. Coli and Coliform bacteria are presented. Increase of faecal bacteria (in Summer and Autumn) was reflected in the period of drought or in the period of increased rainfall in Autumn. The climatic factor is the main reason for the increased level of pollution for the Besnica vas local water distribution system. Minor upward trend is observed in Coliform bacteria and a downward trend in E. coli.

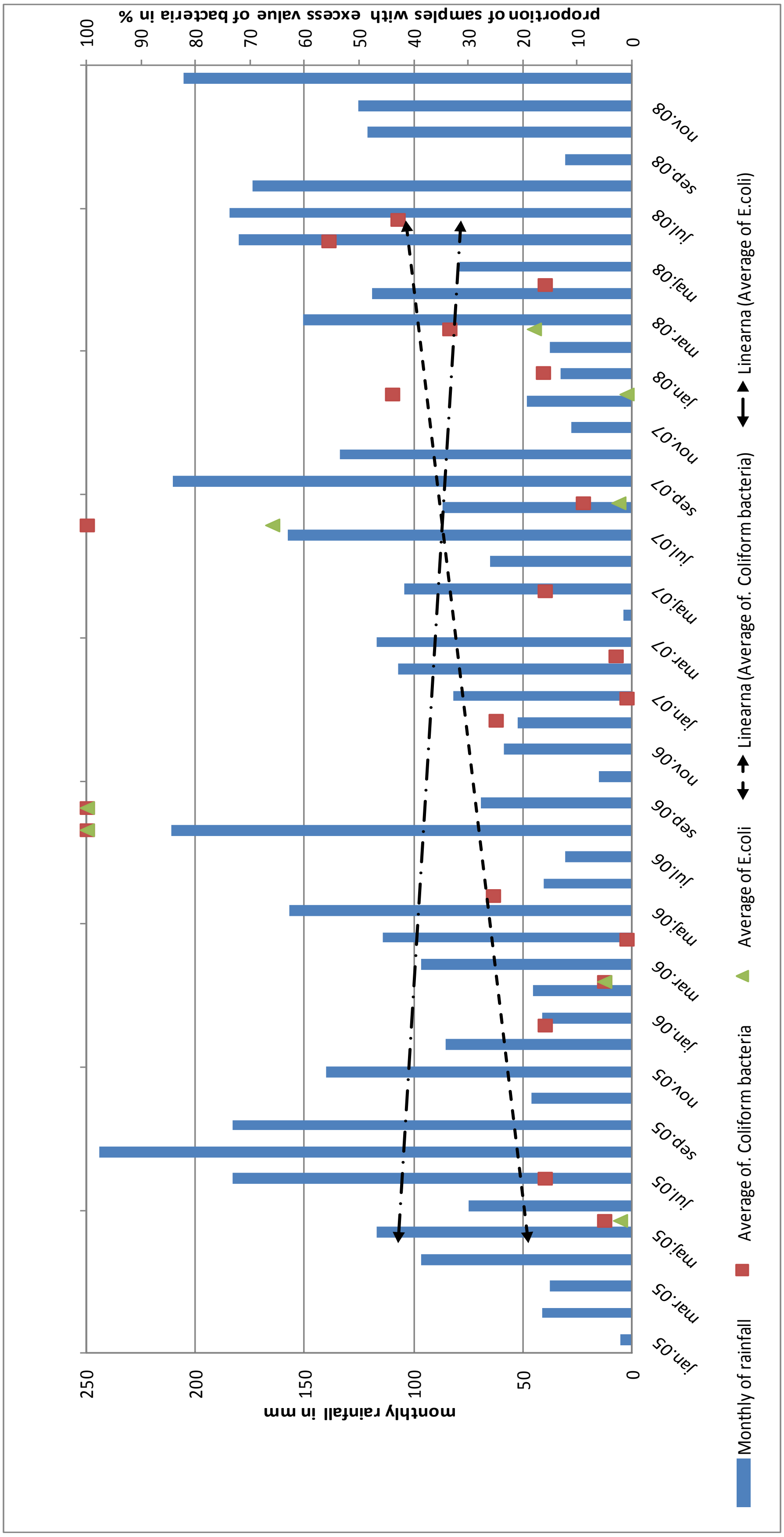


Figure 9: *Share of samples with excess value of bacteria in % and monthly amount of rainfall for the Besnica vas water distribution system*

The **Figure 10** shows that faecal bacteria occur in almost 6 months throughout the year. The reason for this may be found in pollution in the slope, which soil composition contains Carboniferious - Permian (C,P) sandstone and conglomerate. Groundwater is fed by infiltration of rain. During heavy rain period groundwater gets closer to surfaces, which allows for rapid infiltration of contaminated rain water to groundwater that flows into capture, when raining.

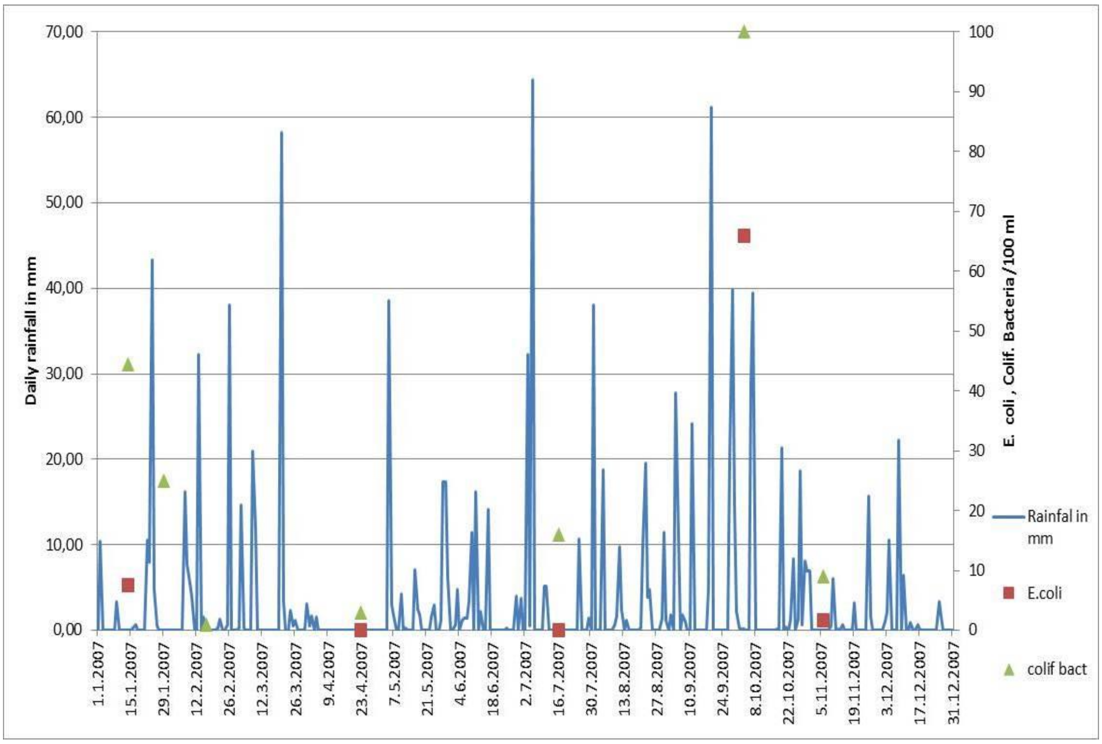


Figure 10: *Faecal bacteria in 2007 according to the daily occurrence of rain for the Besnica Vas capture*.

Figure 11 shows that the highest percentage of samples with faecal bacteria in the Dolgo brdo water distribution system (80 % and more) during the period from January 2007 to December 2009 (Coliform bacteria) and for E. coli in the period from July 2007 to November 2009. Given the rainfall patterns for the period from July to October 200, rainfall can be a reason for the microbiological pollution. In 2010 there was no excess value of bacteria. Due to subject value it is not possible to show the trend line.

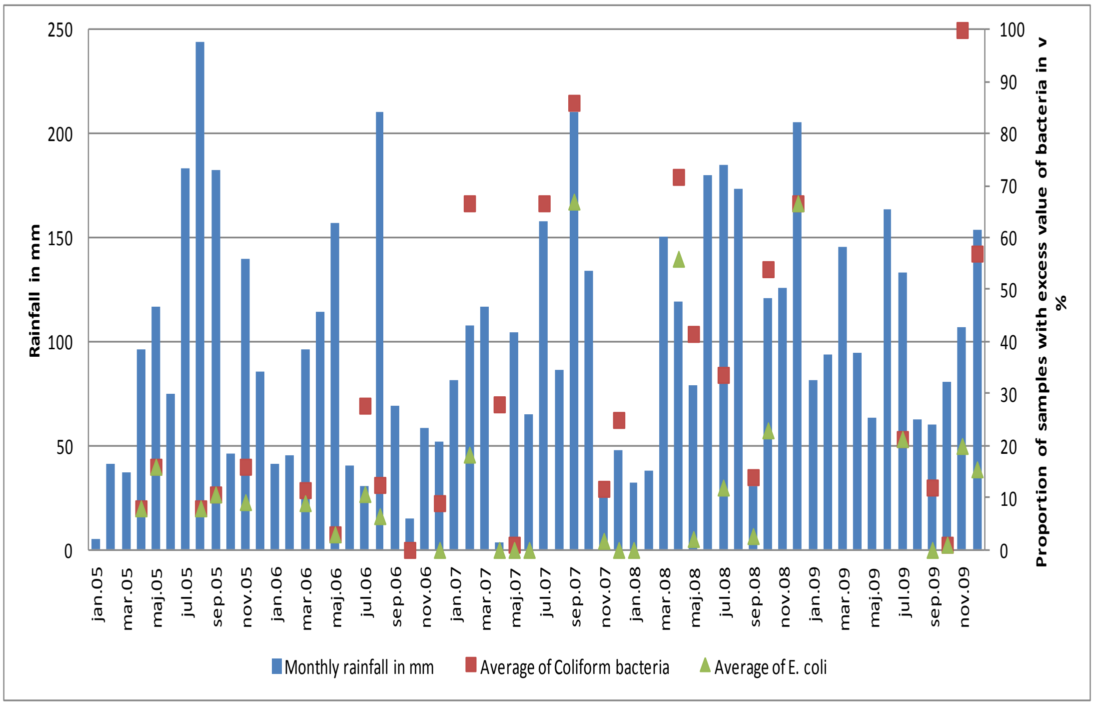


Figure 11: *Share of samples with excess value of bacteria in % and monthly amount of rainfall for the water distribution system of the Dolgo Brdo*

Data source on monthly and annual rainfall was the Meteorological Data Archive ARSO at the Meteorology Office of the Slovenian Environment Agency. Accuracy and quality of the data conforms to the recommendations of the World Meteorological Organization.

The nearest meteorological station for the addressed areas is Ljubljana - Dobrunje. *[73]*

Faecal bacteria per daily occurrence of rain in 2007 for Dolgo Brdo capture in ***Figure 12*** shows the continuous occurrence of fecal bacteria throughout the year. The reason could be due to percolation of rainfall into the groundwater and spillage of fecal waters from septic tanks – from a nearby farm.

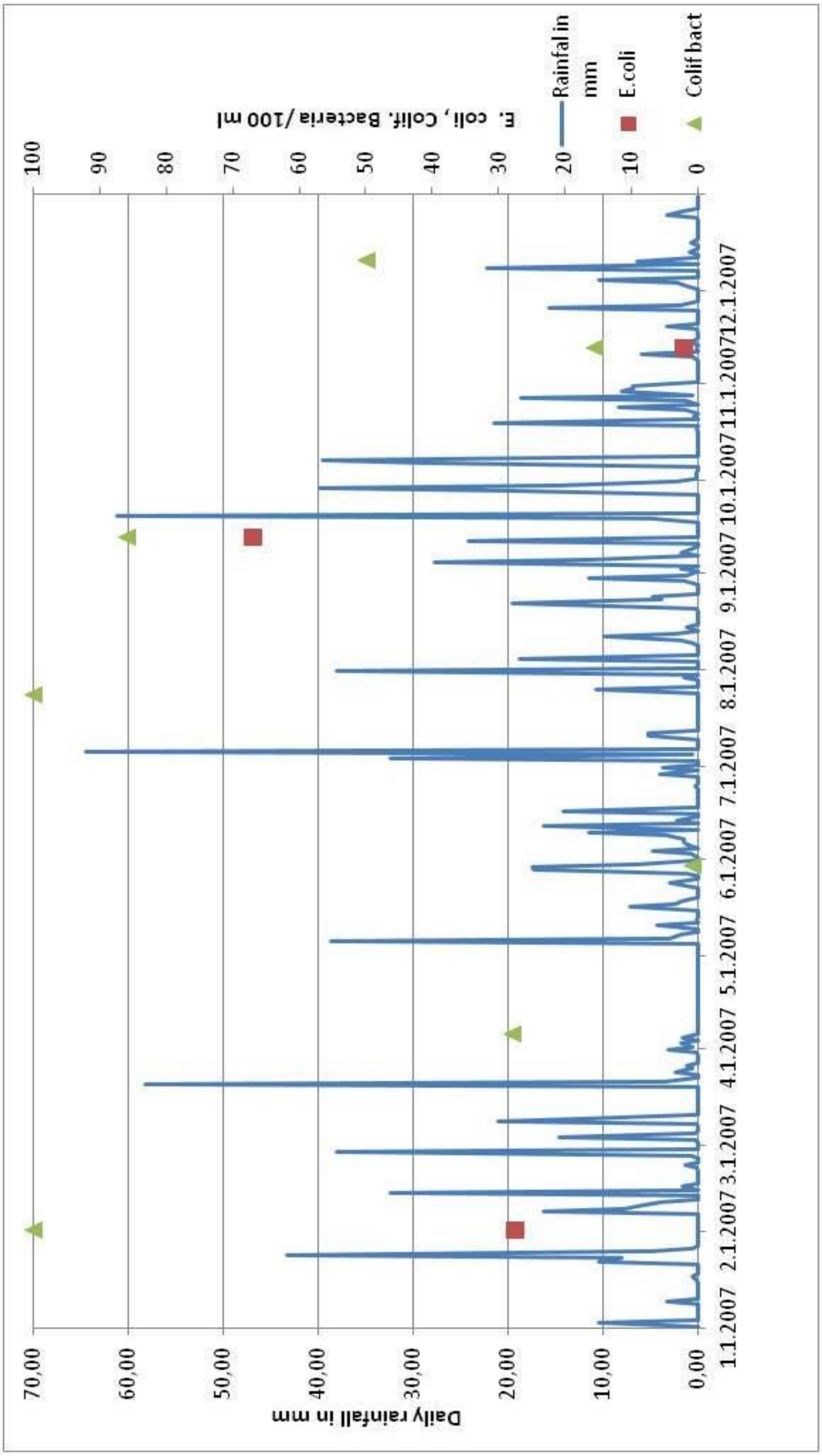


Figure 12: *Faecal bacteria according to the daily occurrence of rain in 2007 for Dolgo Brdo Capture*

Example of drought and microbiological parameters in Spring 2012

In 2012 we included a three - month period for all excess limit values of parameters. There was practically no rain in March; the highest proportion of excess parameters arose in May 2012.

Rainfall data were taken from the meteorological station Dobrunje *[72]*, where the data on daily rainfall show that we recorded only four rainy days in March. According to the information below, it is evident that most samples with an excess limit value (Coliform bacteria and Colonies at 37°) occurred in May and not during drought period. ***[Table 9]***

In March *2012* we found the largest excess value of Colonies at 22° and Colonies at 37 ° (300 unit /ml) in the Bajdovna local distribution system.

In April *2012*, the largest excess value for Colony at 37° (300 units /ml) was found in the Češnjica Janče local distribution system.

In May *2012*, the largest proportion of excess limit values for Enterococci (100µg/ l) was found in the Brezje pri Lipoglavu local distribution system and (84µg/ l) in the Vnajnarje korito local distribution system. The largest proportion of excess limit values for E. coli (53µg/ l) was found in the Brezje pri Lipoglavu local distribution system and (16 µg/ l) was found in the Besnica local distribution system. The largest proportion of excess limit values for Coliform bacteria (100 / l00ml) may be found in Brezje pri Lipoglavu and (200 / l00ml) in Vnajnarje Korito. Excess limit value pH (6,4) was found in the Dolgo Brdo local distribution system.

Table 9 below indicates that the highest proportion of excess limit values occurred in May.

Table 9: *Excess levels in spring period 2012*

Local water distribution sistem	Sampling site		Date	Enterococi	E. coli	Colif. bacteria	Colonies at pri 22°C	Colonies at 37°C	
Bajdovna	Bajdovna - rezervoar	March 2012	29.3.2012				300	300	
Češnjice	Vodovod Češnjice Zagradišče		9.3.2012			4			
Češnjice	Vodohram češnjice		9.3.2012			2			
Žagarski vrh	Dom radioamaterjev žag - vrh		28.3.2012	5		9			
Vnajnarje korito	Vnajnarje15		29.3.2012			1			
Local water distribution sistem	**Sampling site**		**Date**	**Enterococi**	**E. coli**	**Colif. bacteria**	**Colonies at 22°C**	**Colonies at 37°C**	
Besnica	Besnica šola	April 2012	26.4.2012			3			
Češnjice	Češnjice 5		25.4.2012					300	
Janče	OŠ Janče Gabrje		25.4.2012					300	
Vnajnarje	Vnajnarje 17		23.4.2012			1			
Vnajnarje	Vnajnarje 8		23.4.2012			1			
Local water distribution sistem	**Sampling site**		**Date**	**Enterococi**	**E. coli**	**Colif. bacteria**	**Colonies at 22°C**	**Colonies at 37°C**	**pH**
Besnica	Besnica šola omrežje	May 2012	15.5.2012	33	16	5			
Brezje pri lipoglavu	Zajetje		15.5.2012	100	53	200			
Zagradišče	Zagradišče 6		15.5.2012			6			
Besnica	Besnica 9b		18.5.2012	9	1	1			
Bajdovna	Vodovod B		18.5.2012			17			
Vnajnarje korito	Vodovod Vnajnarje 14		18.5.2012	84	10	100			
Besnica vas	Besnica 12		21.5.2012	3	1	34			
Dolgo brdo	Dolgo brdo 10		22.5.2012	8	3	66			6,4
Janče gabrje	OŠ Janče gabrje		22.5.2012					240	
Janče gabrje	Gabrje 1		22.5.2012					300	
Žagarski vrh	Dom radioamaterjev žagarski vrh		22.5.2012			3		180	
Tuji grm	Tuji grm 9		22.5.2012					300	

The data above presents critical captures (Vnajnarje, Dolgo Brdo, Besnica vas) in the form of the three graphs below ***[Figure 13],*** which clearly shows the increased rainfall in May and the resulting steady growth of bacteria (E. Coli in Colif. Bact) for all three captures.

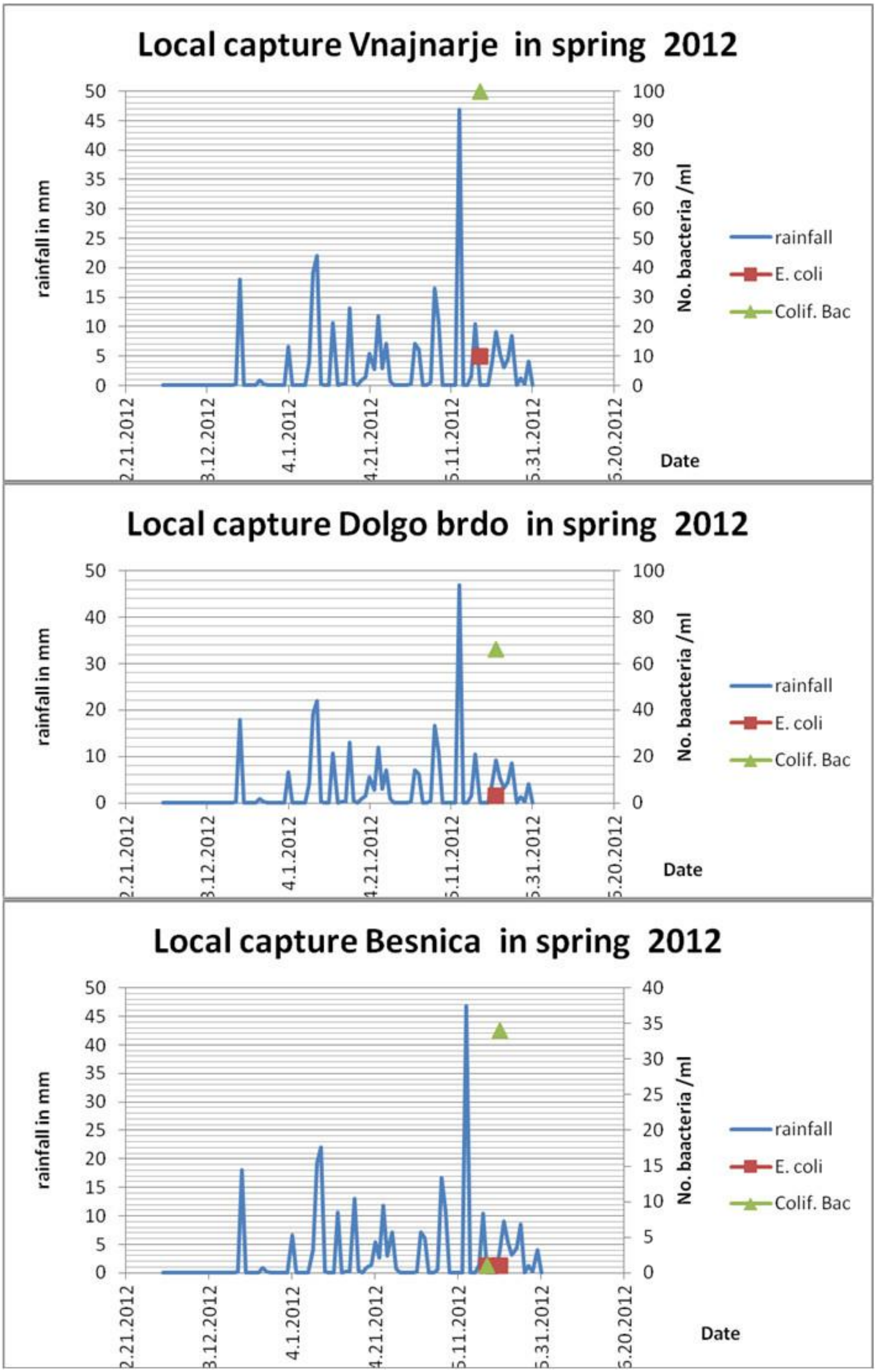


Figure 13: *Three (3) critical local captures in Spring 2012*

3.4 Water quality of local captures management of J.P. VO - KA and comparison with captures managed by MOL

Internal control over the drinking water compliance in the local water supply systems with captures, managed by the J.P.VO-KA is carried out in accordance with the provisions of Rules on Drinking Water (Official Gazette of RS 19/04, 35/04, 26/06, 92/06, 25/09).

Three (3) Local water distribution systems (with captures), managed by J.P. VO - KA in the Municipality of Ljubljana *[Table 4]* are:

- Lipoglav
- Prežganje
- Mali vrh pri Prežganju

Reviewed reports from J.P. VO - KA on sampling and field measurement and reports on tests of physical and chemical parameters by the Institute of Public Health of Maribor (2005 - 2010) *[31]* show that samples from water distribution systems in the period from 2005 to 2010 comply with the applicable legislation.This means that no parameters exceeded the limit value, therefore these captures are not present in the data base, which was set for the purpose of this master thesis and consists only of exceeded values of parameters.

4 ANALYSIS OF INTERVIEWING CAPTURE ADMINISTRATORS

In collaboration with the administrators 34 captures were successfully examined in the form of an interview survey; for seven (7) captures there were no useful information, because they had been connected to other municipalities or are not present in databases. Six (6) local water capture are operated by the J.P VO - KA and 34 are operated by Municipality of Ljubljana. 85 % of all captures in MOL area were successfully examined.

Therefore, a review of individual local captures was performed in order to obtain data on the number of people receiving supply or water consumers, covering an inventory of facilities, the maintenance of these facilities and a description of the constructed distribution network including water connections. The survey took place over the period from Spring to Autumn 2010. A Questionnaire was prepared for the local managers of captures and the results of surveying reflect their statements. Data are displayed regarding estimated risk, which is in the range from one to five or ten, from lowest to the highest values.

Figure 14 shows threats to water sources from one to ten. It can be seen that 18 % of water supplies are identified as having the highest risk on the scale and only 2 % are the least threatened. These survey responses have given administrators captures. As the highest risk were mainly attributed to external factors (location of capture, nearby roads, farms, waste)

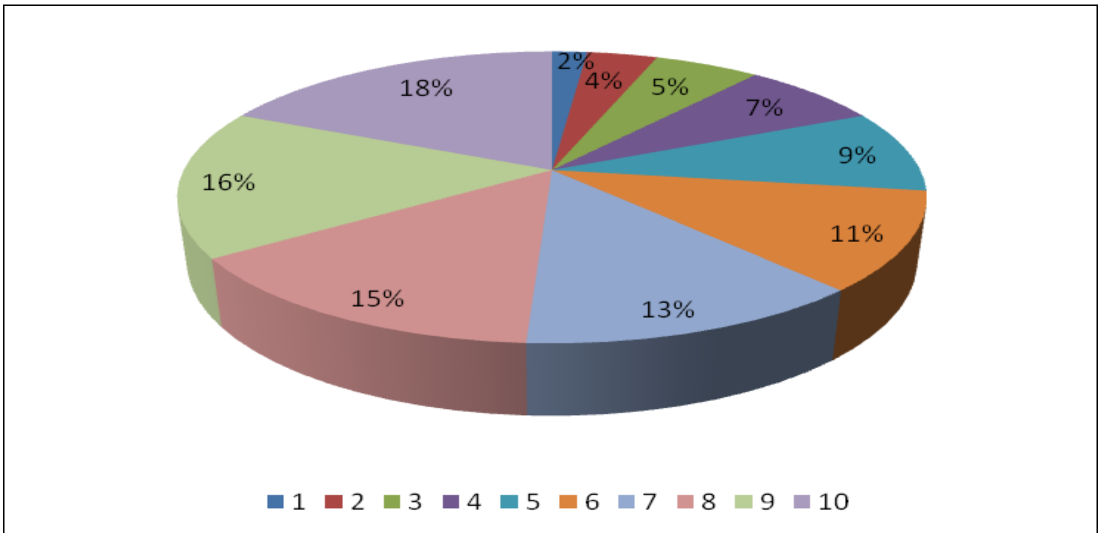


Figure 14: *Threats to water sources (Legend: 1 ... lowest risk* **,** *10* **...** *highest risk).*

Figure 15 shows no detected presence of illegal activities in recharge areas affecting the environment in most captures (85 %). An 11 % share is represented by catchments areas, where there is an illegal building (or a built facility located in the immediate vicinity of the inner water protection zone) in the close vicinity. The issue of illegal construction in the immediate vicinity of the capture is the issue of legality of proceedings at the local and state level.

In reviewing the ground I noticed two illegal installation housing facility about 10 - 50 m from the fence which is placed capture). Both captures had septic tanks.

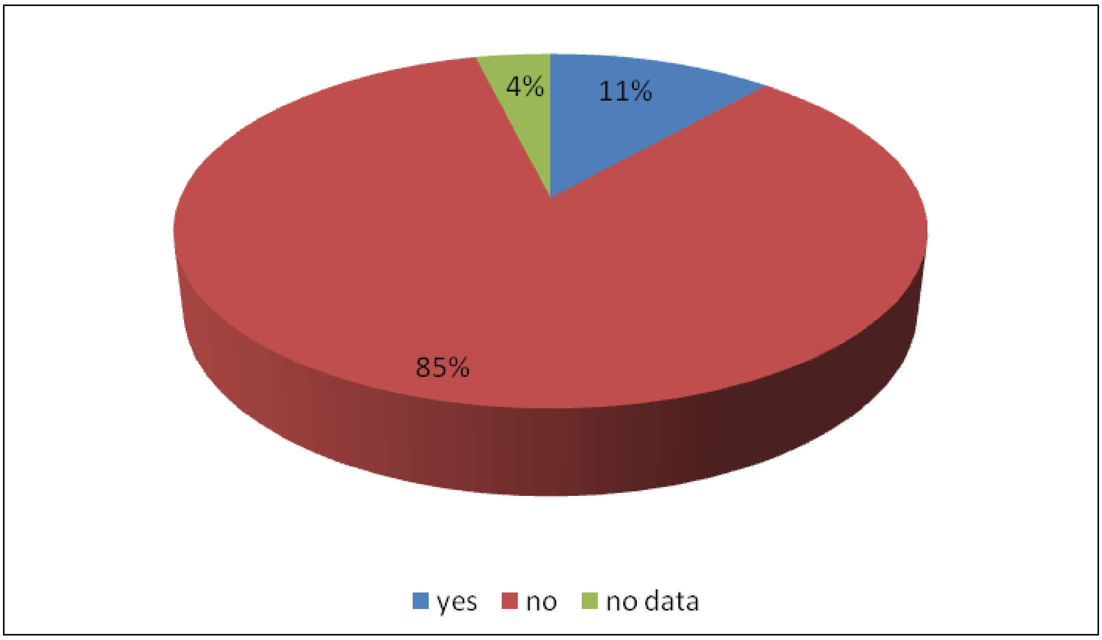


Figure 15: *Presence of illegal construction in the vicinity of the captures.*

During the interview, municipal waste (plastic, furniture parts and pieces of iron) was observed in the area of three captures. During the field survey and interviewing suppliers in the environment around capture there was no evidence of pollution by sewage and other waste.

According to interviews and the actual state of captures, I think municipal waste is not one of the main causes of water pollution in the capture. The main reason should be sought in rainfall, fertilization and fecal waters).

The **Figure 16** shows that 77 % of the surveyed capture managers said that also municipal wastes (e.g. household appliances tyres, furniture, and plastic waste) were observed near their captures.

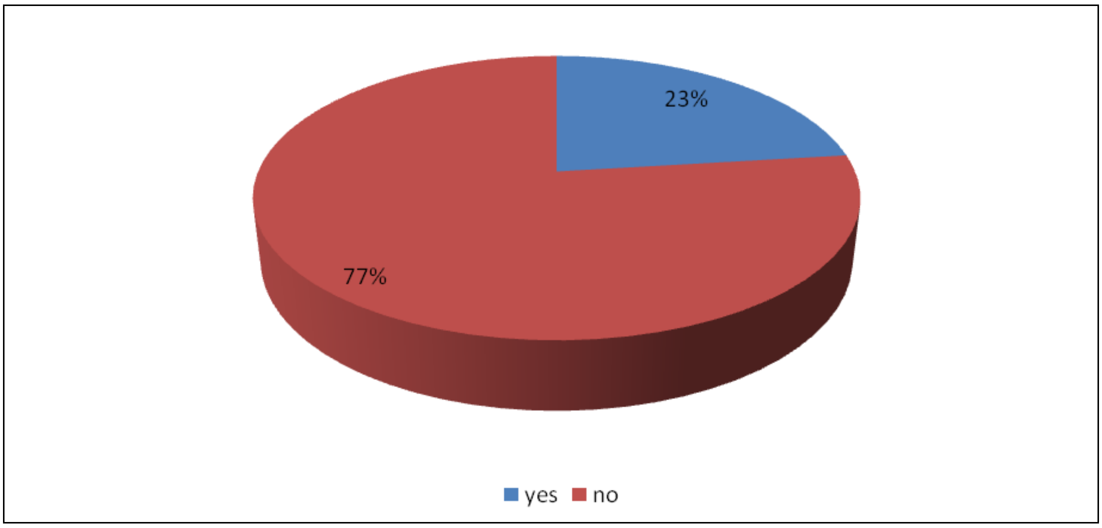


Figure 16: *The presence of municipal waste in the vicinity of capture.*

According to the **Figure 16** in this area the waste is regularly removed (with the context of city ordinances by J.P. Snaga.) I have noticed that is not a lot of pollution on this area.

The next question was about the efficiency and economics of internal control (in terms of maintenance, cleaning, etc.) by the local committees of responsible persons.

Figure 17 shows how economically suppliers control local water captures. 7 % of those in charge believe it is sensible and economical to continue monitoring and ensuring the capture, while the higher proportion of suppliers - trustees (33 %) say that the control is not effective due to obstruction of access, location and weather conditions.

A larger proportion of capture - trustees said that transition to the new capture or borehole is justified. The situation in the field and the responses of members of local committees indicate that 7 % believe that the connection was not meaningful. In many cases, it was found that the reason for the transition was the current financial opportunity rather than a capture problem.

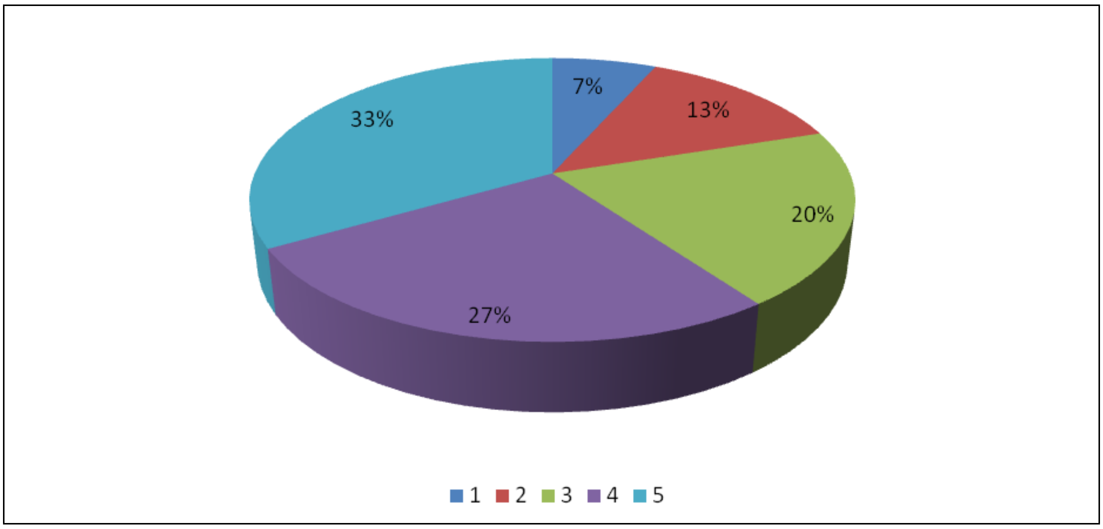


Figure 17: *Cost control of water captures by the managers (Legend: 1 is not economical, 5 is high economical).*

Figure 18 Shows that according to the managers' responses, 70 % of captures were built between 1960 and 1970, while the smallest proportion (13 %) were built between 1990 and 2000.

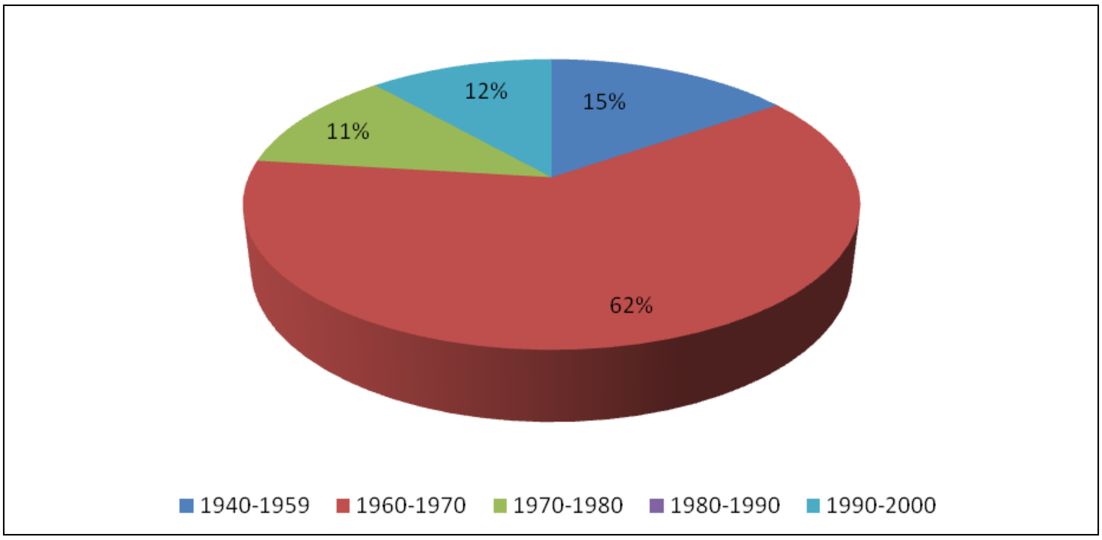


Figure 18: *Local capture of buildings divided by age.*

Persons in charge of water supply committees were asked to tell about the time of capture restoration. **Figure 19** shows the statements of person in charge: half of the captures were restored in 1990 and 2000, 22 % in 2007 and 18 % in 2005. This means 5 - 20 years since the last restoration, which is also one of the risks of pollution.

More than half of the captures older than 40 years have future plans for transition to new wells. A review of the field and identified states shows that age alone is not a prerequisite for building more polluting as primary reasons lie outside the catchment.

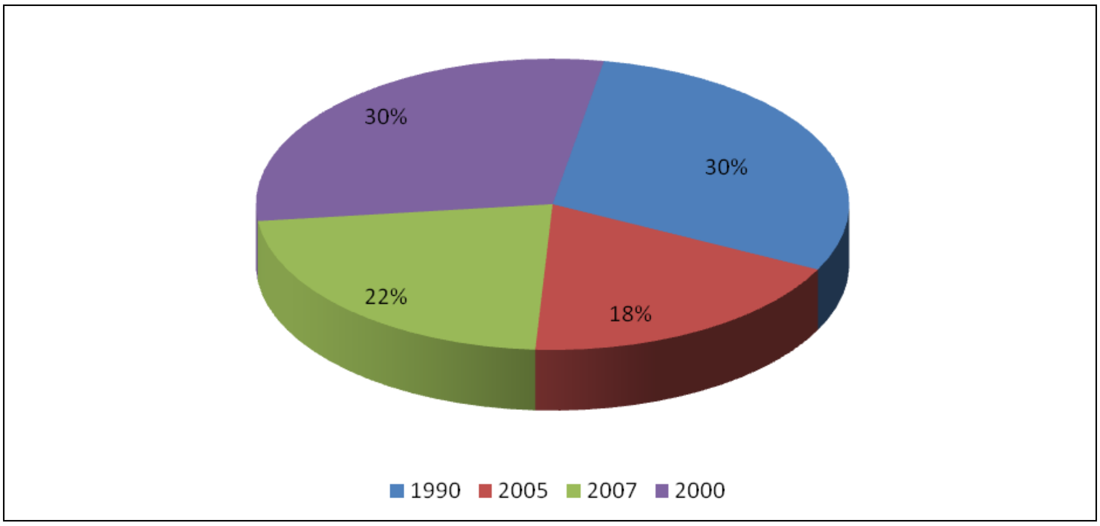


Figure 19: *Local captures renovated by year*

According to the suppliers trustees, the majority of captures are made of concrete (84 %), while more than 15 % of the captures were constructed from other materials (rocks, plastic, bricks*) **[Figure 20]***

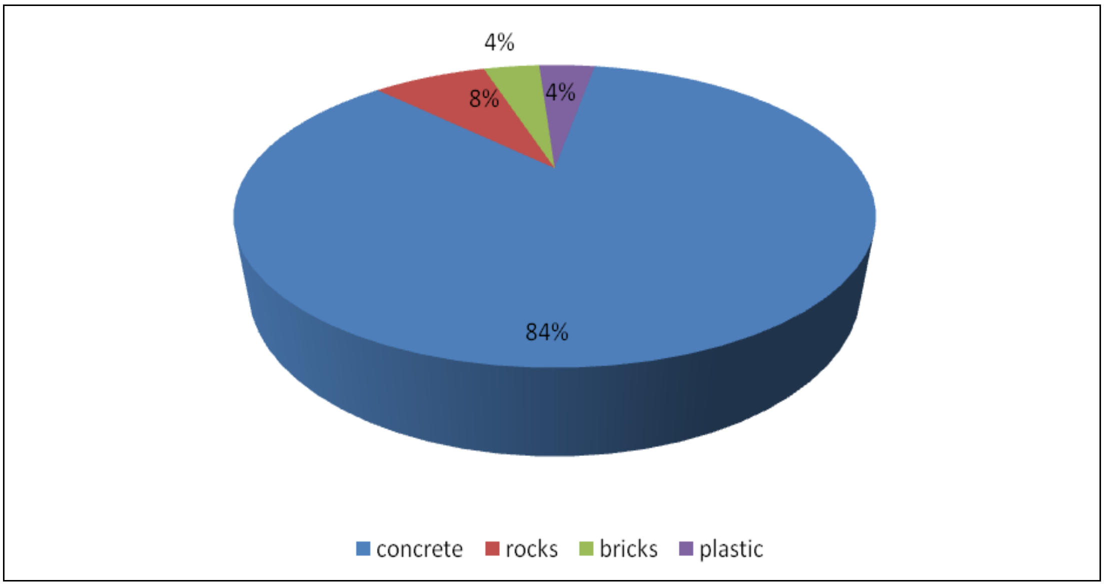


Figure 20: *Local capture by type of material.*

Figure 21 shows the need to look towards nature for a greater share of the risk factors for contamination. Thus, global changes, which are also reflected in the climate (droughts, floods, sudden temperature drops and increases inconsistent with the seasons) are the dominant causes of water pollution in the catchments area.

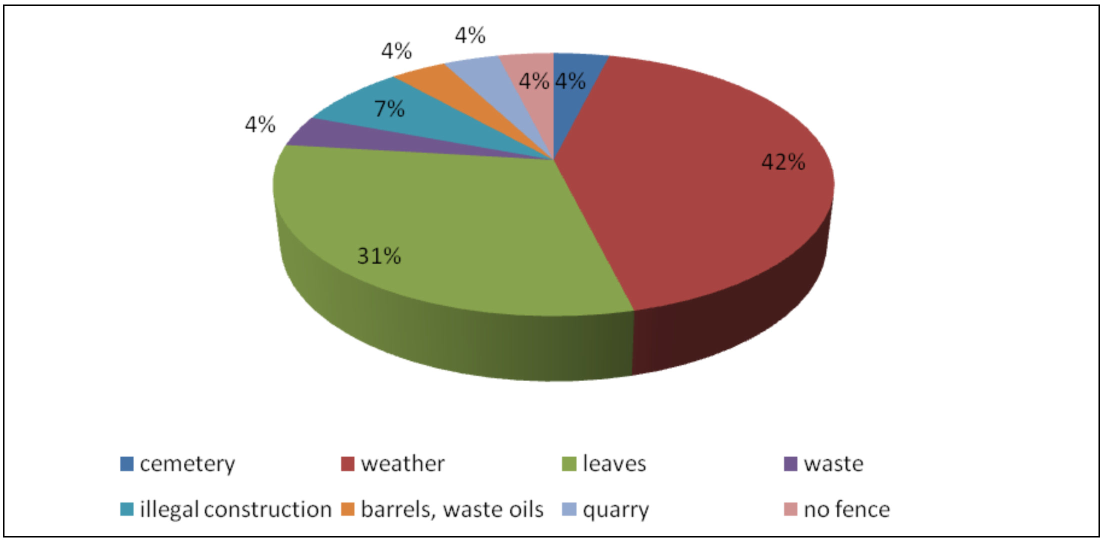


Figure 21: *Risk factors with regard to the subject of risk.*

5 DPSIR MODEL

Table 10 shows the synthesis of all existing data collected from the reports *[12]* and data collected from the situation in the field and interviewing caretakers of water committees according to the DPSIR method.

Data under factor **(D) Driving forces** - include a list of all observed factors in the field near the captures (i.e. industrial plants, agriculture, traffic, etc.). In addition to field visits we also collected data by conducting an interview. Data under factor **(P) Pressures -** include all consequential factors causing pressures on the environment (i.e. discharge of waste water into the environment). Data under factor **(S) State Parameters** - include percentage of samples, which during the selected period, contained limit excess values of microbiological and physical-chemical parameters (2005 - 2010). These cover data for the main water distribution system, to which captures and boreholes belong. Data under factor **(I) Impacts** - refer to consequent impact on the local population, economy, and ecosystems. They represent the results of my assessment given what we have seen in the field. Data under factor **(R) Responses** - cover actions and protection of the capture. These were obtained on the basis of interviews conducted with caretakers and the manager of the capture and data obtained from the manager of the capture *[37- 68]*.

Table 10: *DPSIR tables for individual captures*

	LOCAL WATER DISTRIBUTION SISTEM - BAJDOVNA, Local capture BAJDOVNA, Local capture ANDREJAC ZGORNJI		
D	WPZ 1	• Forest road above the capture • Road Bajdovna • Bajdovna Vnajnarje • Spills of hazardous	 
	WPZ 2	• Meadows and small fields (gardens) • Septic tanks	
P	WPZ 1	• Leakage of motor oil • Leakage of fertilizers	
	WPZ 2	• Sepage from septic tanks	
S	• Enterococci: 31, 25: %, E. coli: 40,6 %, Colif. bact: 65,6 %, Colonies at 37°: 3,12%, pH: 3,12		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Prevent fertilisation of meadows at the narrowest area of capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Organize drainage of the road Bajdovna - Vnajnarje so the surface water runs off out of the water protection area. • Prevent runoff of the surface water of the forest road that runs above the capture into the capture area. • Necessary remediation of septic tanks near holiday cottages so they will be impermeable to water. • In the future there is a plan for the water distribution system Bajdovna to regularly supply the new capture with borehole ZGB-1/05 in Zgornja Besnica.		

	LOCAL WATER DISTRIBUTION SISTEM - BESNICA VAS , Local capture BESNICA JERNAČEV HRIB		
D	WPZ1	• An occasional torrent • Brook upstream from the capturesr	
	WPZ 2	• Logging and harvesting of timber in the forest • Meadows along the road Pečar, Žagarski vrh	
P	WPZ 1	• Runoff dangerous substances into the water	
	WPZ 2	• Runoff motor oil in Sinking of storm water runoff capture • Runoff dangerous substances in to the stram the ground	
S	• Enterococci: 2,7 %, E coli: 37,8 %, Colif. bact: 100% , Colonies at 37 °: 2,7 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Order priority of actions in the following order and then actions in the immediate and wider area. • Organize drainage of surface water above the capture preventing it from flowing into the capture. • Forest owners should be warned about the potential for groundwater contamination at fuel spills when logging and harvesting the timber in the forest. • After the construction of planned water distribution system through the valley Besnice, which will be supplied by a capture with borehole ZGB - 1/05 in Zgornja Besnica, it will be possible to supply the water distribution system Besnica – vas with healthy drinking water.		

	LOCAL WATER DISTRIBUTION SISTEM – ZGORNJA BESNICA, Local capture - MATJAŽEVA DRAGA		
D	WPZ 1	• Polluted rain water that runs down the hill in capture • Poorly constructed a captures (tank) • Oesophagus on the edge of meadows	
	WPZ 2	*	
P	WPZ 1	• Entery of pesticides and nitrates in groundwater • Runoff dangerous substances into the water • The possibility of contamination tank	
	WPZ 2	*	
S	• Enterococci: 2,2 %, E. Coli: 26,6 %, Colif. bact.: 97,7 %, Colonies at 37 °: 4,4,%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for domestic purposes, • Capture renovation. • Implementation of remedial actions in the water protection area according to the proposed order. • Strict adherence of protection regime in the water protection area. • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture. • After inclusion of the capture with borehole ZGB -1/05 into supply with drinking water, the local capture Matjaževa draga should only be used as a replacement in case of interruption of draining from the borehole.		

	LOCAL WATER DISTRIBUTION SISTEM - BESNICA ŠOLA , Local capture BESNICA ŠOLA		
D	WPZ 1	• The forest trail that runs above the capture Logging and harvesting of timber in the forest	
	WPZ 2	• Logging and harvesting of timber in the forest • Waters of the stream that passes through the water protection area (large area)	
P	WPZ 1	• Runoff contaminated storm water into the groundwater • Leakages of oil in the ground	
	WPZ 2	• Sinking of precipitation in the weathered debris and after the capture	
S	• Enterococci: 3,12 %, E coli: 65,6 %, E. coli, Colif. bacteria: 96, 8 %, Colonies at 22°: 6,2 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for nutritional purposes, • Implementation of remedial actions in the water protection area according to the proposed order. • Capture renovation. • Strict adherence of protection regime in the water protection area. • Systematic monitoring of physic and microbiological quality of drinking water from the capture. After the development programme of construction - renovation of water distribution systems implementation of water distribution system was intended through the valley Besnica that will be supplied by the new capture with borehole ZGB-1/05 in Zgornja Besnica. New water distribution system will also supply consumers of the water distribution system Besnica - school. After the implementation of remedial action the current capture could serve as a replacement capture in case of emergency.		

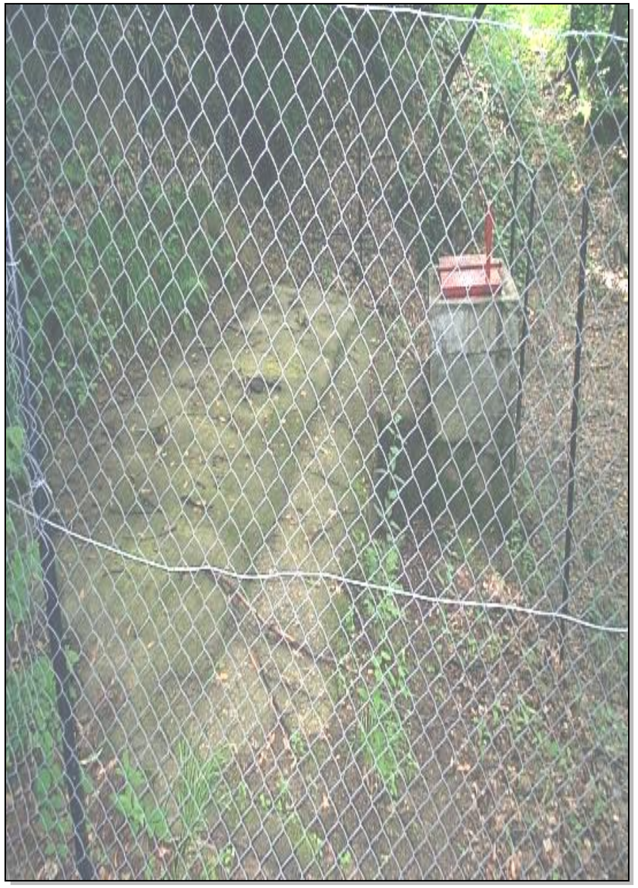
	LOCAL WATER DISTRIBUTION SISTEM - BREZJE PRI LIPOGLAVU, Local capture BREZJE PRI LIPOGLAVU; Borehole B-1/89		
D	WPZ 1	• The Quarry north of capture meadows and fields in the vally Brezniškega potoka • Septic tanks/ wastewater and faecal water • Stables and midden (farm) • Weekend in close proximity to wells • Occasionally active quarries northeast of Brezje • Inadequate storage of petroleum products • Tanks for fuel oil	
	WPZ 2	• The quarry • Wild landfill in Repče, • Septic tanks, • Inadequate storage of petroleum products	
P	WPZ 1	• Leakages of oil in the ground • Runoff of faecal water and slurry in groundwater • Leakages of dangerous substances into groundwater • Leakages of oil in the ground	
	WPZ 2	• Direct contamination of groundwater • Runoff of faecal water and slurry in groundwater • Runoff from the road surface to pasture • Leakages of dangerous substances into groundwater	
S	• E. coli: 12, 5%, Colif. bact: 87, 5%, Colonies at 37°: 12, 5%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		

	LOCAL WATER DISTRIBUTION SISTEM - **BREZJE PRI LIPOGLAVU, Local capture BREZJE PRI LIPOGLAVU; Borehole B-1/89**	
R	• Prohibit extraction of dolomite sand in the sandpit above the capture. • Prohibit pouring of slurry and liquid manure and fertilisation of meadows (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Recommended organic farming. • Water from Brezno creek should be routed in leak proof ditch for approximately 50 meters downstream to the borehole. • A warning sign should be placed before the entry into protection zone. • Rehabilitate illegal waste dumps • Prohibit digging in quarries • Organise septic tanks and cesspools according to regulations • Check adequacy of storing petroleum products • Organise rainwater drainage of the roads • Warn forest owners about the necessary measures in case of fuel and lubricant spills during logging and harvesting of timber in the forest	

	LOCAL WATER DISTRIBUTION SISTEM - DOLGO BRDO, Local capture POD GAŠPERJEM		
D	WPZ 1	• Meadows • Forest road just above the capture • Descrepit car parking • Unregulated septic tank and cesspools in Gašper farm • Logging and harvesting of timber in the forest Meadows and fields under Gašper Forest road above the capture	
	WPZ 2	• Logging and harvesting of timber in the forest	
P	WPZ 1	• Runoff of faeces • Runoff of motor oil in the logging • Dietary intake of pesticides and nitrates • Runoff from forest areas • Seepage of polluted storm water at the borehole	
	WPZ 2	• Runoff of motor oil from cars	
S	• Enterococci: 3,0 %, E. coli: 64,6%, Colif. bacteria: 75,3 %, Colonies at 37°: 10,7%, pH: 23%, Clostr. Perf.: 1,5%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		

R	• Priority order of actions (first implement measures in the area of capture and in strict protection zone according to the stated order and then measures in the wider area). • Capture needs to be renewed. • Prevent fertilisation of meadows at the narrowest area of capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Septic tank and cesspool near the Gašper farm require rehabilitation making the septic tank and cesspool facility impermeable. • Drainage of the road Janče - Koške Poljane need to be properly arranged so that surface water can run off outside the protection zones. • Prevent runoff of surface water from the forest road, which runs just above the capture, into the capture area. • Remove worn out vehicles parked along the Gašper farm. • Forest owners should be warned about the potential for groundwater contamination at fuel spills when logging and harvesting the timber in the forest.	

	LOCAL WATER DISTRIBUTION SISTEM - JANČE GABRJE, Local capture JANČE MOČILO, LAŠČE 1, 2	
D	WPZ 1	• Meadows • Fields • Logging and harvesting of timber in the forest
	WPZ 2	• Road Janče Gabrje • Unsettled septic tanks and cesspools in Janče
P	WPZ 1	• Runoff of dangerous oil • Runoff motor oils • Entry of pesticides and nitrates • Runoff of dangerous oil
	WPZ 2	• Runoff from road surfaces • Runoff of faecal water
S	• E. coli: 20,6%, Colif. bact: 86,2%, Colonies at 37°: 3,4%, pH: 6,8, Mg: 3,4, Fe: 3,4	
I	• Impact on human health, impact on ecosystems, impact on quality of life	
R	• Prevent intense fertilisation of meadows at the supply area of the capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Septic tank and cesspool in Janče require rehabilitation making the septic tanks and cesspool facilities impermeable. • Drainage of the road Janče - Gabrje need to be properly arranged so that the surface water can run off outside the protection zones. • Check storage of petroleum products. • Measures to control and prevent the presence of risk factors that could threaten human health, are very expensive. • Given the fact that there are insufficient quantities of water for supply in the dry season, water distribution system Janče - Gabrje requires a new water source.	



	LOCAL WATER DISTRIBUTION SISTEM - JAVOR VRH; Local capture PRI BREZOVARJU		
D	WPZ 1	• Logging and wood harvesting • Cesspools and septic tank	
	WPZ 2	• Fertilizing meadows nad fields • Forest Road	
P	WPZ 1	• Runoff motor oils • Incorrectly released faecal slurry and water from septic tanks	
	WPZ 2	• Entry of pesticides and nitrates in the soil • Runoff motor oils	
S	• Enterococci: 4,4%, E. coli: 15,5%, Colif. bact: 96,2 %, Colonies at 37 °: 3,7%, pH: 3,7 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• It is necessary to prohibit fertilisation of meadows and fields. (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Septic tanks and cesspools require rehabilitation (to impermeability). • Inform forest owners of the threat to captured drinking water in case of fuel and lubricant spills in the forest. • Drainage of the rainwater from the road in the narrower part of the capture needs to be properly arranged. • Implementation of remedial actions in the water protection area according to the proposed order. • Strict adherence of the protection regime in the water protection area. • Organic farming should be carried out on the agricultural land. • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture.		

	LOCAL WATER DISTRIBUTION SISTEM - PODMOLNIK, Local capture POD MARENČKOM		
D	WPZ 1	• Meadow, orchard, road in Podmolnik • Septic tanks in houses • Inadequate storage of petroleum products	
	WPZ 2	• Fields, meadows • Unsettled septic tanks in housing • Forest road • Inadequate storage of petroleum products	
P	WPZ 1	• Rinsing and runoff from road areas • Leakage of faecal water and slurry onto nearby meadows, creek • Spill of petroleum products	
	WPZ 2	• Runoff of contaminated rainwater from the road and handling areas in cases of accidents and spills • Runoff slurry, • Leaching of nitrates pesticides in soil	
S	• Enterococci: 9,4 %, E. Coli: 39,6 %, Coliform. Bact.: 88, 6 %, Colonies at 37°: 15,0 %, Desetilatrazin: 0,53 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• All contaminants and risk factors in the catchment area are uncontrollable and pose an unacceptable health risk for users. • Therefore, a new water source - Local capture with borehole D-1/05 (pri Dolinarju) has been made for the supply of water distribution system).		

	LOCAL WATER DISTRIBUTION SISTEM – PODMOLNIK, Local capture – PRI DOLINARJU	
D	WPZ 1	• Logging and harvesting of timber in the forest • Forest road at capture • The quarry
	WPZ 2	• Forest road • Road which leads to the quarry
P	WPZ 1	• Rinsing and seepage into the groundwater
	WPZ 2	• The quarry Rinsing the road surface (during rainfall) • The quarry Rinsing the road surface (during rainfall)
S	• No data	
I	• Impact on human health, impact on ecosystems, impact on quality of life	
R	• Capture of groundwater in the vicinity of the drainage catchment with replacement borehole D-1/05 in the quarry. • This source can replace all addressed captures that supply • water distribution system Podmolnik with drinking water.	

	LOCAL WATER DISTRIBUTION SISTEM - JAVOR NOVI VAS, Local capture JAVOR MOČILA 1, 2 (BOREHOLE J-3/89 Ž) AND (BOREHOLE J - 4/02)		
D	WPZ I	• Logging and harvesting of timber in the forest	
	WPZ II	• Meadows in the southwestern part of the catchment area	
P	WPZ I	• Runoff of dangerous substances in to the groundwater	
	WPZ II	• Entry of pesticides and nitrates in the soil	
S	• Enterococci 3,4 % , Colif. Bact. 100%		
I	• Impact on human health, impact on ecosystems, impact on quality of life, species extinction bird (Falco tinnunculus)		
R	• Warning signs need to be placed on the road Javor – Ravno Brdo in both directions, where the road crosses the protection zone. • Inform forest owners of the threat to captured drinking water in case of fuel and lubricant spills in the forest and along the forest trails. • Arrange drainage of the surface water from the road in the narrower part of the capture. • Perform sealing (clams) of the creek in the narrower part of captures. • Implementation of remedial actions according to the proposed order. • Strict adherence of protection regime in the water protection area. • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture.		

	LOCAL WATER DISTRIBUTION SISTEM - MALI VRH ; Local capture - MALI VRH PRI PREŽGANJU		
D	WPZ I	• Meadows, fields and orchards on the north side of the road • Meadows, which extends to capture to the forest. • Logging and timber in the forest • The forest road along the valley of the capture and of capture	
	WPZ II	• Meadows, fields and orchards on the north side of the road • Logginand harvesting of timber in the forest • Weekend with septic tanks	
P	WPZ I	• Leaching of nitrates, pesticides, organic fertilizers • Runoff of faecal water in groundwater	
	WPZ II	• Runoff from roadways hazardous substances • Runoff oil • Runoff of faecal water in groundwater	
S	• No data		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Prevent intense fertilisation of meadows at the supply area of the capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil); • Septic tanks and cesspools near the farm require rehabilitation. • Organize drainage of the roads so the water flows dispersedly of the road on the meadow and does not disappear underground in the		

	soil so quickly. • Prevent drainage of rainwater of the forest trail that runs just above the captureoverage, in the capture area. • Arrange septic tanks of holiday cottages making them impermeable. • Water should be added with chlorine for nutritional purposes; • Implementation of remedial actions in the water protection area according to the proposed order. • Strict adherence of protection regime in the water protection area. • Organic farming should be performed on agricultural land; • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture	

	LOCAL WATER DISTRIBUTION SISTEM PODLIPOGLAV - Local capture POD PUGLEDOM		
D	WPZ I	• Logging and timber • The forest trail that runs above the capture	
	WPZ II	• Logging and wood harvesting	
P	WPZ I	• Runoff to pasture	
	WPZ II	• Runoff motor oil in the ground	
S	• E. Coli: 22,5% , Colif. bacteria:100%		
I	• Impact on human health, impact on ecosystems, impact on quality of life,		
R	• Capture should be physically protected and equipped with a warning sign. • Narrow area of capture should be arranged so the rainwater flows past the capture. Channels should be installed in a semicircle under the breakoff edge. • Forest owners in the protection zone areas should be cautioned when logging and harvesting of timber.		

	LOCAL WATER DISTRIBUTION SISTEM PODLIPOGLAV; LOCAL CAPTURE PRI ANŽKU		
D	WPZ I	• Logging and harvesting of timber in the forest • Meadow which extends from the capture of forest • Potential fuel spills during cutting and harvesting of timber in the forest	
	WPZ II	• Potential spils of fuel and lubricants duing cutting and harvesting of timber in the forest	
P	WPZ I	• Runoff motor oil in the ground	
	WPZ II		
S	• Coliform bacteria: 10%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for nutritional purposes. • Implementation of remedial actions in the water protection area according to the proposed order. • Strict adherence of protection regime in the water protection area; • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture. • To prevent the flow of rainwater into the capture area concrete curbs need to be installed on the upper side or channels so the water runs of outside the capture area, and also arrange capture for it. • Warn forest owners about the potential for groundwater contamination if fuel spills occur when logging and harvesting of timber in the forest.		

	LOCAL WATER DISTRIBUTION SISTEM – PREŽGANJE- MALO TREBELJEVO Local capture »PEČOVJE		
D	WPZ I	• Greenhouses (strawberries), nursery • Dysfunctional septic tanks and cesspools	
	WPZ II	• Logging and harvesting of timber in the forest just above capture • Arable land with corn	
P	WPZ I	• Runoff pesticides into the grounwater • Runoff of faecal slurry and water	
	WPZ II	• Runoff motor oils • Runoff to pasture	
S	• E. coli: 66,6 %, Colif. Bact.: 66,6%, Colonies at 37 °: 66,6% Clostridium perf. 33,3%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		

R	• Maintain channels through which surface water passes by the capture • Remove greenhouses and relocate them outside the protection zone areas, • Prohibit production of strawberries in the field under the road Prežganje - Volavlje, • Prevent fertilisation of meadows on the water - capture catchment area of the capture • Check for adequacy of storing petroleum products and permeability of septic tanks and cesspools near houses • Arrange drainage of the road Prežganje - Volavlje where water still runs of the road onto the capture area despite rehabilitation, • Warn forest owners about the potential for groundwater contamination if fuel spills occur when logging and harvesting of timber in the forest.	

LOCAL WATER DISTRIBUTION SISTEM – Local capture SADINJA VAS SP. with borehole S-1/92			
D	WPZ I	• Arable land with corn Forest road • Forest Road, passing through the upper catchment, • Wild landfill at the end of the forest road, south of the captures • Wild landfill (drums) downstream of captures • Logging and harvesting of timber in the forest	
	WPZ II	-	
P	WPZ I	• Direct contamination of groundwater • Blasting causes	

		turbidity of water • Runoff of waste ground • Leakages of dangerous substances into groundwater • Runoff motor oils	
	WPZ II	-	
S	• E.coli: 15, 3%,Colif.bact: 100%, Colonies at 37°: 15, 3%, Colif. Bact: 97, 6%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Drinking water from the capture with a borehole S -1/92 is wholesome a few times a year, especially after really heavy rain it is slightly turbid so the water supply process is disrupted. • Implementation of proposed remedial actions, as follows, would probably prevent contamination of water in the capture so the drinking water supply from the capture would be acceptable in terms of health • The upper capture should be excluded from use. • Use only groundwater from the capture with borehole S -1/92, if possible; • Remove all illegal waste dumps; • Warn forest owners about the potential threat to captured drinking water in case of fuel and lubricant spills when working in the forest; • Drinking water from the borehole should be used for supplying households that use water from the local capture Izber; • Determine the impact of the quarry KPL on turbidity of water in the borehole.		

	LOCAL WATER DISTRIBUTION SISTEM - ŠENTPAVEL, Local capture ŠENTPAVEL with BOREHOLE ŠP-1/98		
D	WPZ I	• Wild landfield • Unsettled septic tanks in holiday homes • Meadows, orchards and fields of maize • Road and Podmolnik • Forest road • Indequate storage of petroleum products	
	WPZ II	• Fields Meadows • Pastures and orchards • Septic tanks in houses • Road to Podmolnik • Forest road past the capture • Logging and harvesting of timber in the forest The quarry along the road	
P	WPZ I	• The outflow of faecal water • Contamination of ground water	
	WPZ II	• Runoff motor oils • Direct contamination of groundwater	
S	• E. Coli: 46,1%, Colif. Bacteria: 100%		
I	• Impact on human health, impact on ecosystems, impact on quality of life, loss of biodiversity (sponges Amanita cesarea) and flower (Centaurium minus)		
R	• Remove all illegal waste dumps located west of the borehole; • Warn forest owners about the potential threat to captured drinking water in case of fuel and lubricant spills in the forest trail; • Prohibit storage of timber next to capture; • Check permeability of septic tanks near holiday cottages and possible inadequate storage of petroleum products;		

	LOCAL WATER DISTRIBUTION SISTEM JAVOR ŽAGARSKI VRH - Local capture ŽAGARJEV IZVIR - 1, ŽAGARJEV IZVIR- 2	
D	WPZ I	• Unresolved septic tank • Meadows,orchards and fields of capture • Road Pečar - Javor • Logging and harvesting of timber in the forest
	WPZ II	-
P	WPZ I	• Runoff of faecal water and slurry in groundwater • Entry of pesticides and nitrites • Runoff tanks and slurry • Runoff from road surfaces • Runoff motor oils
	WPZ II	-
S	• Enterococci: 1,8 % , E coli : 43,3 % , Colif. bact: 96,2 % Colonies at 37 °: 3,7 % , pH: 3,7 %	
I	• Impact on human health, impact on ecosystems, impact on quality of life	
R	• Prevent intense fertilisation of meadows at the supply area of the capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Necessary rehabilitation of septic tanks. • Warn forest owners about the potential for groundwater contamination at fuel spills when logging and harvesting of timber in the forest.	

<table>
<tr><th></th><th colspan="3">LOCAL WATER DISTRIBUTION SISTEM - LOCAL CAPTURE ČEŠNJICE</th></tr>
<tr><td rowspan="2">D</td><td>WPZ I</td><td>Meadows and field east of capture
Logging and harvesting of timber in the forest</td><td rowspan="8"></td></tr>
<tr><td>WPZ II</td><td>-</td></tr>
<tr><td rowspan="2">P</td><td>WPZ I</td><td>Entry of pesticides and nitrates in the soil
Runoff motor oils</td></tr>
<tr><td>WPZ II</td><td>-</td></tr>
<tr><td>S</td><td colspan="2">E. Coli : 25 %, Colif. Bact: 97,9%, Colonies at 22°: 4,1 %</td></tr>
<tr><td>I</td><td colspan="2">Impact on human health, impact on ecosystems, impact on quality of life</td></tr>
<tr><td>R</td><td colspan="2">Drinking water from local captures for Češnjice is often not wholesome, so water supply is not safe.
Because of microbiological contamination of drinking water there is a greater risk for waterborne diseases and also epidemics (there are several faecal contaminants of water in the water protection zone; after rain groundwater flows towards the capture quickly and shallowly beneath the surface).
Implementation of remedial actions and other preventive measure does not prevent water contamination in captures in the long run in such way, by which drinking water supply would be acceptable in terms of health.</td></tr>
</table>

	LOCAL WATER DISTRIBUTION SISTEM - LOCAL CAPTURE ZAGRADIŠČE		
D	WPZ I	• Forest road over the seizure • Permeation of rainwater in seizure • Midden and stable in Tablar • Logging and harvesting of timber in the forest	
	WPZ II	-	
P	WPZ I	• Spill of dangerous goods by road • Seepage of polluted storm water at the borehole • Rinse the road surfaces in the soil • Runoff motor oils • Runoff slurry in groundwater	
	WPZ II	-	
S	• No data		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Prevent intense fertilisation of meadows at the supply area of the capture (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil). • Warn forest owners about the potential for groundwater contamination at fuel spills when logging and harvesting of timber in the forest. • Rehabilitate the cesspit and arrange the stable by the farm. • Supply water distribution system Češnjica - Zagradišče with sufficient quantities of healthy drinking water, therefore water needs to be supplied from the water distribution system of Ljubljana (Sadinja vas - Češnjica) or with water from the borehole ZGB -1/05 in Zgornja Besnica.		

	LOCAL WATER DISTRIBUTION SISTEM - VNAJNARJE / ZABUKOVJE, Local capture ZABUKOVJE , Local capture S SODČKOM		
D	WPZ I	• Meadows, orchards and fields • Forest road (chart track)	 
	WPZ II	• Logging and timber in forest	
P	WPZ I	• Entry of pesticides, nitrates in the soil • Runoff from road surfaces	
	WPZ II	• Runoff motor oils	
S	• E. coli: 11,1%, Colif. bact: 85,1%, pH = 14,8 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for nutritional purposes; • Implementation of remedial actions in the water protection area according to the proposed order; • Strict adherence of protection regime in the water protection area; • Organic farming should be performed on agricultural land; • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture		

	LOCAL WATER DISTRIBUTION SISTEM VNAJNARJE SMREČJE **Local capture pod Kostevcem**		
D	WPZ I	• Stables • Orchard • Fields • Pastures of capture • Disorderly cesspools and septic tank • Arable land	
	WPZ II	• Logging and harvesting of timber in the forest	
P	WPZ I	• Runoff motor oils • Rinse off pesticides and nitrates • Runoff and sewage slurry to grassland • Rinse the road surface	
	WPZ II	• Runoff motor oil	
S	• E. coli: 4,7 %, Colif. bact.80,9%, Colonies at 37°: 14,2 % pH: 14,2%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for nutritional purposes; • Implementation of remedial actions in the water protection area according to the proposed order; • Strict adherence of protection regime in the water protection area; • Organic farming should be performed on agricultural land • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture • Water supply from the capture is not safe on the long run (also not from the capture using a small barrel), so it needs to be replaced with sufficient quantities of healthy drinking water. We suggest connecting pipeline from captures Janče to captures Vnajnarje		

	LOCAL WATER DISTRIBUTION SISTEM - VNAJNARJE KORITO **Local capture KORITO**		
D	WPZ I	• Orchard • Forest road, which runs just above the capture • The path to the meadows and fields	
	WPZ II	• Logging and harvesting of timber in the forest	
P	WPZ I	• The entry of pesticides and nitrates in the soil	
	WPZ II	• The entry of pesticides and nitrates in the soil	
S	• Enterococci: 4,4 %, E.coli: 57,7 %, Colif. bact: 95,5%, Colonies at 37°, 4,4% pH: 2,2 %, Clostri. perf : 2,2 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life, extinction of species (Salamandra salamandra)		
R	• Water should be boiled for nutritional purposes • Implementation of remedial actions in the water protection area according to the proposed order; • Organic farming should be performed on agricultural land; • Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture. • Water supply from the capture is not safe so it needs to be replaced with sufficient quantities of healthy drinking water. • Anticipated construction of connecting pipeline from captures Janče to captures Vnajnarje. After connecting the water distribution system to the new water source the capture needs to be excluded from the water supply.		

	LOCAL WATER DISTRIBUTION SISTEM VOLAVLJE LOCAL CAPTURE FAROVŠKI STUDENEC: lower, top		
D	WPZ I	• Logging and harvesting of timber in the forest, • Meadows above captures	
	WPZ II	• Road Janče-Gabrje, • Meadows of the road Gabrje – Janče	
P	WPZ I	• Leakage of motor oil	
	WPZ II	• Leakage of motor oil	
S	• Enterococci: 4,7%, E. Coli: 52,3 %, Colif. Bact: 21,4 %, Clost. perfr: 4,7 %		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• Water should be boiled for nutritional purposes; • Implementation of remedial actions in the water protection area according to the proposed order; • Strict adherence of protection regime in the water protection area; • Organic farming should be performed on agricultural land. • Systematic monitoring of physico - chemical and microbiological quality of drinking water from the capture • Following the development programme of construction – renovation of water distribution systems the capture should be preserved and maintained also after connecting water distribution system to the new water source (after connection to a new water source the capture will still supply two households).		

	LOCAL WATER DISTRIBUTION SISTEM TUJI GRM; Local Capture - Tuji Grm 1, 2		
D	WPZ I	• Meadows underneath the church sv. Nicholas - foreign road Janče Tuji Grm	
	WPZ II	• Road Janče – Tuji Grm	
P	WPZ I	• Entry of pesticides and nitrates	
	WPZ II	• Runoff from road surfaces	
S	• Enterococci: 2,8 %, E. coli: 45,8 %, Colif. bact: 100%, Colonies at 37°: 6, 25%		
I	• Impact on human health, impact on ecosystems, impact on quality of life		
R	• First implement measures in the capture area and narrower protection zone according to the specified order and then measures in the area of wider protection zone): • Prevent fertilisation of meadows in the area located northeast of Janče (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil) • Implement control over drainage of surface water of the road Janče – Tuji Grm through channels past the captures (cleaning of channels) • In the vicinity of the capture for Tuji Grm it is impossible to capture additional quantities of quality drinking water, so we anticipated the construction of connecting pipeline from Janče local capture to local capture Vnajnarje .		

6 DETAILED DESCRIPTION OF THREE RISK LOCAL CAPTURES AT RISK

On the basis of the analytical results (microbiological and physical - chemical), interviewing, personal perceptions in the field and preparion of the DPSIR model we selected three captures, which proved to be the most critical regarding drinking water quality. The reason for the continuous occurrence of non - compliant samples is basically due to external factors (rainfall, outdoor pollutants - septic tanks, liquid manure,..). Secondary pollution factors are the location and surroundings of the captures themselves and the geological composition of the soil.

6.1 Local water distribution system Besnica Vas - local capture Jernačev hrib

The water distribution system supplies 30 people and some livestock. There is a sufficient volume of water in the capture Jernačev hrib also during drought period. During the period of heavy rain and thaw, water in the capture gets muddiy and is not consistent with requirements of the Rules of drinking water *[15]* during that time. The water distribution system is supplied with drinking water from the local capture Besnica - Jernačev hrib and is managed by the Municipality of Ljubljana.

The local capture *[Figure 22, 23]* is located on the steep left bank of the valley south of the Sp. Besnica village, under the Pečar - Javor road. Groundwater is captured in the cracked sandstone.

Figure 22: *Local capture – Jernačev hrib*

During the drought period the capture discharge totals 0,15 l/sec, at medium water level 0,25 l/sec and at high water level 0,3 l/sec. *[Table 5]*

Geological and hydrogeological conditions in the wider catchment area

The entire catchment area of capture consists of severely cracked Carboniferous - Permian (C,P) sandstone and conglomerate. The basic rock is covered by a thin layer of sand - clay weathered debris. Groundwater flows into the captured source relatively deeply below the surface.

During heavy rain (torrent) part of the water flows across the weathered debris and disappears underground near the capture, thus, contaminating the water within the capture. Groundwater is fed by infiltration of rain, therefore, it is possible that a part of the water flows into the capture, which then disappears underground upstream of the capture.

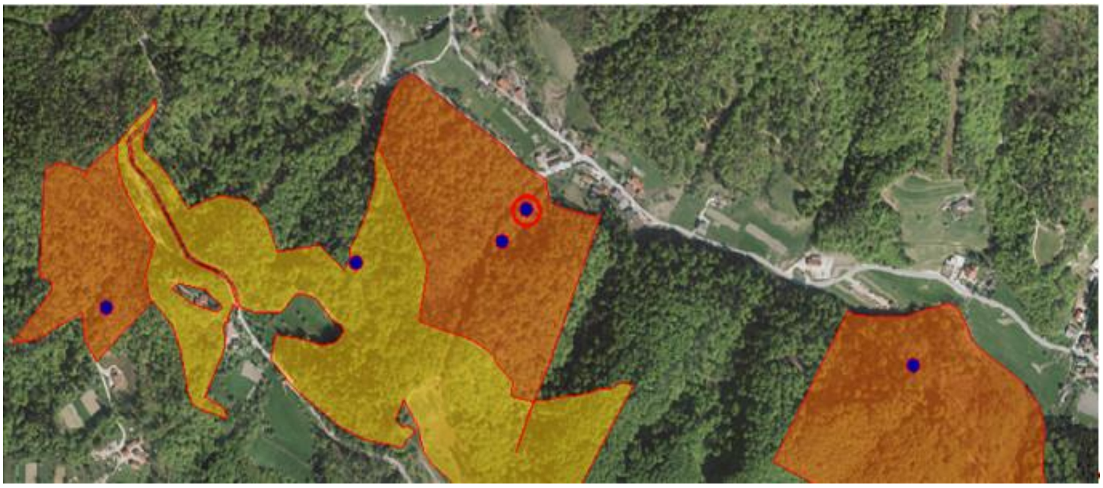


Figure 19: *Local capture Jernačev Hrib with water protection zone*

Microbiological factors and quality

Microbiological factors are present in the water (bacteria of faecal origin). Identified presence of bacteria of faecal origin in the water indicates the possible presence of viruses and parasites.

Table 11 shows excess values of Coliform bacteria (2005 - 2008) for the Jernačev hrib capture.

Examination of drinking water samples over the period 2005 - 2010 *[12]* have shown that water from the capture, especially after heavy rain, is sometimes not in conformity with Rules on drinking Water *[15]*, because of deviations of one or more microbiological parameters at the same time. Identified presence of bacteria of faecal origin in the water indicates the possible presence of viruses and parasites. Since drinking water becomes microbiologically contaminated in the capture, the water intended for human consumption needs to be boiled occasionally.

Table 11: *Jernačev hrib – excess limit values for microbiological parameters*

Year	Date	Enterococi	E. coli	Colif. bacteria
2005	7.4.2005	0	0	16
2006	8.5.2006	0	0	20
2007	6.11.2007	0	0	7
2007	16.2.2007	0	0	1
2008	3.11.2008	0	0	26
2008	21.5.2008	0	0	0,1

Physical - chemical factors and quality

Physical - factors are present in the water. After heavy rain water in the capture slightly muddies, which can be eliminated by implementing remedial actions. Other physical - chemical factors are not present in the water.

Examination of drinking water samples indicates that water from the capture complies with requirements of the Rules on drinking water *[15]* except that occasionally, after heavy rain, the water is slightly turbid. Indicator parameters (temperature, pH value, colour, visible impurities, taste, smell, turbidity, consumption Kmn07, or oxidizing potential) show relatively rapid changes in water quality, depending on the rainfall.

Threats to water resources and aquifer vulnerability

The entire supply area of the capture consists of cracked layers of sandstone and conglomerate, so the aquifier belongs in a low level of vulnerability. Despite that, the water source is threatened by the flowing of surface, torrential water that is kept in the capture.

The capture was initially poorly designed. In the case of heavy rain the surface water from the occasional torrent disappears underground in the capture area and flows into the capture. Better implementation of the capture, with removal of torrential water past the capture would significantly improve the quality of the water in the capture**.** Thus, rehabilitation of the capture was carried out in 2010 so the contaminated surface water cannot flow into the capture.

Possible sources of groundwater contamination as a risk factor for microbiological and physical - chemical contamination:

- Creek upstream
- Occasional torrent above the capture
- Logging and harvesting of timber in the forest.
- During heavy rain period groundwater rises closer to the surface, which allows for rapid infiltration of contaminated rain water into the groundwater that flows into capture, when raining.

Rating

Drinking water from the capture from time to time, especially after heavy rain, is unsuitable from a health aspect, thus, making supply from the capture unsafe. Implementation of remedial and other preventive measures could reduce contamination of water in the capture making the supply from the capture possible, but not entirely safe. Water needs to be boiled occasionally, when used for nutritional purposes.

Preventive measures

- Water should be boiled for nutritional purposes. Implementation of remedial actions in the water protection area according to the proposed order.
- Strict adherence of theprotection regime within the water protection area.
- Systematic monitoring of physic - chemical and microbiological quality of drinking water from the capture.

Assessment of potential risks: medium risk

- Due to the presence of possible contaminants in the water protection area and failure to comply with the water protection regime there is a possibility of minor groundwater contamination with microbiological and physical - chemical contaminants.
- Implementation of all remedial actions and other measures for the protection of the aquifier could reduce the possibility of groundwater contamination flowing into capture so that the supply of drinking water from the capture could be possible, however all risk factors for water contamination in the capture cannot be removed.

Conclusions

It is expected that implementation of proposed remedial actions and other preventive measures will reduce water contamination in the capture making the drinking water supply from the capture acceptable in terms of health.

According to the development program for construction - renovation of water distribution systems it will supply the new capture with borehole ZGB-1/05 in Zgornja Besnica. The new water distribution system will also supply consumers in the local water distribution system Besnica - vas. The current capture could be a replacement capture for emergency use after implementing remedial actions.

6.2 Local water distribution system Dolgo Brdo (Local capture Pod Gašperjem)

The water distribution system supplies 28 consumers with drinking water.There is lack of water during drought period and provision needs to be delivered by tanks. Capture Pod Gašperje is on the southern slope of the hill, south - east of the Gašper farm.

[Figure 24, 25] Since the Municipality of Ljubljana did not introduce an initiative

for the protection of the water source at Gašper it is not protected by a new Regulation *[8]*.

Figure 20: *Local capture Pod Gašperjem*

The capture was poorly designed so that part of the water flows past the capture. Groundwater is captured in severely cracked Carboniferous - Permian sandstone and weathered debris. Capture discharge during the high water level is 0,3 l/sec, during the medium water level 0,15 l/sec and during prolonged drought 0,05 l/sec. Pass the capture, during the medium water level, flows at approximately 0,15 l/sec. There is lack of water during drought.

Geological and hydrogeological conditions in the wider catchment area

The entire supply area of the capture consists of: Carboniferous - Permian (C,P) sandstones with layers of slate clay stone *[Table 5]*.The basic rock is covered by a thick layer of sand - clay weathered debris. Groundwater flows through the weather - beaten rock near the surface. Porous weathered aquifer is supplied only by rainwater infiltration. In the wider area of local capture »Pod Gašperjem« there are two more captures, namely, the capture for Gašper and the capture for Bučar. Minimum capture discharge is 0,02 l/sec or 0,08 l/sec. Both drain groundwater from the weathered sandstone.

Figure 21: *Local capture Pod Gašperjem*

Microbiological quality

Examination of drinking water samples *[Table 12]* have shown that water from the capture, especially after heavy rain, sometimes was not in conformity with the Rules on drinking Water *[15]* because of deviations of one or more microbiological parameters at the same time. Identified presence of bacteria of faecal origin in the water indicates the possible presence of viruses and parasites.

For the local capture Pod Gašperjem the below table clearly indicates the highest excess limit value for Colif. bacteria in the year 2006 (90 / 100ml).

Table 12: *Local capture Pod Gašperjem - limit values for microbiological parameters*

Year	Date	Enterococci	E. coli	Colif. Bacteria	pH
2005	9.8.2005	0	16	16	0
2005	9.8.2005	0	0	0	5,9
2006	20.7.2006	0	2	20	0
2006	20.7.2006	0	40	90	0
2006	20.7.2006	0	0	0	6,3
2007	23.7.2007	0	0	0	6,1

Physico - chemical quality

Examination of drinking water samples indicate that water from the capture does not comply with requirements of the Rules of drinking water *[15]* due to low pH (slightly less than 6,5) after heavy rain and also due to turbidity. Indicator parameters (temperature, pH value, colour, visible impurities, taste, smell, turbidity, consumption KmnO4, or oxidizing potential) show relatively rapid changes in water quality, depending on the rainfall.

Threats to water resources and aquifer vulnerability

In the area of meadows and up to the road Janče - Koške Poljane groundwater runs just below the surface so that contamination of groundwater flowing into the capture can quickly take place. This area belongs to the I. level of vulnerability. Less vulnerable is the immediate hinterland around the capture, which is forested, and the area above the road until the Vrh Zid or above the Gašper farm. This capture is seriously compromised *[Table 12]*, because there are meadows and fields in the hinterland that are heavily fertilized and the road Janče - Koške Poljane, from which rainwater flows onto the water protection area of the capture. The Gašper farm has a non - organised septic tank and a cesspool so that contamination of water in the capture may also occur from here. In case of heavy rain, groundwater becomes contaminated with surface water that percolates into the groundwater.

Rating

Drinking water from the capture (and always after heavy rain) is unsuitable from a health perspective and supply from the capture is unsafe. Implementation of remedial and other preventive measures could reduce contamination of water in the capture making the supply from the capture possible, but not entirely safe.

Preventive measures

- Water should be cooked nutritional purposes

- Capture must be renewed
- Implementation of remedial measures in water protection area for the proposed order
- strict compliance regime to protect the water protection zone,
- systematic monitoring of physico - chemical and microbiological quality of drinking water capture (regular and periodic testing parameters and potential risks of the contaminants present in the water protection area - an annual program of testing drinking water samples from capture under the internal control for professional consultation with a competent Institute of health

The order priority of remedial actions:

- Intense fertilization of meadows in the water - capture catchment area needs to be prevented (due consideration should be given to the Decree on the input of dangerous substances and plant nutrients into the soil),
- Septic tank and cesspool near the Gašper farm require rehabilitation making the septic tank and cesspool facility impermeable,
- Drainage of the road Janče - Koške Poljane needs to be properly arranged so that surface water can run off outside the protection zones,
- Runoff of surface water from the forest road, which runs just above the capture, into the capture area, needs to be prevented,
- Worn out vehicles parked along the Gašper farm need to be removed,
- Forest owners should be warned about the potential for groundwater contamination at fuel spills when logging and harvesting the timber in the forest.

Assessment of potential risks: medium risk

Drinking water from capture often (every time, after raining), is not health care appropriate and the capture is not safe. With the implementation of preventive measures can reduce water pollution in capture, but not so good that drinking water capture will be completely safe.

Conclusions

Despite implementation of all remedial actions for the protection of the aquifier it is impossible to remove all potential risk factors. Groundwater flows near the surface and can quickly be contaminated. Following construction of the local water distribution system Dolgo Brdo with water distribution system Janče - Tuji Grm that will be supplied by the borehole J-1/02, the current capture can serve as a capture.

6.3 Local water distribution system: Vnajnarje - Korito, Vnajnarje – Zabukovje, Vnajnarje - Smrečje

At Vnajnarje there are three distinct local water distribution systems: Vnajnarje – Korito *[Figure 26, 27]*, Vnajnarje - Zabukovje and Vnajnarje - Smrečje. Water distribution system Vnajnarje - Korito supplies the west part of the village Vnajnarje (66 users) with water, local water distribution system Vnajnarje - Smrečje east part of Vnajnarje (20 users) and local water distribution system Vnajnarje - Zabukovje the north - eastern part of Vnajnarje (16 users). There is lack of water in the case of drought and provision needs to be delivered by tankers.

Local capture Korito is just above the road between Marolt and Jančar on the southern slope of the ridge, which extends west from Tičence

Figure 22: *Local capture Korito*

We included two springs with a total average discharge of 0,1 l/sec. During the drought period their discharge is reduced to 0,03 l/sec so that water is delivered by tankers. There is a water collector placed nearby with capacity of 8 m^3.

***Geological and hydrogeological conditions in the wider catchment area*:**

All captures are made under the ridge west of the peak of Tičenec. The ridge consists largely of Carboniferous - Permian (C,P) sandstone with rare layers of slate claystone. Sandstone is deeply weathered. Groundwater flows toward the captures through the weathered debris closely beneath the surface. Captures are located at the contact of the weathered debris with layers of slate claystone. In the hinterland of the captures there are meadows, orchards and fields so that groundwater, especially during heavy rain period, contaminates with percolation rainfall.

Microbiological quality:

Examination of drinking water samples have shown that water from the capture often fails to comply with the Rules of drinking Water *[15]* because of deviations in one or more microbiological parameters at the same time (bacteria Esherichia coli, Enterococci, total Coliform bacteria and Aerobic bacteria).

Local capture *Korito [Table 13]* indicates that the largest proportion of Colif. Bacteria was found during the years 2007 and 2009, namely (100 / 100ml) and pH was exceeded only in the year 2008 (6,3 / 100ml)

Table 13: *Local capture Korito - Excess limits for microbiological parameters*

Year	Date	Enterococci	E. coli	Colif. bacteria	pH
2005	16.8.2005	0	0	9,2	0
2006	03.2.2006	0	0	2	0
2007	27.2.2007	0	0	0	0
2007	17.7.2007	0	100	100	0
2009	22.9.2009	0	1	100	0
2009	16.3.2009	0	0	44	0
2008	06.5.2008	0	0	0	6,3

Physical - chemical quality:

Examinations show that water from the captures occasionally, especially after a heavy rain period, does not comply with requirements of the Rules of drinking water

[15] due to turbidity and persistently low pH value (it ranges between 5,5 and 6,5, standard value ranges between 6,5 to 9,5). Indicator parameters (temperature, colour, visible impurities, taste, smell, turbidity, conductivity, consumption KmnO4, or oxidizing potential) show relatively rapid changes in water quality, depending on the rainfall.

Threats to water resources and aquifer vulnerability:

Groundwater flows in the weathered debris directly beneath the surface so there is a great potential of groundwater contamination with percolation contaminated rainwater that falls on the area of meadows, field and orchards in the water - capture catchment area. All water sources are severely threatened especially during heavy rain periods when groundwater flows relatively fast towards captures. Use of fertilizers on the meadows, pesticides in orchards, and grazing on meadows (sheep) makes supply with drinking water from the captures dangerous. Water - capture catchment area belongs to the I. level of vulnerability.

Rating:

Local capture Korito is designed relatively well. Water is captured at the contact of deeply weathered sandstone with clay weathered debris of slate claystone. The exact method of capture is unknown. Immediate hinterland of the captures is covered by the forest; there are meadows, an orchard and fields in the hinterland, which pose a great threat to underground water flowing towards the capture due to fertilisation and pesticides.

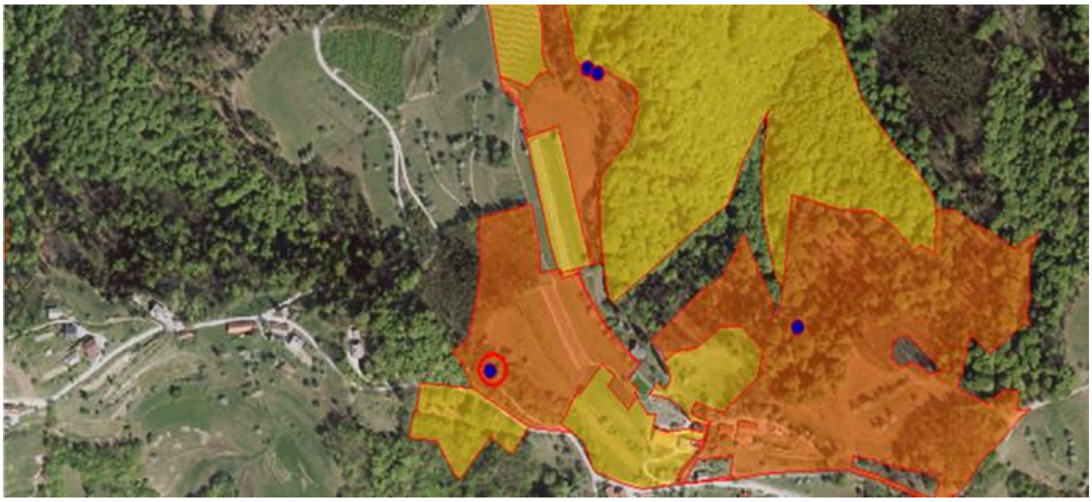


Figure 23: *Local capture Korito with water protection zone*

Preventive measures:

- Water should be boiled for nutritional purposes;
- Implementation of remedial actions in the water protection area according to the proposed order
- Strict adherence of protection regime in the water protection area;
- Organic farming should be performed on agricultural land;
- Systematic monitoring of physical - chemical and microbiological quality of drinking water from the capture

Assessment of drinking water health compliance and safety of supply

Assessment of drinking water health compliance is given based on hydrogeological and sanitary - technical data on the capture and based on the data of the multi – annual, systematic surveillance of drinking water health compliance on the water distribution systems Vnajnarje (data from the ZZV LJ) *[12]*

- Local capture Korito (Local water distribution system Vnajnarje - Korito)
- Local capture Zabukovje (Local water distribution system Vnajnarje - Zabukovje)
- Local capture pod Kostevcem, local capture s Sodčkom (Local water distribution system Vnajnarje - Smrečje)

Conclusions:

Water supply from the captures is unsafe and should be replaced with sufficient quantities of healthy drinking water. A construction of interconnector pipeline from local capture Janče to local capture Vnajnarje has been planned following the Development program of construction - renovation of water distribution systems. After connecting the water distribution system to the new water source the capture needs to be excluded from the water supply.

7 DISCUSSION

The working hypothesis, stating that the local water distribution system with captures in the eastern part of Ljubljana, which are managed by the Municipality of Ljubljana (MOL) are more endangered in terms of achieving good quality in comparison with other captures in eastern part of Ljubljana, which are managed by the public utility (J. P. VO - KA), was confirmed by following results from the master thesis:

1. The quality of water in the distribution system, managed by J.P. VO-KA has good quality and is according to standards for drinking water. The reason for this is that maintenaince of captures from J.P. VO-KA is professional in comparison with captures from MOL wich are mainly maintained by local people.

2. Water from most local water distribution systems, managed by the Municipality of Ljubljana, during the period 2005 - 2010 often do not reach microbiological quality standards *[Figure 7, 8, 9, 10, 11, 12]*. In 2005 there were 17 captures (or 62.9% of all examined captures) whith exceeded threshold values. In 2006, there were 22 captures (or 81.4% of all examined captures) in 2008 there were 24 local captures or 88.8% of all examined local captures, which contained exceeded threshold values. In 2009 there were 17 local captures exceeding thresholds values or 62.9% of all examined captures.

3. Given the results of the physical - chemical examination of drinking water it can be concluded that drinking water during this five – year period was generally less physically and chemically polluted than the microbiological aspect:

   - In the period from 2005 to 2009, each year there were some (4 to 10) samples with exceeding pH values exceeded the threshold value.

   - In 2008, the taste was unacceptable in four (4) cases.

   - The limit value for desetylatrazine was exceeded once (1) in 2005.

   - For some areas, where the water is captured near the surface, after abundant rainfall, water is particularly heavily contamined with physical and chemical agents, creating a possibility of waterborne diseases and epidemics.

4. Impact on water quality is determined also by land use in the recharge area of paricular capture. Local water distribution systems with captures (managed by MOL) are still exposed to pollution from agricultural land, septic tanks and cesspools, inadequate wastewater collecting systems from settlements, runoff of polluted rainwater from the roads, illegal waste, uncontrolled discharges of dangerous substances into the soil and also construction activities, which appeared in the recharge area.

5. According to the inquiry (poll) and review of professional reports most captures were originally designed without prior hydrogeological and sanitary hygienic examinations and without adequate professional supervision. Captures were built through the voluntary work of local inhabitants, therefore, most of them do not meet sanitary - technical requirements, since water may become polluted from the narrowest area of the capture.

6. Besides, field survey and results from inquiry *[Table 5]* have indicated that landowners in the water protection areas often ignore protective measures set by the Decree *[8]* or are even not aware of them.

7. The managers of local water supplies and water committees in local communities do not have necessary professional qualifications for this task and perform this function on a voluntary basis.

Proposals for improvement of the management of local water supply:

- Based on surveys and interviews *[Table 7]* with local managers we can conclude that it is very important (longterm perspective) to raise awareness of the potential pollution and to set appropriate guidelines for active prevention.
- It is necessary to establish alternative water resources with better water quality and quantity within the investigated area, which could be gained by deep wells. It should be mentioned that the Municipality of Ljubljana slowly began with rehabilitation of water distribution system and captures in 2012. In the eastern part of the district Sostro, there are already deep boreholes

drilled, which in total yield approximately 25 l /sec of healthy drinking water. When the supply system will be built, water from the boreholes will replace the water from polluted captures.

8 CONCLUSIONS

The purpose of this study was to find out the drinking water quality of the local water distribution systems, which are managed by Municipality of Ljubljana (MOL) and Public water utility J.P. VO - KA. Results of the study have shown that drinking water from local water supply systems managed by MOL is very often microbiologically polluted, whereas drinking water from local water supply systems managed by J.P. VO - KA has a good drinking water quality.

The reason is that maintenance of captures from J.P. VO - KA is numerically easier to control in comparison with captures from MOL wich is also maintained with the help of local administration.

Pollution of water sources could be prevented by more control of land use in the recharge area: more strict control of inappropriate storage of oil and other hazardous and noxious substances, illegal waste dumps, seepage from traffic roads, gravel/rock excavations, use of pesticides and fertilisers on agricultural areas. Besides, continuous cooperation with the local population, water protection committees and other institutions should take place.

Furthermore, existing inspection (supervision) of water sources is in present state in the domain of the state. This has been proved to be inefficient, since state has other intersts that such small captures. Therefore it would be more efficient, if local inspection would be performed by local communities (e.g. Municipality).

ABSTRACT

In the recent years significant evidence has been collected that support climate changes, which affects the floods and droughts and hence the potential pollution and change in water quality at water captures.

This survey presents the key findings of an analysis of the local water supply in the Municipality of Ljubljana and all changes which affect the local area water quality. The detailed review covers local water supply located in the eastern part of Ljubljana.

The main reason for writing and revising the existing theme was given by the global climate change, as well as unexpected floods in the Ljubljana region. The idea for researching this type of theme was already developed in 2000, however, the concept fell on fertile ground, so that all additional factors and monitoring the profession in this area have only further confirmed our first thought of the high importance of protecting drinking water as a local level commodity.

When conducting this survey we also encountered the question as to whether it is possible to assume and protect local captures on the long - term, which are under care of the inhabitants of Ljubljana and public company Vodovod Kanalizacija.

The study also used the DPSIR (Driving forces, Pressures, State, Responses) methodology in order to allow a more detailed overview of local catchments so that potentially threatened water captures are captured using a matrix effect and impact on the existing and planned land use control displays the status of more concrete captures through tables and graphs.

In the present master's thesis, based on a review of all the existing literature, all accessible studies and field work, we have described the actual threat to local drinking water captures and have also determined the status of water captures by analyzing the existing use of premises and quality of water source for the specific time period (2005 - 2010).

With the help of field recharge, an inventory of existing land use and an inventory of potential contaminants in the area of individual water supply, a survies were conducted of individual captures. Based on the analysis of the technical conditions of the captures along with proposed measures for improvement, the statistical processing of the results from the microbiological and physical - chemical analysis of groundwater samples was carried out.

The research work sought to identify threats to existing local captures in the Municipality of Ljubljana from a sanitary - technical point of view (water quality on human health) and hydro geological aspects (quantitative and qualitative status of the particular groundwater) and to outline measures to improve the situation.

Ljubljana has 25 local water distribution systems registered to which individual captures belong. 3 (three) of them are being managed by the Public company Vodovod - Kanalizacija and are not problematic from the perspective of quality. The remaining 22 local water distribution sistems are being managed by the Municipality of Ljubljana, and three (3) local water distribution sistem are being managed by J.P.VO-KA. Other captures do not have continuous data for selected period and are not under public supervision or are already connected to other municipalities. According to data found in the field and based on the excess levels of microbiological and physic - chemical parameters, the captures Jernačev hrib, the capture under Gašper and the capture Korito are those that are more pronounced.

Due to the excessive amounts of data (over 15,000 reviewed reports on 150 parameters for 25 water distribution systems) this survey focuses only on the excessive limit values of parameters, which occurred under individual water distribution system in a period of five years. We have particularly highlighted details on the captures in question.

We have conducted an analysis on the quality and capture discharge according to hydrogeological conditions of each particular capture. An overview of the technical condition of the buildings in the following paragraphs also includes suggestions of measures to improve the situation, particularly where there is water contamination due to improperly implemented water capture from the spring.

We have interviewed many caretakers of local captures in order to demonstrate the active role of inhabitants in protecting particular local capture and in addition to the above we also made some proposals to better protect the local capture.

Based on the study data on captures for the local water distribution systems (review of all available data studies of the company Hidroconsulting, Geological Survey of Slovenia, J.P. VO - KA, etc.) and through collecting the data on the qualitative and quantitative status for particular captures over several years, we then conducted field work and sampling.

Based on the status present in the field we later conducted field mapping of the existing land use and implemented an inventory of potential contaminants in the water supply area of individual capture.

A survey of the caretakers for individual captures was conducted along with a summary of the data collected from laboratory analysis of water samples from captures with regard to selected parameters. An analysis of the technical condition of the captures follows while at the end proposals to remedy the situation are offered. The statistical treatment of the results from the microbiological and physical - chemical analysis of the groundwater samples is presented in the form of graphs and tables with comments

Key words: water supply, local capture, local water resource, local water distribution system, borehole, water well.

POVZETEK

V zadnjih letih je zbranih vedno več dokazov, ki govorijo v prid spremembam podnebja, ki vpliva na poplave ter posledično tudi na potencialno onesnaženost in spremembo kvalitete vode vodnih zajetij.

Pričujoča raziskava prikazuje trenutno situacijo ter analizo za nekaj letno obdobje o izbranih lokalnih zajetjih v Mestni občini Ljubljana ter vse spremembe, ki vplivajo na kakovost vode tamkajšnjega območja. V podrobnejši pregled in analizo so bila zajeta lokalna zajetja, ki se nahajajo na vzhodnem delu Ljubljane.

Poglaviten razlog za pisanje in pregled obstoječe tematike pa so dale povod globalne spremembe podnebja ter tudi nepričakovane poplave na Ljubljanskem območju. Ideja o pisanju na tovrstno tematiko se je porodila že v letu 2000, tako da so vsi dodatni dejavniki in poplave v preteklih letih samo potrdili prvo misel o visoki pomembnosti varovanja vode kot dobrine na lokalnem nivoju.

Pri raziskovanju se mi je porajalo tudi vprašanje ali je možno primerjati in ustrezno zaščititi lokalna zajetja, ki so v oskrbi krajanov mesta Ljubljane in javnega podjetja Vodovod Kanalizacija.

Uporabljen je DPSIR model za podrobnejši pregled nad lokalnimi zajetji, tako da se preko potencialno ogroženih vodnih zajetij s pomočjo matrike vplivov in učinkov glede na obstoječo in planirano rabo prostora bolj nadzorno prikaže stanje konkretnih zajetij preko tabel in grafov.
V pričujočem magistrskem delu je tako na podlagi pregleda obstoječe literature, vseh dostopnih študij ter terenskega dela opisana dejanska ogroženost lokalnih vodnih zajetij pitne vode, ugotovljeno pa je tudi stanje vodnih zajetij z analizo obstoječe rabe prostora in kakovosti vodnega vira za časovno obdobje (2005 - 2010).

S pomočjo terenskega kartiranja in popisa obstoječe rabe prostora ter popisa potencialnih onesnaževalcev v napajalnem območju posameznega zajetja je bil izveden anketni popis upravljavcev posameznih zajetij. Na podlagi analiz tehničnega stanja zajetij s predlogi ukrepov za izboljšanje stanja so bile izvedene statistične

obdelave rezultatov mikrobioloških in fizikalno kemijskih analiz vzorcev podzemne vode.

Namen magistrskega dela je bilo ugotoviti ogroženost še obstoječih lokalnih zajetij v Mestni občini Ljubljana iz sanitarno - tehničnega vidika (stanje zajetij), zdravstvenega vidika (kakovost vode za zdravje ljudi) in hidrogeološkega vidika (količinsko in kakovostno stanje zajete podzemne vode) ter podati ukrepe za izboljšanje stanja.
V analizo je bilo vzetih 40 lokalnih zajetij. Šest (6) zajetij je v upravljanju Javnega podjetja Vodovod Kanalizacija, 34 jih je v upravljanju Mestne občine Ljubljana, ostalih sedem (7) zajetij pa nima uporabnih podatkov ali niso pod javnim nadzorom ali pa je zajetje že priključeno ostalim občinam. Po podatkih iz analiz najbolj izstopajo zajetja lokalnega vodovodnega sistema Dolgo brdo, Vnajnarje korito in Besnica vas.

Uporabljen je DPSIR model (D - gonilne sile, P - pritiski, S - stanje, I - vplivi, R – odzivi) za podrobnejši pregled nad lokalnimi zajetji, tako da se preko potencialno ogroženih vodnih zajetij s pomočjo matrike vplivov in učinkov glede na obstoječo in planirano rabo prostora bolj nadzorno prikaže stanje konkretnih zajetij preko tabel in grafov.

Zaradi prevelike količine podatkov (pregledanih čez 15.000 dokumentov - poročil na 150 parametrov za 25 vodovodnih sistemov oz. za 40 zajetij), se ta raziskava osredotoča samo na presežne mejne vrednosti vseh mikrobioloških in fizikalno kemijskih parametrov za vodovodne sisteme in njihova zajetja v obdobju 5 let.

Izdelana je bila analiza kakovosti in izdatnosti zajetij glede na hidrogeološke razmere posameznega zajetja. Pregled tehničnega stanja objektov zajema v nadaljevanju naloge tudi predloge ukrepov za izboljšanje stanja, kjer prihaja do onesnaženja vode zaradi nestrokovno izvedenega zajema vode iz izvira.

Preko anketiranja skrbnikov lokalnih zajetij je prikazana aktivna vloga krajanov pri varovanju posamičnega lokalnega vira, podani pa so tudi predlogi za boljšo zaščito lokalnega vira. Na podlagi študijskih podatkov o zajetjih za lokalne vodovode (pregled vseh dostopnih študijskih podatkov podjetja Hidroconsulting, Geološkega zavoda Slovenije, J.P. VO - KA, itd.); ter zbiranja podatkov kakovostnega in količinskega stanja za posamezna zajetja za nekaj letno obdobje, je potekalo terensko in laboratorijsko delo.

Iz stanja na terenu se je tako izvedlo terensko kartiranje obstoječe rabe prostora in izvedel popis potencialnih onesnaževalcev v napajalnem območju posameznega zajetja.

Opravljen je bil anketni popis upravljavcev posameznih zajetij ter povzeti podatki takratnih laboratorijskih analiz vzorcev vode iz zajetij za izbrane parametre. Podane so analize tehničnega stanja zajetij v nadaljnjih poglavjih pa tudi predlogi ukrepov za izboljšanje stanja. Statistična obdelava rezultatov mikrobioloških in fizikalno - kemijskih analiz vzorcev podzemne vode je prikazana v obliki grafov in tabel z komentarji.

Ključne besede: vodni vir, lokalno zajetje, lokalni vodni vir, lokalni vodovodni sistem, vrtina, vodnjak.

9 REFERENCES

[1] Ivey J.L., De Loë, Kreutzwiser, Ferreyra, C. March 2006. An institutional perspective on local capacity for source water protection. Guelph Water Management Group, Department of Geography, University of Guelph, Guelph, Ont. Canada NIG2WI.

[2] Hunter Paul R., MacDonald Alan M., Carter C. Richard. November 2010. Water Supply and Health. Plos Medicine.

[3] Richardson Hopi Yip, Nichols Gordon, Lane Chris, Lake LainR., Hunter Paul R. May 2009. Microbiological surveillance of private water supplies in England - The impact of environmental and climate factors on water quality. School of medicine.

[4] Timmer D.K., De Loe R.C., Kreutzwiser. May 2005. Source water protection in the Annapolis Valley, Nova Scotia: Lessons for building local capacity. Land Use Policy, Canada.

[5] Exner Martin, Hartemann, Hunter R Paul, Levi Yves, Loret Jean - Francis, Mathys Werner,Villesot Daniel, Wilhelm Michael. August 2011. Consensus report: E. Coli 0104: H4 (HUSECO4) and the potential threat to European water supplies. International Journal of Hygiene and Environmental Health.

[6] Odlok o varstvu virov pitne vode. Ur.l RS št. 71/93.

[7] Odlok o varstvu lokalnih virov pitne vode. Ur.l RS št. št. 78/00.

[8] Uredba o vodovarstvenem območju za vodno telo vodonosnikov Ljubljanskega barja in okolice Ljubljane

[9] Statistični urad Republike Slovenije. 2012. http://www.stat.si/novica_prikazi.aspx?id = 3769 (12. mar. 2012).

[10] Potočnik V., Vudrag M. 2001. HACCP sistem: namen in uporaba. Ljubljana, Zavod za zdravstveno varstvo.

[11] Zavod za zdravstveno varstvo. 2010. Notranji nadzor na osnovah Haccap. Ljubljana, Zavod za zdravstveno varstvo.

[12] Arhivski podatki ZZV LJ o sistematičnem spremljanju zdravstvene ustreznosti pitne vode na lokalnih vodovodih Mestne občine Ljubljana (Letna in druga poročila o skladnosti pitne vode na lokalnih vodovodih v upravljanju Mestne občine Ljubljana)

[13] Zakon o vodah. Ur.l RS št. 67/02, 110/02, 57/08.

[14] Pravilnik o oskrbi s pitno vodo. Ur.l RS št. 35/06.

[15] Pravilnik o pitni vodi. Ur.l RS št. 19/04, 35/04, 26/06, 92/06, 25/09.

[16] Pravilnik o kriterijih za določitev vodovarstvenega območja. Ur.l RS št. 64/04, 5/06.

[17] Zakon o zdravstveni ustreznosti živil in izdelkov ter snovi, ki prihajajo v stik z živili /ZZUZIS/. Ur.l RS št. 52/00) 2. člen 4. alineja.

[18] Direktiva o pitni vodi (98/ 83/ ES) in varnosti oskrbe, izvidi laboratorijskih preiskav vzorcev pitne vode 2005 - 2011.

[19] Ministrstvo za zdravje RS. 2005. Program monitoringa pitne vode, Ljubljana.

[20] Ministrstvo za zdravje RS. 2006. Program monitoringa pitne vode, Ljubljana.

[21] Ministrstvo za zdravje RS. 2007. Program monitoringa pitne vode, Ljubljana.

[22] Ministrstvo za zdravje RS. 2008. Program monitoringa pitne vode, Ljubljana.

[23] Ministrstvo za zdravje RS. 2009. Program monitoringa pitne vode, Ljubljana.

[24] Ministrstvo za zdravje RS. 2010. Program monitoringa pitne vode, Ljubljana.

[25] Jung E. Kim, Herrera Jose E., Huggins D., Braam J., Koshowski S. Effect of pH on the concentrations of lead and trace contaminants in drinking water: A combined batch, Pipe loop and sentinel home study *Original Research Article Water Research* 45, 9, (April 2011) 2763 - 2774.

[26] Reyes A. M. V. Letelier R. De la Iglesia, B. González G. Lagos. Centro de Minería 2007. Microbiologically induced corrosion of copper pipes in low - pH water. Facultad de Ingeniería, Pontificia Universidad Católica de Chile, Santiago, Chile Laboratorio de Microbiología.

[27] Rompré A, Servais P., Baudart J., De - Roubin M., Laurent P. 2002. Detection and enumeration of coliforms in drinking water: current methods and emerging approaches Original Research Article. *Journal of Microbiological Methods* 49, 1, (March 2002) 31-54.

[28] Meier H, Koob C., Ludwig W., Amann R., Frahm E., Hoffmann S., Obst U., Schleifer K.H. 1997. Detection of enterococci with rRNA targeted dna probes and their use for hygienic drinking water control Original Research Article. *Water Science and Technology* 35, 11-12 (1997) 437- 444.

[29] Steyer A, Godič Torkar K., Gutiérrez - Aguirre I., Poljšak - Prijatelj M. 2011. High prevalence of enteric viruses in untreated individual drinking water sources and surface water in Slovenia 2011. Institute of microbiology and immunology, faculty of medicine, University of Ljubljana.

[30] Priloga I pravilnika o pitni vodi, del A mikrobiološki parametri. Ur.l. RS št. 19/04, 35/04, 26/06, 92/06.

[31] Zavod za zdravstveno varstvo Maribor 2005-2011, Poročila o vzorčenju in meritvah na terenu 2005 - 2011 http://www.jhl.si/vo-ka/informacije / kakšno vodo pijemo / lokalni - vodovodni - sistemi (12. mar. 2012).

[32] European Commission. 2008. Groundwater Protection in Europe – The new groundwater directive – Consolidating the EU regulatory framework.

[33] Tschering K., Helming K., Krippner B., Sieber Stefan, Paloma S.G. 2011. Does research applying the DPSIR framework support decision making? Land Use Policy 29 (2012) 102-110.

[34] Borja A., Galparsoro I., Solaun O., Muxika I., Tello E. M., Uriarte A., Valencia V. 2005. The European Water Framework Directive and the DPSIR, a methodological approach to assess the risk of failing toachieve good ecological status Estuarine, Coastal and Shelf Science 66 (2006) 84 e 96.

[35] Daniels Peter L. 2009. DPSIR Climate change, economics and Buddhism - Part I: An integrated environmental Griffith School of Environment, Griffith University. 2009

[36] Lozar Manfreda, K. 2006. Načini anketiranja. Http://WWW.stat.si/popis2002/gradivo/si-92. pdf (12. Feb. 2007).

[37] Mencej Z., J. Rogelj, GZL. 1989. Predlog varovanja pitne vode v vrtini J-3/89 pri Javorju.1989

[38] Mencej Z. 1979. Pomembnejši vodonosniki v karbonatnih kamninah na vzhodnem območju Mestne občine Ljubljana, II. faza, Hidroconsulting, d. o. o.1979

[39] Hidroconsulting d.o.o. 1992. Varovanje pitne vode zajetja »Pečovje« pri Prežganju, predlog sanacijskih ukrepov v varstvenih pasovih. 1992

[40] Mencej Z. 1998, Poročilo o rezultatih kaptažne vrtine PM-1/98 v Podmolniku in Strokovne podlage za zavarovanje zajetja pitne vode z vrtino PM 1/98 v Podmolniku Hidroconsulting, 1998.

[41] Kmetec M. 1998. Poročilo o rezultatih kaptažne vrtine ŠP-1/98 v Šentpavlu in strokovne podlage za zavarovanje zajetja pitne vode z vrtino ŠP-1/98 v Šentpavlu, Hidroconsulting, d. o. o. 1998

[42] Mencej Z., Hidroconsulting, d. o. o. 1993. Zajetja pitne vode in perspektivni

vodni viri.

[43] Mencej Z., Hidroconsulting, d. o. o. 1994. Rezultati raziskav za zajem dodatnih količin pitne vode za vodovod Lipoglav in varovanje zajetja pitne vode z vrtino L-1/94.1994

[44] Mencej Z. 1993. Zajetja pitne vode in perspektivni vodni viri v občini Moste–Polje, Hidroconsulting, d. o. o.1993

[45] Mencej Z., Hidroconsulting, d. o. o. 1997. Pomembnejši vodonosniki v karbonatnih kamninah na vzhodnem območju Mestne občine Ljubljana, II. Faza.1997

[46] Kmetec M., Hidroconsulting, d. o. o. 1998. Poročilo o rezultatih kaptažne vrtine ŠP- 1/98 v Šentpavlu in strokovne podlage za zavarovanje zajetja pitne vode z vrtino ŠP-1/98 v Šentpavlu.1998

[47] Mencej Z, Hidroconsulting, d. o. o. 1998. Poročilo o rezultatih kaptažne vrtine PM-1/98 v Podmolniku in strokovne podlage za zavarovanje zajetja pitne vode z vrtino PM-1/98 v Podmolniku. 1998

[48] Mencej Z. 2002. Zajetje pitne vode z vrtino J-1/02 pri Jančah, Hidroconsulting, d. o. o.

[49] Mencej Z. 2002. Poročilo o rezultatih kaptažne vrtine J- 4/02 za vodovod Javor. 2002. Poročilo o rezultatih kaptažne vrtine J-4/02 za vodovod Javor.2002

[50] Hidroconsulting d. o. o. 2002. Poročilo o rezultatih kaptažne vrtine J-1/02 pri Jančah in strokovne podlage za zavarovanje vodnega vira " zajetje z vrtino J-1/02.2002

[51] Mencej Z., Hidroconsulting, d. o. o. 2002. Zajetje pitne vode z vrtino J-1/02 pri Jančah Možnosti oskrbe krajev in naselij v Krajevni skupnosti Besnica s kvalitetno pitno vodo. 2002

[52] Hidroconsulting, d. o. o. 2003. Poročilo o rezultatih kaptažne vrtine SB-1/03 pri spodnji Besnici in strokovne podlage za zavarovanje vodnega vira"zajetje z vrtino SB-1/03.2003

[53] Mencej Z., Hidroconsulting, d. o. o. 2003. Zajetje z vrtino RB-1/03 za oskrbo Ravnega Brda s pitno vodo in strokovne podlage za zavarovanje zajetja.2003

[54] Mencej Z., Buser I., Hidroconsulting, d. o. o., 2004. Črpalni poskus na zajetju z vrtino ŽV-1/01 na Žagarskem vrhu. 2004

[55] Mencej Z, Hidroconsulting, d. o. o. 2004. Vzdrževalna in sanacijska dela na lokalnih vodovodih Mestne občine Ljubljana - Poročilo o izvedenih delih v letu

2004.

[56] Mencej Z., Hidroconsulting, d. o. o. 2004. Sanacija zajetja pitne vode za vodovod Tuji Grm.2004

[57] Mencej Z., Hidroconsulting, d. o. o. 2004. Poročilo o rezultatih kaptažne vrtine SB-1/03 pri Spodnji Besnici in strokovne podlage za zavarovanje vodnega vira »Zajetje z vrtino SB-1/03« 2004

[58] Mencej Z. 2004. Vzdrževalna in sanacijska dela na lokalnih vodovodih Mestne občine Ljubljana - Poročilo o izvedenih delih v letu 2004, Hidroconsulting, d. o. o. 2004

[59] Mencej Z. 2004. Sanacija zajetja pitne vode za vodovod Tuji Grm, Hidroconsulting, d. o. o. 2004

[60] Hidroconsulting, d. o. o 2005. Strokovne podlage za izvedbo postopka za dodelitev vodnega dovoljenja za izkoriščanje podzemne vode iz vrtine ZGB-1/05, Hidrogeološko poročilo za vrtino ZGB-1/05 v Zgornji Besnici.2005

[61] Hidroconsulting, d. o. o. 2005. Strokovne podlage za pridobitev vodnega dovoljenja za oskrbo s pitno vodo iz nadomestnega vodnega vira”zajetje z vrtino D-1/05 pri Dolinarju (Hidrogeloški del). 2005

[62] Mencej Z., Hidroconsulting, d. o. o. 2005 . Poročilo o izvedenem čiščenju vrtine S-1/92 in predlogi načina obratovanja vodovoda Sadinja vas.2005

[63] Mencej Z. 2005. Strokovne podlage za pridobitev vodnega dovoljenja za oskrbo s pitno vodo iz vrtine D-1/05 pri Dolinarju za vodovod Podmolnik - Hidrogeološki del, Hidroconsulting, d. o. o. 2005

[64] Hidroconsulting, d. o. o 2005. Strokovne podlage za izvedbo postopka za dodelitev vodnega dovoljenja za izkoriščanje podzemne vode iz vrtine ZGB-1/05, Hidrogeološko poročilo za vrtino ZGB -1/05 v Zgornji Besnici.

[65] Hidroconsulting, d. o. o. 2005. Strokovne podlage za pridobitev vodnega dovoljenja za oskrbo s pitno vodo iz nadomestnega vodnega vira”zajetje z vrtino D-1/05 pri Dolinarju (Hidrogeloški del).2005

[66] Mencej Z. 2004. Poročilo o rezultatih kaptažne vrtine SB-1/03 pri Spodnji Besnici in strokovne podlage za zavarovanje vodnega vira »Zajetje z vrtino SB-1/03« Hidroconsulting, d. o. o. 2004

[67] Mencej Z. 2005. Poročilo o izvedenem čiščenju vrtine S-1/92 in predlogi načina obratovanja vodovoda Sadinja vas, Hidroconsulting, d. o. o. 2005

[68] Mencej Z. 2005. Strokovne podlage za pridobitev vodnega dovoljenja za oskrbo

s pitno vodo iz vrtine D-1/05 pri Dolinarju za vodovod Podmolnik - Hidrogeološki del, Hidroconsulting, d. o .o .2005

[69] EPA. 2012. http://water.epa.gov/drink/contaminants/secondarystandards.cfm (12. mar. 2012).

[70] Iron and Manganese in Household Water. North Carolina Cooperative Extension Service. Publication Number: HE - 394 Last Electronic Revision: March 1996 (JWM)

[71] Gantzer Pa, Bryant Ld, Little Jc. Controlling soluble iron and manganese in a water-supply capture using hypolimnetic oxygenation.Virginia

[72] Podatkovne baze Atlasa okolje. Ur.l. RS št. 115/07. http://meteo.arso.gov.si/met/sl/app/webmet/ okolice (12. mar. 2012)

ACKNOWLEDGMENT

I would like to thank my parents who have heard me and supported me generously.

Sincere thanks to my mentor, doc. dr. Barbara Čenčur Curk for the professional consultations - every dialogue with you was of great importance for me.

I would like to express my thanks to Ms. Danica Kopriva, who selflessly helped me in searching for data and other literature and allowed me to be present during implementation of concrete sampling in the field.

I would also like to give my special thanks to Mr. Miroslav Kocuvan for the detailed explanation of captures and boreholes as well as his assistance in the search for statistical reports.

Last, but not least, I would also like to thank the Institute of Public Health and its co - workers in the laboratory and especially my friends: Mojca P., Bojan Z. and Bojana Č. for their moral incentive, all debates and positive advice.